ENVIRONMENT CANADA
CONSERVATION AND PROTECTION
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THOMPSON RIVER FISH SURVEY

MERCURY, CADMIUM, COPPER AND ZINC CONTENT OF RAINBOW TROUT AND MOUNTAIN WHITEFISH

Regional Program Report 86-09

By

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ABSTRACT

Mercury, cadmium, copper and zinc content of muscle and liver tissue was measured from rainbow trout and mountain whitefish collected from the Thompson River system. Higher mean concentrations of mercury and copper were found in the muscle tissue of South and Lower Thompson River rainbow trout compared to North Thompson River rainbow trout. Albeit the liver tissue sample size was small, these differences were not reflected by liver tissue. Liver tissue samples are considered to better reflect environmental contamination of water with heavy metals. The lower level of mercury in the North Thompson River rainbow trout may reflect the smaller size of fish sampled. Muscle tissue copper content was also higher in Lower Thompson River mountain whitefish than North Thompson River mountain whitefish. There were no apparent differences between rivers for either muscle or liver tissue zinc levels. Liver tissue cadmium levels were higher in North Thompson River rainbow trout and mountain whitefish compared to either the South or Lower Thompson River fish. Muscle tissue cadmium levels were below detectable levels in all cases.

The metal content of muscle tissue was well below any reference levels reported for fish for human consumption. The observed differences could reflect mineralogical differences of the drainages.

RÉSUMÉ

On a mesuré le contenu en mercure, cadmium, cuivre et zinc des tissus musculaires et hépatiques d'échantillons de truites arc-en-ciel et de corégones provenant de la Thompson et de ses affluents. On a relevé de plus grandes concentrations mayennes de mercure et de cuivre dans les tissus musculaires de la truite arc-en-ciel prise dans la Thompson sud et le cours inférieur de fleuve que dans les tissus des échantillons provenant de la Thompson nord. Les tissus hépatiques ne montrent pas cette différence quoique le tissu examiné ait été réduit en taille. Les échantillons de tissu hépatique sont considérés comme reflétant davantage la contamination de l'eau par les métaux lourds. Le niveau plus bas de mercure noté dans les tissus de la truite arc-en-ciel provenant de la Thompson nord résulte peut-être des dimensions plus réduites des échantillons examinés. On a noté également que la concentration en cuivre dans les tissus musculaires du corégone était plus forte dans les échantillons provenant du cours inférieur de la Thompson que dans ceux qui provenaient de la Thompson nord. On n'a relevé aucune différence notable entre les parties du fleuve en ce qui concerne les concentrations de zinc dans les tissus musculaires ou hépatiques. Les taux de concentration de cadmium dans les tissus hépatiques étaient plus élevés pour la truite arc-en-ciel et le corégone de la Thompson nord que pour les échantillons provenant de la Thompson sud ou du cours inférieur de la Thompson. Le taux de concentration de cadmium dans les tissus musculaires n'atteignaient pas le niveau détectable, cela dans tous les cas examinés.

Pour les poissons destinés à la consommation le taux, de concentration des métaux dans les tissus musculaires s'est révélé être bien en dessous de tout niveau de référence. Les différences observées pourraient résulter des différences minéralogiques entre les bassins hydrographiques.

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SUMMARY AND CONCLUSIONS

Muscle tissue mercury levels were significantly higher in South and Lower Thompson River rainbow trout than North Thompson River rainbow trout. This may in part be related to the smaller size of the North Thompson River fish. Liver tissue mercury levels were not significantly different albeit the sample size was quite small. Mean muscle tissue mercury levels were 0.042 ug/g (wet weight), 0.084 ug/g and 0.077 ug/g for the North, South and Lower Thompson Rivers respectively. Those levels are an order of magnitude lower than the 0.5 ug/g (wet weight) federal Food and Drug Directorate guideline for fish for human consumption. Muscle tissue mercury levels were not significantly different for North Thompson River and Lower Thompson River mountain whitefish ($\bar{x}$ of 0.071 ug/g in both cases).

Mean muscle tissue copper levels were significantly higher in Lower Thompson River rainbow trout than North Thompson River rainbow trout and in Lower Thompson River mountain whitefish compared to North Thompson River mountain whitefish. Mean muscle tissue copper levels were higher in South Thompson River rainbow trout compared to North Thompson River rainbow trout. The reason for these differences is not clear as muscle tissue is not considered to be a good indicator of copper contamination of receiving waters whereas liver tissue is. There were no obvious differences in liver tissue copper levels albeit the sample size was small and copper levels in rainbow trout livers were highly variable.

Muscle and liver tissue zinc levels were not significantly different between rivers for rainbow trout or mountain whitefish. Muscle tissue cadmium levels were all below detectable concentrations. However, the liver tissue cadmium levels were higher in North Thompson River rainbow trout and mountain whitefish than South or Lower Thompson River fish.

Although there are no existing standards for muscle tissue copper and zinc levels, the levels in Thompson river fish are well below the 100 ug/g (wet weight) standard formerly reported by the federal Food and Drug Directorate for fish for human consumption. Mean muscle tissue copper levels ranged between 0.62 ug/g to 2.87 ug/g for rainbow trout and 0.75 ug/g to

2.38 ug/g for mountain whitefish. Mean muscle tissue zinc levels for rainbow trout ranged between 6.18 ug/g to 7.07 ug/g and 4.22 ug/g to 4.55 ug/g for mountain whitefish.

The observed differences in metal levels of fish collected from the three rivers could reflect the mineralogical and geographical differences of the drainages. The Kamloops Lake region is an area of mercury and copper mineralization. The South and Lower Thompson Rivers are located downstream of major lakes while the North Thompson River is not. Future studies of this nature should focus on liver tissue samples. When comparing the elemental composition of fish tissues, its desirable that the stage of life cycle (age), size and reproductive state of the fish be comparable.

1 INTRODUCTION

In 1981, the Environmental Protection Service conducted a field study to assess the levels of contaminants in Thompson River fish. With the assistance of staff from the Fish and Wildlife Branch and Waste Management Branch (Kamloops office), resident rainbow trout (Salmo gairdneri) and mountain whitefish (Prosopium williamsoni) were taken by beach seine, gillnet or angling. Fish were collected from the North Thompson River upstream of McLure and the Lower Thompson River near Walhachin in August 1981 and from the South Thompson River near Chase in September 1981 (Figure 1).

The emphasis of the study was to assess the possible bioaccumulation of chlorinated organics of pulpmill orgin in liver and muscle tissue of resident fish. Samples of muscle tissue and extra liver tissue samples were also analyzed for heavy metal content. This report presents the results of the heavy metal analyses. Results of the chlorinated organic analyses are reported by Rogers and Mahood, 1983.

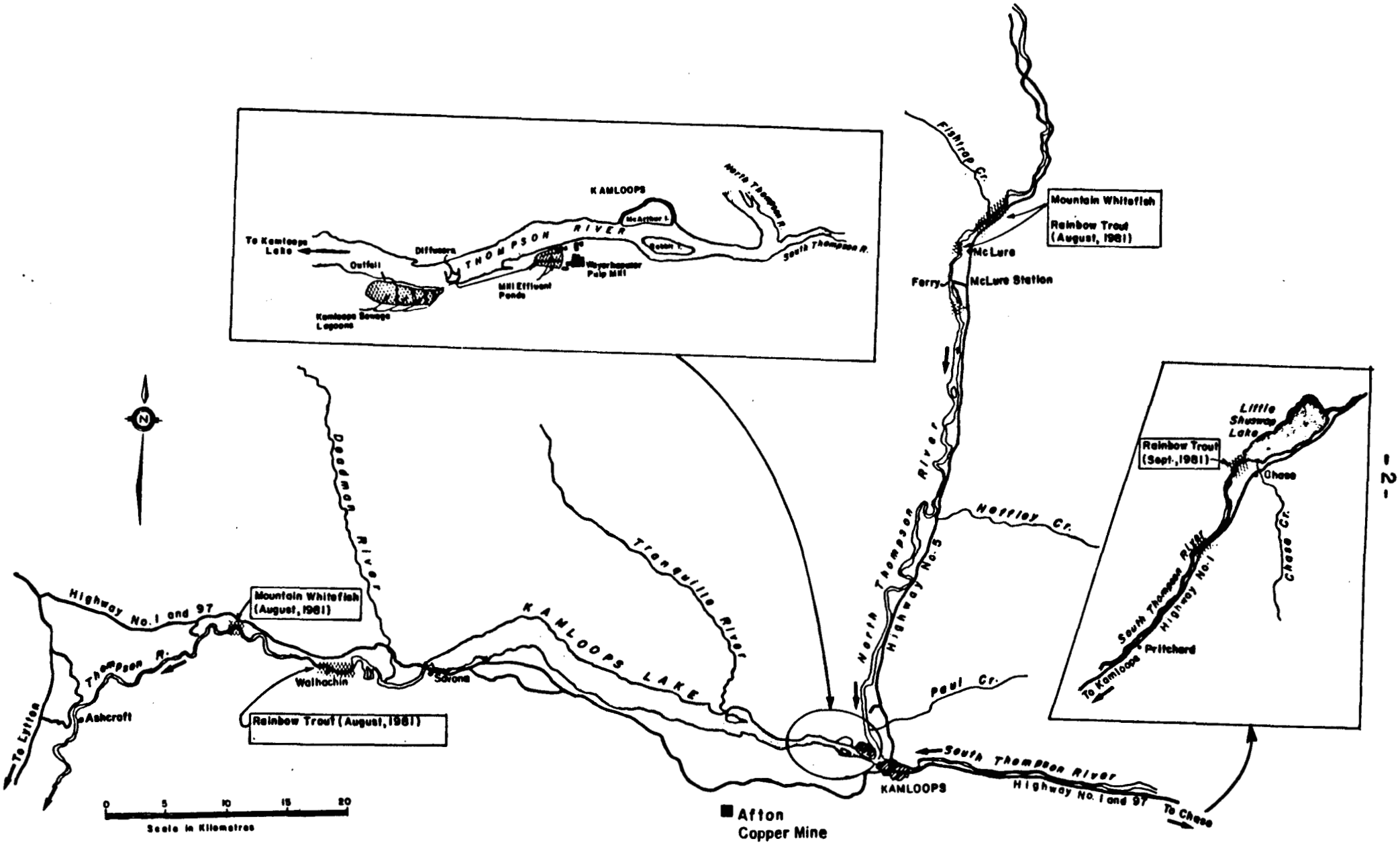

FIGURE 1 GENERAL LOCATION OF AREAS WHERE FISH WERE COLLECTED

2 METHODS

After collection, the fish were placed in polyethylene sample bags and stored in a cooler with wet ice. Prior to dissection each fish was weighed, lengthed and wiped with a paper towel to remove any mucous. Weight and length measurements were not obtained for the South Thompson River rainbow trout. However, those fish were of a comparable size to the Lower Thompson River rainbow trout.

Liver tissue samples were dissected with clean (acetone rinsed, dried with a kimwipe tissue) stainless steel dissecting instruments. Each liver was placed in a separate heat-treated glass sample container and immediately frozen over dry ice. Liver tissue samples not used for organic analyses were tested for heavy metals. A block of epaxial muscle (anterior/dorsal section) tissue free of bone and skin was obtained later from frozen whole fish and placed in a whirl pac.

2.1 Tissue Analyses

Liver and muscle tissue samples were analyzed at the EPS/DFO laboratory in West Vancouver (Anon, 1979). Mercury was analyzed by flameless atomic absorption spectrophotometry and cadmium, copper and zinc by Inductively Coupled Argon Plasma (ICAP) emission spectrophotometry. Except for mercury, the analytical methods used at the laboratory were tested against NBS reference tissue samples (Table 1). The laboratory analyses are very similar to the reference samples in all cases.

TABLE 1 CADMIUM, COPPER AND ZINC REFERENCE SAMPLES

	EPS ANALYSIS		NBS REFERENCE SAMPLE	
	Oyster Tissue (1566)	Bovine Liver (1577)	Oyster Tissue (1566)	Bovine Liver (1577)
Cu	67 ± 5	197 ± 5	63.0 ± 3.5	193 ± 10
Zn	868 ± 56	146 ± 6	852 ± 14	130 ± 10
Cd	3.6 ± .3	.34 ± .06	3.5 ± .4	.27 ± .04

2.2 Glass Sample Container Analyses

An assessment was made at a later date to determine if contamination of liver tissue from the glass sample container was likely. Distilled water was placed in the container, frozen and then unthawed and analyzed one month later. Unthawed samples were poured into acid washed polyethylene sample bottles. Mercury samples were acidified with nitric-dichromate acid (5 ml/100 ml sample) and cadmium/copper/zinc samples with nitric acid (0.5 ml/100 ml sample). Mercury was analyzed on a Pharmica Model 100 mercury analyzer, copper and zinc by ICAP and cadmium by atomic absorption spectrophotometry (Anon, 1979).

3 RESULTS AND DISCUSSION

3.1 Glass Sample Container Analysis

The results for distilled water stored in heat-treated glass sample containers indicates that contamination of liver samples is not likely (Table 2). Metal levels (Hg, Cd, Cu, Zn) are below detectable levels in all cases.

TABLE 2 HEAT-TREATED GLASS SAMPLE CONTAINER ANALYSIS

METAL (ug/l)	DISTILLED H_2O CONTROL			DISTILLED H_2O FROM GLASS CONTAINER		
	1	2	3	1	2	3
Cd	< .5	< .5	< .5	< .5	< .5	< .5
Cu	< 5	< 5	< 5	< 5	< 5	< 5
Hg	< .05	< .05	< .05	< .05	< .05	< .05
Zn	< 2	< 2	< 2	< 2	< 2	< 2

3.2 Tissue Metal Levels

Results for individual fish analyses are reported in Appendix I (a-d). Metal levels are expressed on a wet weight basis in this report. Statistical differences were determined by analysis of variance followed by multiple comparisons of tissue elemental values using Tukeys' test (Zar, 1984).

3.2.1 Mercury. The mean mercury content for rainbow trout liver tissue was 0.075 ug/g (S.D. = 0.034), 0.095 ug/g (0.050) and 0.061 ug/g (0.015) for the North, South and Lower Thompson Rivers respectively (Table 3, Figure 2). The mean mercury content for rainbow trout muscle tissue was 0.042 ug/g (S.D. = 0.008), 0.084 ug/g (0.016) and 0.077 ug/g (0.026) for the North, South and Lower Thompson Rivers respectively (Table 3, Figure 2). Muscle tissue mercury levels are significantly greater ($p < .05$) in the South and Lower Thompson Rivers than the North Thompson River. The North Thompson

TABLE 3 MEAN MERCURY, CADMIUM, COPPER AND ZINC CONTENT OF LIVER AND MUSCLE TISSUE FROM THOMPSON RIVER RAINBOW TROUT

METAL (ug/g wet weight)	NORTH THOMPSON		SOUTH THOMPSON		LOWER THOMPSON	
	Liver $\bar{x} \pm$ (S.D.)	Muscle $\bar{x} \pm$ (S.D.)	Liver $\bar{x} \pm$ (S.D.)	Muscle $\bar{x} \pm$ (S.D.)	Liver $\bar{x} \pm$ (S.D.)	Muscle $\bar{x} \pm$ (S.D.)
Hg	.075 (.034)	.042 (.008)	.095 (.060)	.084* (.016)	.061 (.015)	.077** (.026)
Cd	.56 (.36)	< .08 (.01)	.14 (.03)	< .09 (.01)	.14 (.08)	< .09 (.004)
Cu	43.9 (17.4)	.62 (.13)	41.1 (44.9)	1.68 (.87)	24.6 (13.7)	2.87** (1.44)
Zn	33.7 (7.8)	7.07 (.75)	36.9 (5.5)	7.01 (1.23)	31.0 (5.1)	6.18 (1.72)
Fish Weight (g)						
Hg	68 (20)	61 (22)	-	-	349 (41)	373 (85)
Cu/Zn	50 (17)	59 (20)	-	-	398 (121)	374 (85)
Fish Fork Length (cm)						
Hg	17.4 (2.7)	16.8 (2.6)	-	-	32.5 (1.2)	33.3 (2.3)
Cu/Zn	16.6 (2.2)	17.0 (2.3)	-	-	34.2 (3.1)	33.3 (2.3)
n						
Hg	3	4	3	5	3	6
Cu/Zn	3	6	3	6	3	6

* significantly greater than North Thompson ($p < .05$)

** significantly greater than North Thompson ($p < .05$)

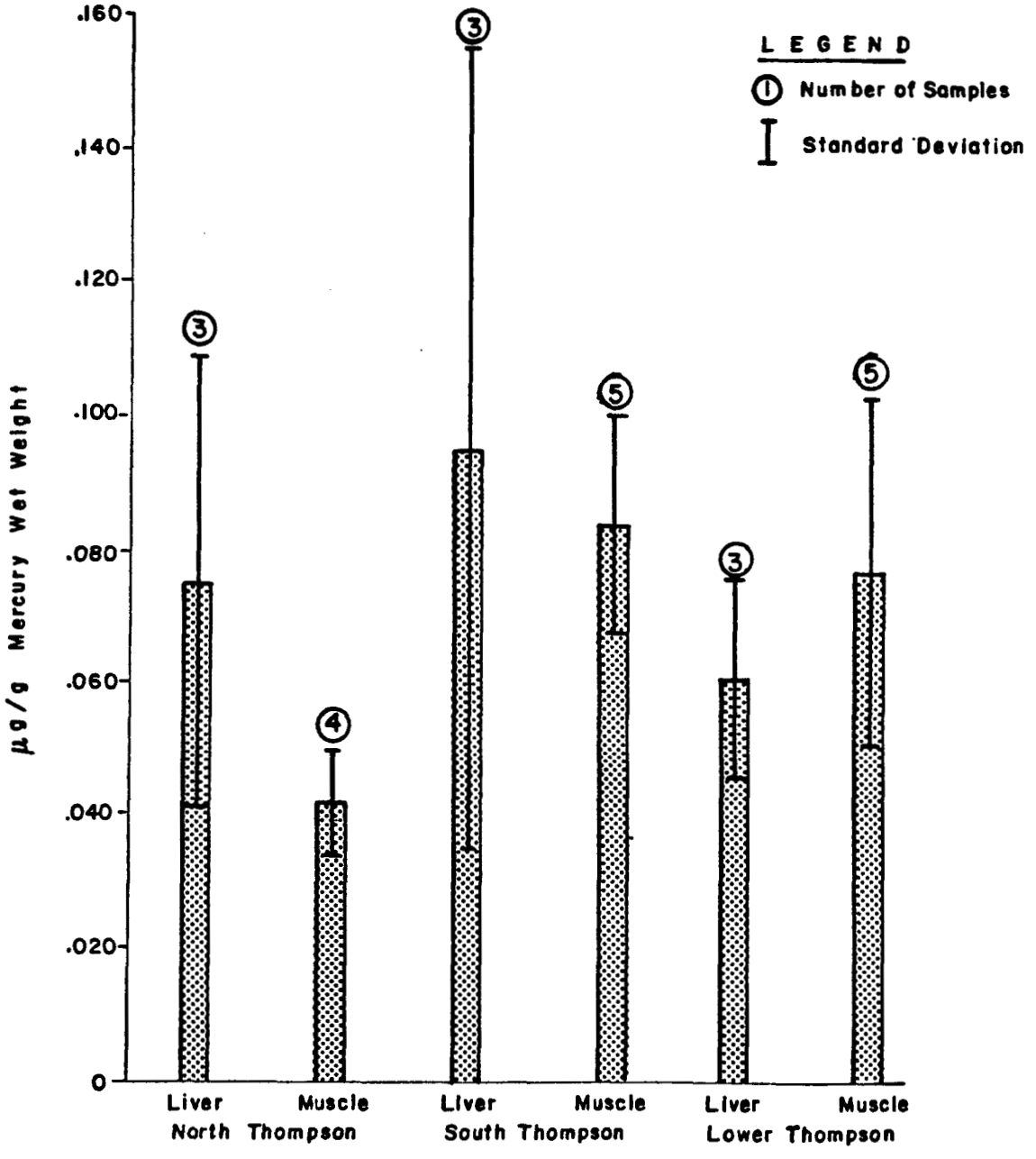

FIGURE 2 MEAN MERCURY CONTENT OF MUSCLE AND LIVER TISSUE FROM THOMPSON RIVER RAINBOW TROUT

River fish were significantly smaller ($\bar{x}$ wgt = 68 g) than the Lower Thompson River fish ($\bar{x}$ wgt = 349 g) (Table 3). The South Thompson River rainbow trout were of a comparable size to Lower Thompson River fish although weight/length data are not presented. Older and bigger fish on an average have higher mercury concentrations than smaller and younger fish (Skurdal et al., 1985; MacCrimmon et al., 1983). This may account for the higher mercury content in the South and Lower Thompson River fish. As well, the differences may reflect the differences in the mineralization of the drainages. Garrett et al., 1980 reported the Kamloops Lake area as being a major area of mercury mineralization. Northcote et al. (1975) did not find any relationship between muscle mercury content and fish size for rainbow trout in the Lower Fraser River but his samples did not cover the range of sizes observed in this study. Singleton (1983) did find a significant positive correlation between muscle mercury content and fish size for Dolly Varden in the Fraser River.

The highest concentrations of mercury are detected in such tissues as the liver and kidney but they are slowly eliminated from these organs and subsequently accumulate in the muscle (Garrett et al., 1980). Mercury uptake would first become apparent in the liver due to its higher metabolic rate. The mercury levels in muscle tissue of the South and Lower Thompson River rainbow trout are similar to those of Fraser River salmonids (Table 4). The muscle tissue mercury levels are approximately an order of magnitude lower than the federal Food and Drug Directorate 0.5 ug/g Hg (wet weight) administrative guideline for fish for human consumption (Stancil, 1980).

The mean mercury content for mountain whitefish liver tissue was 0.077 ug/g (SD = 0.020) and 0.061 ug/g (0.010) for the North and Lower Thompson Rivers respectively (Table 5, Figure 3). Mountain whitefish samples were not obtained for the South Thompson River. The mean mercury content of mountain whitefish muscle tissue was 0.071 ug/g (0.037) for the North Thompson River and 0.071 ug/g (0.007) for the Lower Thompson River (Table 5). The size of fish from both rivers was comparable ($\bar{x}$ wgt = 288 g for North Thompson River and $\bar{x}$ wgt = 289 g for Lower Thompson River). Mercury levels are approximately and order of magnitude lower than the 0.5 ug/g food consumption guideline.

TABLE 4 COPPER, MERCURY AND ZINC CONTENT OF SEVERAL FRASER RIVER SALMONIDS

SPECIES	SAMPLE SIZE	$\bar{x}$ FORK LENGTH (cm) (range)	MEAN MUSCLE TISSUE METAL CONTENT (ug/g wet weight)			REFERENCE
			Cu (range)	Hg (range)	Zn (range)	
Rainbow trout	41	30.7 (23.1 - 44.2)	.66 (.22 - 1.02)	.09 (.02 - .31)	5.03 (3.2 - 9.21)	Northcote 1975
Rainbow trout	6	32.8 (25.6 - 46.0)	.65 (< - 1.08)	.09 (< - .14)	4.83 (3.92 - 6.05)	Singleton 1983
Mountain Whitefish	6	26.1 (19.2 - 29.7)	.66 (.38 - .85)	.12 (.03 - .29)	4.61 (3.41 - 7.20)	Northcote 1975
Dolly Varden	29	34.7 (22.4 - 60.6)	.32 (< - 1.03)	.10 (< - .22)	4.16 (3.04 - 5.54)	Singleton 1983

< = less than minimum detection level

TABLE 5 MEAN MERCURY, CADMIUM, COPPER AND ZINC CONTENT OF LIVER AND MUSCLE TISSUE FROM THOMPSON RIVER MOUNTAIN WHITEFISH

METAL (ug/g wet weight)	NORTH THOMPSON		SOUTH THOMPSON		LOWER THOMPSON	
	Liver $\bar{x} \pm$ (S.D.)	Muscle $\bar{x} \pm$ (S.D.)	Liver $\bar{x} \pm$ (S.D.)	Muscle $\bar{x} \pm$ (S.D.)	Liver $\bar{x} \pm$ (S.D.)	Muscle $\bar{x} \pm$ (S.D.)
Hg	.077 (.020)	.071 (.037)	-	-	.061 (.010)	.071 (.007)
Cd	.18 (.04)	< .09 (.01)	-	-	< .09 (.01)	< .09 (.01)
Cu	2.83 (.50)	.75 (.34)	-	-	3.78 (1.22)	2.38* (.83)
Zn	22.3 (1.8)	4.22 (.31)	-	-	23.0 (1.1)	4.55 (.40)
Fish Weight (g)						
Hg	263 (47)	288 (42)	-	-	255 (64)	289 (66)
Cu/Zn	312 (22)	288 (42)	-	-	330 (99)	289 (66)
Fish Fork Length (cm)						
Hg	29.2 (1.5)	30.3 (1.9)	-	-	29.9 (2.1)	30.6 (1.7)
Cu/Zn	31.4 (1.8)	30.3 (1.9)	-	-	31.5 (2.1)	30.6 (1.7)
n						
Hg	3	6	-	-	2	6
Cu/Zn	3	6	-	-	2	6

*significantly greater than North Thompson ($p < .05$)

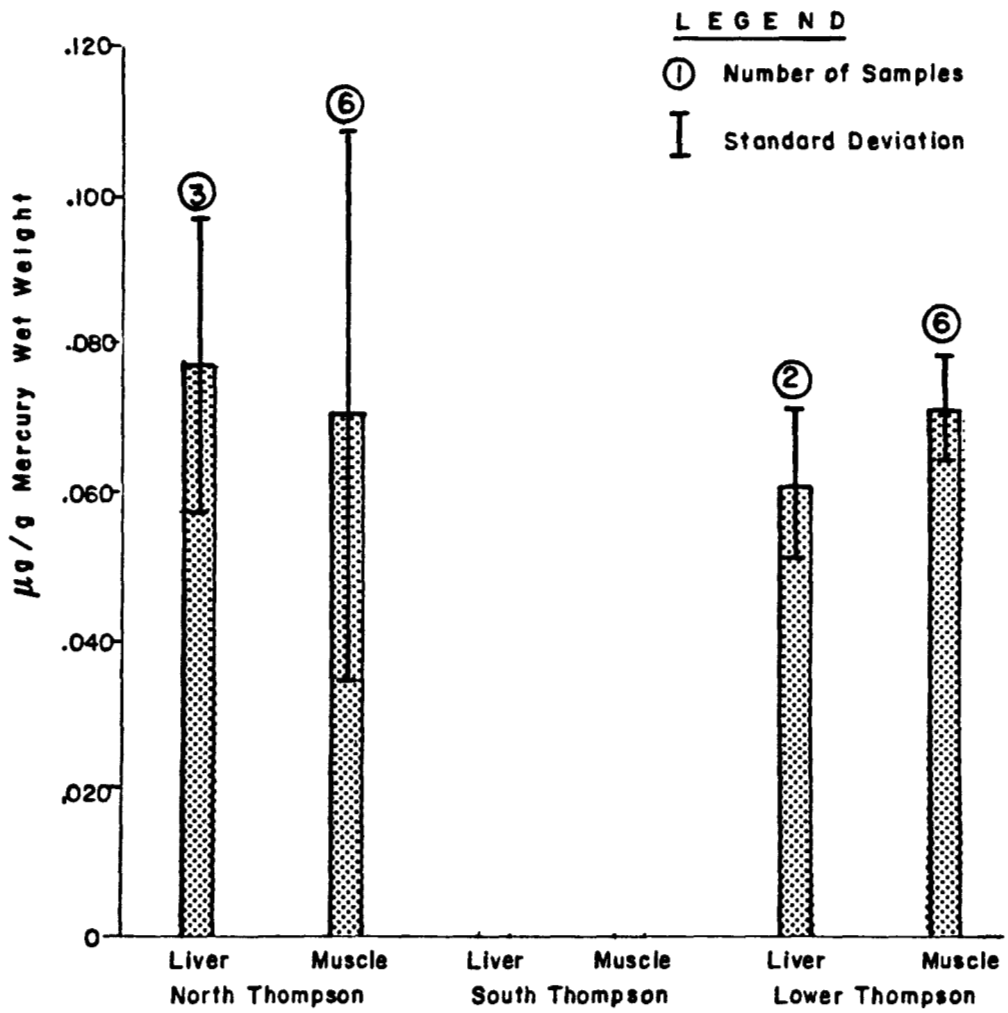

FIGURE 3 MEAN MERCURY CONTENT OF MUSCLE AND LIVER TISSUE FROM THOMPSON RIVER MOUNTAIN WHITEFISH

3.2.2 Copper. The mean copper content for rainbow trout liver tissue was highly variable and especially so for South Thompson River fish (Table 3). The mean copper content of rainbow trout muscle tissue was much lower than the liver tissue. Liver tissue mean concentrations were 71, 24 and 9 times greater than muscle tissue for the North, South and Lower Thompson Rivers respectively. The mean copper content for rainbow trout muscle tissue was 0.62 ug/g (S.D. = 0.13), 1.71 ug/g (0.89) and 2.87 ug/g (1.44) for the North, South and Lower Thompson Rivers respectively (Figure 4). South and Lower Thompson River muscle tissue copper levels were higher than for the North Thompson River but only the Lower Thompson mean was significantly greater ($p < .05$). The reason for this is not clear but may reflect differences between the size of fish as well as differences in the mineralization of the different drainages. The presence of copper deposits in this part of the region is exemplified by the Afton Copper Mine (Figure 1). Northcote (1975) did not find any relationship between muscle copper content and fish size for rainbow trout. Singleton (1983) reported a significant but low positive correlation between muscle copper content and fish size for Dolly Varden. He felt however that copper content was probably independent of fish size. Shearer (1984) reported that for hatchery-reared rainbow trout (ova to 1500 g) the concentration of all elements (except K), in the muscle of fish > 10 g, remained constant despite increasing fish weight. He reported a liver to muscle copper ratio of 171:1 ($\bar{x}$ liver = 101 ug/g, $\bar{x}$ muscle = 0.59 ug/g). Wilson et al., 1980 assessed the relationship between tissue copper levels (muscle, liver) and water copper concentration. They did not find any obvious relationship between muscle copper content and fish size nor between muscle copper content and the copper concentration in the water. Wilson et al., 1980 did find that liver copper content did increase with increased water concentrations and also with fish size in several of the locations.

The mean muscle tissue copper levels for the South and Lower Thompson River rainbow trout are higher than for other salmonids from the Fraser River while North Thompson River mean levels are similar (Table 4). The sample size for liver tissues in this study was not large enough to adequately assess differences between the three rivers.

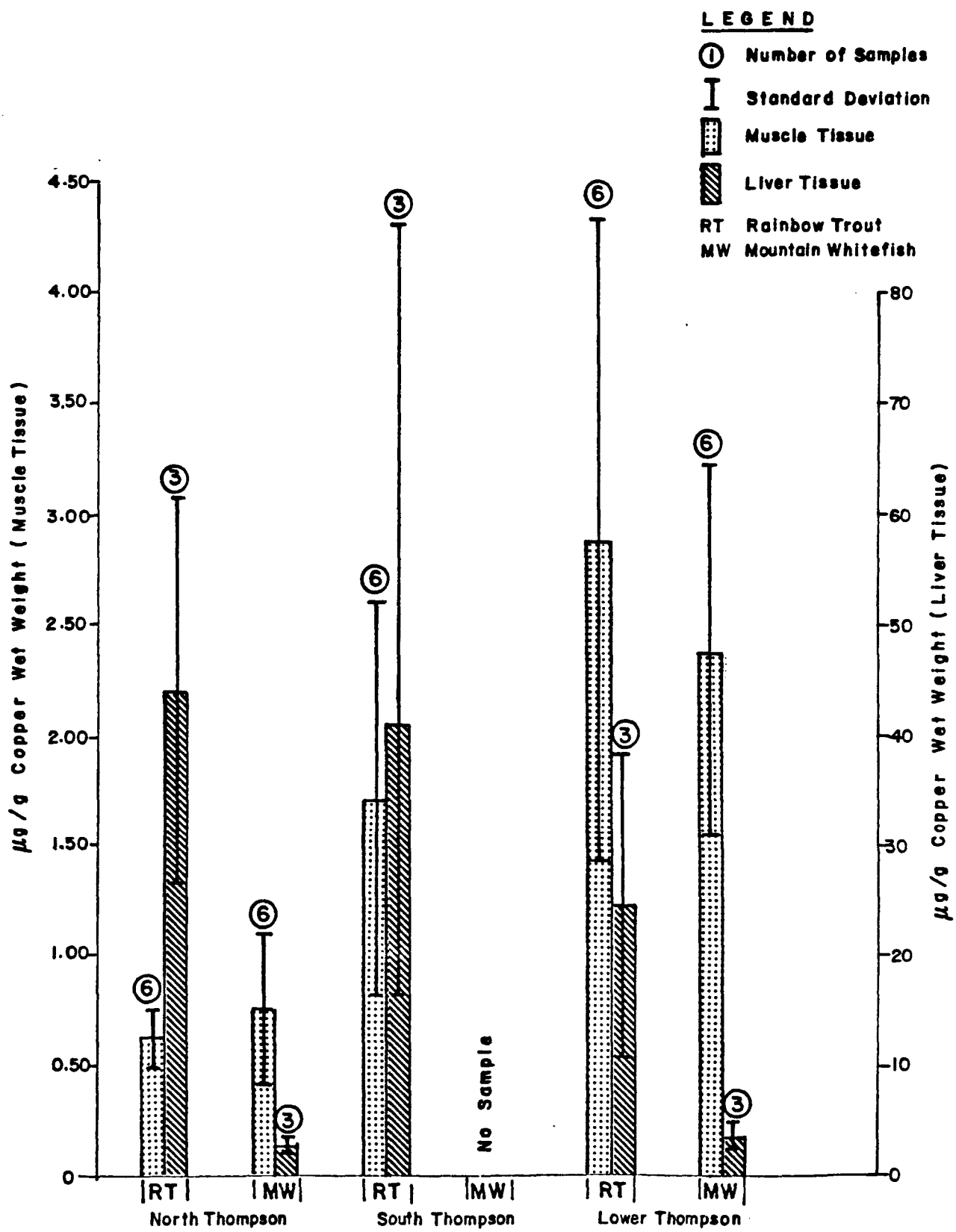

FIGURE 4 MEAN COPPER CONTENT OF MUSCLE AND LIVER TISSUE FROM THOMPSON RIVER RAINBOW TROUT AND MOUNTAIN WHITEFISH

The mean copper content for mountain whitefish muscle tissue was significantly greater ($p < .05$) in Lower Thompson River fish than North Thompson River fish (2.38 ug/g compared to 0.75 ug/g) (Table 5, Figure 4). Samples were not collected from the South Thompson River. Mean liver tissue copper levels were 1.6 to 3.8 times higher than muscle tissue for North and South Thompson Rivers respectively.

Muscle tissue copper levels are well below the former 100 ug/g (wet weight) federal Food and Drug Directorate regulation effective between 1975 to 1978 (Stancil, 1980).

3.2.3 Zinc. The mean zinc content for rainbow trout liver was comparable between all rivers, as was the muscle tissue content (Table 3, Figure 5). The same was true for mountain whitefish (Table 5, Figure 5). For rainbow trout, the ratio of liver:muscle zinc content was 5:1 and is similar to that reported by Shearer (1984) (5.3:1).

Wilson et al., 1980 reported that there was no obvious relationship between muscle tissue metal content and size or age of trout, nor between flesh content and the concentration of zinc in the water. Liver zinc levels did increase with increased zinc concentrations in the water but not with increased fish size. Holcombe et al., 1979 reported the zinc levels in muscle did not increase with increased zinc levels in the water whereas liver tissue levels did.

Thompson River fish zinc levels are comparable to levels for salmonids from the Fraser River (Table 4). Levels are well below the former 100 ug/g (wet weight) federal Food and Drug Directorate regulation effective between 1975 to 1978 (Stancil, 1980).

3.2.4 Cadmium. The cadmium content of rainbow trout and mountain whitefish muscle tissue for all three rivers was below detectable levels (Tables 3 and 5). For rainbow trout, the mean cadmium liver tissue content was greater for North Thompson River fish (0.56 ug/g) than South and Lower Thompson River fish (0.14 ug/g) (Table 3). The same pattern, was true for mountain whitefish liver tissue (North Thompson $\bar{x}$ = 0.18 ug/g, Lower Thompson $\bar{x}$ = < .09 ug/g) but the sample size was even smaller than for rainbow trout livers) (Table 5).

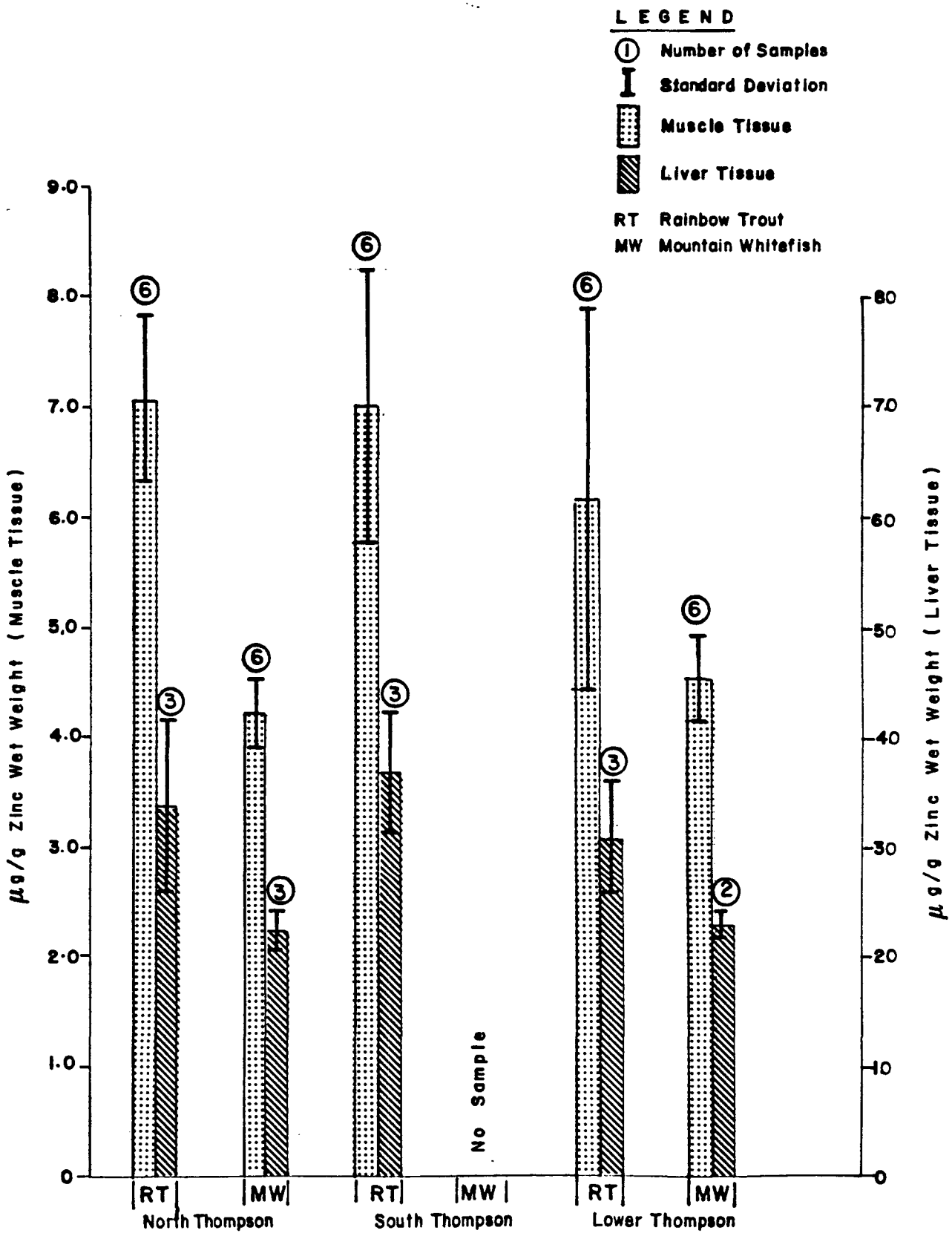

FIGURE 5 MEAN ZINC CONTENT OF MUSCLE AND LIVER TISSUE FROM THOMPSON RIVER RAINBOW TROUT AND MOUNTAIN WHITEFISH

Wilson et al., 1980 did not find any obvious relationship between cadmium muscle concentrations and the size or age of trout, nor between the muscle concentrations and the concentration of cadmium in the water. They did report that liver cadmium concentrations increased with increased cadmium concentrations in the water. Cadmium liver concentrations increased with fish length, weight and age at several of the locations.

Benoit et al., 1976 reported that kidney, liver and gill tissue accumulated the greatest amounts of cadmium at each exposure concentration. No significant increases in cadmium edible muscle content were measured at any exposure concentrations.

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APPENDIX I

APPENDIX I(a) MERCURY RESULTS

NORTH THOMPSON					SOUTH THOMPSON					LOWER THOMPSON				
FORK LENGTH (cm)	WEIGHT (g)	SEX	HG (ug/g wet weight) Liver	Muscle	FORK LENGTH (cm)	WEIGHT (g)	SEX	HG (ug/g wet weight) Liver	Muscle	FORK LENGTH (cm)	WEIGHT (g)	SEX	HG (ug/g wet weight) Liver	Muscle
RAINBOW TROUT														
20.3	90	-	.038		-	-	-	.068		31.8	315	M	.076	
17.0	65	-	.104		-	-	-	.163		31.8	338	M	.046	
14.9	50	-	.082		-	-	-	.053		33.8	395	M	.061	
20.3	90	-		.033	-	-	-		.057	31.8	315	M		.079
17.0	65	-		.040	-	-	-		.095	31.8	338	M		.087
14.9	50	-		.053	-	-	-		.083	33.8	395	M		.062
14.9	40	-		.042	-	-	-		.095	30.6	258	M		.048
					-	-	-		.089	36.2	475	M		.062
										35.7	460	M		.122
MOUNTAIN WHITEFISH														
30.5	300	F	.095							28.4	210	F	.054	
29.5	280	M	.082							31.3	300	F	.068	
27.5	210	F	.055											
30.5	300	F		.062						28.4	210	F		.070
29.5	290	M		.056						29.0	250	M		.064
27.5	210	F		.036						31.3	300	F		.072
33.5	335	M		.074						31.7	312	F		.071
30.7	290	M		.142						33.0	400	F		.084
30.1	310	F		.056						30.0	260	M		.064

APPENDIX I(b) COPPER RESULTS

NORTH THOMPSON					SOUTH THOMPSON					LOWER THOMPSON				
FORK LENGTH (cm)	WEIGHT (g)	SEX	CU (ug/g wet weight) Liver	Muscle	FORK LENGTH (cm)	WEIGHT (g)	SEX	CU (ug/g wet weight) Liver	Muscle	FORK LENGTH (cm)	WEIGHT (g)	SEX	CU (ug/g wet weight) Liver	Muscle
RAINBOW TROUT														
14.9	40	-	24.6		-	-	-	7.31		30.6	258	M	31.8	
19.1	70	-	58.4		-	-	-	92.1		36.2	475	M	33.2	
15.7	40	-	48.8		-	-	-	24.0		35.7	460	M	8.9	
20.3	90	-		.65	-	-	-		3.4	31.8	315	M		2.1
17.0	65	-		.59	-	-	-		1.4	31.8	338	M		2.4
14.9	50	-		.54	-	-	-		1.7	33.8	395	M		5.5
14.9	40	-		.58	-	-	-		1.3	30.6	258	M		2.5
19.1	70	-		.86	-	-	-		.99	36.2	475	M		3.4
15.7	40	-		.51	-	-	-		1.3	35.7	460	M		1.4
MOUNTAIN WHITEFISH														
33.5	335	M	2.6							33.0	400	F	4.6	
30.7	290	M	3.4							30.0	260	M	2.9	
30.1	310	F	2.5											
30.5	300	F		.76						28.4	210	M		1.8
29.5	280	M		.62						29.0	250	M		3.1
27.5	210	F		.75						31.3	300	M		3.6
33.5	335	M		.47						31.7	312	F		2.1
30.7	290	M		.53						33.0	400	M		1.5
30.1	310	F		1.4						30.0	260	M		2.1

APPENDIX I(c) ZINC RESULTS

NORTH THOMPSON					SOUTH THOMPSON					LOWER THOMPSON				
FORK LENGTH (cm)	WEIGHT (g)	SEX	ZN (ug/g wet weight) Liver	Muscle	FORK LENGTH (cm)	WEIGHT (g)	SEX	ZN (ug/g wet weight) Liver	Muscle	FORK LENGTH (cm)	WEIGHT (g)	SEX	ZN (ug/g wet weight) Liver	Muscle
RAINBOW TROUT														
14.9	40	-	41.6		-	-	-	43.1		30.6	258	M	36.7	
19.1	70	-	26.1		-	-	-	32.8		36.2	475	M	29.3	
15.7	40	-	33.4		-	-	-	34.8		35.7	460	M	26.9	
20.3	90	-		6.3	-	-	-		5.8	31.8	315	M		4.8
17.0	65	-		6.0	-	-	-		8.8	31.8	338	M		6.5
14.9	50	-		7.6	-	-	-		7.7	33.8	395	M		4.6
14.9	40	-		7.9	-	-	-		7.6	30.6	258	M		8.7
19.1	70	-		7.4	-	-	-		6.2	36.2	475	M		7.6
15.7	40	-		7.2	-	-	-		5.8	35.7	460	M		4.8
MOUNTAIN WHITEFISH														
33.5	335	M	21.1							33.0	400	F	22.2	
30.7	290	M	24.4							30.0	260	M	23.7	
30.1	310	F	21.4											
30.5	300	F		4.0						28.4	210	M		4.1
29.5	280	M		4.5						29.0	250	M		4.2
27.5	210	F		3.9						31.3	300	M		4.9
33.5	335	M		3.9						31.7	312	F		4.7
30.7	290	M		4.7						33.0	400	M		4.3
30.1	310	F		4.3						30.0	260	M		5.1

APPENDIX I(d) CADMIUM RESULTS

NORTH THOMPSON					SOUTH THOMPSON					LOWER THOMPSON				
FORK LENGTH (cm)	WEIGHT (g)	SEX	CD (ug/g wet weight) Liver	Muscle	FORK LENGTH (cm)	WEIGHT (g)	SEX	CD (ug/g wet weight) Liver	Muscle	FORK LENGTH (cm)	WEIGHT (g)	SEX	CD (ug/g wet weight) Liver	Muscle
RAINBOW TROUT														
14.9	40	-	.98		-	-	-	.17		30.6	258	M	.11	
19.1	70	-	.33		-	-	-	.14		36.2	475	M	.23	
15.7	40	-	.38		-	-	-	.11		35.7	460	M	< .09	
20.3	90	-		< .08	-	-	-		< .09	31.8	315	M		< .09
17.0	65	-		< .08	-	-	-		< .09	31.8	338	M		< .08
14.9	50	-		< .08	-	-	-		< .09	33.8	395	M		< .09
14.9	40	-		< .07	-	-	-		< .08	30.6	258	M		< .08
19.1	70	-		< .09	-	-	-		< .10	36.2	475	M		< .09
15.7	40	-		< .09	-	-	-		< .09	35.7	460	M		< .09
MOUNTAIN WHITEFISH														
33.5	335	M	.22							33.0	400	F	< .10	
30.7	290	M	.16							30.0	260	M	< .09	
30.1	310	F	.16											
30.5	300	F		< .09						28.4	210	M		< .09
29.5	280	M		< .10						29.0	250	M		< .09
27.5	210	F		< .09						31.3	300	M		< .10
33.5	335	M		< .09						31.7	312	F		< .10
30.7	290	M		< .10						33.0	400	M		< .10
30.1	310	F		< .10						30.0	260	M		< .09