LAKE WATER QUALITY ASSESSMENT AND CONTAMINANT MONITORING OF FISHES AND SEDIMENTS FROM MONTANA WATERS

FINAL REPORT TO:

U.S. ENVIRONMENTAL PROTECTION AGENCY

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INTRODUCTION

Montana has about 7,000 lakes, reservoirs and ponds larger than 5 acres covering a total of 834,000 acres (EPA Total Waters Computer Database 1993). Most of these waters support fishing. Angling provides nearly 2,400,000 days of recreation annually, of which approximately half is lake fishing. Several mid-western states, including those surrounding the Great Lakes, have developed comprehensive sampling programs to determine if sportfishes are contaminated with pollutants. A variety of contaminants, both organic and inorganic, are being monitored and many states issue consumption advisories because of the presence of contaminants in edible portions of fish. Among the most notable contaminants are methylmercury and polychlorinated biphenyls (PCB's). At least 21 states and two Canadian Provinces presently issue advisories because of mercury contaminated freshwater fishes. Thirty-three states issue advisories because of PCB's in fishes.

Polychlorinated biphenyls have been used as coolants for electrical transformers and capacitors, heat transfer fluids, flame retardants, paints, plasticizers, lubricants and pesticides. PCB's are volatile, and thus are subject to atmospheric transport. Consequently, they are sometimes found in locations where no apparent waterborne sources are present. PCB's have a high tendency to bioaccumulate in fishes and other aquatic life.

Mercury exists in many forms in natural waters. However, methylmercury is the most toxic and bioaccumulative chemical species. Unfortunately, bacteria present in most natural waters are capable of converting inorganic mercury to methylmercury (Wood et al. 1968; Jensen and Jernelov 1969). Hence, mercury entering waters in any form potentially poses a hazard. Although the most severe examples of mercury contamination occur near industrial sources, recent work has shown that in some environments, small quantities of mercury originating from natural weathering (Phillips et al. 1987) or atmospheric transport (Roloff 1991) can result in accumulations of mercury in fishes that exceed federal action levels.

Recreational fishermen are potentially a high risk group because they sometimes consume large amounts of fish. Moreover, many anglers fish the same locations repeatedly. Accordingly, we have completed a screening survey to determine concentrations of both mercury and PCB's in sportfishes and sediments from Montana waters. We also assessed the trophic status of these waters to expand our clean lakes assessment data base.

The waters that were monitored encompassed all of Montana's major river drainages including the Missouri, Yellowstone, Kootenai, and Clark Fork. These waters range in size from 330 hectares (Cooney Reservoir) to 99,151 hectares (Fort Peck Reservoir) and from 11 to 122 meters maximum depth (Table 1). We focused mostly on lakes and reservoirs for this project because they are sinks for pollutants such as PCB's and mercury which tend

Table 1. Waterbodies monitored including outlet drainage, river basin, surface area, and maximum depth.

Water body	Outlet drainage	River basin	Surface area (ha)	Maximum depth (m)
Bighorn Lake	Bighorn River	Yellowstone	3,337	122
Big Spring Creek	--	Missouri	--	--
Canyon Ferry Res.	Missouri River	Missouri	14,237	50
Clark Canyon Res.	Beaverhead R.	Missouri	1,978	29
Cooney Reservoir	Red Lodge Creek	Yellowstone	330	19
Flathead Lake	Flathead River	Clark Fork	50,995	118
Fort Peck Res.	Missouri River	Missouri	99,151	64
Fresno Res.	Milk River	Missouri	1,617	12
Georgetown Lake	Flint Creek	Clark Fork	1,479	11
Hauser Lake	Missouri River	Missouri	1,538	21
Hebgen Lake	Madison River	Missouri	5,127	24
Holter Lake	Missouri River	Missouri	1,943	37
Lake Elwell	Marias River	Missouri	7,081	46
Lake Frances	Marias River	Missouri	2,240	14
Lake Koocanusa	Kootenai River	Kootenai	10,927	113
Lake Mary Ronan	Ronan Creek	Clark Fork	612	14
Nelson Reservoir	Milk River	Missouri	1,579	12
Seeley Lake	Clearwater R.	Clark Fork	424	41
Silver Creek	--	Missouri	--	--
Swan Lake	Swan River	Clark Fork	1,085	40
Tongue River Res.	Tongue River	Yellowstone	1,417	15
Willow Creek Res.	Willow Creek	Missouri	351	23

to be associated with sediments. Further, newly impounded reservoirs are often susceptible to mercury problems. We also monitored Silver Creek near Helena and Big Spring Creek near Lewistown--locations where previous monitoring has detected the presence of contaminants.

All of the waters monitored are accessible to the public and are surrounded by a variety of recreational facilities and fishing access sites managed by both state and federal agencies. These are among the most highly utilized water bodies in Montana and altogether account for over 50% of the statewide angling pressure on lakes and reservoirs. Hence, these are high priority waters for contaminant monitoring and determination of trophic status.

Salmonid fisheries supported in several of these waters include kokanee salmon, lake trout, bull trout, brook trout, rainbow trout, brown trout, cutthroat trout, lake whitefish, and mountain whitefish. Some waters also support cool or warmwater species including walleye, northern pike, yellow perch, largemouth bass, and burbot.

In all cases, the species monitored are highly sought by recreational anglers and are relatively abundant. Additionally, whenever possible, predators and relatively long-lived species were chosen because of the positive relationships that exist between position in the food chain, longevity, and tissue residues of both PCB's and methylmercury. Finally, because salmonids generally have a relatively high lipid content and because PCB's are lipophilic, we selected salmonids for monitoring in all locations where salmonids represent an important recreational angling species. We did not include rough fish species in this survey because human consumption and risk is the primary concern.

METHODS

Lake water column

Summertime Secchi depth, total phosphorus, and chlorophyll *a* were measured at the surface of each lake or reservoir following standard methods. Secchi depth and total phosphorus were used to compute Carlson's trophic state index (Carlson 1977) and to assign each lake or reservoir its trophic status.

The hand pump and filter apparatus used to collect chlorophyll *a* samples did not allow the field sampler to pass sufficient volumes of water through the filters to yield reliable chlorophyll *a* readings in the laboratory. Hence, chlorophyll *a* was not included in calculating Carlson's TSI for these lakes.

Trophic status was based on the **average** of the Carlson index values computed for Secchi depth and total phosphorus. An average index value of 35 was used as the transition value between oligotrophic and mesotrophic lakes; an average value of 50 was considered the transition between mesotrophic and eutrophic lakes.

Lake bottom sediment

A bottom sediment sample was collected from near mid-reservoir at each sample site using an Ekman Dredge. Samples were transferred to a glass jar, stored on ice, and subsequently frozen. Aluminum foil was placed between the lid and the glass as a quality assurance measure.

Mercury in wet sediment was determined using cold vapor atomic absorption spectrophotometry (EPA 1979). The minimum detection limit was 0.05 μg/g (wet weight basis). A separate sample aliquot was used to determine sediment moisture content and concentrations were subsequently converted and reported on a dry sediment basis.

Concentrations of PCB's in sediment were determined by the method of EPA (1981); limit of detection was 0.05 μg/g (wet basis). A standard curve was constructed for each arochlor (PCB isomer) and the correlation coefficient was not less than 0.99. Standards analyzed throughout the testing were required to fall within 20% of the standard curve. Quality control measures for both mercury and PCB's included reagent blanks, spike and recovery, analysis of reference samples, and both blind and laboratory duplicates (results of duplicate analysis are summarized in Table 2). Sediment collected from one of the reservoirs (Canyon Ferry) served as the in-house quality control.

Table 2. Results of duplicate analyses for sediment samples (dry weight basis); nd indicates none detected.

Sample location	Sample type	Concentration (µg/g) Hg	Concentration (µg/g) PCB	Sample location	Sample type	Concentration (µg/g) Hg	Concentration (µg/g) PCB
Canyon Ferry	lab	0.18	nd	Hauser	lab	0.23	nd
		0.15	nd			0.23	nd
Clark Canyon	lab	0.17	--	Hebgen	lab	0.84	nd
		nd	--			0.74	nd
Cooney	lab	0.16	nd	Holter	lab	0.08	nd
		0.19	nd			0.08	nd
Flathead	lab	--	nd	Koocanusa	lab	0.05	nd
		--	nd			0.08	nd
Fort Peck	lab	0.21	nd	Seeley	lab	0.05	nd
		0.21	nd			0.07	nd
Bighorn	blind	nd	nd	Mary Ronan	blind	0.09	nd
		nd	nd			nd	nd

Fish tissue

During 1992, fish were collected from each of seven reservoirs; the remaining locations were sampled the following year. Gill nets were used for collections in most waters and electrofishing was used in Big Spring and Silver Creeks. The most important sport fishes were intentionally selected from each location because these are the fish that anglers consume.

Fish were individually wrapped in aluminum foil and frozen. Prior to processing, fish were thawed, weighed and measured. Samples of each species were grouped into two or more size categories and fillets from a given size group were combined and ground to form a single composite sample which was placed in a glass jar and frozen before transfer to the laboratory. The only exception was Silver Creek where individual fish were analyzed. Fish tissue was analyzed for mercury using the method of Olsen et al. (1975). Concentrations of PCB's in fish tissue were determined by gas chromatography (AOAC 1990). The method detection limit was 0.05 $\mu g/g$ for both mercury and PCB's. Quality assurance/quality control measures included spike and recovery, analysis of reference materials, reagent blanks, and blind and laboratory duplicates. Results of duplicate analyses are summarized in Table 3.

Table 3. Results of duplicate analyses for fish tissue.

Sample type	Conc. (µg/g) Hg	PCB	% Lipid	Sample type	Conc. (µg/g) Hg	PCB	% Lipid	Sample type	Conc. (µg/g) Hg	PCB	% Lipid
lab	0.05	nd	16.9	lab	0.40	0.05	2.8	lab	--	nd	6.2
	0.06	nd	17.0		0.35	nd	2.6		--	nd	6.2
lab	0.14	--	--	lab	0.11	--	--	lab	0.10	nd	0.9
	0.14	--	--		0.06	--	--		0.09	nd	1.0
blind	0.09	nd	17.1	lab	--	0.08	--	lab	0.08	nd	8.5
	0.10	nd	16.4		--	0.07	--		0.08	nd	8.7
blind	0.60	nd	2.9	blind	0.66	--	--	lab	--	nd	2.7
	0.67	nd	2.9		0.75	--	--		--	nd	2.8
blind	0.35	nd	0.5	lab	0.13	--	--	lab	--	0.06	7.5
	0.38	nd	0.5		0.15	--	--		--	0.06	7.6
blind	0.11	nd	1.8	lab	0.77	--	--	blind	0.76	0.20	6.1
	0.12	nd	1.8		0.71	--	--		0.78	0.15	5.9
blind	nd	nd	2.0	lab	0.16	--	--	lab	0.06	--	--
	nd	nd	2.0		0.16	--	--		0.06	--	--
lab	0.10	nd	0.4	blind	0.16	nd	0.5				
	0.10	nd	0.4		0.16	nd	0.7				
lab	0.13	nd	10.3	lab	nd	nd	1.8				
	0.10	nd	10.7		nd	nd	1.8				

RESULTS & DISCUSSION

Lake water quality

Only 4 of the 20 most popular lakes and reservoirs in Montana (Flathead, Elwell, Mary Ronan, and Swan) were classified as oligotrophic (Table 4). Lake Elwell (Tiber Reservoir) on the Marias River was a borderline case and further sampling may show this reservoir to be mesotrophic. Flathead, Mary Ronan and Swan are all located in the Flathead Valley and all are showing signs of cultural eutrophication. Flathead and Swan have Clean Lakes Program Phase I projects in progress and Flathead is the subject of a coordinated State/Tribal TMDL.

Blooms of toxic blue-green algae have been documented in Canyon Ferry, Fort Peck, Hebgen, and Nelson reservoirs (WQB unpublished data). Such blooms in Fort Peck and Hebgen--the two mesotrophic reservoirs in this group--occurred in bays separate from the main lake. Periphyton samples have been collected from all of these waters as part of a continuing Lake Water Quality Assessment project to develop bioassessment protocols for Montana lakes and reservoirs.

Table 4. Trophic status of lakes and reservoirs monitored during this assessment.

Waterbody	T-P Mg/L	Secchi disk depth	TSI T-P	TSI SD	Trophic status
Bighorn Lake	0.031	1.5	54	54	eutrophic
Canyon Ferry Res.	0.029	1.6	53	53	eutrophic
Clark Canyon Res.	0.018	4.5	46	38	mesotrophic
Cooney Res.	0.016	1.5	44	54	mesotrophic
Flathead Lake	0.002	>7	14	<30	oligotrophic
Fort Peck Res.	0.008	5.5	35	35	mesotrophic
Fresno Reservoir	0.020	1.8	47	52	mesotrophic
Georgetown Lake	0.014	3.5	42	42	mesotrophic
Hauser Lake	0.039	1.0	57	60	eutrophic
Hebgen Lake	0.020	3.0	47	44	mesotrophic
Holter Lake	0.043	2.1	58	49	eutrophic
Lake Elwell	0.004	3.0	24	44	oligotrophic
Lake Francis	0.007	4.0	32	40	mesotrophic
Lake Kookanusa	0.006	2.0	30	50	mesotrophic
Lake Mary Ronan	0.005	7.0	27	32	oligotrophic
Nelson Res.	0.052	1.2	61	57	eutrophic
Seeley Lake	0.006	3.5	30	42	mesotrophic
Swan Lake	0.005	4.0	27	40	oligotrophic
Tongue Res.	0.026	2.0	51	50	eutrophic

PCB's in sediments and fishes

Of the twenty-two waterbodies sampled, none had detectable levels of PCB's in sediments (Table 5). Only walleye from Holter Lake, rainbow trout from Big Spring Creek and Seeley Lake, and lake trout from Flathead Lake had detectable concentrations of PCB's in muscle tissue (Table 6). The PCB concentrations found in fishes from both Seeley Lake and Holter Lake were very low -- just barely above the detection limit of 0.05 $\mu g/g$. However, PCB's in rainbow trout from Big Spring Creek and lake trout from Flathead Lake ranged up to 0.24 and 0.94 $\mu g/g$, respectively. The source of PCB's in these water bodies is not presently known.

The lipid content in muscle tissue was generally greater in older larger fish than in smaller fish and tended to be higher in salmonids than in other species. Kokanee salmon had a particularly high lipid content, approaching nearly 20% in some locations. The largest size group of kokanee from all three locations where they were sampled contained a smaller lipid percentage than smaller size groups because these fish were in a prespawning condition and had begun to deplete their lipid stores.

Mercury in sediments and fishes

Mercury concentrations in sediments ranged from below detection in several reservoirs to 0.84 $\mu g/g$ in Hebgen Lake (Table 5). There are no known anthropogenic sources of mercury to any of

Table 5. Mercury and PCB concentrations (dry basis) in sediments from various Montana waters (nd indicates none detected).

Waterbody	Concentration (μg/g)[a] Hg	PCB	Waterbody	Concentration (μg/g)[a] Hg	PCB
Bighorn	nd	nd	Hebgen	0.84	nd
Canyon Ferry	0.18	nd	Holter	0.08	nd
Clark Canyon	0.17	nd	Koocanusa	0.05	nd
Cooney	0.10	nd	Mary Ronan	nd	nd
Flathead	nd	nd	Nelson	nd	nd
Fort Peck	0.21	nd	Seeley	0.32	nd
Fresno	nd	nd	Swan	nd	nd
Frances	nd	nd	Tiber	nd	nd
Georgetown	0.13	nd	Tongue	nd	nd
Hauser	0.23	nd	Yellowtail	nd	nd

[a]Concentrations were estimated on a dry weight basis by adjusting for percentage of moisture.

Table 6. Mercury and PCB concentrations (wet weight basis) and percentage lipid of muscle tissue from various size groups of fishes from Montana waters (nd indicates none detected).

Waterbody	Fish species	Size range (in)	N	Conc. µg/g Hg	Conc. µg/g PCB	% Lipid
Bighorn Lake	Walleye	9.8 - 15.1	12	0.20	nd	0.3
		19.2 - 20.7	4	0.58	nd	0.8
		27.0 - 27.5	2	1.4	nd	4.4
Big Spring Creek	Rainbow trout	6.9 - 11.9	11	nd	0.07	1.8
		12.7 - 14.0	11	nd	0.16	3.6
		14.2 - 16.3	10	nd	0.24	3.1
Canyon Ferry Reservoir	Rainbow trout	8.9 - 12.5	9	0.11	nd	1.3
		14.7 - 17.4	8	0.11	nd	4.3
		18.2 - 19.7	8	0.14	nd	2.7
	Yellow perch	5.2 - 6.9	50	0.10	nd	0.4
		7.0 - 9.3	52	0.11	nd	0.4
		9.4 - 11.6	11	0.20	nd	0.3
	Burbot	14.8 - 17.7	8	0.18	nd	0.5
Clark Canyon Reservoir	Rainbow trout	11.6 - 15.9	20	0.08	nd	7.9
		17.0 - 19.4	13	0.12	nd	6.3
		20.2 - 22.8	6	0.16	nd	3.7
	Burbot	26.2 - 27.1	3	0.07	nd	0.3
Cooney Reservoir	Rainbow trout	7.6 - 9.2	13	0.07	nd	1.5
		11.7 - 12.9	15	nd	nd	1.3
		13.7 - 16.0	13	nd	nd	2.0
	Walleye	8.8 - 13.1	23	0.30	nd	0.2
		16.7 - 22.2	5	0.39	nd	3.2
		25.6 - 27.4	2	0.37	nd	3.3
Flathead Lake	Lake trout	18.0 - 21.6	10	0.29	nd	1.9
		21.7 - 26.7	5	0.42	0.08	2.3
		27.6 - 31.1	7	0.64	0.12	6.0
		31.4 - 32.2	6	0.76	0.20	6.1
		32.1 - 34.3	5	0.87	0.22	6.8
		34.5 - 35.2	3	0.79	0.42	8.8
		36.5	1	0.77	0.94	11.4
		37.0 - 38.8	3	1.15	0.41	5.2

Table 6 (continued). Mercury and PCB concentrations (wet weight basis) and percentage lipid of muscle tissue from various size groups of fishes from Montana waters (nd indicates none detected).

Waterbody	Fish species	Size range (in)	N	Conc. µg/g Hg	Conc. µg/g PCB	% Lipid
Flathead Lake (continued)	Lake whitefish	11.4 - 14.1	9	0.12	nd	1.1
		15.2 - 17.7	15	0.18	nd	1.6
		17.9 - 18.9	9	0.22	nd	1.8
Fort Peck Reservoir	Walleye	8.8 - 14.9	26	0.28	nd	0.3
		15.1 - 20.8	22	0.35	nd	0.5
		21.7 - 27.3	15	0.58	nd	2.7
	Northern pike	20.8 - 24.9	5	0.34	nd	0.6
		26.8 - 28.4	5	0.37	nd	1.0
		28.6 - 32.8	7	0.43	nd	1.1
		34.3 - 36.0	2	0.57	nd	3.4
	Lake trout	24.7 - 28.5	6	0.28	nd	9.1
		28.9 - 32.0	5	0.53	nd	10.7
Fresno Reservoir	Walleye	9.1 - 14.0	19	0.16	nd	0.5
		14.5 - 17.3	15	0.27	nd	0.7
		>17.3	10	0.75	nd	0.8
Georgetown Lake	Brook trout	10.7 - 12.5	8	0.10	nd	1.1
		12.8 - 15.0	8	nd	nd	1.7
		15.8 - 15.9	3	nd	nd	2.6
	Kokanee	11.7 - 13.3	13	0.05	nd	3.2
Hauser Reservoir	Kokanee	6.3 - 7.1	27	0.05	nd	3.2
		11.5 - 13.0	8	0.05	nd	16.9
		16.9 - 20.6	9	0.19	nd	6.1
	Rainbow trout	10.4 - 12.1	13	0.10	nd	1.8
		15.9 - 17.6	6	nd	nd	5.6
	Yellow perch	5.3 - 7.7	15	nd	nd	0.3
		8.1 - 10.1	10	nd	nd	0.3
		11.1 - 14.4	3	0.14	nd	0.2
Hebgen Lake	Brown trout	11.2 - 13.8	6	0.17	nd	1.6
		14.7 - 17.7	9	0.26	nd	1.6
		19.2 - 25.6	9	0.60	nd	2.9

Table 6 (continued). Mercury and PCB concentrations (wet weight basis) and percentage lipid of muscle tissue from various size groups of fishes from Montana waters (nd indicates none detected).

Waterbody	Fish species	Size range (in)	N	Conc. µg/g Hg	Conc. µg/g PCB	% Lipid
Holter Reservoir	Kokanee	10.5 - 14.1	10	0.09	nd	18.7
		15.8 - 16.6	8	0.09	nd	17.1
		19.5 - 22.1	9	0.38	nd	8.1
	Rainbow trout	12.6 - 13.5	8	0.08	nd	2.1
		14.0 - 17.5	10	0.07	nd	4.8
		17.7 - 19.5	7	nd	nd	5.6
	Walleye	12.0 - 19.5	8	0.25	nd	0.8
		19.7 - 24.1	9	0.32	0.08	1.8
		25.0 - 26.7	5	0.40	0.05	2.8
Lake Elwell	Walleye	9.5 - 10.7	28	0.23	nd	0.5
		10.9 - 14.4	14	0.54	nd	0.6
		16.9 - 19.7	4	0.78	nd	0.7
Lake Frances	Walleye	12.4 - 14.0	15	0.45	nd	0.4
		16.0 - 17.8	10	0.75	nd	0.5
		18.4 - 20.8	5	0.91	nd	0.5
Lake Koocanusa	Burbot	14.2 - 16.1	6	0.10	nd	0.3
		17.1 - 21.3	9	0.25	nd	0.3
	Kokanee	9.3 - 11.9	21	0.13	nd	10.3
		12.8 - 14.0	8	0.11	nd	10.0
		14.1 - 15.2	10	0.11	nd	1.8
Lake Mary Ronan	Rainbow trout	13.2 - 15.2	4	nd	nd	3.5
		15.5 - 16.6	3	nd	nd	4.5
	Kokanee salmon	8.7 - 9.7	9	0.22	nd	10.0
		9.9 - 10.5	10	0.13	nd	10.5
		10.7 - 12.0	7	0.13	nd	10.5
Nelson Reservoir	Walleye	14.0 - 17.5	11	0.13	nd	0.6
		19.0 - 20.6	9	0.16	nd	0.8
		22.1 - 23.2	6	0.64	nd	1.2
		24.5 - 26.0	3	0.67	nd	1.1
	Northern pike	24.0 - 26.1	4	0.15	nd	1.0

Table 6 (continued). Mercury and PCB concentrations (wet weight basis) and percentage lipid of muscle tissue from various size groups of fishes from Montana waters (nd indicates none detected).

Waterbody	Fish species	Size range (in)	N	Conc. µg/g Hg	Conc. µg/g PCB	% Lipid
Seeley Lake	Rainbow trout	18.2 - 20.1	3	nd	0.06	7.5
	Mountain whitefish	9.3 - 10.4	15	nd	nd	1.0
		10.6 - 11.1	14	0.08	nd	0.8
		11.2 - 11.6	11	0.10	nd	1.0
Silver Creek	Cutthroat trout	12.7	1	1.6	--	--
		17.1	1	3.1	--	--
		18.7	1	3.0	--	--
Swan Lake	Kokanee salmon	7.5 - 11.2	7	0.06	nd	4.9
		12.2 - 12.9	4	0.07	nd	6.2
		14.3 - 17.7	2	0.08	nd	8.5
	Bull trout	11.3 - 17.0	13	0.10	nd	0.9
		17.8 - 19.5	7	0.12	nd	1.3
		19.6 - 23.2	5	0.10	nd	7.6
Tongue River Reservoir	Walleye	10.2 - 12.9	13	0.13	nd	0.3
		16.1 - 22.5	10	0.26	nd	0.6
		25.0 - 26.4	2	0.46	nd	0.1
	Northern pike	24.9 - 26.2	6	0.17	nd	0.8
		28.2 - 30.0	2	0.30	nd	0.5
Willow Creek Reservoir	Rainbow trout	8.1 - 13.4	7	0.06	nd	2.5
		15.2 - 17.7	8	0.06	nd	5.8
		17.9 - 19.3	6	0.08	nd	3.8

the twenty reservoirs sampled. However, it is possible that mercury lost during gold mining may have been deposited in some of these waters. The relatively high concentration of mercury in Hebgen Lake sediments may originate from geothermal springs and geyser basins arising in Yellowstone National Park. Geyser basins are common in the Gibbon, Firehole and Madison River drainages which are located immediately upstream of Hebgen Lake.

Other than for Hebgen Lake, mercury concentrations in reservoir sediments are relatively low compared to other waters reported in the literature; however, previous work has shown that the physical and chemical environment in some impoundments promotes methylation of mercury and its subsequent accumulation by fishes (Phillips et al. 1987). Consequently, given the right set of conditions, even small amounts of mercury in the environment can result in relatively high concentrations in fishes.

Concentration of mercury in fish muscle tissue ranged from below detection in some locations to 3.1 $\mu g/g$ in cutthroat trout from Silver Creek (Table 6). Locations where some fishes were found to contain upwards of 0.5 $\mu g/g$ include Bighorn Lake, Flathead Lake, Fort Peck Reservoir, Fresno Reservoir, Hebgen Lake, Lake Elwell, Lake Francis, Nelson Reservoir, and Silver Creek. In general, mercury concentrations in fish muscle tissue tended to increase with fish size and age; piscivorous species such as northern pike, walleye, brown trout and lake trout tended to have higher concentrations of mercury than rainbow trout, kokanee salmon, or yellow perch.

SUMMARY

Four of the 20 lakes and reservoirs sampled (Flathead, Elwell, Mary Ronan, and Swan) were classified as oligotrophic. Six reservoirs - Bighorn, Canyon Ferry, Hauser, Holter, Nelson and Tongue - were classified as eutrophic and the remainder are mesotrophic.

Mercury and PCB's in sediments were low in all locations sampled except for mercury in Hebgen Lake which was 0.84 μg/g. Mercury in Hebgen Lake is believed to originate from geothermal areas in Yellowstone Park.

PCB's in fishes from Big Spring Creek near Lewistown and Flathead Lake ranged up to 0.24 and 0.94 μg/g, respectively. Sources of PCB's to these waters have not been identified. PCB's in fishes from other waters sampled were near or below the detection limit (0.05 μg/g).

Mercury concentrations in larger predator species were moderately high (between 0.4 and 1.4 μg Hg/g) in Bighorn Lake, Flathead Lake, Fresno Reservoir, Hebgen Lake, Lake Elwell, Lake Francis, Tongue River Reservoir and Nelson Reservoir. Elevated mercury in these fishes is believed to be a result of the unique physical and chemical conditions that occur in some impoundments rather than from man-caused contamination. Mercury in cutthroat trout from Silver Creek near Helena exceeded 3.0 μg/g. Mercury in Silver Creek originates from previous gold mining activities. Silver Creek is restricted to catch-and-release fishing because of health concerns.

The residue data for mercury and PCB's in fish flesh are presently being reviewed by officials in the Montana Department of

Health and Environmental Sciences and a decision as to the need for health advisories is forthcoming.

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