MERCURY CONTAMINATION OF FISH FROM PINCHI LAKE, B.C.

by

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Taking inventory of fish from Pinchi Lake for the examination of mercury contamination in fish.

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ABSTRACT

Mercury determinations were made on 40 fish tissue samples from Pinchi Lake, B.C. in August, 1974 in order to assess the potential health hazard associated with the consumption of mercury-contaminated fish by fishermen.

High levels of mercury, in excess of the Canadian Food and Drug Directorate of 0.5 ppm, occurred in several species of fish from Pinchi Lake. Lake trout was found to have the highest level of mercury content in axial muscle tissue ($\bar{x}$=5.23 ppm). Mercury levels of up to 29 ppm was also found in liver samples from lake trout.

A linear relationship between axial muscle mercury content and total fish weight was observed for rainbow trout. Combining the mercury concentration in all fish species also produced a linear relationship between mercury concentration and fish weight. Due to the insufficient sample size it could not be determined if the above linear relationship also applied to lake trout. However, a positive correlation between muscle mercury and lake trout weight was observed.

INTRODUCTION

Since at least 1970 concern has been expressed regarding the possible health hazard associated with sport-fishermen consuming mercury-contaminated fish from Pinchi Lake, B.C.. The "mercury crisis" which resulted from the discovery of biological methylation of inorganic mercury by micro-organisms in nature (Mercury, 1970) fostered this concern.

The purpose of this study, therefore, was to monitor fish from Pinchi Lake and to determine the levels of mercury present in the sport-fish populations. Since methyl mercury is readily accumulated (i.e. directly and through the food chain) and retained by fish (Mercury, 1970) a relationship between weight and species of fish to tissue mercury content was examined in an endeavour to reveal which fish are potentially more hazardous to the sport-angler. A positive correlation between weight of fish and tissue mercury content has been reported in the literature (Fimreite, et al, 1971; Friberg and Vostal, 1972; Johnels, et al, 1967) for a limited number of fish species. A more detailed and up-to-date examination of mercury contamination of the indigenous fish of Pinchi Lake was, therefore, attempted.

Pinchi Lake was selected for examination of mercury contamination due to the findings of a mercury monitoring program of freshwater lakes by the Fish and Wildlife Branch in the summer of 1970 (Peterson, et al, 1970). The first lakes studied in 1970 were those lying within and bordering upon the Pinchi Fault Zone; a geological feature that extends for a distance of about 150 miles northwest of Fort St. James (Figure 1). The area contains numerous mercury-bearing

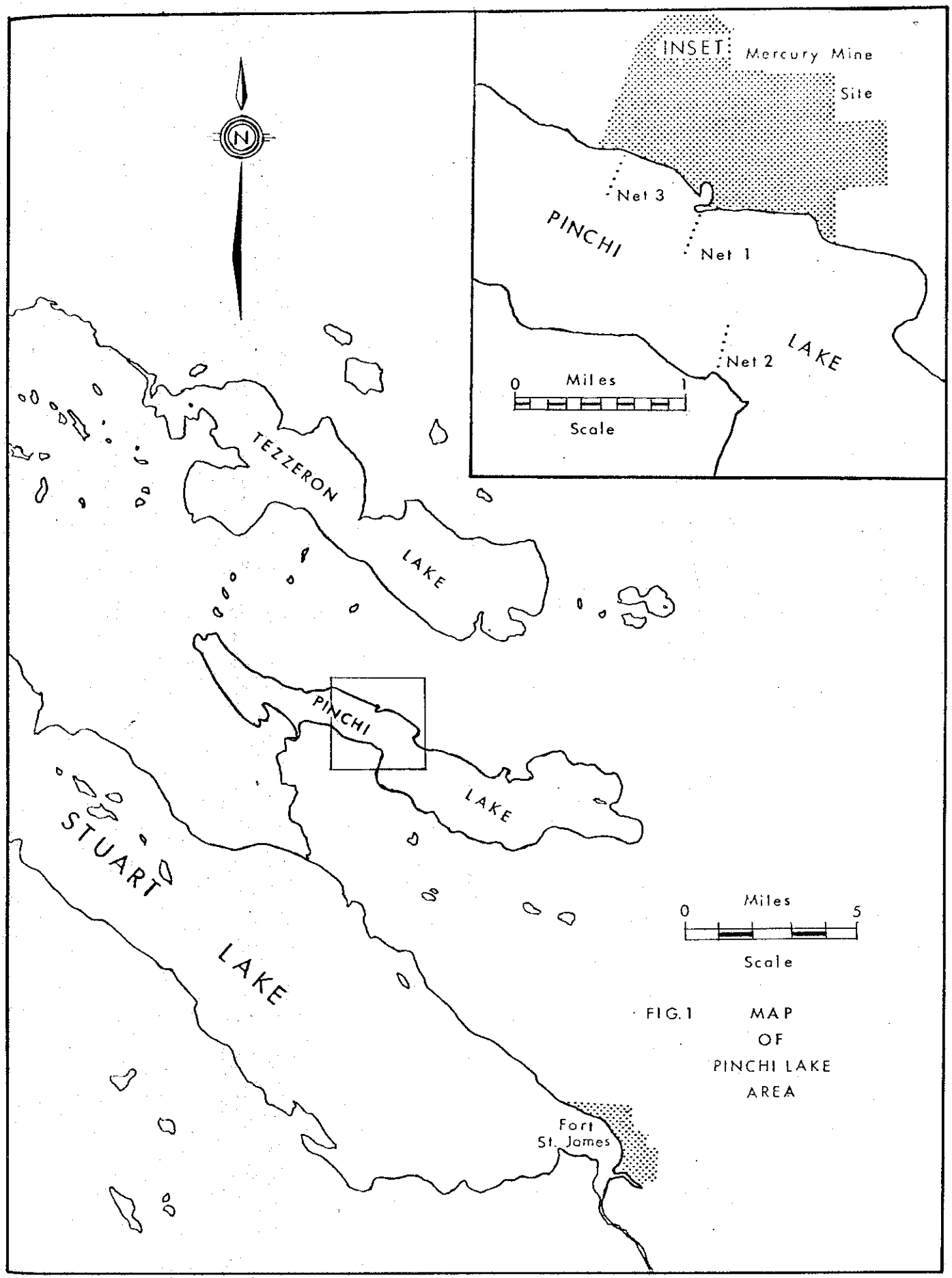


FIG. 1 MAP OF PINCHI LAKE AREA

ore deposits (cinnabar). Some 20 cinnabar occurences are known along the Pinchi Fault Zone from a point east of Fort St. James to a point north of Omineca River. Approximately twenty lakes were sampled in 1970 and all lakes contained fish with varying amounts of mercury residues. Pinchi Lake was the only one found to contain fish with dangerous levels of mercury (Peterson et al, 1970). Lake trout, Salvelinus namaycush, from Pinchi Lake were found to have the highest mercury contamination in Canada with a mean level of 5.78ppm (Fimreite et al, 1971). A safe limit set by the Canadian Food and Drug Directorate for mercury in fish consumed by humans is 0.5 ppm. However, the World Health Organization uses a level of 0.05ppm. Pinchi Lake was subsequently posted by the Fish and Wildlife Branch with signs warning anglers against eating their catch.

Since axial muscle is the part of the fish consumed by humans, it was selected as the most suitable tissue for primary examination of mercury levels. This tissue is also used world-wide for the examination of mercury present in aquatic environments (Johnels et al, 1967).

The excessive mercury contamination found in Pinchi Lake in 1970 is believed to have originated from a mercury mine that operated during the Second World War (mine operation 1940-44) and which dumped untreated tailings into the lake. Natural cinnabar ore deposits are also believed to account for the high background levels of mercury. Cominco of Trail re-opened the old mercury mine at Pinchi Lake in August, 1968 and was in operation at the time of this study.

The possible detrimental effects of high mercury concentration on both fish and wildlife is discussed in context with this study.

MATERIALS AND METHODS

Three gangs of variable mesh-size nylon gill nets were used to sample the fish populations in Pinchi Lake between August 7th and 8th, 1974 (Table I and Figure 1).

TABLE I Fish net settings on Pinchi Lake for the examination of mercury contamination in fish

*Gill net	Time set	Time Lifted	Depth at Shallow end	Mesh Size	Depth at Deep End	Mesh Size	Section Length	Mesh Sizes
#1 rocky deep area	13:00 Aug.7	12:30 Aug.8	12feet	1 inch	35 feet	1 inch	40 feet	1,3½,2, 3,1½,2½, 2½,1½,3 2,3½,1, inch
#2 weedy shallow area	13:00 Aug.7	12:30 Aug.8	5 feet	1 inch	20 feet	4½ inch	50 feet	1,2,3, 1,2,3, 4½, inch
#3 rocky deep area	13:00 Aug.8	12:30 Aug.9	12 feet	1 inch	35 feet	4½inch	50 feet	1,2,3, 1,2,3, 4½, inch

* All gill nets were sinking nets and were set perpendicular to shore.

All fish were removed from the nets, identified and counted by Fish and Wildlife Branch lake inventory personnel. Fish for mercury analysis were measured, weighed, sexed, and stomach contents analyzed. The fish selection criteria was based on the numbers and types of fish netted. Since only 40 samples could be analyzed a significant sample size could be collected for only two species: rainbow and

lake trout.

The tissue samples consisted of dorsal axial muscle taken anteriorly to the dorsal fin of the fish. Two liver samples from lake trout were also submitted for analysis. The axial muscle samples consisted of : 10 rainbow trout (Salmo gairdneri); 11 lake trout (Salvelinus namaycush); 6 kokanee (Oncorhynchus nerka); 3 largescale suckers (Catostomus macrocheilus); 3 peamouth club (Mylocheilus caurinus); 3 lake whitefish (Coregonus clupeaformis) and 2 mountain whitefish (Prosopium williamsoni).

The tissue samples were placed in glass vials with aluminum foil between the cap and bottle. Analytical grade ethanol was used as a preservative. The samples were submitted for analysis of mercury residues (total mercury) by wet digestion and flameless atomic absorption spectrophotometry at the B.C. Department of Agriculture Pesticide Laboratory, Vancouver.

RESULTS

High mercury levels were found in the muscle tissues of both sports and coarse fish from Pinchi Lake (Table II and appendix i). The mercury analysis of Pinchi Lake fish, summarized in Table II, show that all samples contained mercury levels near to and in excess of the Canadian Food and Drug Directorate limit of 0.5 ppm of mercury in food to be consumed by humans. Lake trout were found to have the highest level of mercury in axial muscle tissue with a mean level of 5.23 ppm (Table II). Extremely high mercury levels were also found in the liver from lake trout ($\bar{x}$ = 15 ppm) (Table II).

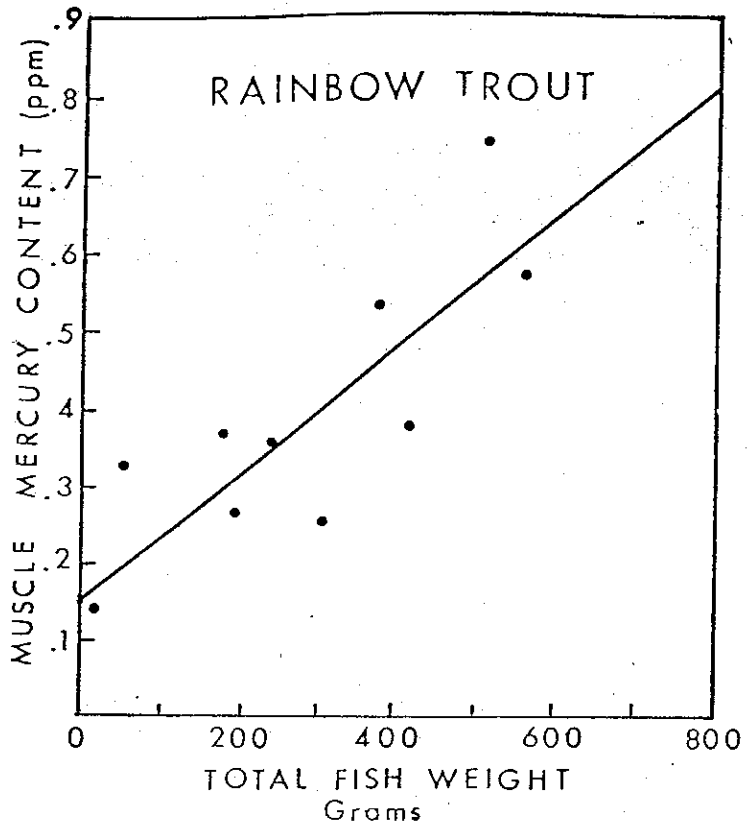
Statistical analysis of the rainbow trout data indicated a positive linear relationship between the weight and the mercury content of the fish (significant at the 1 percent level of probability with $F_{(1,8)} = 19.03$ - Figure 2). Regression analysis of all fish species data combined also indicated a positive linear relationship between weight and mercury content of the fish (significant at the 5 percent level of probability $F_{(1,36)} = 4.085$ - Figure 3). The regression line equation for all fish species combined ($y = 0.9771 + 0.0013x$) was calculated from all observations (appendix i). The coefficients of determination for rainbow trout, lake trout and combined fish species indicated that 70, 80 and 68 percent respectively of the variance in mercury content is associated with the variance in weight (Figures 2 and 3). The correlation coefficients indicate a 95.25, 83.67 and 82.00 percent association between the two variables for each fish species respectively.

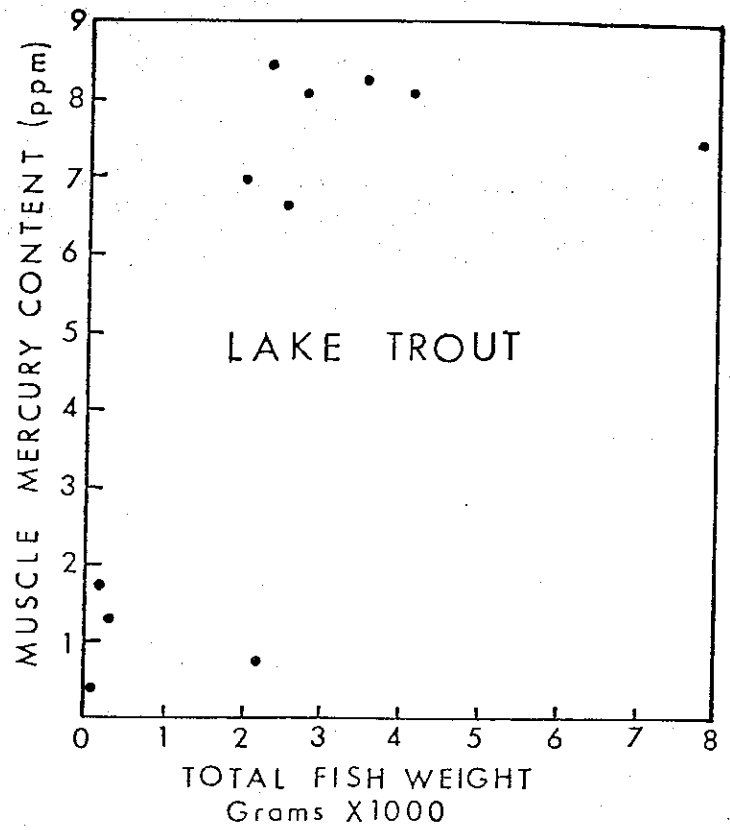
Pinchi Lake fish inventory revealed a high sport fisheries potential (appendix ii). Rainbow trout, lake trout, kokanee and whitefish were sport varieties commonly found in the gill nets.

TABLE II Fish muscle samples analyzed for total mercury (ppm)*
Mean, range and standard deviation values.

Species	Sample size	Weight range ($\bar{x}$) S.D.	Length range ($\bar{x}$) S.D.	Mercury range ($\bar{x}$) S.D.
Rainbow Trout	10	25-580 (294.5) 186.3	13.6-38.4 (28.5) 7.60	0.05-0.73 (.40) 0.171
Lake Trout	11	25-8300 (2627) 2325.7	23.9-83.0 (56.6) 14.54	0.36-8.31 (5.23) 3.387
Kokanee	6	145-190 (163) 16.3	21.8-25.5 (23.7) 1.25	0.32-0.76 (.49) .180
Large Scale Sucker	3	1100-1275 (1175) 90.1	44.0-48.5 (45.8) 1.60	2.03-3.27 (2.59) .639
Peamouth Club	3	186-215 (204) 15.6	24.5-26.0 (25.3) .765	1.68-2.25 (1.90) 0.309
Mountain Whitefish	2	205-525 (264) 226.3	26.0-33.4 (29.7) 5.23	0.49-0.83 (0.66) 0.240
Lake Whitefish	3	200-450 (325) 125.0	25.5-33.5 (29.8) 4.04	0.28-7.41 (2.47) 4.070
Liver Samples From Lake Trout	2	2300-8300 (5300) 1618.9	61.8-83.0 (72.4) 14.99	15-29 (15) 2.878

* Wet Weight
S.D. Standard Deviation





Correlation coefficient	0.953	0.937
Coefficient of determination	0.907	0.700
Standard error of estimate	0.0912	
regression equation	y = 0.163 + 0.0008x	

FIGURE 2.- RELATIONSHIPS OF TOTAL MERCURY CONTENT TO TOTAL FISH WEIGHTS

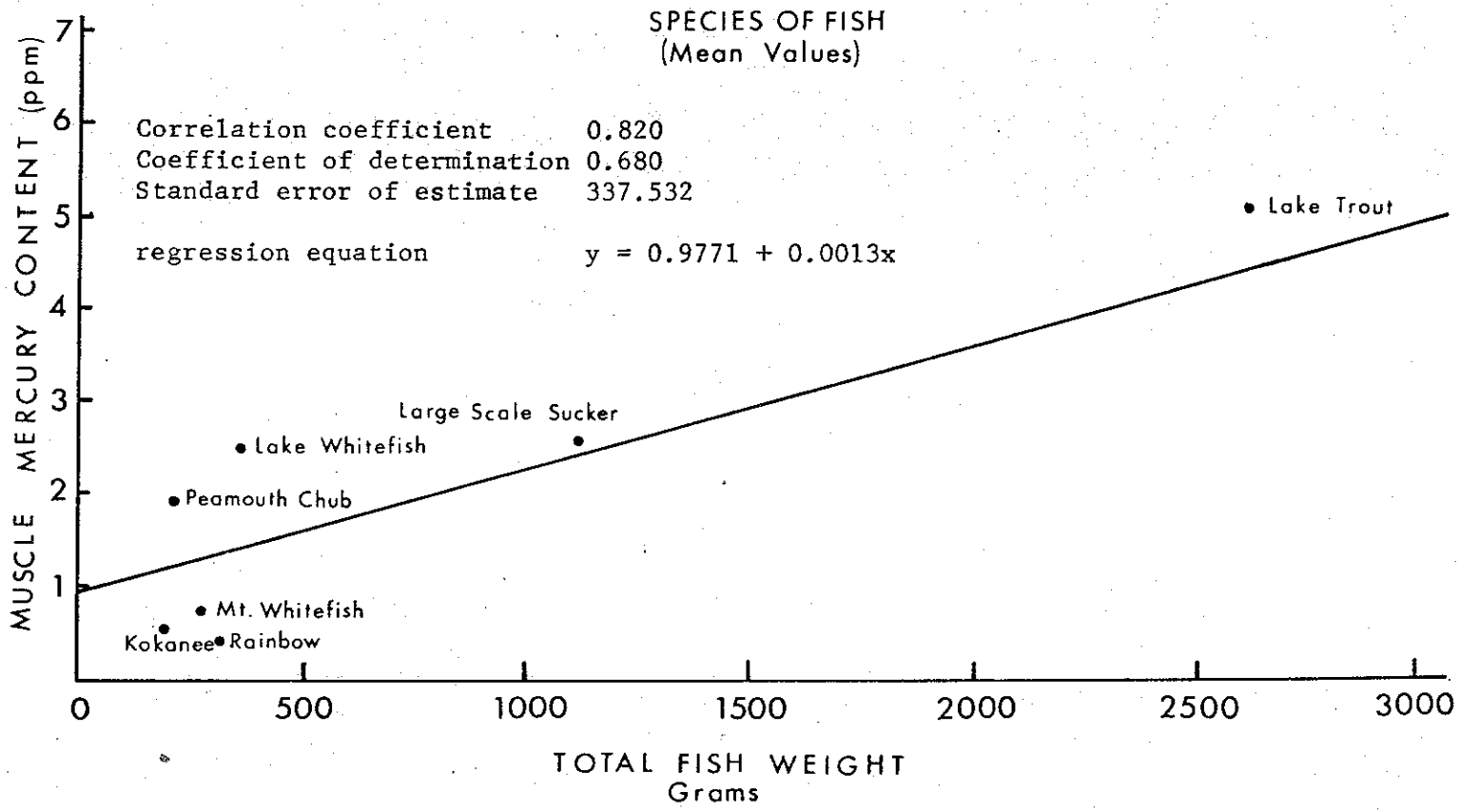


FIGURE 3.- RELATIONSHIPS OF TOTAL MERCURY CONTENT TO TOTAL FISH WEIGHT

DISCUSSION

The continuing hazard that mercury contaminated fish from Pinchi Lake present to the sports fisherman is of concern to the Fish and Wildlife Branch. This study indicates that the fish from this lake should not be consumed. If the sportsman is to risk eating these fish, his maximum risk will be in eating large lake trout. His minimum risk of poisoning will be from eating small rainbow trout. Statistical analyses of the rainbow trout and the combined fish species data indicated a positive linear relationship between total fish weight and axial muscle mercury content. Larger fish contained more mercury per unit weight than smaller fish (Figures 2 and 3).

Researchers have analyzed methyl mercury concentrations in fish of known ages and weights and found that total methyl mercury and also relative proportions of methyl mercury to total mercury increased with age and weight (Friberg and Vostal, 1972; Fimreite et al, 1971). The observed relationship was linear within the weight limits studied. However, variations were higher in areas with extremely high levels of mercury contamination. Statistical analysis of the Pinchi Lake fish was limited due to the small sample size and, in the case of the lake trout, narrow weight range.

The interspecific variation in mercury content of Pinchi Lake fish was high. Regression analysis of all fish species combined indicated this difference in mercury levels was dependent on the fish weight (Figures 2 and 3). However, reasons for species differences in mercury content might be related to diet and habitat (Kleinert and Degurse, 1972). When comparing mercury levels of different fish species the trophic level of each species should be considered. For example, the lake trout in Pinchi Lake were

found to be feeding on whitefish which were also found to have high levels of mercury in their tissues. The whitefish were found to be feeding at a lower trophic level; primarily on aquatic insects (Table I). Lake trout could, therefore, accumulate more mercury in their tissues than whitefish.

The indirect accumulation of mercury through the food chain has been demonstrated under laboratory conditions and also indicated by field data (Fimreite et al, 1971; Rucker and Amend, 1969; Peterson et al, 1970). Seasonal fluctuations in mercury levels also occur and are dependent on the rates of food intake and metabolism of the fish (Fimreite et al, 1971). Species differences in the biological half-life of methyl mercury have been found to exist even within various fish species from the same area (Friberg and Vostal, 1972). A larger sample size than that used in this study and a variety of fish species with similar weights is required to investigate interspecific variation in mercury content.

The fisheries inventory of Pinchi Lake indicates a high sport-fisheries resource value for rainbow trout, lake trout and whitefish (appendix ii). However, these fish had mercury levels in excess of the Canadian Food and Drug Directorate limit of 0.5 ppm in food for consumption by humans (Table II and appendix i).

On the basis of date collected in Neigata, Japan, it was concluded that the daily consumption of fish containing 5 to 6 ppm of mercury could be lethal (Friberg and Vostal, 1972). Therefore, a prolonged daily consumption of lake trout from Pinchi Lake, having the highest mean mercury level of 5.23 ppm, could have very deleterious effects on the consumer's health (Table II).

Detrimental effects of high mercury concentrations have been reported on fish populations. Such effects may manifest themselves in the form of sublethal changes such as loss of reproductive capabilities, behavioural changes or organ damage. For example, sublethal levels of mercury in water, as low as 0.01 ppm, reduced the avoidance behaviour of mosquitofish (Gambusia affinis) to bass predation (Kania and O'Hara, 1974). Mercury concentrations as low as 0.67 ppm were found in mosquitofish which exhibited significant behavioural alterations.

Accumulation of mercury in food chains has been well documented (Kleinert and Dequrse, 1972) and, in fact, is demonstrated by mercury levels in fish-eating birds from Pinchi Lake. Red-necked Grebes, have been found to accumulate liver levels of mercury up to 17.4 ppm which is close to the lethal levels for Red tailed hawks (Fimreite et al, 1971). Sublethal levels of mercury have also been found to affect the reproductive capacity of wild birds causing decreased populations (Lundholm, 1968).

The high mercury levels found in Pinchi Lake during this study suggest that the mercury mine operation, in the past or present, might be a source of contamination. Birds and fish collected by Fimreite et al (1971), before the Pinchi Lake Cominco mine reopened in 1968 contained abnormally high mercury concentrations which suggests that the mine tailings (cinnabar or mercury) from the mining operations nearly 30 years ago are still an important source of contamination. Mercury levels in fish from the surrounding lakes, where cinnabar deposits are present, have been found to be high, though lower than Pinchi Lake levels thus indicating influence from the mercury mining during 1940-44 and possibly from the present operation (Peterson et al, 1970).

CONCLUSIONS

The consumption of Pinchi Lake fish by fishermen is potentially hazardous to their health due to the excessively high mercury content in the fish tissues. The larger the fish, the greater the risk of mercury poisoning to the consumer as a result of the larger fish containing relatively more mercury per unit weight than smaller fish. Some fish species, such as lake trout, are a greater mercury poisoning risk than others as a result of species variation in mercury content, though the results of this study indicate primarily a weight dependence.

The results of this study and the above considerations warrants the posting of Pinchi Lake warning fishermen of the potential health hazard associated with the consumption of mercury contaminated fish.

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APPENDICES

Appendix i

Fish axial muscle samples analyzed for total mercury (ppm)

Sample No.	Species	Weight (grams)	Length (cm)	Sex	Total Mercury (ppm)
1	Rainbow Trout	25	13.6	Immature female	0.15
2	" "	65	17.5	" "	0.34
3	" "	185	25.7	" "	0.38
4	" "	200	26.8	" "	0.27
5	" "	250	28.5	" "	0.37
6	" "	310	30.2	" "	0.26
7	" "	380	31.8	Maturing male	0.53
8	" "	425	34.1	Maturing female	0.38
9	" "	525	38.1	Maturing male	0.73
10	" "	580	38.4	" "	0.58
18	Lake Trout	25	23.9	Immature -	0.36
36	" "	275	29.6	Immature female	1.88
38	" "	300	29.0	Immature male	1.22
11	" "	2100	65.2	Maturing male	6.95
39	" "	2300	61.8	" "	0.70
12	" "	2400	61.2	" "	8.31
13	" "	2600	61.1	Maturing female	6.54
14	" "	2700	64.2	Immature male	8.04
15	" "	4300	70.5	Maturing male	8.02

Fish tissue samples analyzed for total mercury (ppm) (continued)

Sample	Species	Weight (grams)	Length (cm.)	Sex	Total Mercury (ppm)
16	Lake Trout	3600	72.8	Maturing male	8.19
17	" "	8300	83.0	" "	7.36
23	Kokanee	145	21.8	Maturing female	0.76
21	"	150	23.2	" "	0.32
22	"	155	23.1	Maturing male	0.65
20	"	165	24.2	" "	0.38
19	"	170	24.1	Maturing female	0.40
37	"	190	25.5	" "	0.37
27	Large Scale Sucker	1100	45	" "	2.46
26	" " "	1150	44	" "	2.03
25	" " "	1275	48.5	" "	3.27
29	Peamouth Chub	186	24.5	" "	2.25
36	" "	210	25.5	" "	1.68
28	" "	215	26.0	" "	1.76
31	Mountain Whitefish	205	26.0	Immature female	0.49
35	" "	525	33.4	Maturing female	0.83
32	Lake Whitefish	200	25.5	Immature female	0.28
33	" "	325	30.5	" "	0.49
34	" "	450	33.5	Maturing female	7.41
40	Liver from #39				29.00
45	Liver from #17				15.00

Appendix ii

Fish species inventory of Pinchi Lake
(list in increasing numbers from each gill net)

Gill Net #	Species	Number Netted
1	Kokanee (Oncorhynchus nerka)	2
	Lake Trout (Salvelinus namaycush)	6
	Mountain Whitefish (Prosopium williamsoni)	9
	Peamouth Chub (Mylocheilus caurinus)	10
	Pygmy Whitefish (Prospufm coulteri)	11
	Red-Sided Shiner (Richardsonufs balteatus)	34
	Lake Whitefish (Coregonus clupeoformis)	68
2	Lake Trout (Salvelinus namaycush)	2
	Squawfish (Ptychocheilus oregonensis)	4
	Lake Whitefish (Coregonus clupeoformis)	7
	Fine Scale Sucker (Catostomus catostomus)	8
	Kokanee (Oncorhynchus nerka)	9
	Mountain Whitefish (Prosopium williamsoni)	16
	Rainbow Trout (Salmo gairdneri)	22
	Large Scale Sucker (Catostomus macrocheilus)	44
	Peamouth Chub (Mylocheilus caurinus)	54
	Red-Sided Shiner (Richardsonufs baltealus)	225
	TOTAL NO. OF SPECIES NETTED: 11 TOTAL	531

Stomach contents from netted fish consisted of flying insects from Rainbow Trout and Whitefish from Lake Trout, the rest were either empty or had unidentifiable contents. The fish from net number 3 are not recorded for species inventory, only for the mercury samples.