

GREAT LAKES INDIAN FISH & WILDLIFE COMMISSION

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• MEMBER TRIBES •

MICHIGAN

Bay Mills Community
Keweenaw Bay Community
Lac Vieux Desert Band

WISCONSIN

Bad River Band
Lac Courte Oreilles Band
Lac du Flambeau Band

MINNESOTA

Fond du Lac Band
Mille Lacs Band

Red Cliff Band
St. Croix Chippewa
Sokaogon Chippewa

To: Neil Kmiecik, Biological Services Director

From: Sara Moses, Environmental Biologist

A handwritten signature in blue ink that reads "Sara K. Moses".

Date: February 8, 2016

Re: Mercury-Based Consumption Advice for Ceded Territory Muskellunge

Introduction

Under the current Great Lakes Restoration Initiative (GLRI) grant #GL00E01452-0 (*Mercury Testing and Updating of Fish Consumption Advisories for Ojibwe Tribes of the Lake Superior Region*), GLIFWC has committed to developing mercury-based fish consumption advice for muskellunge (*Esox masquinongy*). Muskellunge are often harvested by GLIFWC member tribes within the ceded territories. Between 1985 and 2014, tribal members harvested 7,126 muskellunge during the spring spearing season, with annual totals ranging from 55 to 343 fish throughout this time period (Hmielewski, 2015).

Muskellunge are the largest predatory subsistence or game fish in inland waters within the treaty ceded territories. They can become very large, with the Wisconsin state record weighing in at just under 70 pounds and 64 inches. These fish may live to the age of 20 years or more. They are highly piscivorous, residing at the top of the aquatic food web. As a result of their trophic status, longevity, and size, muskellunge have an increased potential to bioaccumulate environmental contaminants, including mercury.

There is a scarcity of published literature documenting mercury levels in muskellunge. A search of peer reviewed literature identified only three studies that included such information. Flaherty *et al.* (2003), in an assessment of mercury exposure through fish consumption by Wisconsin ice anglers, cited a mean muskellunge mercury concentration of 0.28µg/g. The mercury data was supplied by the Wisconsin Department of Natural Resources, but there is no information regarding the number of samples, tissue type, fish size, harvest location, or other summary

statistics (e.g. range or standard error of mercury concentrations). Kamman *et al.* (2003) reported a mean muskellunge mercury concentration of 0.98µg/g for fish averaging 79.4cm (31.3 inches). This value represented the mean of 18 fillets (skin on versus off not specified) and was the highest level reported for the 13 freshwater species included in the study. The mercury data was provided by various state and provincial governments in northeastern North America, encompassing a region that extended east to, but did not include, the Great Lakes Region. Finally, Rypel (2010) compiled mercury data for fish in 32 Wisconsin lakes from the U.S. EPA national mercury database (<http://www.epa.gov/waterscience/fish/mercurydata.html>). The mean muskellunge mercury concentration was 0.845µg/g (range: 0.041-2.200µg/g), which encompassed data from 32 lakes and represented fish with a mean length of 85.4cm (33.6 inches).

Muskellunge Records Available in the Mercury Databases

GLIFWC and its member tribes have been interested in expanding the GLIFWC mercury database to include additional muskellunge records due to this species’ potential for accumulating significant concentrations of mercury, its importance to the tribes, and the scarcity of existing muskellunge mercury data both within the existing database and within the published scientific literature. Muskellunge sample collection and mercury testing has been added to the current GLRI mercury grant (#GL00E01452-0). Efforts by GLIFWC’s Inland Fisheries staff to increase muskellunge sampling for GLIFWC’s Mercury Program have resulted in the collection and mercury testing by GLIFWC of 189 additional muskellunge between 2011 and 2015. Skin-off fillets were tested for total mercury by the Lake Superior Research Institute (LSRI) at the University of Wisconsin – Superior. In total, GLIFWC has generated 284 of the 523 available muskellunge mercury records available within the ceded territories. The remainder were collected by state (MI, MN, WI) agencies, with the exception of four muskellunge collected and tested by the Lac du Flambeau Band of Lake Superior Chippewa. These are a combination of both skin-on and skin-off fillets. Table 1 summarizes the number of available ceded territory mercury records by state. The vast majority, 488 of 523 records, are from the Wisconsin ceded territory.

Table 1. Number of records available in the fish mercury databases for muskellunge collected within the ceded territories of Michigan, Minnesota, and Wisconsin

	Total number of muskellunge mercury records	Number of Records Generated by GLIFWC	Number of lakes with muskellunge mercury records	Number of lakes with sample size of n≥4*
All Ceded Territories	523	284	123	47
MI Ceded Territories	7	0	2	1
MN Ceded Territories	28	0	5	3
WI Ceded Territories	488	284	116	43

* This is the minimum sample size required to develop lake-specific consumption advice according to GLIFWC’s methodology (Madsen *et al.*, 2008).

Selecting a Normalization Length for Determining Fish Consumption Advice

Because mercury concentration increases with increasing fish length, mercury concentrations of muskellunge must be normalized to a fish of a pre-selected length in order to determine a single safe consumption rate. A number of factors were taken into account when selecting the length at which muskellunge fish consumption advice would be generated, including: size of fish with available mercury data, size of fish harvested by GLIFWC member tribes during the spring spearing season, percent of harvest that advice is protective of at a given length, state and tribal size limits for harvest, and reference lengths for existing state consumption advisories.

The length distribution of the 523 muskellunge records in the mercury database are shown in Figure 1. The mean length of all samples is 35.6 inches and median is 36.1 inches. Lengths range from 14.1 to 54.0 inches.

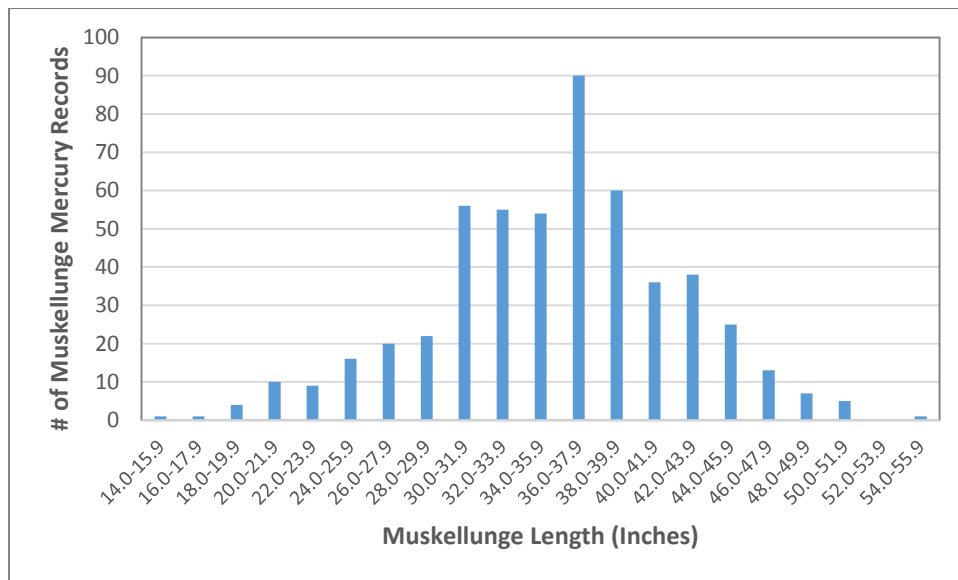


Figure 1. Size distribution of muskellunge in the mercury databases

Fish length has been recorded for 7,076 of the 7,126 muskellunge speared by GLIFWC member tribes between 1985 and 2014 in Wisconsin during the spring spearing and netting season. The mean length was 37.9 inches for this entire time period, with a range of 13 to 57 inches (Hmielewski, 2015). Annual averages have been similar, ranging from 35.4 to 39.9 inches. The length-frequency distribution for muskellunge harvested by GLIFWC member tribes during spring 2014, the most current year available, as well as for the entire period from 1985-2014 is shown in Figure 2. The size distribution of the muskellunge in the mercury database is very similar to that of tribally harvested muskellunge.

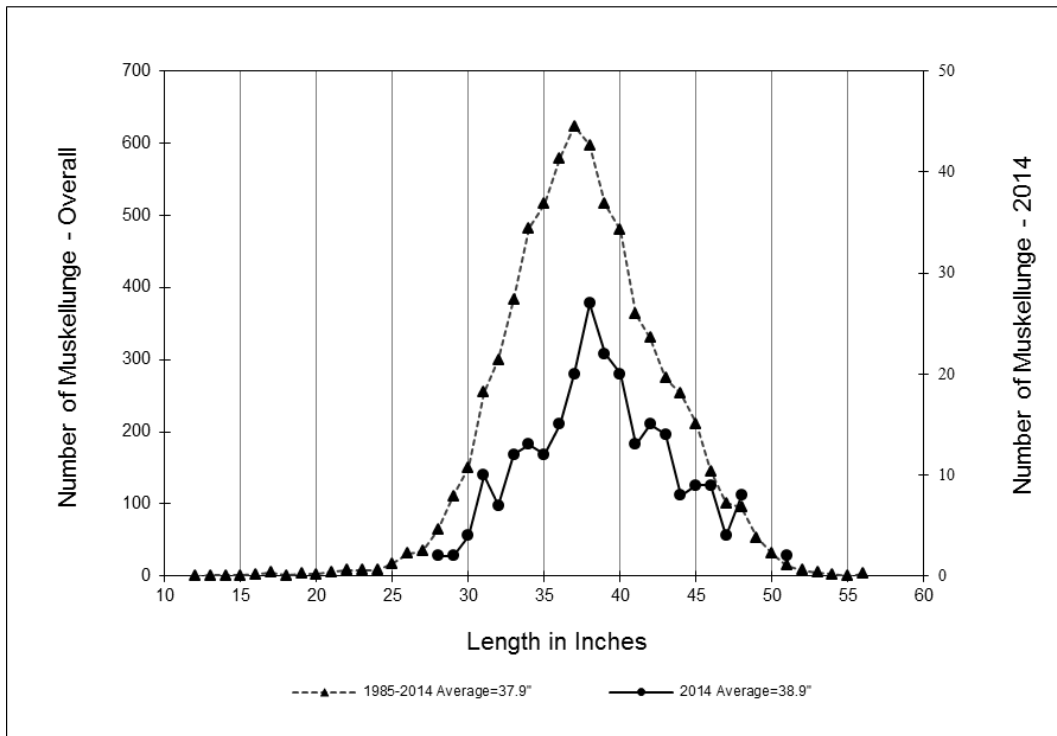


Figure 2. Length-frequency of muskellunge speared by GLIFWC member tribes in Wisconsin during spring 2014 and during the 30-year period from 1985-2014 (Hmielewski, 2015)

When developing fish consumption advice for walleye, a reference length of 20 inches is used. For the 30 year period from 1985-2014, 94.1% of walleye harvested during the spring spearing and netting season in Wisconsin were under 20 inches. Therefore, the fish consumption advice for walleye communicated by GLIFWC’s Mercury Maps is protective for 94.1% of the fish typically harvested. In order to meet a similarly protective percentage for muskellunge, length frequencies for the same time period were analyzed. Of the muskellunge harvested by the tribes during each spring season from 1985-2014, 93.3% were under 46”.

According to the GLIFWC Model Code, under a tribal spearing permit the first muskellunge may be of any size, thereafter at least ½ of the catch must be at least 32 inches. The Wisconsin Department of Natural Resources (WDNR) currently manages muskellunge as a trophy fish by establishing high minimum length requirements and low daily bag limits for fishers, promoting the increased presence of larger individuals within the population. The minimum legal size for Wisconsin state anglers is 40 inches. Similarly, the state angler minimum legal sizes in Michigan and Minnesota are 42 and 54 inches, respectively. None of these three states indicate a reference size for their consumption advice of muskellunge, likely because all fish harvested must be very large (40 to 54 inches, depending on the state), so the size range of fish consumed by state anglers is small.

Considering all of the information above, it was decided to explore the safe fish consumption advice for muskellunge at two reference lengths. The following lengths were chosen:

- 38 inches: This length is representative of the average muskellunge harvested by GLIFWC member tribes over a 30-year period (1985-2014). Since 38" is the approximate median length of muskellunge harvested, the advice generated at this normalization length would be protective of ~50% of tribally harvested muskellunge.
- 46 inches: Advice developed for this length muskellunge is protective for 94% of the muskellunge harvested by GLIFWC member tribes. Thus, it is similarly protective as the walleye consumption advice displayed on GLIFWC's Mercury Maps.

Selecting a Geographic Unit for Developing Fish Consumption Advice

GLIFWC's Mercury Maps, which communicate walleye fish consumption advice, are lake-specific, meaning each of approximately 450 lakes is analyzed individually and appropriate safe fish consumption generated for each lake. The mercury data for muskellunge is much more limited than that available for walleye. Of the 123 lakes within the ceded territories that have muskellunge mercury data available, 47 (38%) have a sufficient number of samples ($n \geq 4$) to generate lake specific advice. This represents a small percentage of the lakes available for muskellunge harvest to the tribes. For example, in 2014 tribal muskellunge quotas were established for 349 lakes in Wisconsin, and muskellunge were harvested from 73 of those lakes. But, the lakes for which sufficient data is available to develop lake-specific consumption advice disproportionately represent the lakes where harvest most often takes place. For example, although quotas were established for 349 Wisconsin lakes in 2014, 60% of the muskellunge harvested were taken from 29 of the 43 Wisconsin lakes for which lake-specific muskellunge consumption advice was developed here.

Lake specific advice was generated when sufficient data was available. In addition, due to the large number of potential harvest lakes with insufficient data for generating lake-specific advice, general ceded-territory wide advice was generated by combining all available muskellunge mercury data.

Generation of Fish Consumption Advice for Muskellunge

Mercury concentrations of muskellunge (skin-on and skin-off fillets) in the databases ranged from 0.086 to 3.06 $\mu\text{g/g}$ (ppm), with an average of 0.72 $\mu\text{g/g}$ and a median of 0.59 $\mu\text{g/g}$. A plot of mercury concentration versus muskellunge length for all lakes combined is show in Figure 3, below.

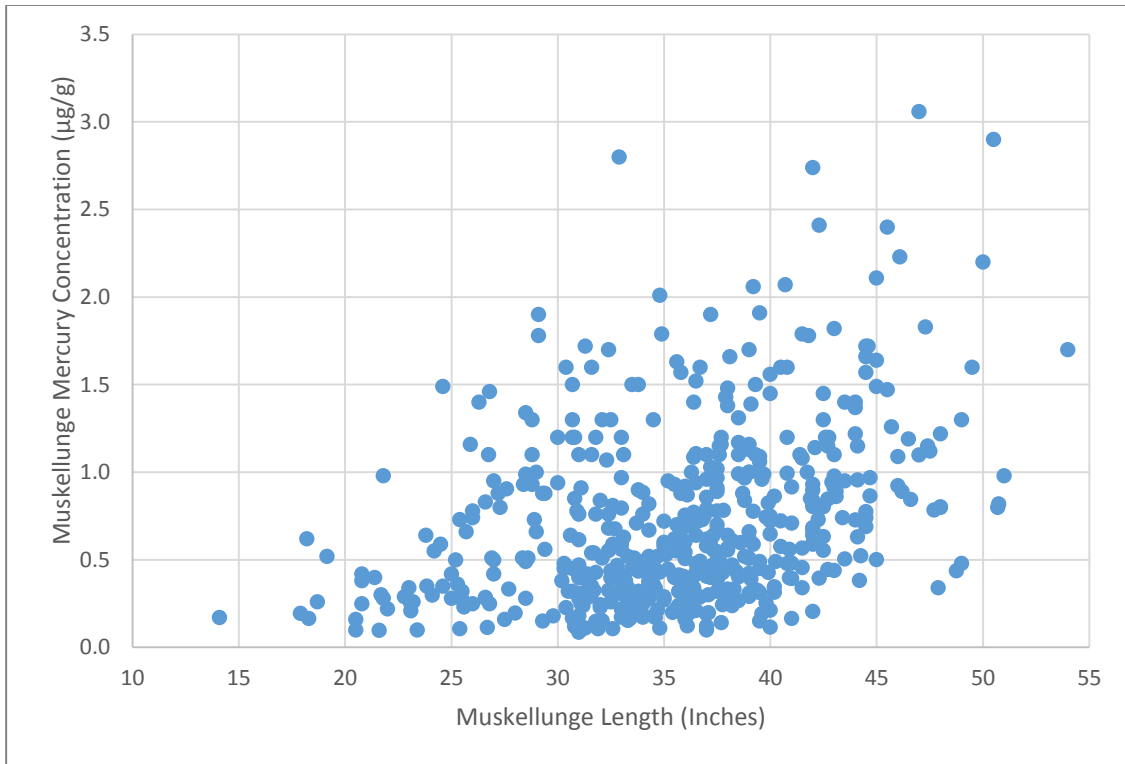


Figure 3. Muskellunge length versus mercury concentration for all samples in the mercury databases (MI, MN, and WI; n=523)

An analysis similar to that used to assign color codes to inland lakes for the walleye Mercury Maps was performed for muskellunge. The major modification was that fish mercury was normalized to a 38-inch and a 46-inch muskellunge, rather than the 20-inch length typically applied to walleye.

The results based on the available information are summarized in Table 2, below.

Table 2. Consumption recommendations for muskellunge up to 38 and 42 inches for the sensitive¹ and general² populations

State	County	Lake	Safe Number of Meals per Month: 38" Musky		Safe Number of Meals per Month: 46" Musky	
			General Population	Sensitive Population	General Population	Sensitive Population
ALL	ALL	ALL	2	0	2	0
MI	Alger	Kingston L	8	2	8	2
MN	Cook	Crescent L	4	1	2	1
MN	Lake	Dumbbell L	2	0	1	0
MN	St Louis	Boot L	0	0	0	0
WI	Ashland	English L	1	0	1	0
WI	Ashland	Moquah L	1	0	0	0
WI	Ashland	Potter L	1	0	1	0
WI	Ashland	Spider L	1	0	0	0
WI	Ashland	Spillerberg L	1	0	1	0
WI	Bayfield	Namekagon L	2	0	1	0
WI	Burnett	Big McKenzie L	4	1	2	0
WI	Oneida	Booth L	4	1	1	0
WI	Oneida	Buckskin L	2	0	2	0
WI	Oneida	Clear L	1	0	1	0
WI	Oneida	Minocqua L	4	1	2	0
WI	Oneida	Pelican L	2	0	1	0
WI	Oneida	Squirrel L	4	1	2	0
WI	Oneida	Tomahawk L	4	1	2	1
WI	Polk	Bone L	4	2	4	1
WI	Polk	Deer L	2	0	2	0
WI	Sawyer	Callahan L	2	0	2	0
WI	Sawyer	Grindstone L	4	1	2	0
WI	Sawyer	L Chippewa	4	1	2	1
WI	Sawyer	L Winter	2	0		0
WI	Sawyer	Lac Courte Oreilles	4	1	2	0
WI	Sawyer	Round L	4	1	2	0
WI	Sawyer	Sand L	2	0	2	0
WI	Sawyer	Sissabagama L	2	1	1	0
WI	Sawyer	Tiger Cat FL	2	0	1	0
WI	Vilas	Ballard L	1	0	1	0
WI	Vilas	Big Arbor Vitae L	8	2	4	1
WI	Vilas	Big L (Boulder JCT)	2	0	2	0
WI	Vilas	Big Muskellunge L	4	1	2	0
WI	Vilas	Big St Germain L	4	1	4	1
WI	Vilas	Brandy L	2	0	2	0

Table 2 Continued....

State	County	Lake	Safe Number of Meals per Month: 38" Musky		Safe Number of Meals per Month: 46" Musky	
			General Population	Sensitive Population	General Population	Sensitive Population
WI	Vilas	Clear L	2	0	1	0
WI	Vilas	Irving L	1	0	1	0
WI	Vilas	Kentuck L	2	1	2	0
WI	Vilas	Little Arbor Vitae L	8	2	4	2
WI	Vilas	Little John L	8	4	4	1
WI	Vilas	Little St Germain L	8	2	4	2
WI	Vilas	N Twin L	4	1	2	1
WI	Vilas	Trout L	4	1	2	0
WI	Vilas	Upper Gresham L	2	0	1	0
WI	Vilas	White Sand L	2	0	2	0
WI	Vilas	Wildcat L	4	1	2	1
WI	Washburn	Shell L	2	0	1	0

¹ **Sensitive Population:** women of childbearing age and children under 15.

² **General Population:** women beyond child bearing age and men 15 and older.

Overall, the mercury-based consumption advice for muskellunge is more restrictive than for walleye. This was expected because mercury biomagnifies within food webs and muskellunge occupy a higher trophic level than walleye. When all muskellunge mercury data from ceded territory inland waters is combined, the consumption advice for both a 38" and 46" muskellunge is 2 meals per month for the general population and "do not eat" for the sensitive population. But, this advice can be refined for the 47 lakes for which sufficient data is available to develop lake specific advice. Table 3, below, summarizes the number of lakes falling in to each of the five advice categories for the consumption of a 38" or 46" muskellunge by the general and sensitive populations.

Table 3. Number of lakes (out of 47 lakes with consumption advice developed) per consumption advice category for 38" and 46" muskellunge

	38" Muskellunge		46" Muskellunge	
	General Population	Sensitive Population	General Population	Sensitive Population
8 meals/month	5 (11%)	0 (0%)	1 (2%)	0 (0%)
4 meals/month	16 (34%)	1 (2%)	6 (13%)	0 (0%)
2 meals/month	17 (36%)	5 (11%)	21 (45%)	3 (6%)
1 meal/month	8 (17%)	17 (36%)	16 (34%)	9 (19%)
Do not eat	1 (2%)	24 (51%)	3 (6%)	35 (74%)

Comparison with Existing State Fish Consumption Advisories for Muskellunge

The general statewide fish consumption guidelines for muskellunge are:

- Wisconsin: General Population – 1 meal per month. Sensitive Population – Do not eat.
- Minnesota: General Population – 1 meal per week. Sensitive Population – Do not eat.
- Michigan: General and Sensitive Populations – 1 meal per month.

None of the lakes for which lake-specific fish consumption advice was developed in this memo had lake-specific advice issued by the states for muskellunge that differed from the general statewide advice. The ceded-territory wide muskellunge consumption advice developed here (2 meals/month for the general population and “do not eat” for the sensitive population) falls within the range of advice issued by the states that range from 1-4 meals/month for the general population and 0-1 meals/month for the sensitive population. A small number of lakes for which lake-specific advice was generated in this report, resulted in less restrictive consumption advice than that issued by the states, allowing up to 8/meals per month for the general population and 2 or 4 meals/month for the sensitive population, depending on the size of the muskellunge. Further, our lake specific analysis demonstrates that there may be certain lakes for which advice that is more restrictive than the state may be warranted, with some lakes having advice of “do not eat”, even for the general population.

Future Plan

GLIFWC’s current GLRI Mercury Grant includes funds to test for mercury in up to 30 additional muskellunge per year for the next 4 years (2016-2019). The information provided in this report will be presented to GLIFWC’s Voigt Task Force in March, 2016 and their feedback solicited as to whether they would like to see lake-specific maps, similar to the existing walleye Mercury Maps, generated for muskellunge.

Literature Cited

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Rypel AL. 2010. Mercury concentrations in lentic fish populations related to ecosystem and watershed characteristics. *Ambio* 39: 14-19.

Cc: John Coleman, Environmental Section Leader
Mark Leuhring, Inland Fisheries Biologist
Joe Dan Rose, Inland Fisheries Section Leader