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Mercury Concentrations in Yellow Perch (*Perca flavescens*) from Vilas County, Wisconsin: 1920s Versus 1980s

J. F. Amrhein,[1] S. W. Geis[2]

[1] Wisconsin Department of Natural Resources, Post Office Box 7921, Madison, WI 53707, USA
[2] Wisconsin State Laboratory of Hygiene, 2601 Agriculture Drive, Box 7996, Madison, WI 53707, USA

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The Wisconsin Department of Natural Resources (WDNR) has been extensively monitoring mercury levels in fish from the state's lakes since the mid 1980's. The state has tested over 1,000 of Wisconsin's 15,000 lakes. Currently, fish from 350 lakes, or approximately 30% of those waters tested have levels which are above the level of human health concern for mercury (Wisconsin Department of Natural Resources, 2000, *Important Health Information for People Eating Fish from Wisconsin Waters*). An updated fish consumption advisory is issued annually, generating public concern over potential increases in pollution and inquiries into historic and current sources of mercury contamination. Continued concern prompted the WDNR to investigate historic levels of contamination for comparison to recent observations in order to establish possible trends. Studies conducted on sediment cores taken from lakes throughout North America have indicated an increase in mercury deposition presumably due to increased anthropogenic activity since the mid to late 1800's (Swain and Helwig 1989; Swain et al. 1992; Engstrom and Swain 1997; Fitzgerald et al. 1998; Lockhart et al. 1998).

MATERIALS AND METHODS

In order to quantify mercury levels in historic fish, WDNR removed fillets from preserved specimens of yellow perch (*Perca flavescens*) from the collection at the University of Michigan Museum of Zoology. These fish were originally collected as part of a fish distribution survey conducted in 1927 and 1928 from Wildcat, Muskellunge, Mud, Big Muskellunge, and Trout lakes in Vilas County, Wisconsin (Fig. 1). The samples were likely preserved according to standard museum procedure. According to museum records, whole fish specimens from that period were fixed in a 10% solution of formalin for one week, washed in water for one day, and stored in 70% ethyl alcohol (Kelly et al. 1975). There was no written record of alcohol exchange. Subsamples of alcohol from the specimen jars were saved and analyzed to determine any loss of mercury from the fish samples.

Correspondence to: J. F. Amrhein

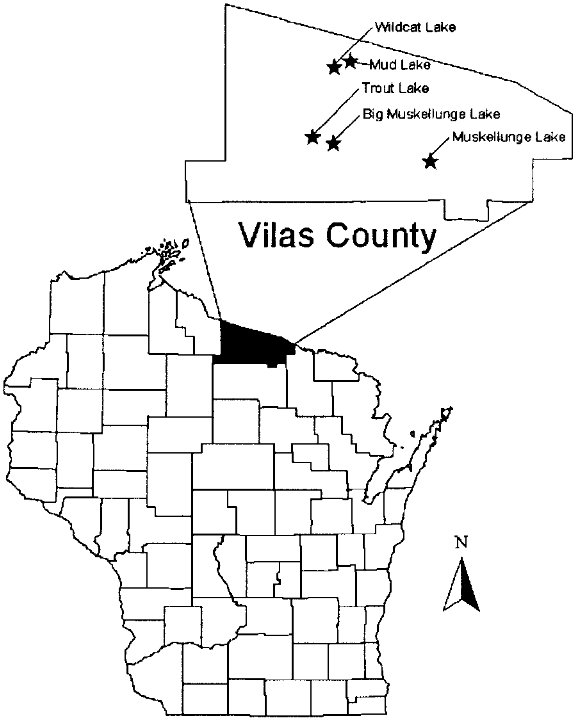

Figure 1. Location of lakes used in comparison of mercury in yellow perch muscle tissue, 1920's vs 1980's, in Vilas County, WI, USA.

In August 1987 and May 1988, yellow perch were collected from each respective waterbody by angling and fyke netting. Length and weight measurements were recorded for both historic and recent specimens. In order to demonstrate possible variation in mercury concentration due to length, samples which covered a range of lengths were selected for analysis. Scale samples were taken from each fish in order to determine age versus length and mercury correlation. A skin-off fillet was removed from each specimen, ground in a Waring blender, and frozen at $-10^{\circ}C$.

Prior to analysis, fresh and preserved fish tissue was freeze-dried to eliminate the variable of dehydration due to storage of the archived samples in alcohol. Samples were analyzed for total mercury according to standard methods employed by the Wisconsin State Laboratory of Hygiene (Sullivan and Delfino 1982).

RESULTS AND DISCUSSION

Analysis of the alcohol showed no mercury at a detection limit of 4 ug/l. A total of 162 fish were used in the analysis; 80 yellow perch were collected between 1927 and 1928 and 82 specimens were collected between 1987 and 1988. Percent moisture in 1927 and 1928 fish muscle tissue (preserved in alcohol) ranged from 68.5% to 82.2% with a mean of 76.2%. Mean percent moisture in 1987 and 1988 fish muscle tissue was 81.2% and ranged from 74.8% to 84.0%. Fish ranged in size from 110 mm to 280 mm. Mercury concentrations for the archived fish ranged from 0.15 ug/g to 0.74 ug/g dry weight with a mean of 0.42 ug/g. Concentrations for the more recent specimens ranged from 0.15 to 1.16 ug/g with a mean concentration of 0.53 ug/g. Fish data and lake information are found in Table 1.

Table 1. Mercury Concentrations (ug/g dry wt) in Yellow Perch Muscle Tissue from Five Northern Wisconsin, USA Lakes.

Lake	**Acreage**	**Lake Type**	**Year**	**Sample Size**	**Mercury Mean ug/g dry wt (Std Dev)**
Big Muskellunge	930	Seepage	1927	6	0.54 (0.08)
			1988	10	0.52 (0.16)
Mud	12	Seepage	1927	20	0.22 (0.23)
			1987	15	0.76 (0.23)
Muskellunge	272	Drainage	1927	22	0.53 (0.09)
			1988	20	0.26 (0.12)
Trout	3816	Drainage	1927	19	0.38 (0.10)
			1987	16	0.68 (0.23)
Wildcat	305	Drainage	1927	13	0.42 (0.13)
			1988	21	0.47 (0.16)

The effects of preservation are primarily related to changes in tissue weight due to dehydration. Analysis of fish tissue on a dry-weight basis eliminated the variable of dehydration caused by the preservation process. There was no evidence of mercury loss from the fish tissue to the alcohol. However, one aspect that was not addressed in this study is the possible leaching of lipids into the preservative and the corresponding effects on net concentration of mercury levels in preserved tissue.

Although mercury concentration is frequently correlated with size and age of the fish, this was not consistently the case with these data (Fig. 2 and 3). The relationship varied in significance depending on the lake and the year evaluated. With the exception of one lake (Trout Lake), there was not a significant

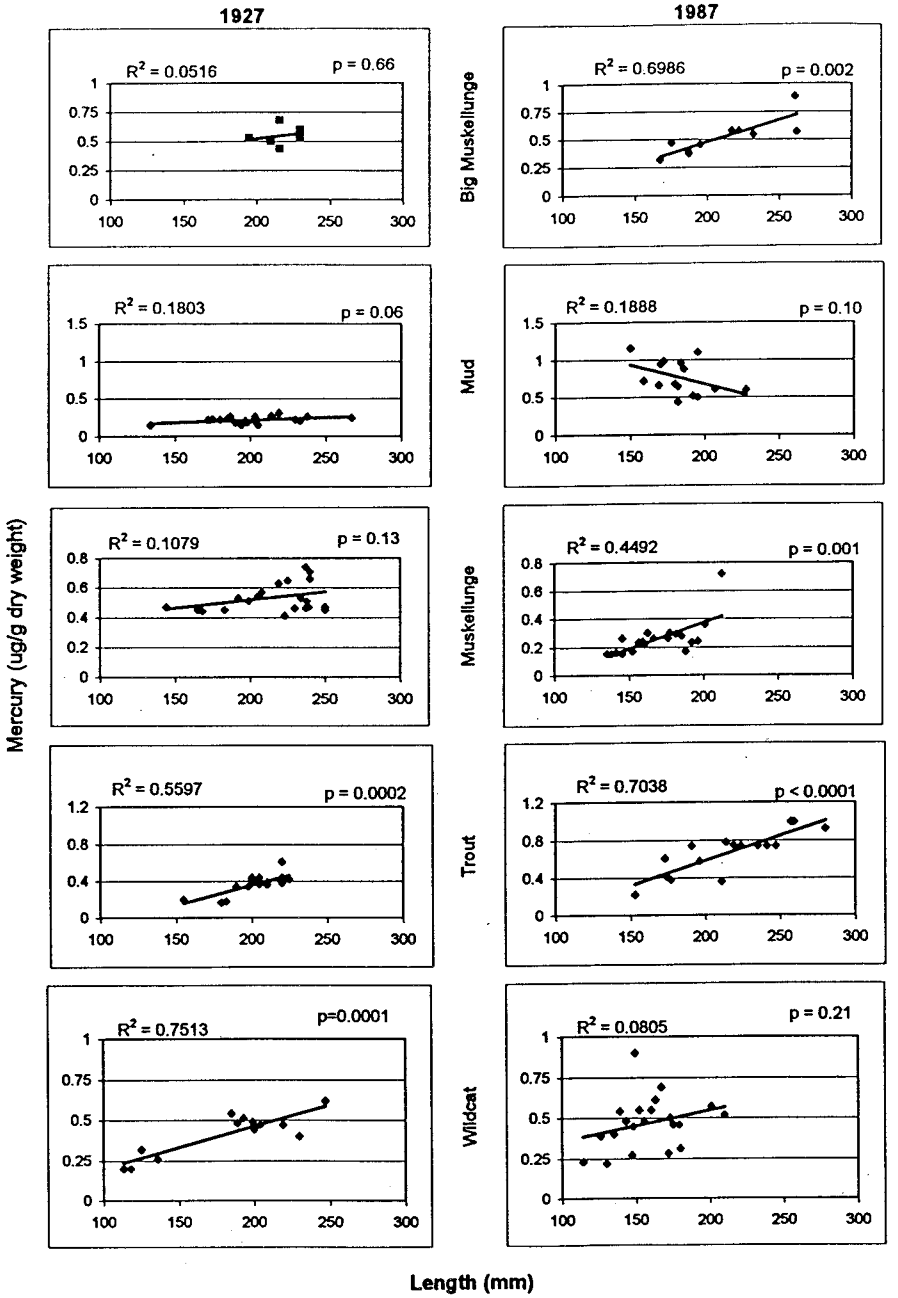

Figure 2. Mercury in yellow perch muscle tissue vs. length for lake and year

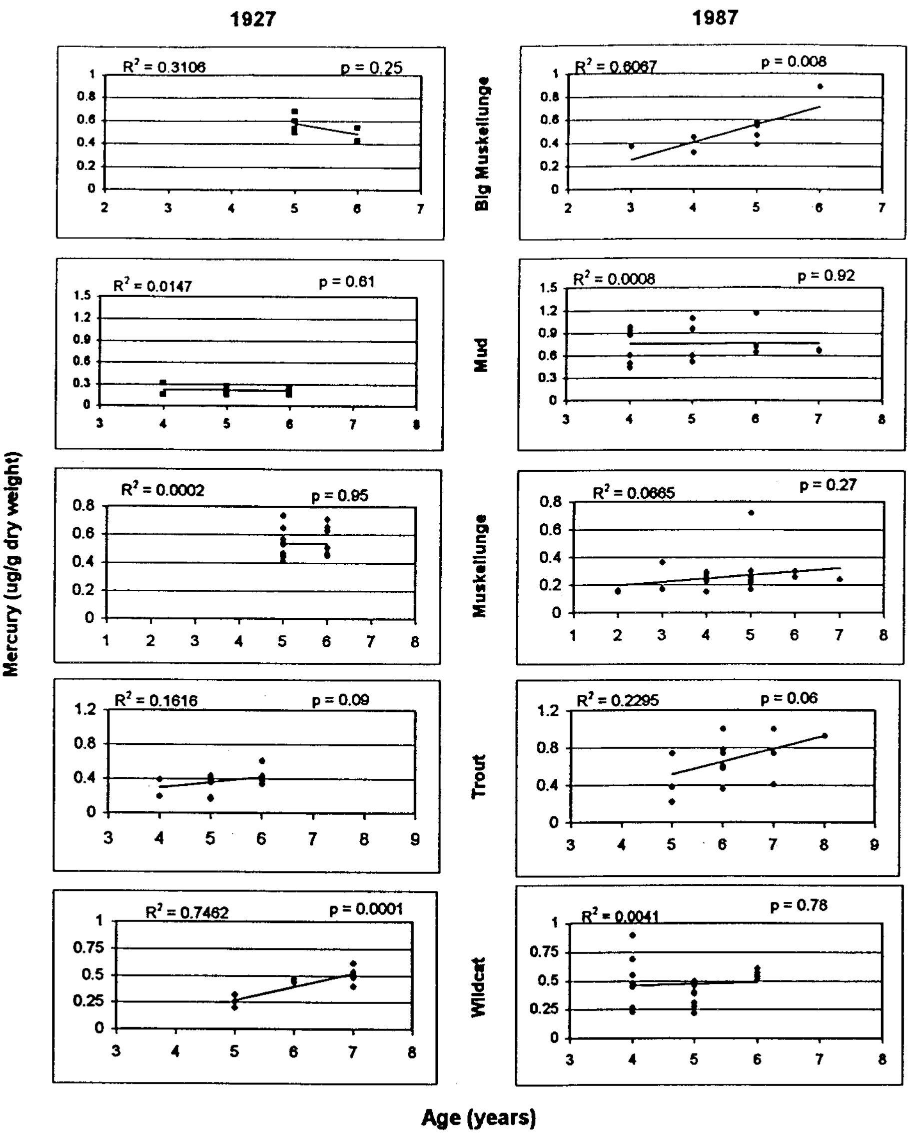

Figure 3. Mercury in yellow perch muscle tissue vs. age for lake and year

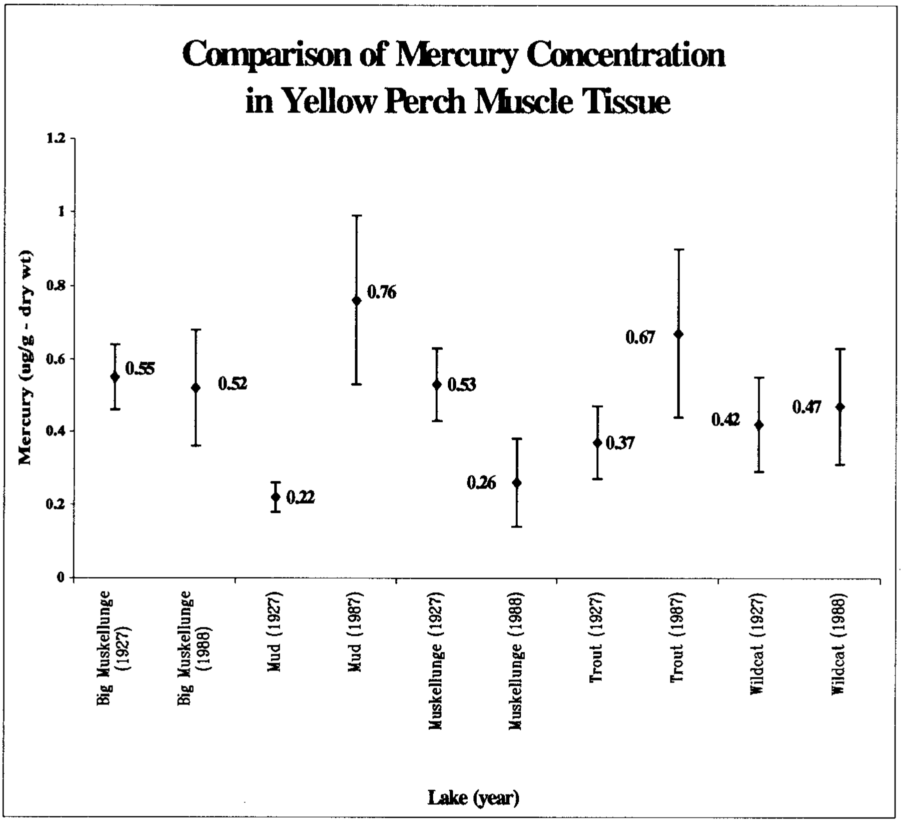

Figure 4. Comparison of mercury concentration in yellow perch muscle tissue: 1920's vs. 1980's

relationship between length or age and mercury concentration between years ($p > 0.05$).

Because of this apparent lack of relationships for individual lakes, the data for each respective lake and year were pooled and the mean mercury concentration calculated (Fig. 4). For two of the lakes (Mud and Trout) there was a significant increase in mercury concentration from the 1920's to the 1980's ($p < 0.05$). There was a significant decrease in mercury concentration in Muskellunge Lake. Two of the lakes (Big Muskellunge and Wildcat) did not exhibit a significant change in mercury concentration. Neither the size of the water body nor the lake geomorphology (type) appeared to be a factor in determining the mercury trends.

A Mixed Model Analysis of Variance (SAS 1998) where lake was treated as a random variable and length and year as fixed effects was performed on all of the data where the 1920's and 1980's fish were pooled respectively. This analysis showed there was a significant relationship between length and mercury concentration ($p = 0.0001$) and that the relationship between length and year was marginally significant ($p = 0.066$).

The data comparisons in this study show that trends in mercury bioaccumulation in fish flesh are variable by individual lake. However, comparing the combined historic and recent datasets indicates a probability that mercury concentrations in yellow perch overall are higher now than in the 1920's. Although this study used yellow perch, these findings are similar to other studies using archived walleye and northern pike samples from other freshwater systems (Kelly et al. 1975; Swain and Helwig 1989). Yellow perch are a primary forage species for higher level piscivores such as walleye, northern pike and bass. The trend may be more evident in these higher trophic species as the effects of bioaccumulation at another level on the food chain become more pronounced.

Recognizing the major contribution of anthropogenic sources of mercury to the global mercury load, state and federal governments are looking at enacting restrictions on mercury emissions to the atmosphere. Engstrom and Swain (1997) noted a recent decrease in mercury concentration in surficial lake sediments presumably due to local management actions designed to reduce mercury losses to the environment. However, there are many biotic and abiotic variables which influence the production of methyl mercury and subsequent uptake by fish (Gilmour and Henry 1991; Gilmour et al. 1992; Bodaly et al. 1993; Ramlal et al. 1993; Zhang and Planas 1994; Matilainen and Verta 1995; Watras et al. 1995; Pak and Bartha 1998). Historical data is lacking to determine whether or not conditions are more or less favorable for the production and uptake of methyl mercury today. Since mercury methylation rates are not related to average sediment mercury concentration alone (Ramlal et al. 1993), it is uncertain as to whether or not source control will have an effect on mercury bioaccumulation in fish and the subsequent need for future advisories.

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