Metals Residues in Brown Trout (*Salmo trutta*) from the Clark Fork and Little Blackfoot Rivers -- 1978

by

Glenn R. Phillips

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INTRODUCTION

Since the initiation of mining activity in the Silver Bow valley in the late 1800's, the upper Clark Fork River in southwestern Montana has had an extended history of metals pollution. Metals in the drainage originate primarily from mining, milling, and smelting industries and to a lesser extent from storm sewers and municipal discharges near Butte and Anaconda. Fish populations were severely depleted in much of the upper Clark Fork prior to the implementation of water pollution control programs mandated by the Clean Water Act of 1972. Subsequently, improved waste treatment procedures have dramatically reduced metals in the river and have led to the recovery of a viable salmonid fishery.

Two previous investigators (Van Meter 1974; Dent 1975) examined residues of toxic metals in tissues of fishes from the drainage to evaluate potential hazards to sportfishermen who consume these fish. This study was initiated as a follow up to the earlier work and was designed to evaluate metals residues in edible tissue relative to fish age. The latter was not considered in earlier monitoring and is an important factor because some metals, most notably mercury, have a tendency to bioaccumulate with age.

Fifty brown trout (*Salmo trutta*) were collected for metals residue determinations from each of three locations in the Upper Clark Fork drainage on September 18-19, 1978. River sections sampled included two locations in the Clark Fork River downstream from Anaconda (pH Shack and Williams Tavenner Bridge) and one location in the Little Blackfoot River (the Dana Section) just upstream from its confluence with the Clark Fork River (Fig. 1).

Cooperators on the project included the Anaconda Minerals Company, the Montana Department of Fish, Wildlife and Parks, and The Water Quality Bureau of the Montana Department of Health and Environmental Sciences. Frank Abercrombie, of the analytical laboratory of the Montana Bureau of Mines and Geology was contracted to do the metals analyses.

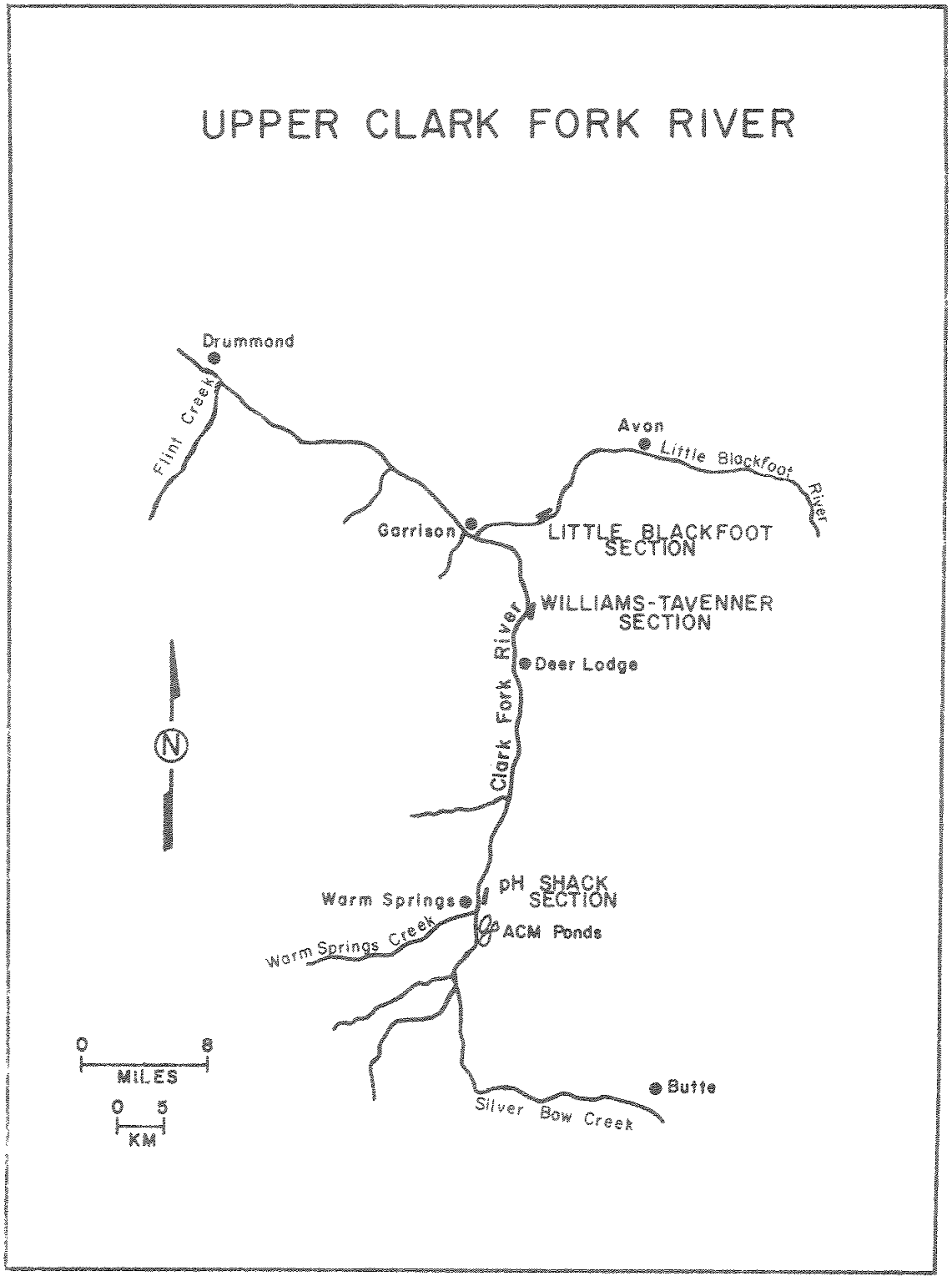

Figure 1. Map of the Clark Fork and Little Blackfoot Rivers showing locations where brown trout were collected.

MATERIALS AND METHODS

Fish were sampled with electrofishing gear and visually sorted at the time of collection to try and obtain representative samples for each of several age classes. From the pH Shack Section we collected 17, 18, 6, and 3 brown trout representing age classes I, II, III, and IV, respectively. Similarly the sample sizes broken down by age class (proceeding consecutively from I to IV) for the other two sampling locations were 12, 14, 15, and 6 for Williams Tavenner and 8, 15, 9, and 6 for Little Blackfoot. Scales from several of the fish from each location could not be aged; and therefore were not used in any of the data summaries described in this report.

In the field, trout were weighed and measured and scales were collected. Following field sampling, fish were taken to an indoor location and a portion of a fillet was removed from each fish above the lateral line and between the origin of the dorsal fin and the caudal peduncle. The dissection was performed using teflon coated pans and razor blades; tissue aliquots were placed in whirl-pak plastic bags and frozen. In the laboratory, fillets were skinned, making every attempt to remove skin and bones. Nevertheless, scales were occassionally left behind as became apparent during the digestions. Fat was scraped from the skin to the extent possible and returned to the tissue. Tissue was placed inside ziploc bags and macerated by hammering the bags with the flat side of an aluminum meat tenderizer until the tissue approached the consistency of a puree. The sample was then frozen and further pulverized with the meat tenderizer while frozen. Samples were finally returned to the freezer and random samples of tissue were taken from the bag using teflon coated scouplas.

Wet tissue samples to be analyzed for mercury were digested in sodium hydroxide while those analyzed for lead, cadmium, copper, zinc, and arsenic were digested in a mixture of nitric and hydrochloric acids. Mercury was quantified by cold vapor atomic absorption spectrophotometry (Magos 1971), arsenic by hydride generation (Vijan et. al. 1976) and the remaining metals by induction coupled plasma atomic emission spectroscopy (ICPAES). A Varian model AA4 was employed for mercury determinations while an Applied Research Laboratory model 34000 ICPAES was used for the remaining metals. Detection limits (in ng/g) were 0.2, 1, 5, 10, 40, and 80 for Pb, As, Hg, Cd, Cu and Zn respectively. All results are reported on a wet weight basis.

Quality control activities included routine analyses of replicates, standard solutions, reference standards (NBS bovine liver, orchard leaves, and IAEA fish tissue) and blanks; and spike and recovery of standard solutions mixed with tissue digests. Results are summarized in Appendices A and B. In general, the results for certified reference standards and spikes show that the operational methodology was reliable. However, variations in duplicate analyses for several of the metals, in particular cadmium, copper, and lead, were unusually large, rendering the results statistically invalid. It is speculated that these metals were not uniformly distributed in the tissue matrix, perhaps owing to the presence of fragments of bone, skin and scales. Because of this inconsistency, interpretation with respect to these metals is limited.

RESULTS AND DISCUSSION

None of the metals were present at concentrations that constitute a hazard to human health or to aquatic life. Means, standard deviations, and ranges of concentrations of all of the metals analyzed are summarized in Table 1 and the raw data are listed in Appendices C-G. Fish from all locations contained approximately 77 % moisture, a typical figure for salmonids.

Mercury

None of the fish sampled exceeded the present U.S. Food and Drug Administration action level (1.0 ug Hg/g); the highest concentration observed was 0.47 ug Hg/g. Not unexpectedly, mercury in tissue increased with fish age and there were some noteworthy differences in rate of uptake between locations (Fig. 2). Brown trout from the Little Blackfoot River and from the Williams Tavenner Section of the Clark Fork River contained higher mercury concentrations at a given size and age than did trout from the pH Shack Section of the Clark Fork.

Lower mercury concentrations in fish from the pH Shack Section may be due to the metals complexing ability of the Anaconda Mineral Company's Warm Springs Treatment Ponds. The Clark Fork flows through these ponds immediately upstream from this section and the ponds have been shown to effectively remove trace metals from the water (unpublished data; Water Quality Bureau). Higher mercury in fish from the lower sections could be accounted for by dissolution of metals from the streambed and banks.

Copper, Lead, Cadmium, and Arsenic

There were no apparent relationships between concentrations of copper, lead, cadmium, or arsenic in tissue and age of brown trout nor were there any noteworthy differences between sampling locations. Concentrations within a

Table 1. Means, standard deviations and ranges of length, weight, and metal concentrations in brown trout from two sections of the Clark Fork River and one location on the Little Blackfoot River; sampling conducted September 18-19, 1978.

Location	Age Class	No.	Length (mm)	Weight (gm)	Metal concentration (ug/g) Hg	Cu	Cd	As	Pb	Zn
Clark Fork-pH Shack	I	17	234±23 (188-272)	136±50 (73-213)	0.03±0.01 (0.02-0.04)	0.10±0.27 (ND-0.83)	0.43±0.45 (ND-1.12)	0.16±0.08 (0.02-0.29)	0.17±0.08 (ND-0.34)	4.45±1.85 (1.35-7.75)
Clark Fork-Williams-Tavenner		12	241±15 (218-267)	154±18 (123-195)	0.07±0.01 (0.06-0.09)	0.25±0.76 (ND-2.41)	0.05±0.05 (ND-0.13)	0.10±0.05 (0.05-0.20)	0.08±0.10 (ND-0.25)	4.81±1.10 (3.19-6.52)
Little Blackfoot		8	213±13 (198-239)	104±14 (91-136)	0.07±0.01 (0.05-0.08)	0.05±0.15 (ND-0.43)	0.21±0.23 (ND-0.56)	0.10±0.08 (0.01-0.26)	0.19±0.04 (0.10-0.25)	4.85±0.68 (3.53-5.76)
Clark Fork-pH Shack	II	18	310±33 (246-371)	318±95 (181-599)	0.04±0.01 (0.02-0.07)	0.15±0.29 (ND-0.92)	0.56±0.49 (0.06-1.36)	0.12±0.08 (0.03-0.31)	0.19±0.03 (0.15-0.25)	4.15±2.04 (1.90-5.37)
Clark Fork-Williams-Tavenner		14	297±31 (249-343)	286±82 (163-440)	0.10±0.03 (0.06-0.19)	0.03±0.07 (ND-0.24)	0.11±0.12 (ND-0.45)	0.08±0.04 (0.02-0.17)	0.30±0.42 (ND-1.28)	4.09±1.11 (2.60-6.60)
Little Blackfoot		15	285±23 (249-338)	240±68 (145-404)	0.11±0.04 (0.07-0.18)	0.02±0.04 (ND-0.06)	0.07±0.07 (ND-0.20)	0.15±0.13 (0.03-0.50)	0.17±0.13 (0.03-0.45)	3.55±1.29 (1.49-6.89)
Clark Fork-pH Shack	III	6	366±28 (335-414)	508±113 (377-694)	0.06±0.01 (0.04-0.08)	- -	1.02±0.55 (0.22-1.41)	0.12±0.07 (0.03-0.24)	0.15±0.03 (0.12-0.20)	4.63±0.74 (3.79-5.58)
Clark Fork-Williams-Tavenner		15	361±25 (320-406)	531±118 (363-767)	0.16±0.05 (0.08-0.25)	0.12±0.15 (ND-0.43)	0.09±0.11 (ND-0.20)	0.05±0.04 (0.01-0.12)	0.09±0.10 (ND-0.26)	3.83±1.20 (1.90-6.46)
Little Blackfoot		9	351±30 (310-399)	467±132 (331-690)	0.18±0.07 (0.10-0.31)	0.12±0.15 (ND-0.39)	0.21±0.41 (ND-1.10)	0.28±0.26 (0.05-0.83)	0.24±0.12 (0.07-0.36)	3.69±0.61 (2.88-4.89)
Clark Fork-pH Shack	IV	3	452±58 (412-518)	993±445 (735-1505)	0.08±0.02 (0.03-0.10)	- -	0.83±0.64 (0.20-1.48)	0.01±0.02 (ND-0.03)	0.17±0.08 (0.11-0.26)	3.52±0.58 (3.12-4.18)
Clark Fork-Williams-Tavenner		6	432±38 (406-503)	984±667 (672-1716)	0.18±0.13 (0.05-0.41)	0.25±0.22 (ND-0.53)	0.41±0.57 (ND-1.26)	0.13±0.16 (0.02-0.45)	0.21±0.45 (ND-1.12)	3.92±1.04 (2.65-5.20)
Little Blackfoot		6	439±43 (394-498)	948±286 (721-1397)	0.19±0.15 (0.06-0.47)	0.28±0.37 (ND-0.97)	0.22±0.35 (0.02-0.93)	0.18±0.29 (0.02-0.76)	0.17±0.09 (0.08-0.27)	3.76±0.39 (3.37-4.34)

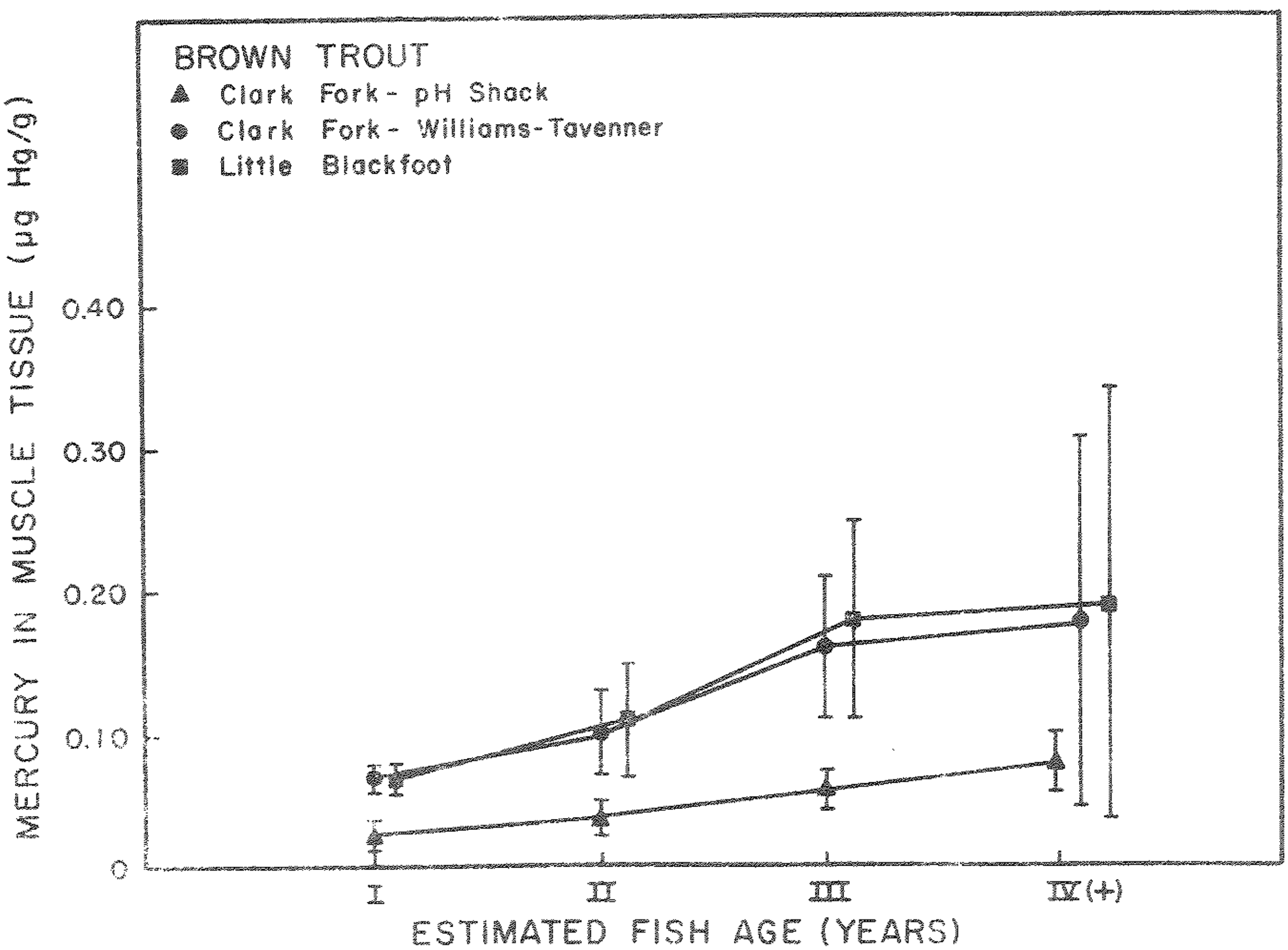

Figure 2. Mercury concentrations relative to age in brown trout from the Clark Fork and Little Blackfoot Rivers.

given age class and location were so highly variable that the standard deviations often exceeded the sample means. As mentioned earlier, poor agreement between replicate analyses of the same sample (other than for arsenic) complicates interpretation. However, it is worth noting that the mean concentrations of these metals found in brown trout during this study are considerably below tolerance or action levels established by the United States and Canadian governments. Tolerance levels for lead and copper (Canadian Food Directorate) are 10 and 100 ug/g and action levels for arsenic (United States Department of Agriculture) are 0.7 and 2.2 ug/g for beef and beef liver, respectively. There is presently no action level established for cadmium in foods.

It should be noted that most metals do not tend to accumulate in muscle tissue. Benoit (1976) showed that brook trout (Salvelinus fontinalis) exposed to cadmium during laboratory experiments accumulated cadmium in gill, kidney and liver but did not accumulate cadmium in muscle tissue. Holcomb (1976) reported similar results for lead. Miller (1982) observed no correlation between cadmium in water and cadmium in muscle tissue of brook trout from various reaches of Prickly Pear Creek where the cadmium concentration in water varied; however, gill and liver were correlated. In general, Miller (1982) found gill and liver to be the best indicators of cadmium, copper, and lead in water. This is not surprising considering that gill is an important route of entry of metals into the body and liver is the site of metals detoxification. Gill and liver are probably the tissues that should be monitored if the intent of the monitoring is to determine the metals exposure history of the organism. However, as mentioned earlier, muscle tissue was chosen for this study because our primary concern was for human health.

Zinc

Zinc concentrations varied little between locations and fish age classes, averaging 3.52-4.85 ug/g (wet basis) or 16.0-22.1 ug/g (dry basis). Goettl et al. (1972) reported that the baseline zinc concentration in muscle tissue of rainbow trout (Salmo gairdneri) was 20 ug/g (dry basis), a concentration similar to those present in this study. Dent (1975) reported higher concentrations of zinc (7.04-9.68 ug/g; wet basis) in muscle tissue of brown trout collected earlier from the Clark Fork River. This may reflect a lowering of ambient zinc concentrations in the river although no water quality data to support this conclusion was reviewed. Kameda et al. (1968) found that marine fish accumulated very little zinc in muscle tissue although some organs, particularly gill, attained relatively high concentrations of zinc. Like most of the metals discussed previously, zinc is more appropriately monitored in gill and liver if the intent of the monitoring is to determine the metals exposure history of the organism.

CONCLUSIONS AND RECOMMENDATIONS

1. None of the metals examined during this study are present in fish tissue at concentrations that constitute a hazard to human health or to fish life.

2. Brown trout from the downstream sampling section of the Clark Fork River and from the Little Blackfoot River contained higher mercury concentrations than trout of similar ages from the upper Clark Fork. This may be due to the complexing and removal of mercury from the upper section by the Warm Springs Ponds.

3. The accuracy of analyses using certified reference materials speaks well for the operational procedures employed; however, poor reproducability of duplicate analyses for copper, cadmium, and lead indicate that there was a problem with the sample matrix. In future studies, care should be taken to ensure that skin, bone, and scales are not present in the tissue sample and that the sample aliquot is homogeneous.

4. Liver and gill, because of their important metabolic roles, tend to accumulate metals to a greater extent than most other tissues including muscle. These organs should be analyzed instead of muscle tissue when the intent of the monitoring is to determine the metals exposure history of the organisms; mercury is an exception.

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APPENDIX A. Quality control results for certified reference standards and spike and recovery.

Sample[a]	% Recovery[b]					
	Cd	Cu	Pb	Zn	Hg	As
NBS orchard leaves	73	71	83	93	-	-
NBS bovine liver	89	79	c	c	-	-
IAEA fish tissue	100	124	88	c	-	-
Spike and recovery[d]	77(3)	67(3)	77(3)	58(3)	90(8)	86(5)

[a] NBS denotes National Bureau of Standards and IAEA denotes International Atomic Energy Association.

[b] Spikes were 5 mg/g for cadmium, copper, lead, and zinc; 0.1 ug/g for mercury; and 2 ug/g for arsenic.

[c] Variability of the control as great or greater than the level of the spike.

[d] Mean % recovery; number of replicates in parenthesis.

APPENDIX B. Results of replicate analyses of the same sample including number of replicates, average percent deviation of replicates, and coefficient of variation of the average percent deviation.

Metal	No. replicates	Mean % deviation	Coefficient of variation
Zinc	38	24.5	109
Lead	25	117.7	159
Cadmium	27	739.9	174
Mercury	33	8.3	83
Copper	6	439.6	127
Arsenic	38	37.0	67

APPENDIX D. Lengths, weights, percentage wet weights, and concentrations of mercury, copper, cadmium, arsenic, lead and zinc in Age II brown trout from two sections of the Clark Fork River and one location in the Little Blackfoot River; sampling conducted September 18-19, 1978.

Location	Length (mm)	Weight (gm)	Wet (%)	Metal concentration (ug/g)[a] Hg	Cu	Cd	As	Pb	Zn
Clark Fork-	295	277	75.0	0.04	0.92	0.21	0.06	0.20	4.15
pH Shack	295	268	77.0	0.04	0.30	1.19	0.14	0.16	5.37
	335	349	77.9	0.02	--	0.22	0.07	0.14	4.37
	264	186	76.7	0.04	--	1.27	0.19	0.25	5.20
	343	372	79.8	0.07	--	1.36	0.03	0.22	4.48
	302	295	79.0	0.05	--	0.25	0.03	0.16	3.91
	262	222	76.2	0.03	ND	0.06	0.16	0.21	3.02
	310	295	78.6	0.04	ND	0.99	0.13	0.17	3.94
	302	313	77.3	0.06	ND	0.04	0.09	0.21	1.90
	330	372	78.0	0.03	ND	0.62	0.07	0.15	3.50
	325	359	77.3	0.04	--	--	0.19	--	--
	320	349	75.0	0.04	0.12	0.92	0.08	0.16	4.09
	295	272	77.7	0.04	--	--	0.10	--	--
	371	599	77.9	0.03	ND	0.06	0.08	0.20	3.97
	328	372	76.7	0.03	ND	0.15	0.27	0.21	4.87
	353	413	80.2	0.06	0.36	0.92	0.09	0.16	5.28
	246	182	78.1	0.02	--	--	0.31	--	--
	284	236	76.9	0.03	ND	0.16	0.13	0.21	4.18
Clark Fork-	343	440	77.8	0.11	ND	0.06	0.10	0.12	3.77
Williams-Tavenner	269	213	79.6	0.08	0.14	0.16	0.08	ND	6.60
	249	177	78.2	0.10	0.24	0.02	0.05	ND	6.04
	292	272	77.2	0.11	ND	0.12	0.12	ND	3.94
	320	372	78.1	0.08	ND	0.10	0.05	0.61	4.34
	338	363	77.6	0.08	ND	0.45	0.13	ND	3.42
	305	281	79.3	0.19	ND	ND	0.05	0.27	3.49
	318	327	77.6	0.12	ND	0.02	0.02	ND	2.86
	272	222	78.2	0.14	ND	0.12	0.17	0.19	3.60
	246	163	79.4	0.06	ND	ND	0.08	0.69	3.86
	320	372	79.4	0.09	ND	0.04	0.02	0.02	3.58
	282	254	77.9	0.07	ND	0.04	0.09	1.28	4.85
	315	345	78.3	0.07	ND	0.12	0.06	0.95	2.60
	284	222	77.1	0.10	ND	0.10	0.03	ND	4.31

[a] ND indicates not detectable.

APPENDIX D. (continued)

Location	Length (mm)	Weight (gm)	Wet (%)	Metal concentration (ug/g)[a]					
				Hg	Cu	Cd	As	Pb	Zn
Little Blackfoot	338	404	78.2	0.15	0.06	0.05	0.20	0.22	1.49
	318	331	79.6	0.17	ND	ND	0.12	0.30	3.64
	249	145	79.4	0.09	ND	ND	0.16	0.31	6.89
	284	236	78.4	0.14	--	--	0.50	--	--
	257	173	79.2	0.08	ND	0.21	0.14	0.45	2.91
	269	209	78.8	0.09	ND	0.10	0.09	0.09	2.23
	315	345	79.2	0.14	ND	0.12	0.15	0.03	3.08
	295	245	79.5	0.18	0.12	0.03	0.03	0.13	4.35
	282	222	76.5	0.07	ND	0.05	0.15	0.03	3.96
	292	241	78.2	0.08	ND	0.20	0.14	0.06	3.43
	274	209	78.7	0.09	ND	0.03	0.03	0.08	3.36
	267	186	78.2	0.07	--	--	0.04	--	--
	290	236	78.0	0.13	0.06	ND	0.03	0.12	3.35
	267	177	78.5	0.10	ND	0.11	0.40	0.14	4.44
	282	232	79.8	0.14	ND	0.08	0.12	0.19	2.96

[a] ND indicates not detectable.

APPENDIX E. Lengths, weights, percentage wet weights, and concentrations of mercury, copper, cadmium, arsenic, lead, and zinc in Age III brown trout from two sections of the Clark Fork River and one location in the Little Blackfoot River; sampling conducted September 18-19, 1978.

Location	Length (mm)	Weight (gm)	Wet (%)	Metal concentration (ug/g)[a] Hg	Cu	Cd	As	Pb	Zn
Clark Fork- pH Shack	368	527	77.8	0.05	--	--	0.08	--	--
	338	377	78.1	0.05	1.52	1.10	0.13	0.14	5.58
	366	495	79.9	0.08	--	0.22	0.03	0.20	4.71
	335	390	77.0	0.05	--	1.41	0.24	0.15	4.42
	378	572	78.3	0.04	--	1.33	0.15	0.12	3.79
	414	695	77.8	0.06	--	--	0.10	--	--
Clark Fork- Williams-Tavenner	378	554	79.4	0.10	ND	ND	0.01	ND	3.21
	363	445	78.8	0.13	0.43	0.06	0.05	0.17	4.76
	391	681	79.1	0.25	0.19	ND	0.04	0.20	3.09
	381	581	81.5	0.14	0.07	0.03	0.02	0.24	2.77
	345	554	82.4	0.08	ND	0.42	0.02	0.17	5.02
	330	413	79.0	0.18	ND	ND	0.12	ND	2.16
	353	518	78.2	0.14	ND	0.05	0.08	ND	3.54
	371	558	79.5	0.19	0.35	0.10	0.07	ND	4.35
	320	363	77.1	0.14	--	--	0.10	--	--
	396	695	77.5	0.13	0.09	0.06	ND	0.26	4.04
	335	395	78.2	0.17	ND	0.09	0.06	ND	1.90
	328	404	78.0	0.12	0.22	0.04	0.03	0.11	4.63
	363	536	78.6	0.12	ND	0.16	0.12	0.11	3.94
	406	767	79.7	0.22	0.21	0.20	0.04	ND	6.46
	363	527	79.5	0.25	ND	0.02	0.06	ND	3.77
Little Blackfoot	371	495	78.5	0.15	ND	ND	0.20	0.30	3.34
	381	617	80.2	0.31	0.05	0.03	0.16	0.36	3.11
	399	690	80.2	0.27	0.10	ND	0.06	0.20	4.22
	315	291	78.7	0.14	ND	0.02	0.17	0.36	3.51
	353	463	78.9	0.18	ND	0.72	0.56	0.34	3.96
	348	499	76.9	0.20	0.04	ND	0.05	0.34	3.73
	325	331	78.9	0.14	0.32	1.10	0.33	0.16	4.89
	356	468	80.0	0.14	0.07	ND	0.83	0.07	2.88
	310	345	78.1	0.10	0.39	ND	0.15	0.07	3.56

[a] ND indicates not detectable.

APPENDIX F. Lengths, weights, percentage wet weights, and concentrations of mercury, copper, cadmium, arsenic, lead, and zinc in Age IV brown trout from two sections of the Clark Fork River and one location in the Little Blackfoot; sampling conducted September 18-19, 1978.

Location	Length (mm)	Weight (gm)	Wet (%)	Metal concentration (ug/g)[a]					
				Hg	Cu	Cd	As	Pb	Zn
Clark Fork-pH Shack	518	1507	78.5	0.10	1.34	1.48	ND	0.11	3.25
	424	735	77.3	0.06	ND	0.20	0.01	0.14	4.18
	411	740	77.9	0.09	--	0.81	0.03	0.26	3.12
Clark Fork-Williams-Tavenner	406	672	77.3	0.41	0.20	ND	0.07	ND	4.52
	427	890	79.0	0.16	0.36	ND	0.02	0.11	3.07
	406	781	81.7	0.10	0.53	1.26	0.45	ND	5.20
	447	1017	78.6	0.05	0.41	0.03	0.04	ND	4.77
	406	826	78.4	0.22	ND	1.02	0.06	1.12	3.30
	503	1716	77.5	0.13	ND	0.15	0.16	ND	2.65
Little Blackfoot	419	790	80.6	0.21	ND	0.16	0.02	0.27	3.57
	432	844	77.3	0.11	0.97	0.06	0.05	0.23	4.15
	404	722	77.8	0.06	0.09	0.02	0.20	0.27	3.37
	498	1398	79.5	0.11	0.20	0.08	0.[illegible]6	0.08	3.68
	485	1217	78.6	0.47	ND	0.04	0.05	0.11	3.46
	394	726	77.6	0.19	0.41	0.93	0.02	0.08	4.34

[a] ND indicates not detectable.

APPENDIX G. Lengths, weights, percentage wet weights, and concentrations of mercury, copper, cadmium, arsenic, lead and zinc in brown trout for which age could not be determined. Fish were collected from two sections of the Clark Fork River and one location on the Little Blackfoot River; sampling conducted September 18-19, 1978.

Location	Length (mm)	Weight (gm)	Wet (%)	Metal concentration (ug/g)[a]					
				Hg	Cu	Cd	As	Pb	Zn
Clark Fork-pH Shack	356	445	79.6	0.08	--	1.08	0.04	0.22	6.18
	386	490	78.0	0.09	--	0.27	0.02	0.23	5.97
	505	1489	73.4	0.07	0.21	0.15	0.02	0.14	3.68
	391	631	78.0	0.05	0.10	0.66	0.04	0.17	3.57
Clark Fork-Williams-Tavenner	338	454	79.0	0.11	0.39	0.05	0.31	0.22	4.85
	384	617	79.6	0.09	0.22	0.03	0.07	0.52	5.09
Little Blackfoot	356	513	78.5	0.23	ND	0.14	0.35	0.33	2.95
	333	386	79.6	0.27	ND	0.11	1.14	0.32	2.30
	384	590	78.8	0.56	ND	0.12	0.66	0.23	4.06
	414	781	80.5	0.20	ND	0.15	0.71	0.29	2.26
	389	717	78.7	0.23	0.43	1.13	0.10	0.47	5.41
	457	944	79.1	0.20	0.11	ND	1.82	ND	3.38
	343	513	79.0	0.17	0.21	0.12	0.10	0.12	3.52
	348	409	80.3	0.24	ND	ND	0.47	0.12	4.11
	386	599	--	0.20	ND	0.07	0.12	0.09	3.91
	345	481	79.3	0.28	0.30	0.08	0.59	0.19	4.42
	307	304	78.6	0.10	ND	0.04	0.13	0.16	4.58

[a] ND indicates not detectable.