Exhibit P-121

Circumpolar health: proceedings of the 3rd international symposium, Yellowknife, NWT

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Imprint	Published for Health and Welfare Canada, 1976
Extent	xviii, 678 p
ISBN	9781487580940, 9781487579876
Permalink	https://books.scholarsportal.info/uri/ebooks/ebooks6/upress6/2021-03-03/1/9781487580940
Pages	669 to 697

SUMMARY

The Cannikin nuclear explosion was a five-megaton underground explosion conducted by the US Atomic Energy Commission (AEC) on Amchitka Island on 6 November 1971. This report concerns blood and urine surveillance of people at Atka, the closest native village to Amchitka (200 miles). Three weeks before the explosion, blood and urine samples from 53 of 85 natives were analysed for Cesium-137, Fe-55, and Tritium. An estimate was also made of the amount of indigenous foods used by the people. One year later, tests were repeated on 35 of the initially sampled population of Atka, and 35 people on Kodiak Island were similarly tested. As controls, 35 native out-patients without acute disease were tested at an Anchorage hospital. Levels of the radionuclides tested did not approach dangerous levels as presently understood. The relationship between radionuclide levels and consumption of indigenous foods requires further study.

REFERENCES

1. Fort, C.W., and Wruble, D.T., Off-site radiological safety for the Cannikin event November 6, 1971. US Atomic Energy Commission. US Environmental Protection Agency (Las Vegas, Nevada, September 1972), pp. 1-25
2. Jenkins, C.E., "Radionuclide distribution in Pacific salmon," Health Physics, 17: 507-12 (1969)

The significance of reports of mercury in various body tissues

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When I first became involved in the mercury situation we were confronted by headlines such as "MERCURY POISONS FOUR CREE INDIANS. Four Cree Indians from a northern Quebec reserve recently spent one week in Montreal's Queen Mary Veterans' hospital where they were treated for mercury poisoning." This, of course, was not the case. The four

Indians concerned were investigated for possible mercury poisoning. Blood mercury levels were "elevated," but no clinical signs were found. As a matter of fact, Canada has no proven case of organic mercury poisoning from eating fish.

Population investigations have now been carried out in three areas of Canada to evaluate the effects of environmental organic mercury, in northwest Quebec (1), in northwest Ontario (4), and in northwest Canada (2).

Our investigation in northwest Quebec was initiated in 1971 as the result of an ecological study carried out by some university students. In studying the effluents from a pulp and paper plant on the Bell-Nottaway river system, the students noted fish mercury levels ranging to three parts per million (ppm). They then tested the blood of 29 Waswanipi Indians from the communities of Matagami and Miquelon, downstream on this river system, and noted whole blood mercury levels ranging to 135 parts per billion (ppb), with an average level of 55 ppb.

It was thus felt necessary to carry out more extensive testing in the area. It had been reported that the mercury content of fish in Mistassini Lake, northeast of the Waswanipi area, was also quite high, so that some testing was also carried out among the Mistassini band of Indians. Field test results were summarized in Table 1. Altogether, over 300 persons of all ages had blood samples drawn for

TABLE 1
Results of field tests in northwestern Quebec

	Matagami, Waswanipi Band	Miquelon, Waswanipi Band	Mistassini, Mistassini Band
Blood mercury			
No. of persons tested	79	141	181
No. with >100 ppb	10	3	9
Highest value recorded	306 ppb	148 ppb	155 ppb
Mean	41.0 ppb	21.6 ppb	36.8 ppb
Hair mercury			
No. of persons treated	11*	56*	
Highest value recorded	44.9 ppm		
No. of physical examinations	49 full**	69 screening 29 full*	None
No. of electromyograms and maze performance tests	11**	56**	None
No. of visual field examinations	8**	None	19*

* r = 0.82 with blood values.
** No significant findings.

mercury determinations by atomic absorption. Twenty-two had whole blood mercury levels greater than 100 ppb, and the highest reading was 306 ppb. Many of these individuals also had hair specimens collected for mercury determination by an atomic absorption method. There was a good correlation (0.82) between hair and whole blood mercury levels.

Approximately half these people had clinical testing done, 78 undergoing complete history and physical examinations, and 69 undergoing a screening battery of simple tests for neurological dysfunction. Sixty-seven persons also underwent electromyography and maze performance testing. There were no clinical findings suggestive of organic mercury excess.

There was some relationship between an individual's stated fish consumption and his blood mercury level. Individuals with blood levels over 100 ppb admitted to fish consumption more than once per week, whereas the majority of individuals stated that their fish consumption was once per week or less. However, the value of such statements was reduced, since the group had previously been warned to reduce their fish consumption. More significantly, children who had attended schools in towns away from home for the previous two years or more had whole blood mercury levels of 0, with one exception who had a whole blood mercury level of 21 ppb.

In the second phase of this investigation, five individuals from Matagami, four of whom had previously demonstrated blood mercury levels of greater than 100 ppb, underwent extensive evaluation at the Montreal Neurological Hospital (Table 2). In addition to routine hospital tests, detailed neurological examinations, electromyograms, nerve conduction studies, electroencephalograms, audiograms, visual field

TABLE 2
Mercury levels of five Indians from Matagami, P.Q., admitted to Montreal Neurological Hospital between 8 and 11 February 1972

Subject No.	Birth date	Blood mercury level (ppb) June 1971	Aug. 1971	Feb. 1972	Hair mercury level (ppm) Feb. 1972
1	1914	227 rbc 17 plasma	187	43	29.2
2	1921	-	306	105	58.7
3	1909	73	127	23	20.8
4	1933	-	172	111	49.6
5	1895	-	-	11	16.8

determinations, blood cytogenetic studies, and blood and hair mercury level determinations were carried out. Again, there were no clinical findings suggestive of organic mercury excess.

More detailed studies of fish subsequently revealed mercury levels ranging to a maximum of 4.44 ppm in the Waswanipi area and to 0.84 ppm in the Mistassini area (unpublished data, Environment Canada).

In northwest Ontario, attention was focused on the Ojibway Indian communities of Grassy Narrows and White Dog, located downstream of a pulp and paper complex and a chlor-alkali plant on the Wabigoon-English River system. In these waterways, fish mercury levels of 27 ppm have been reported (3). In one lake, the average mercury levels of burbot were reported as more than 12 ppm (unpublished data, Ontario Ministry of Natural Resources). These levels are considerably higher than those found in most other waterways serving traditional native communities in Canada.

Blood mercury levels in these communities for the years 1970 and 1972-73 were higher than in those of northwest Quebec (Table 3).

In the spring of 1973, six individuals with blood mercury levels greater than 100 ppb (Table 4) underwent evaluation at the Health Sciences Centre in Winnipeg. The evaluation was similar to that carried out at the Montreal Neurological Hospital, except that it included more extensive biochemical testing, and electronystagmographic studies. Again, no evidence of mercury intoxication was found.

The Ontario Ministry of Health recommended that fish from the Wabigoon-English River system not be eaten. Despite this, fish still are consumed regularly by many in these communities, according to information volunteered by residents. A federal task force (4) felt that the most serious consequences of the mercury situation lay in the economic, social, and cultural fields, and they recommended that a program of socio-economic development for the two communities be instituted as a matter of priority.

A third study in northwest Canada determined whole blood mercury levels in small samples of persons living in selected communities of British Columbia, Alberta, the Yukon, and the western part of the Northwest Territories between August 1972 and March 1973 (Table 5). Levels tended to be low in British Columbia, Alberta, and the Yukon; in the western part of the Northwest Territories they were somewhat higher, but still essentially within acceptable limits.

TABLE 3
Comparison of blood mercury levels for northwestern Ontario and northwestern Quebec

Community	No. of persons tested	No. > 100 ppb	Highest value recorded (ppb)	Mean (ppb)
White Dog, Ont.				
1970	35	3	159	46.4
1972-73	70	7	289	52.0
Grassy Narrows, Ont.				
1970	61	17	385	77.4
1972-73	49	12	222	62.5
Matagami, P.Q.				
1971	76	8	306	44
Miquelon, P.Q.				
1971	146	3	148	21.5
Mistassini, P.Q.				
1971	198	9	155	36.7

TABLE 4
Mercury levels in six Indians investigated in Winnipeg (clinical examination in spring of 1973)

	January 1973	Spring 1973*	
	ppb Hg (total), blood	ppb Hg (total), blood	ppm Hg, hair
Case 1	107	78	45
Case 2	126	55	22
Case 3	172	82	24
Case 4	125	46	20
Case 5	289	91	43
Case 6	126	162	24

* May or June.

Data soon to be reported on levels in Saskatchewan are consistent with figures for British Columbia and Alberta (C.A.R. Dennis, personal communication). The reasons for the higher levels in the Northwest Territories are not readily apparent, but are being looked into by Environment Canada. It is known, however, that in the Northwest Territories special efforts were made to test individuals who spent much time outside of their settlement, fishing, hunting, and trapping. However, in Fort Liard those who spent much time away from their settlement were "out in the bush" when testing was carried out. Thus the individuals tested there were "urbanized" and probably relied mainly on

TABLE 5
Average levels of mercury (ppb) in each community (T, target; C, control)

Community	Mercury average	No. of blood samples	
Alberta			
Ft. McKay	7.64	20	T
Janvier	14.22	20	T
Conklin	9.00	20	T
Beaver Lake	7.97	20	T
Saddle and Frog	9.59	24	T
Gift Lake (Whitefish)	5.98	20	C
McLeod River	5.30	20	T
British Columbia			
Squamish	5.45	20	T
N. Vancouver	5.02	20	C
Pemberton	6.15	21	C
Masset	7.27	20	T
Metlakatla	8.75	14	T
Kitselas	5.75	6	C
Kitsumkalem	6.56	13	C
Kitimat	8.23	16	T
Hazleton	5.91	22	T
Tachie	10.89	22	T
Takla	10.42	20	T
Necoslie	11.47	20	T
Lilloett	6.57	22	T
Lower Nicola	6.20	20	T
St. Mary's	5.03	21	T
Trail	5.98	20	C
Aquatsino	6.14	19	T
Ucluelet	7.43	20	T
Ladysmith	9.54	14	T
The Yukon			
Dawson	5.24	22	T
Old Crow	5.61	22	T
Whitehorse	9.37	20	C
Carcross	7.57	10	T
Burwash	11.57	10	T
Carmacks	9.34	20	T
The Northwest Territories			
Aklavik	16.37	20	T
Tuktoyaktuk	37.76	20	T
Holman	34.01	23	T
Coppermine	19.39	20	T
Yellowknife	14.80	21	C
Detah	20.76	3	T
Ft. Rae	15.00	19	T
Snowdrift	20.79	23	T
Fort Franklin	34.79	12	T
Fort Liard	6.86	15	T

store-bought foods. Fort Liard had the lowest average mercury level of any Northwest Territory community. The Yukon communities were tested before those of the Northwest Territories, and there is some uncertainty as to the type of individual generally sampled in these communities.

All of the above investigations are generally consistent with testing carried out in other countries (5, 6). We may thus conclude that: (1) in northern Canada, some moderately elevated blood mercury levels have been found; (2) there is a relationship between fish consumption and mercury levels; (3) no clinical findings suggestive of organic mercury excess have been detected; (4) Grassy Narrows and White Dog, Ontario, deserve special attention and are, in fact, at the centre of clinical surveillance measures for mercury in Canada.

DISCUSSION

Could it be that by eating sufficient fish or other "native foods," one may sustain somewhat elevated tissue mercury levels? Can it also be that such levels are tolerated through adaptation or interaction? An example of the latter phenomenon would involve selenium, which is found in significant amounts in certain species of fish such as tuna; ingestion of selenium can modify the toxic effects of mercury.

Several years ago, "high" levels of mercury were found in the livers of seals caught near Rankin Inlet, NWT. Eskimos in that area, who apparently considered raw seal liver a delicacy, were advised not to eat the liver. Now, however, it is known that the greater part of mercury in liver is inorganic, which is significantly less toxic than the methylmercury found in fish. It appears that the seal has an enzyme system that degrades methylmercury to inorganic mercury.

In the future, great caution must be exercised in making pronouncements on practical matters such as fish consumption on the basis of laboratory findings alone. Fish is an extremely important source of protein for many native Canadians and fishing is a significant component of their traditional way of life. More attention must be paid to the individual than to his laboratory results.

ACKNOWLEDGMENTS

Blood analyses were performed by the Federal Fisheries and Forestry Department, Montreal, and hair analyses, electromyography, and maze testing by the University of Michigan.

SUMMARY

In northwestern Quebec, over 300 Indians from Matagami, Miquelon, and Mistassini had blood mercury determinations carried out. Field clinical testing was completed on approximately half this number. Twenty-two individuals had blood mercury levels greater than 100 ppb, the highest being 306 ppb. There were no clinical findings suggestive of organic mercury excess; however, there appeared to be a relationship between fish consumption and blood mercury levels. Five residents of Matagami, four of whom had previously shown blood mercury levels greater than 100 ppb, subsequently underwent extensive hospital evaluation. No significant clinical findings were detected. In addition, six Indians from Grassy Narrows and White Dog, Ontario, all with blood mercury levels greater than 100 ppb, underwent similar extensive hospital evaluation. Again, there was no evidence of organic mercury intoxication. Blood levels of mercury were determined in small samples of persons living in various communities of northwest Canada. Levels were low in British Columbia, Alberta, and the Yukon; although somewhat higher in the Northwest Territories, they remained essentially within acceptable limits.

REFERENCES

1. Bernstein, A.D., "Clinical investigation in Northwest Quebec, Canada, of environmental organic mercury effects," Presented at International Symposium: Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Paris, 24-28 June 1974 (proceedings to be published)
2. Environment Research Consultants Ltd., Level of Mercury in the Blood of Persons Living in Selected Communities in Alberta, British Columbia, the Yukon and Northwest Territories (North Vancouver, British Columbia, 1973)
3. Fimreite, N., and Reynolds, L.M., "Mercury contamination of fish in Northwest Ontario," J. Wildlife Management, 37: 62-8 (1973)

4. Final Report, Task Force on Organic Mercury in the Environment: Grassy Narrows and White Dog, Ontario (Ottawa: Health and Welfare Canada, 1973)
5. Skerfving, S., "Methylmercury exposure, mercury levels in blood and hair, and health status in Swedes consuming contaminated fish," Toxicology, 2: 3-23 (1974)
6. den Tonkelaar, E.M., Van Esch, G.T., Hofman, B., Schuller, P.L., and Zwiers, T.H.L., "Mercury and other elements in blood of the Dutch population," Presented at International Symposium: Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Paris, 24-28 June 1974 (proceedings to be published)

Mercury content of Iglooligmiut hair

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Because there is little information on mercury residues in hair, particularly in northern populations, it was decided to analyse samples from an Eskimo population located at Igloolik, NWT (69° 10' N latitude, 83° 59' W longitude). An initial 28 samples were analysed for total mercury and, in addition, for selenium, because of the relationship between these two elements (1). The Freshwater Institute regularly analyses fish products for both selenium and mercury, but the methods used were thought suitable for hair. It was thus agreed to test the reliability of the mercury method by collaborating with another laboratory able to perform neutron activation analysis. Mercury data obtained on the first 28 samples proved interesting and an additional 104 samples were analysed. Selenium data, however, could not be correlated with corresponding mercury levels and selenium analyses were thus terminated after completion of the 28 samples.

METHOD

The method of mercury analyses used was "cold vapour" flameless atomic absorption. A 80 to 120 mg sample of hair was weighed into a graduated digestion tube and a mixture

of 1 mℓ concentrated nitric, 4 mℓ concentrated sulphuric, and 0.5 mℓ of fuming nitric acid was added. Standards (100, 200, 300, 400 ng of Hg as $HgCl_2$) and two reagent blanks were prepared at this time and taken through the entire procedure with the samples. The tubes containing samples, standards, and blanks were placed in an aluminum block which was heated to 170° C and maintained at this temperature overnight to effect digestion. When digestion was complete, that is the samples were clear and colourless, they were removed from the block, cooled, and brought to a constant volume (25 mℓ) with distilled water.

The analysis from this point on was essentially that of Armstrong and Uthe (2). The instrument used was a Perkin Elmer 403 Atomic Absorption Spectrophotometer fitted with a mercury lamp and flowthrough cell. An aliquot of the sample was mixed with reductant solution, ionic mercury being reduced to the atomic state with stannous sulphate and partitioned into the gaseous phase. This phase passed into the flowthrough cell and absorbed an amount of light from the mercury lamp proportional to the amount of mercury in the sample. Necessary dilutions used a 4:1 mixture of water and acid to ensure that the matrix of the samples closely approximated that of the standards.

Selenium was determined by fluorometry, using the method of Hoffman, Westerby, and Hideroglou (3). Sample weights of 60 to 400 mg were used.

The majority of samples used in this study were washed, using a non-ionic detergent, air-dried, and desiccated prior to analysis. Sample size allowed 23 samples to be re-analysed for mercury on an "as received" basis. The mean mercury content of washed samples was approximately 8 per cent higher than that of unwashed samples, a finding similar to that of a previous study (4). Although the difference between washed and unwashed samples was statistically significant, it was not considered biologically significant. Accordingly, data obtained on the "as received" samples has not been adjusted to compensate for this difference.

Twenty-two samples were analysed for mercury by neutron activation analysis. There was good agreement with atomic absorption results, although figures obtained by neutron activation were generally higher. This is quite often the tendency with neutron activation as compared with other methods (L.H. Hecker, personal communication to authors).

TABLE 1
Mercury levels in hair of male population, Igloolik, NWT

Age group (years)	Number of samples	Mean of group (ppm)	Maximum of group (ppm)	Minimum of group (ppm)
0.5-10.5	4	5.62	9.55	2.28
10.5-20.5	5	36.4	94.7	2.70
20.5-30.5	15	15.0	38.7	3.99
30.5-40.5	11	12.3	30.9	4.37
40.5-50.5	5	8.93	13.0	5.80
50.5-60.5	8	9.16	18.3	4.98
60.5-70.5	3	7.43	8.64	6.05
70.5-80.5	1	12.0		

TABLE 2
Mercury levels in hair of female population, Igloolik, NWT

Age group (years)	Number of samples	Mean of group (ppm)	Maximum of group (ppm)	Minimum of group (ppm)
0.5-10.5	5	9.18	17.5	1.94
10.5-20.5	10	27.9	109	2.36
20.5-30.5	29	15.5	93.7	3.77
30.5-40.5	17	15.7	42.5	4.61
40.5-50.5	7	14.4	42.7	5.90
50.5-60.5	10	20.7	97.3	5.47
60.5-70.5	4	9.94	10.5	9.30

RESULTS AND DISCUSSION

Mercury was found in all 134 samples, ranging from a low of 1.94 to a high of 109 ppm. Table 1 shows data for the male population. The number of males sampled was 52, with an overall mean of 13.8 ppm. Table 2 shows data for the female population. The number of females sampled was 82, with an overall mean of 16.9 ppm. The means of both groups are higher than the US norm of 1 to 3 ppm (Hecker, personal communication) and higher than the safety limit of 6 ppm reported in a Finnish Study (5).

Figure 1 shows the distribution of the male and female populations between four arbitrary concentration groupings. Approximately 4 per cent of the Eskimos had levels greater than 60 ppm. This is considered the level at which toxic symptoms may appear (5). Maxima occurred in the 10-20 age group for males and in the 10-30 and 50-60 age groups for females.

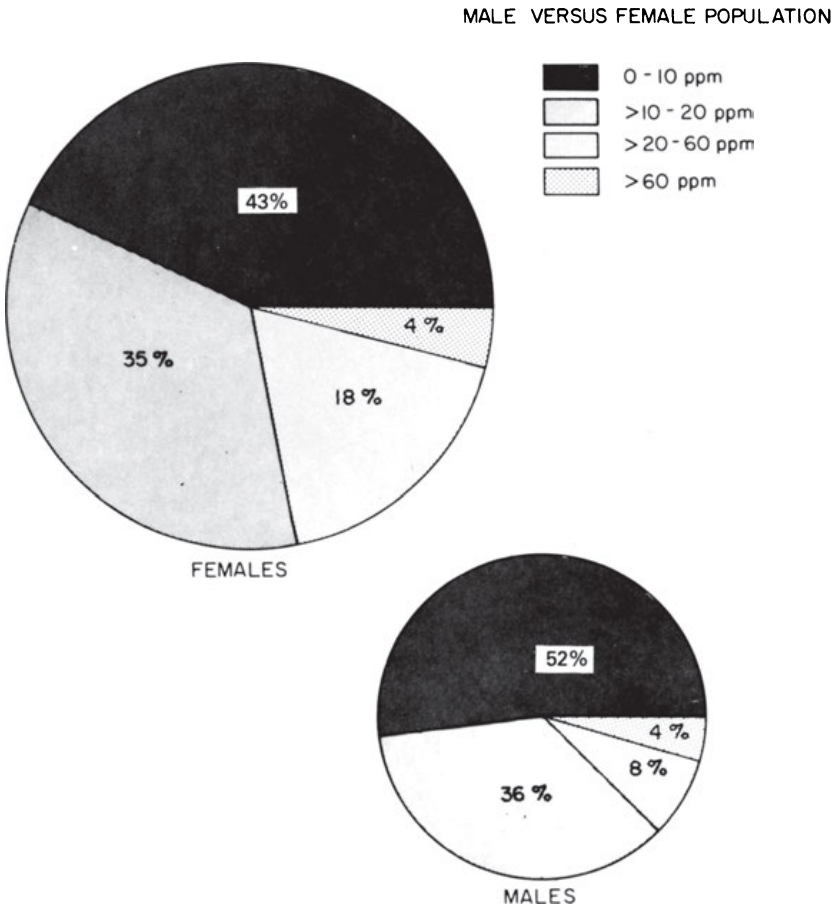

Figure 1 Distribution of male and female population according to mercury levels found in hair samples

Table 3 compares selenium and mercury data on 28 samples. The mean selenium concentration was 2.53 ppm, with individual means of 1.15 ppm for males and 3.95 ppm for females. Levels ranged from 0.69 to 18.5 ppm. No published data could be found on selenium levels in human hair. Five control samples were thus analysed (4 males, 1 female); the mean was 0.90 ppm for the males (range from 0.75 to 1.11 ppm), with a result of 0.77 ppm for the female. There was no apparent relationship between mercury and selenium levels and selenium analyses were thus terminated.

It is difficult to explain the high mercury levels found in this study. Information is not available as to the mercury content of the foods consumed by Iglooligmiuts.

TABLE 3
Mercury and selenium content of hair, Igloolik, NWT

Age (years) and sex	Hg level (ppm)	Se level (ppm)
66 M	7.59	1.46
63 M	8.64	1.66
58 M	4.98	0.74
55 M	7.41	0.84
48 M	13.0	0.90
42 M	8.39	1.93
37 M	30.9	0.90
31 M	9.84	0.91
27 M	10.8	1.26
21 M	38.7	0.88
19 M	64.7	1.41
14 M	10.5	1.26
10 M	7.89	1.01
5 M	2.75	0.96
65 F	10.5	18.5
65 F	9.54	1.19
55 F	5.85	3.28
55 F	11.9	0.76
42 F	9.02	0.69
41 F	10.9	0.99
36 F	24.3	1.72
33 F	19.2	1.04
29 F	9.38	0.91
22 F	3.45	0.83
13 F	15.1	1.18
13 F	58.9	5.27
9 F	15.5	1.37
5 F	6.81	17.5

There is a possibility of external contamination from various hair preparations, but again there is no information to substantiate this. Nor is there any known industrial mercury contamination in that region. Therefore, it may be stated that the hair of Igloolik Eskimos generally has higher levels of mercury than that of Americans but the reason for this remains unknown. Clinical data do not indicate symptoms related to mercury poisoning.

ACKNOWLEDGMENTS

Neutron activation analyses were carried out by Dr Lawrence Hecker of the University of Michigan. The authors also wish to acknowledge the assistance of A. Beal, J. Harding, and

A. Rieger with the laboratory analysis.

SUMMARY

Frontal hair from unselected male and female subjects aged 1 to 71 years was analysed for total mercury, using flameless atomic absorption, and for selenium by fluorometry. The mean mercury concentration in 134 samples was 15.7 ppm (13.8 ppm for males, 16.9 ppm for females, with a range from 1.9 to 109 ppm). The mean selenium concentration of 28 samples was 2.53 ppm (1.15 ppm for males, 3.95 ppm for females, with a range from 0.69 to 18.5 ppm). Mercury levels were higher than expected, and five subjects had readings > 60 ppm, which is considered the level at which toxic symptoms may appear; nevertheless, a full medical history and examination showed no indication of mercury toxicity in any of the subjects.

REFERENCES

1. Ganther, H.E., Goudie, C., Sunde, M.L., Lopecky, M.J., Wagner, P., Sang-Hwan, Oh, and Hoekstra, W.G., "Selenium: relation to decreased toxicity of methyl mercury added to diets containing tuna," Sci., 175: 1122-4 (1972)
2. Armstrong, F.A.J., and Uthe, J.F., "Semi-automated determination of mercury in animal tissue," A.A. Newsletter, 10: 101-3 (1971)
3. Hoffman, I., Westerby, R.J., and Hideroglou, M., "Precise fluorometric microdetermination of selenium in agricultural materials," J.A.O.A.C., 51: 1039-42 (1968)
4. Benson, W.W., and Gabica, J., "Total mercury in hair from 1000 Idaho Residents - 1971," Pestic. Monit. J., 6 (2): 80-3 (1972)
5. Sumari, P., Partanen, T., Hietala, S., and Heinonen, O.P., "Blood and hair mercury content in fish consumers. A preliminary report," Work-environm.-hlth, 9: 61-5 (1972)