RESEARCH REPORT 73

MERCURY LEVELS IN FISH FROM SELECTED WISCONSIN WATERS
(A Preliminary Report)

By
Stanton J. Kleinert
and
Paul E. Degurse

Department of Natural Resources

Madison, Wis.

1971

ABSTRACT

Mercury determinations were made on 1,080 fish filet samples representing 2,144 fish from 103 locations covering 44 of Wisconsin's 70 counties and Wisconsin's boundary waters of Lake Michigan, Green Bay, Lake Superior, and the Mississippi River. All Wisconsin fish analyzed contained some mercury. Mercury levels in fish from waters removed from any known source of mercury use averaged .19 ppm and ranged between .01 and .60 ppm mercury. The highest mercury levels, averaging .80 and ranging between .06 and 4.62 ppm, occurred in fish taken from sections of the Chippewa, Flambeau, and Wisconsin Rivers located below paper mills and below a mercury cell chlor-alkali plant.

Different species vary in mercury content, and the larger fish often contain higher concentrations of mercury than do smaller fish of the same species taken from the same water. Walleye, sucker, redhorse, crappie, and bullhead frequently showed higher mercury concentrations while the panfishes including bluegill, pumpkinseed, and yellow perch often showed lower concentrations. Because different species differ in mercury content, it is essential that all important species in the fishery be sampled before a judgment is made regarding the magnitude of mercury levels in the total fish population of any water under study.

ACKNOWLEDGMENT

Appreciation is expressed to J. G. Konrad for his early involvement with the laboratory analysis and the field personnel of the Department of Natural Resources for sample collection.

The report was prepared by Stanton J. Kleinert, Biologist & Coordinator of Mercury Studies, Bureau of Research; laboratory analyses were under the direction of Paul E. Degurse, Fish Pathologist & Director of the Nevin Laboratory, Bureau of Fish Management.

Edited by Ruth L. Hine

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INTRODUCTION

The Wisconsin Department of Natural Resources began a survey of mercury residues in fish in April, 1970. These investigations were initiated to determine mercury levels in fish from a variety of Wisconsin waters including waters receiving industrial and municipal wastes, waters draining agricultural areas, lakes and streams removed from the urban population centers and waters situated in the various soil and bedrock provinces of the state. The investigation followed Swedish (Hannerz, 1968) and Canadian (Bligh, 1970) reports of mercury contamination of fish. The Wisconsin survey was undertaken to see if problems of mercury contamination were also evident in the Wisconsin fishery.

The fishery investigation was part of a general investigation precipitated by the Canadian announcement in March of widespread mercury contamination of fish in Lake St. Clair associated with industrial pollution. Cooperative sampling programs, involving the Department of Natural Resources, Federal Water Quality Control Administration, and Federal Food and Drug Administration, were immediately begun in Wisconsin. There followed an intensive investigation of mercury pollution in Wisconsin conducted by the Department of Natural Resources. Fish, wildlife, waters, and sediments were monitored. Industrial and municipal sources of mercury discharge were investigated and evaluated. Public hearings concerning aspects of mercury pollution were held by the Department in Madison in May, August, and October. The investigations are continuing. However, much information has already been gathered which is now being published in interim report form. This fisheries report is an interim report and will be expanded in 1971 as additional Wisconsin waters are monitored.

STUDY METHODS

Fish Collections

Fish collections were made by field personnel of the Wisconsin Department of Natural Resources during the period April through September, 1970. Samples most commonly consisted of one fish but ranged up to 20 fish of the same species. Almost all samples consisted of medium and larger fish of sufficient size for use as human food or for commercial processing. Field personnel were instructed to wrap each fish species in separate plastic bags and freeze until delivery could be made to the laboratory.

Analysis

Fish filets, or more specifically fish muscle tissue excluding bone, were processed for mercury analysis. Analysis was made on the wet (not previously dried) sample as follows: The sample (10 g) was digested in a mixture of H_2SO_4·HNO_3 by the standard AOAC procedure (AOAC, 1965). The digestate was oxidized with 5 percent $KMnO_4$ (drop-wise to a persistent color) prior to reduction with $SnCl_2$ and analysis by the flameless atomic absorption procedure of Rathje (1969). A Beckman Model DU atomic absorption spectrometer, equipped with a 10 x 2 cm flow cell and rapid response recorder, was used for analysis. Mercury values were expressed as ppm (parts per million) of total mercury on a wet weight animal tissue basis. Extraction procedures were checked by spiking samples with mercuric chloride; subsequent digestions yielded mercury recoveries ranging from 92 to 102 percent.

Mercury determinations were made on 1,080 fish filet samples representing 2,144 fish taken from 103 locations covering 44 of Wisconsin's 70 counties and Wisconsin's boundary waters of Lake Michigan, Green Bay, Lake Superior and the Mississippi River (Fig. 1). The species composition of the collections generally reflected the fish populations of the waters sampled. Thirty-six percent of the fish sampled were rough fish and 64 percent were game and panfish (Table 1).

Alkalinity and pH in river waters were determined by the methods described in Standard Methods (1965).

Grinding fish tissue prior to digestion in sulfuric and nitric acid

FINDINGS

Background Mercury Levels in Wisconsin Fish

All Wisconsin fish analyzed contained mercury (Table 2). Mercury levels in fish from waters removed from any known source of mercury use averaged .19 ppm and ranged between .01 and .60 ppm (Sites 1, 2, 3, 4, 11, 17, 25, 65, 66, and 52 in Table 2). These values are believed to indicate normal background levels of mercury present in Wisconsin fish. Different species vary in mercury content, and the larger fish often contain higher concentrations of mercury than do smaller fish of the same species taken from the same water. Walleye, sucker, redhorse, crappie, and bullhead frequently showed higher mercury concentrations while the panfishes including bluegill, pumpkinseed, and yellow perch often showed lower concentrations. Because different species differ in mercury content, it is essential that all important species in the fishery be sampled before a judgement is made regarding the magnitude of mercury levels in the total fish population of any water under study.

Problem Waters

Fish samples taken over the 350-mile stretch of the Wisconsin River extending below Rhinelander, the 40-mile stretch of the Flambeau River extending below Cedar Rapids, and the 50-mile stretch of the Chippewa River extending from the junction with the Flambeau to Eau Claire contain mercury residues averaging above the .5 ppm guideline established by the Food and Drug Administration as an "action level" for banning fish from interstate markets. The Wisconsin Department of Health and Social Services warned against the frequent consumption of these fish but advised that one meal of fish per week would not constitute a health hazard. These warnings have been communicated to the public. No other Wisconsin waters are included in the fish consumption warnings. The Chippewa, Flambeau, and Wisconsin Rivers receive waste waters from pulp and paper mills. A mercury cell process chlor-alkali plant (the Wyandotte Chemicals Corporation at Port Edwards) is located on the Wisconsin

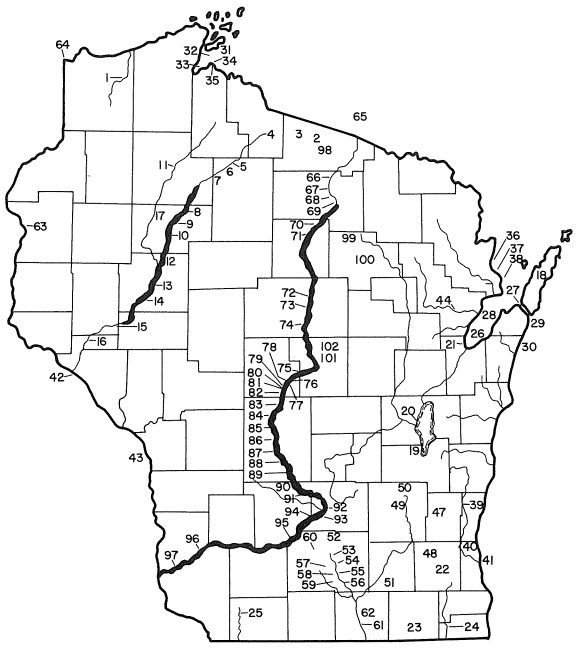

FIGURE 1. Location of Fish Samples and Fish Consumption Warning Areas

River. Mercury levels in fish taken from sections of the three rivers located below these industries (Sites 5-10, 12-14, 70, 71, and 84-89) averaged .80 ppm and ranged from .06 to 4.62 ppm.

Other Wisconsin Waters

Mercury levels in fish samples taken from sections of the Fox and Menominee Rivers and Green Bay (Sites 21, 36-38, and 26-28) averaged .38 ppm. These waters also receive waste waters from pulp and paper mills but contain waters of higher alkalinity and pH than occur in the Chippewa, Flambeau, and Wisconsin Rivers. The Chippewa, Flambeau, and Wisconsin Rivers have an alkalinity of less than 50 ppm and a pH usually of 7.0 or less.

Mercury levels in fish samples taken from the Rock and Fox (Illinois) River system in southern Wisconsin (Sites 47-62, 22-24) averaged .22 ppm mercury. These waters commonly exceed 200 ppm alkalinity and pH values of 8.0. They drain areas of extensive agricultural development interspersed with areas of urban development. No pulp or paper mills are located on the Fox (Illinois) River system. A small paper mill is located on the Rock River at Beloit.

Samples from the other waters sampled averaged below .5 ppm mercury; however, individual fish samples sometimes exceeded this level. Samples from Lake Superior and and the Lake Superior Basin (Sites 1, 31-35, and 64) averaged .34 ppm. Samples from Lake Michigan (Sites 29 and 30) averaged .15 ppm. Samples from the Mississippi River (Sites 42 and 43) averaged .32 ppm. Samples from the lower Milwaukee River and Milwaukee Harbor (Sites 40 and 41) averaged .13 ppm. The lower Milwaukee River drains the most urbanized area of Wisconsin. Milwaukee River waters commonly exceed 200 ppm alkalinity and pH values of 8.0.

DISCUSSION

Mercury Levels in Fish and Other Foods

By September, 1970, the Food and Drug Administration had listed sections of waters in 12 states as containing elevated levels of mercury (Sport Fisheries Institute Bulletin, September, 1970). It seems certain that the number of states reporting fish of elevated mercury levels will increase as sampling programs are undertaken. Many states have not yet initiated sampling programs to identify mercury levels in fish.

To date, there has been little published data on mercury levels in fish to compare with the Wisconsin data. Averaged mercury levels reported in various species of Canadian fish sampled from uncontaminated areas varied between .04 and .76 ppm, but averaged well below .5 ppm mercury (Great Lakes Environmental Conference, 1970). These values are similar to those found in Wisconsin fish sampled in uncontaminated areas and probably reflect background levels naturally present in fish muscle tissue. Averaged mercury levels (ppm) for Canadian fish from contaminated areas ranged as high as 4.14 for rock bass in Lake St. Clair, 2.80 for rock bass in the St. Clair River, and 10.11 for burbot in the Wabigon-English System (Great Lakes Environmental Conference, 1970). Mercury values in freshwater fish in Sweden range as high as 8 ppm with .03 to .18 regarded as a normal background concentration (Hannerz, 1968). Study has shown that small amounts of mercury are present in most food items including wheat, fruits, vegetables, dairy products, turkey, and beef (Table 3). Mercury levels in fish, however, are higher than those reported for other foods.

It has been demonstrated experimentally that fish accumulate mercury directly from the water and from food (Hannerz, 1968). The most important route of accumulation seems to be directly from the water through the outer epithelia. The accumulation rate is fast while the elimination rate is slow, which leads to high concentration factors in fish. Northern pike were shown to concentrate methyl mercury in muscle tissue 2,000 times above part per billion concentrations experimentally added to the water. Mercury occuring in fish tissue is present mainly as a methyl mercury compound according to Swedish reports (Westoo, 1969).

Mercury Levels in Fish and Mercury Use

In general, higher levels of mercury in fish can be related to exposure to wastes from pulp and paper mills which used mercury compounds and chlor-alkali plants employing the mercury cell process (Westoo, 1969). Water chemistry also appears to play a role. The more alkaline waters of southern and eastern Wisconsin contain fish of lower mercury content even where mercury compounds have been used in the past and can be found above background levels in the sediments (Konrad, 1970). The present survey has shown a problem of elevated levels of mercury in Wisconsin fish in sections of the Chippewa, Flambeau, and Wisconsin Rivers. Seventy-one percent of all samples testing over .5 ppm mercury and 95 percent of all fish testing over 1.0 ppm mercury in this survey came from the three rivers. Elsewhere in Wisconsin, levels of individual fish samples sometimes approach or exceed .5 ppm mercury, but the average mercury level in these fish collections is below .5 ppm.

Fish Consumption and Risk of Mercury Poisoning

Testimony by physicians at the Wisconsin Department of Natural Resources mercury hearings and United States Senate Subcommittee hearings on mercury and other toxic metals (held in Washington, D. C., in July and August, 1970) and an extensive review of the literature have revealed no known cases of mercury poisoning in the United States due to fish consumption. Studies of commercial and sports fishermen in Sweden who had consumed fish over an extended period failed to show symptoms of mercury poisoning, although these high fish consumers were shown to have elevated levels of mercury in blood corpuscles, blood plasma and hair (Tejning, 1970). In Minnamata and Niigata, Japan, human illness and death were associated with mercury poisoning from consumption of severely contaminated fish. The fish contamination was due to mercury pollution from industries producing plastics from acetaldehyde and vinyl chloride. The diet of the Japanese suffering mercury poisoning was about 0.4 pound of fish per day containing 20 ppm mercury (Takeuchi, 1970).

Estimated annual consumptions of fish per person are 62 pounds in Japan, 45 pounds in Sweden, and 13 pounds in Canada (Bligh, 1970). The typical American fish eater consumes 10 to 11 pounds of commercial fish products per year, and the average American sport fisherman is estimated to catch 23 pounds of fish annually (Sport Fisheries Institute Bulletin, September, 1970). Sport fishermen in Wisconsin reported an average catch of 58 fish per angler during the winter of 1968-1969 and a catch of 64 fish per angler during the 1969 open water season. Panfish represented 88.5 percent of the catch in winter and 83 percent of the catch during the open water season (Churchill, 1969 and 1970).

In Sweden, the National Health Authorities have set a standard of 1 ppm mercury for fish sold commercially but will issue fish consumption warnings at lower mercury concentrations, depending upon estimated health risks (Dr. A. Jernelov, pers. comm.). The .5 ppm interim action levels established by the Food and Drug Administration and adopted by many of the states is a more conservative guideline. The Canadian Food and Drug Directorate has also adopted the .5 ppm guideline.

CONCLUSION

The Department of Natural Resources has conducted extensive investigations of mercury pollution in Wisconsin. Sources of mercury released to the environment have been identified and action has been taken. Use of mercury compounds in the paper industry was greatly reduced after 1958 when the Food and Drug Administration specified that food wraps not contain mercury. Those mills still using mercury slimacides report replacing these compounds with other chemicals since April of this year. Losses of mercury from the Wyandotte Chemicals Corporation plant (Wisconsin's only mercury cell chlor-alkali plant) to the Wisconsin River have been reduced to trace amounts. However, mercury deposits occur below these industries (Konrad, 1970). Swedish reports (Hasselrot, 1968) suggest that the continuous release of mercury from such deposits in the Chippewa, Flambeau and Wisconsin Rivers may produce elevated levels in fish for many years. Studies are presently underway at the University of Wisconsin to determine the behavior of mercury in river sediments. These studies are focusing on the factors associated with mercury release and chemical change in river sediments. Such basic research is needed before the cycling of mercury in the environment can be understood and ameliorated.

The Department of Natural Resources plans to resample in the Chippewa, Flambeau, and Wisconsin Rivers and to test fish from additional locations for mercury in the spring of 1971. All fish tissue samples used in the mercury program are being held in frozen storage for potential use in testing programs designed to monitor levels of other toxic metals.

The following perspective on the health effects of mercury and other toxic metals in the environment was presented to the U. S. Senate Subcommittee on Energy, Natural Resources, and the Environment in Washington, D. C., on August 27, 1970, by Surgeon General Steinfeld, U. S. Public Health Service:

"The problem of the health effects of toxic metals is a legitimate area for concern; it is not, however, a legitimate cause for hysteria. Toxic metals must be placed in that growing collection of ubiquitous substances, like pesticides or polychlorinated biphenyls, about which we need to know much more. In particular, we need to know much more about the effects of low-level, long-term exposure.

"In the final analysis, there are no nonhazardous substances; there are only nonhazardous ways to use substances, or levels of substances whose use poses no hazard. However, we are not presently faced with widespread, serious human health hazards from these substances. Our concern today is primarily about future generations --that we do not, by our short-sightedness today condemn future generations to irreversible hazardous health effects." (Steinfeld, 1970).

TABLE 1. Fish Species Collected and Analyzed for Mercury

Fish Species		Letter	Percent of
Common Name	Scientific Name	Code	All Samples
Rough Fish and Minnows			
Sucker	Catostomus spp.	S	15
Redhorse	Moxostoma spp.	R	3
Buffalo	Ictiobus spp.	BF	M
Quillback	Carpiodes cyprinus	Q	1
Freshwater Drum	Aplodinotus grunniens	D	4
Carp	Cyprinus carpio	C	12
Goldfish	Carassius auratus	GF	M
Shiner	Notropis spp.	SH	M
Mooneye	Hiodon tergisus	MO	M
Burbot	Lota lota	BB	M
Bowfin	Amia calva	BW	M
Alewife	Alosa pseudoharengus	A	M
Game Fish and Panfish			
Largemouth Bass	Micropterus salmoides	LMB	6
Smallmouth Bass	Micropterus dolomieui	SMB	3
Bluegill	Lepomis macrochirus	B	4
Crappie	Pomoxis spp.	CR	5
Pumpkinseed	Lepomis gibbosus	P	2
Rockbass	Ambloplites rupestris	RB	2
Muskellunge	Esox masquinongy	M	M
Northern Pike	Esox lucius	NP	9
Bullhead	Ictalurus spp.	BU	3
Channel Catfish	Ictalurus punctatus	CC	3
Yellow Perch	Perca flavescens	YP	6
Sauger	Stizostedion canadense	SA	M
Walleye	Stizostedion vitreum	W	13
Cisco	Coregus artedii	CI	M
Brook Trout	Salvelinus fontinalis	BT	1
Lake Whitefish	Coregonus elupeaformis	LW	M
Brown Trout	Salmo Trutta	BR	1
Rainbow Trout	Salmo gairdneri	RT	1
Lake Trout	Salvelinus namaycush	LT	1
Coho Salmon	Oncorhynchus kisutch	CS	1
White Bass	Roccus chrysops	WB	2
Yellow Bass	Roccus mississippiensis	YB	1

M* denotes minor use in the survey constituting less than .5 percent of all fish samples.

TABLE 2. Magnitude of Mercury Levels in Fishes From Various Wisconsin Waters

Sample Location				Species Sampled	ppm Mercury		
County	Water		Site		Low	Avg.	High
BRULE RIVER BASIN							
Douglas	Brule River	1.	T49N, R10W, S10	4S, R, 6W, 4BR, 2RT	.04	.16	.36
CHIPPEWA-FLAMBEAU							
Vilas	Escanaba Lake	2.	Escanaba Lake	YP, W	.03	.08	.12
Vilas	Trout Lake	3.	Trout Lake	S, R, BB, 2SMB, 4B, 4P, 4RB, 2NP, M, 3YP, 5W, LW, LT	.05	.11	.39
Iron	Flambeau River	4.	Flambeau Flowage	2R, BB, P, 4RB, 5NP, 5YP, 6W	.14	.38	.60
Price	Flambeau River	5.	In Park Falls	10S, R, 2M, 5NP, YP, W	.06	.26	.46
Price	Flambeau River	6.	Below Park Falls	5S, 2CR, P, BU, YP, W	.15	.39	.60
Price	Flambeau River	7.	Crowley Flowage	CR, 3P, 2BU, 2YP	.33	.44	.69
Rusk	Flambeau River	8.	Big Falls Flowage	4S, 6R, 2CR, RB, 2NP, 2BU, 2W	.11	.63	1.12
Rusk	Flambeau River	9.	Above Ladysmith	3S, 7BU, 10W	.55	.97	1.57
Rusk	Flambeau River	10.	Below Ladysmith	3S, 3R, 3BU, W	.58	1.28	2.03
Sawyer	Chippewa River	11.	Chippewa Flowage	5S, 8W	.11	.14	.26
Chippewa	Chippewa River	12.	Holcombe Flowage	10S, 3C, B, 9CR, 4NP, 5W	.18	.55	1.00
Chippewa	Chippewa River	13.	Lake Wissota	9S, 4CR, 2RB, 5NP, 3W	.23	.66	1.33
Chippewa	Chippewa River	14.	Below Lake Wissota	5NP	.43	1.09	2.12
Eau Claire	Chippewa River	15.	Below Eau Claire	8S, R, 4C, 3CC	.11	.43	.75
Pepin	Chippewa River	16.	Below Durand	5S, 8C, 4MO, SMB, CR, 5W, CC	.11	.32	.69
Rusk	Murphy Flowage	17.	Murphy Flowage	B, NP	.11	.36	.60
DOOR DRAINAGE							
Door	Kangaroo Lake	18.	Kangaroo Lake	B, YP, W	.09	.15	.28
FOX RIVER DRAINAGE							
Fond du Lac	Fond du Lac R.	19.	River Mouth	S	-	.20	-
Winnebago	Lake Winnebago	20.	Asylum Bay	5D, 6CR, 2NP	.01	.17	.37
Brown	Fox River	21.	River Mouth	S, D, 3C, 2W, 2WB	.11	.36	1.92
FOX (ILLINOIS) RIVER DRAINAGE							
Waukesha	Pewaukee Lake	22.	Pewaukee Lake	S, B, NP, YP	.01	.13	.20
Walworth	Lake Geneva	23.	Lake Geneva	4S, 2C, SH, SMB, 5LMB, B, RB, 2NP, YP, 3W, 2BR	.04	.37	1.11
Racine	Fox River	24.	Below Burlington	4S, R, 2C, 3SMB, 3CR, RB, NP, 4CC, YP, WB	.05	.29	.95

TABLE 2 (Cont.)

Sample Location				Species Sampled	ppm Mercury		
County	Water		Site		Low	Avg.	High
GALENA RIVER							
Lafayette	Galena River	25.	T2N, R1E, S27	2S, 3SMB	.04	.06	.08
GREEN BAY							
Brown	Green Bay	26.	East of Fox River Mouth	8C, NP, BU, YP, W	.06	.21	.37
Door	Green Bay	27.	N. of Sturgeon Bay Canal	S, BF, A, 4CI, 3LT	.19	.30	.45
Oconto	Green Bay	28.	East of Oconto	5S, SMB, B, CR, 2NP, 2BU, YP, 2W, 2BR	.09	.36	.75
LAKE MICHIGAN							
Door	Lake Michigan	29.	East of Algoma	2BR, 2RT, CS	.05	.08	.12
Kewaunee	Lake Michigan	30.	East of Kewaunee	A, BT, 3BR, RT, CS	.06	.21	.70
LAKE SUPERIOR							
Bayfield	Lake Superior	31.	Apostle Islands	3S, 2LW, 2BR, 2LT	.09	.30	.60
Bayfield	Lake Superior	32.	Off Boyd Creek	5S, 5W	.21	.44	.72
Ashland	Lake Superior	33.	Lower Chequamegon Bay	5S, 2YP	.05	.09	.13
Ashland	Lake Superior	34.	Oak Point	5SMB, 5W	.22	.44	.84
Ashland	Lake Superior	35.	Kakagon Sloughs	2C, SMB, RB, BU, YP	.18	.30	.66
MENOMINEE RIVER							
Marinette	Menominee River	36.	Above Marinette	R, NP, 2YP	.27	.53	.66
		37.	In Marinette	R, 2SMB, 3RB, 2NP, YP	.30	.44	.69
		38.	River Mouth	2S, 2C, 2BF, A, 3LMB, 5P, 2NP, 4BU, 3YP, 8W	.15	.44	1.30
MILWAUKEE RIVER							
Ozaukee	Milwaukee River	39.	At Thiensville	2S, R, 3C, P, 3NP, 2BU	.11	.35	.22
Milwaukee	Milwaukee River	40.	Above North Avenue	3C, GF	.11	.15	.18
Milwaukee	Milwaukee River	41.	Milwaukee Harbor	S, 2C, CC, CS	.05	.11	.22
MISSISSIPPI RIVER							
Pepin	Mississippi R.	42.	Lake Pepin	S, C, 4LMB, 2B, 6CR, 3NP, BU, 9CC, YP, 5W	.07	.33	.78
La Crosse	Mississippi R.	43.	Below Stoddard	S, C, LMB, B, CR, NP, BU, CC, W	.15	.30	.55
OCONTO RIVER							
Oconto	Oconto River	44.	Above Oconto Falls	S, B, CR, 2NP, BU, 2YP	.08	.12	.20
PESTIGO RIVER							
Marinette	Peshtigo River	45.	Above Peshtigo	S, R, SMB, 2RB, 4NP, BU, 3YP	.05	.29	.59
Marinette	Peshtigo River	46.	Below Peshtigo	S, C, A, NP, BU, YP	.14	.22	.30

TABLE 2 (Cont.)

Sample Location				Species Sampled	ppm Mercury		
County	Water		Site		Low	Avg.	High
ROCK RIVER DRAINAGE							
Washington	Rubicon River	47.	Below Hartford	3C	.07	.14	.18
Waukesha	Lake LaBelle	48.	Lake LaBelle	BF, C, B, CR, W	.04	.13	.18
Dodge	Rock River	49.	Lake Sinnissippi	5C, W	.01	.04	.12
Dodge	Rock River	50.	Horicon	C, 6NP	.07	.12	.16
Jefferson	Rock River	51.	Lake Koshkonong	4C, 3CC	.02	.08	.15
Dane	Nevin Hatchery	52.	Hatchery Ponds	10RT	.08	.10	.14
Dane	Lake Mendota	53.	Lake Mendota	4D, 4C, 3LMB, SMB, 5B, RB, 2NP, 3YP, 3W, 4WB	.03	.25	.75
Dane	Yahara River	54.	Below Lake Mendota	5D, 2C, 2LMB, B, 2RB, 2NP, 3W, WB	.04	.22	.69
Dane	Lake Monona	55.	Lake Monona	3D, 5C, 4LMB, B, P, RB, NP, 2W, 2YP, WB	.09	.22	.33
Dane	Yahara River	56.	Below Lake Monona	6D, 7C, 13LMB, 5B, 3P, 2NP, 3YP, 3W, 3WB	.05	.25	.53
Dane	Lake Kegonsa	57.	Lake Kegonsa	3D, 4C, 2LMB, B, CR, P, NP, YP, 2W, 3WB, 4YB	.05	.16	.29
Dane	Starkweather Creek	58.	Creek Mouth	3D, 3C, B, CR, P, YP, 4W, WB, YB	.06	.17	.53
Dane	Lake Waubesa	59.	Lake Waubesa	D, 2C, 6LMB, B, CR, P, 2NP, W, 2YP, WB, 4YB	.13	.38	.80
Dane	Lake Wingra	60.	Lake Wingra	5C, BF, 5LMB, B, 2CR, P, NP, YP, YB	.03	.20	.58
Rock	Rock River	61.	Below Janesville	R, 2C, 2CR, NP, CC, 2YB	.05	.11	.20
Rock	Spaulding Pond	62.	Spaulding Pond	LMB, NP	.06	.07	.08
ST. CROIX RIVER							
Polk	St. Croix River	63.	Below St. Croix Falls	BF, 6S, 5D, 4C, 6SMB, 2CR, NP, 2CC, 2SA, W, WB	.18	.43	1.40
ST. LOUIS RIVER							
Douglas	St. Louis River	64.	River Mouth	6S, BU, 2YP, 3W	.10	.62	.97
WISCONSIN RIVER DRAINAGE							
Vilas	Wisconsin River	65.	Lac Vieux Desert	S, NP, 3YP, 5W	.06	.12	.19
Oneida	Wisconsin River	66.	Rainbow Flowage	R, CR, RB, NP, BU, YP, 3W	.17	.29	.67
Oneida	Wisconsin River	67.	Above McNaughton	RB, NP, BU, 4YP	.08	.24	.38
Oneida	Wisconsin River	68.	Below McNaughton	2S, M	.28	.35	.41

TABLE 2 (Cont.)

Sample Location				Species Sampled	ppm Mercury		
County	Water		Site		Low	Avg.	High
WISCONSIN RIVER DRAINAGE (CONT.)							
Oneida	Wisconsin River	69.	Boom Lake	S, B, CR, NP, BU, YP, W	.10	.28	.50
Lincoln	Wisconsin River	70.	Lake Alice	S, LMB, B, CR, BU, W	.17	.92	1.85
Lincoln	Wisconsin River	71.	Lake Mohawksin	S, B, CR, NP, BU, YP, W	.65	.97	1.72
Marathon	Wisconsin River	72.	Lake Wausau	S, C, LMB, B, NP, YP, W	.16	.62	.95
Marathon	Wisconsin River	73.	Below Mosinee Dam	S, C, W	.10	.36	.65
Marathon	Wisconsin River	74.	Lake DuBay	S, NP, BU, YP	.12	.28	.40
Wood	Wisconsin River	75.	Above Biron Dam	S, C, B, NP, W	.32	.42	.49
Wood	Wisconsin River	76.	Below Biron Dam	S, 2C, NP	.38	.50	.58
Wood	Wisconsin River	77.	Above Centralia Dam	C	-	.56	-
Wood	Wisconsin River	78.	Above Wyandotte Chemical	S, C, NP, W	.37	.54	.78
Wood	Wisconsin River	79.	Below Wyandotte Chemical	S, C, W	.46	.58	.73
Wood	Wisconsin River	80.	Moccasin Cr. Mouth	2S, C	.38	.50	.58
Wood	Wisconsin River	81.	Highway 73 Bridge	S, C	.60	.61	.61
Wood	Wisconsin River	82.	Below Nekoosa Dam	S, Q, W	.44	1.62	2.98
Adams-Juneau	Wisconsin River	83.	Upper Petenwell Flowage	3C, B, 2CR, 2NP, 4W	.68	2.36	4.62
Adams-Juneau	Wisconsin River	84.	Petenwell Flowage	C, B, NP, YP	.61	.94	1.25
Adams-Juneau	Wisconsin River	85.	Below Petenwell Dam	C, CR, NP, YP, SH	.80	1.14	1.50
Adams-Juneau	Wisconsin River	86.	Buckhorn Bridge	2S, C, LMB, B, CR, WB	.21	.38	.64
Adams-Juneau	Wisconsin River	87.	Above Castle Rock Dam	C, W	1.10	2.22	3.34
Adams-Juneau	Wisconsin River	88.	Below Castle Rock Dam	2C, NP, 2W	.17	.38	.55
Adams-Juneau	Wisconsin River	89.	Above Dells Dam	S, C, CR, W	.93	1.23	1.35
Sauk	Wisconsin River	90.	Below Dells Dam	3S, R, Q, B, 3W	.55	1.09	2.00
Sauk	Wisconsin River	91.	Below Dells Creek	S, R, Q, 2C, W	1.00	1.83	3.02
Columbia	Wisconsin River	92.	Below I-94 Bridge	S, 3C, LMB, NP	.45	.53	.75
Columbia-Sauk	Wisconsin River	93.	At Merrimac	D, YP, W	.80	.83	.90

TABLE 2 (Cont.)

Sample Location				Species Sampled	ppm Mercury		
County	Water		Site		Low	Avg.	High
WISCONSIN RIVER DRAINAGE (CONT.)							
Dane-Sauk	Wisconsin River	94.	Below Prairie du Sac Dam	BF, D, 2C, SMB, LMB, W, WB	.20	.48	1.00
Iowa-Sauk	Wisconsin River	95.	Spring Green	S, 3Q, C, NP, SA, 2W	.20	1.01	2.64
Grant-Crawford	Wisconsin River	96.	Boscobel	2R, 5Q, 4D, LMB, YP	.56	1.07	2.91
Grant-Crawford	Wisconsin River	97.	Bridgeport	4R, 3C, 2W, WB	.57	.84	1.34
Vilas	Stormy Lake	98.	Stormy Lake	5CS	.10	.16	.27
Langlade	E. Eau Claire River	99.	Ackley Township	S, BT	.09	.13	.17
Langlade	Spring Brook	100.	Antigo	S, 3BT	.18	.32	.38
Portage	Little Plover River	101.	Plover Township	5BT	.09	.14	.22
Portage	Lower Tomorrow River	102.	Amherst Township	S, 3C	.16	.22	.33
Juneau	Yellow River	103.	Above Bullhorn Bridge	W	-	.25	-

TABLE 3. Mercury Residue Levels (ppm Hg Wet Weight)

General Food Items (Toronto)

Sage	0.08	Onion	0.01
Dill	0.33	Spinach	0.06
Dill (home-grown)	0.17	Potatoes	0.04
Parsley	0.03	Beans (Wh.)	0.02
Poppy Seeds	0.01	Corn	0.02
Sunflower Seeds	0.006	Pumpkin	0.008
Walnut	0.07	Apple	0.05
Milkpowder	0.01	Wheat	0.04
Cheese	0.01	Cream of Wheat	0.02
Custard Powder	0.02	Beef	0.01
Noodle	0.02	Turkey	0.03
Cocoa	0.07	Fresh Oysters	0.06
Carrots	0.02	Salmon	0.08

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