

St. Louis River Fish Mercury

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Purpose

This data analysis is the response to a request by Carri Lohse-Hanson (MPCA) and Pat McCann (MDH) for an evaluation of fish mercury data for the St. Louis River compared to the average for northeast Minnesota. A target for the St. Louis River Delisting Framework's fish consumption advisory beneficial use impairment includes the statement: "Tissue concentrations of contaminants of concern in representative samples of resident fish are not significantly elevated from regional background samples." This data analysis follows the approach of the Minnesota Statewide Mercury TMDL (<http://www.pca.state.mn.us/wfhy9ef>), using standardized length northern pike and walleye as indicators of mercury concentrations in fish, because these two species are top predators that have the highest mercury concentrations in aquatic food webs.

Data Analysis

The fish contaminant database was queried for the St. Louis River and its tributaries. The only tributary with fish contaminant data was Whiteface River.

For comparison among waterways and over time, I used standardized predator fish mercury concentrations that I refer to as SPF-Hg. Standardized total body lengths are 55 cm for Northern pike (NP) and 40 cm for walleye. Rather than the usual concentration units of parts per million (ppm, mg/Kg), SPF-Hg are in parts per billion (ppb). Also, instead of using linear regression to predict Hg from length, I used a weighted average length-specific Hg, which I described in the supplementary information for Monson 2009 (<http://pubs.acs.org/doi/suppl/10.1021/es8027378>). This alternative method to calculate standardized length concentrations allows for the use of small sample numbers and composites if they are near the standard length.

For the "regional background" mercury concentrations, SPF-Hg were calculated for lakes within two Level 3 Ecoregions, Northern Lakes and Forest and Northern Minnesota Wetlands. Data from 1982 to 2009 were averaged for a mean SPF-Hg for each lake. These two Ecoregions made up the NE Region in the Statewide Mercury TMDL and the remaining Ecoregions made up the SE Region.

The St. Louis River is divided into three reaches for fish consumption advisories: above Cloquet, Cloquet to Fond du Lac Dam, and Fond du Lac Dam to Lake Superior, which I refer to as Upper, Middle, and Lower reaches. There are data going back to 1971 but before 1990 they were usually only one or two composite samples for a particular species. The following analysis selected Hg data from 1980 to 2009. The mercury and PCB data are summarized by species for 1980 to 2009 in Appendix A.

Results

Regional Background

The results for the regional background mercury concentrations are summarized in Table 1. SPF-Hg were available for northern pike (NP) in 515 lakes and for walleye (WE), 460 lakes. In addition, the two species were

combined where they coexisted to give 607 mean SPF-Hg. My usual preference for a measure of central tendency mercury concentrations is the median because it is not influenced by the extreme values and it is easier than the geometric mean to explain and understand. The median, arithmetic mean, and geometric mean are similar for this set of data and I used mean SPF-Hg for the smaller set of SPF-Hg in the St. Louis River; therefore, I used the arithmetic mean for the comparison of background to St. Louis River SPF-Hg (see Conclusion).

Table 1 Summary statistics of SPF-Hg for lakes in the NE region for period 1982-2009 and based on new Level 3 Ecoregions (NLF and NMW)

Statistic	NP	WE	Mean (NP + WE)
N of Cases	515	460	607
Minimum	68	66	68
Maximum	1291	1267	1291
Median	314	287	305
Geometric Mean	310	298	311
Arithmetic Mean	355	348	357
Lower C.L.*	339	329	341
Upper C.L.*	372	366	372

*95% Confidence Limits of Arithmetic Mean

St. Louis River

The SPF-Hg for northern pike and walleye in the St. Louis River are summarized by year in Table 2. Northern pike had similar SPF-Hg in the Upper and Lower reaches (no data for the Middle reach). Walleye had the most data; they were present in all three reaches and had seven years of data in the Lower reach. Walleye mean SPF-Hg for years 1982 to 2005 for the Upper, Middle, and Lower reaches were 294 ppb, 394 ppb, and 544 ppb, respectively. The highest SPF-Hg was walleye in 2004 from the Lower reach (971 ppb).

Table 2 Summary of SPF-Hg for the St. Louis River

Species - Reach	1982	1984	1988	1989	1991	1993	1996	2000	2001	2002	2004	2005	Mean	Max
Northern pike														
Upper								363				325	344	363
Lower	336			194		361		361					313	361
All Reaches	336			194		361		362				325	323	363
Walleye														
Upper								349		208		324	294	349
Middle			320		329				427	499			394	499
Lower	564	767		217		466	474	346			971		544	971
All Reaches	564	767	320	217	329	466	474	347	427	353	971	324	447	971

Individual fish Hg concentrations for walleye from 1990 to 2005 are shown by year and by reach in Figure 1 to show there was a wide range of Hg concentrations in the 1990s, while the 2004 set of fish were all relatively high concentrations. Table 3 gives the collection locations, lengths and Hg concentrations of the 2004 walleye from the Lower reach. Four fish between 18" and 22" were in the range of 1.2 to 1.5 ppm, while the two larger

fish, at 22.1" and 23.2", were 0.874 and 0.904 ppm. The relationship between Hg concentration and fish length is typically a positive relationship, but 2004 walleye from the Lower reach show a negative relationship (Figure 2). Incidentally, this illustrates a benefit of the weighted average method over the regression method to derive the SPF-Hg if the Hg-length relationships are not screened. The standard length for walleye is 40 cm, or 15.75 in. The regression from these seven fish the latter gives an SPF-Hg 2,100 ppb!

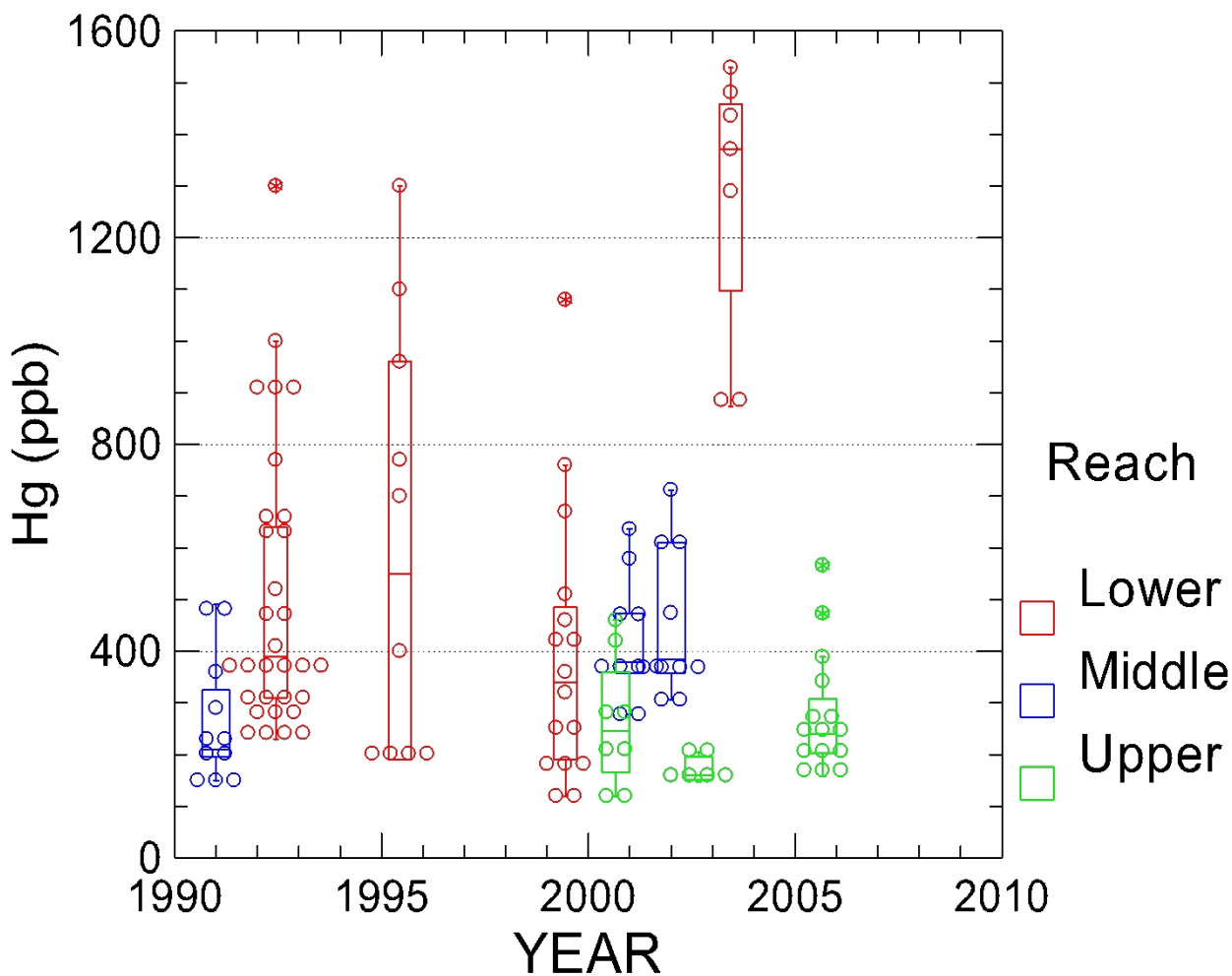


Figure 1 Walleye Hg concentrations by year for Lower (below FDL dam), Middle (Cloquet to FDL dam), and Upper (above Cloquet) river reaches

Table 3 Walleye collected below FDL dam in 2004

Location	Length (in)	Hg (ppm)
EAST OF FOND DU LAC, GN 20	20.6	1.290
GRASSY POINT, GN 10	23.2	0.904
SPIRIT LAKE, GN 14	22.1	0.874
SPIRIT LAKE, GN 17	21.6	1.481
	21.3	1.371
	19.9	1.436
	17.9	1.529

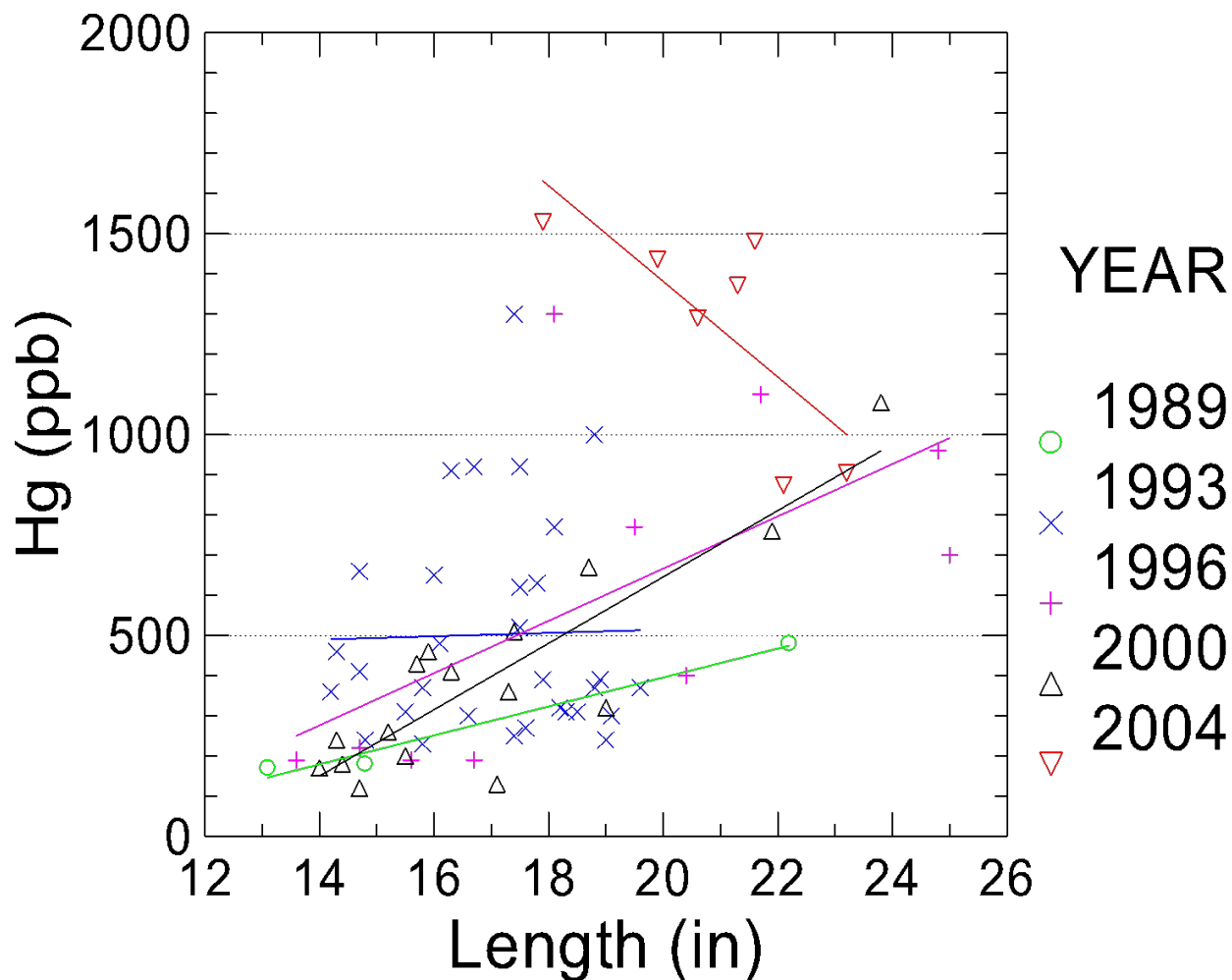


Figure 2 Hg for WE below FDL dam. Hg (y-axis) on log scale. Linear regression line through each year of data. Horizontal grid lines at 0.2, 0.57, and 1.0 ppm

Conclusion

The mean (\pm 95% C.L.) for SPF-Hg walleye in the regional dataset was 348 ppb (\pm 19 ppb). The SPF-Hg for walleye in the Lower reach of the St. Louis River was 544 ppb. The St. Louis River walleye SPF-Hg does not fall within the 95% confidence limits of the regional background SPF-Hg for walleye; therefore, walleye in the Lower reach of St. Louis River appears to have significantly higher mercury concentrations than the regional background.¹

¹ Note that it would not be appropriate to evaluate statistical significance using the confidence limits for the St. Louis River mean SPF-Hg because it is a mean of annual values at the same location, while confidence limits for the regional mean are for multiple sites.

Appendix A Summary of Hg and PCB fish data for St. Louis and Whiteface rivers

River	Reach	SPEC	Year			N of Fish	Length (in)			Hg (ppm)			PCBs (ppm)*			
			N	First	Last		N	Min	Max	Mean	Min	Max	N	Mean	Min	Max
St. Louis	Upper: above Cloquet	CHC	49	1992	2005	65	49	12.7	29.1	0.439	0.174	0.802	34	0.023	< 0.01	0.077
		NP	19	2000	2005	19	19	13.7	31.0	0.306	0.164	0.720	4	< 0.01	< 0.01	< 0.01
		RKB	4	2005	2005	15	4	4.9	8.0	0.176	0.101	0.311				
		SMB	46	2000	2005	46	46	8.8	17.0	0.318	0.090	0.877	3	< 0.01	< 0.01	< 0.01
		SRD	9	2005	2005	33	9	14.0	17.8	0.286	0.140	0.412				
		WE	29	2000	2005	29	29	9.7	17.1	0.252	0.120	0.566	1	< 0.01	< 0.01	< 0.01
		WSU	5	2005	2005	16	5	14.4	19.1	0.327	0.184	0.531				
	Middle: Cloquet to FDL dam	C	4	1983	2002	7	4	19.6	26.6	0.415	0.337	0.492	4	0.548	0.090	1.500
		CHC	2	2002	2002	2	2	23.6	23.9	0.579	0.386	0.772	2	0.210	0.210	0.210
		NP	1	1986	1986	1	1	35.5	35.5				1	0.050	0.050	0.050
		SMB	12	2000	2002	12	12	7.7	16.9	0.409	0.170	0.714	2	< 0.01	< 0.01	< 0.01
		WE	33	1986	2002	39	33	10.6	22.2	0.374	0.150	0.712	4	0.030	< 0.01	0.050
		WSU	14	1982	2002	32	14	11.6	19.1	0.299	0.154	0.980	4	0.035	< 0.01	0.050
	Lower: FDL dam to Lake Superior	BKS	10	1993	2000	21	10	6.1	11.3	0.106	0.040	0.300				
		C	5	1986	2006	13	7	11.1	28.7	0.270	0.110	0.437	2	1.175	< 0.01	2.340
		CHC	17	2000	2004	17	17	12.2	19.3	0.281	0.110	1.220	17	0.161	0.019	0.789
		LST	6	1993	2000	13	6	12.3	27.4	0.108	0.020	0.190	4	0.096	0.013	0.177
		NP	39	1980	2000	65	39	16.3	31.0	0.361	0.220	0.590	17	0.184	< 0.01	2.200
		SMB	14	1998	2009	14	14	10.9	16.9	0.500	0.280	0.760	11	0.063	0.019	0.280
		SRD	1	2009	2009	5	1	15.9	15.9	0.259	0.259	0.259	1	0.025	0.025	0.025
SUF		1	1989	1989	3	1	6.2	6.2	0.054	0.054	0.054	1	< 0.01	< 0.01	< 0.01	
WE		75	1980	2004	93	75	13.1	25.0	0.594	0.120	1.529	37	0.207	< 0.01	3.600	
WSU		47	1980	2000	80	47	13.3	19.1	0.223	0.020	0.450	18	0.172	< 0.01	1.030	
YP		3	1996	1996	3	3	7.9	10.6	0.203	0.140	0.270	3	< 0.01	< 0.01	< 0.01	
Whiteface	CHC	8	1999	1999	8	8	16.6	21.5	0.318	0.220	0.500	8	0.017	0.012	0.021	
	NP	3	1999	1999	3	3	17.9	20.6	0.213	0.180	0.270					
	SMB	2	1999	1999	2	2	13.0	14.5	0.305	0.220	0.390					
	SRD	1	1999	1999	2	1	15.6	15.6	0.220	0.220	0.220					
	WE	4	1999	1999	4	4	12.2	16.0	0.280	0.250	0.320					
	WSU	1	1999	1999	3	1	16.8	16.8	0.240	0.240	0.240					

Years: 1980-2009