STATE OF MICHIGAN

Health Consultation

Muskrat muscle analytical results
for St. Clair River Area of Concern

Algonac, Michigan

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Michigan Department of Community Health

Division of Environmental Health

Lansing, Michigan

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Acronyms and Abbreviations

AOC	Area of Concern
ATSDR	Agency for Toxic Substances and Disease Registry
BPAC	Binational Public Advisory Council
BUI	Beneficial Use Impairment
DDT	Dichlorodiphenyltrichloroethane
EPA	U.S. Environmental Protection Agency
GLRI	Great Lakes Restoration Initiative
HCB	Hexachlorobenzene
kg	kilograms
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
ng	nanograms
OCS	Octachlorostyrene
PCBs	Polychlorinated biphenyls
µg	micrograms

Summary of Findings

The Michigan Department of Community Health (MDCH) assessed the public health risk of consuming muskrat muscle meat from the St. Clair River Area of Concern (AOC). A convenience sample of muskrat muscle was analyzed for persistent, bioaccumulative chemicals. The resulting dataset cannot be extrapolated beyond the existing data due to the small sample size.

Five chemicals were detected in the muskrat muscle. Four of the chemicals were found at concentrations that represent minimal risk to public health. Polychlorinated biphenyls (PCBs) were detected in one of six samples. However, the amount detected could result in consumption guidance of no more than 24 serving per year. Such consumption guidance would only apply if this PCB concentration occurred frequently in the muskrat population.

Given the limited dataset, MDCH cannot determine if unlimited consumption of muskrat muscle from the St. Clair River AOC could harm people's health.

Background

In 1991, the St. Clair River was designated as an Area of Concern (AOC) under the Great Lakes Water Quality Agreement. The St. Clair River AOC has a Binational Public Advisory Council (BPAC) made up of local, state, and federal representatives from Michigan (United States) and Ontario (Canada). The BPAC works to address the designated beneficial use impairments (BUIs) affecting the St. Clair River.

The BPAC has published documents describing the type of impairments found on the St. Clair River; some of those impairments are due to chemical contamination[1]. Upriver chemical releases from industrial and agricultural activities are the likely source of chemical contaminants in St. Clair River fish. Methylmercury, polychlorinated biphenyls (PCBs), and dioxin-like chemicals found in some species of St. Clair River fish cause public health consumption advisories[2].

[1] St. Clair River Stage 1 Remedial Action Plan Report. 1997. www.epa.gov/glnpo/aoc/stclair/pdfs/1992_1997_SCR_Stg1_Stg2_IM_Up.pdf

[2] Michigan Department of Community Health. 2014. Michigan Fish Consumption Advisory Program Guidance Document. http://www.michigan.gov/documents/mdch/MDCH_MFCAP_Guidance_Document_417043_7.pdf

Muskrats live in the delta wetlands of the St. Clair River. Muskrats eat a wide variety of plants, such as cattails, sedges, arrowhead, pondweed, and ferns. When plant foods are scarce, muskrat have been known to eat animals such as snails, fish, frogs, and salamanders; although, animals tend to make up a small portion of a muskrat's diet[3].

Harvesting muskrats from the St. Clair River AOC is a long-standing tradition for people from Walpole and Harsens Islands, as well as the surrounding region. Native Americans and Aboriginal people harvested more than 100,000 pelts per year prior to 1980[1]. Those numbers declined to around 10,000 pelts by 1989. A 1986 survey of Walpole Island's First Nation households, found that 56 percent of households consumed muskrat meat[1].

In 1987, a small number of muskrat fat (7), liver (10), and muscle (8) samples from Walpole Island were analyzed for organochlorine chemicals. Hexachlorobenzene (HCB) and total PCBs were at low parts per billion (ppb) concentrations (1-2 ppb) in some of the muscle samples[1].

In 2012, MDCH acquired a US Environmental Protection Agency (EPA) Great Lakes Restoration Initiative (GLRI) grant to partner with the MDEQ and evaluate the status of fish consumption BUIs. MDCH and MDEQ partnered with the St. Clair River AOC BPAC to conduct the St. Clair River AOC evaluation of fish. Although not officially part of the BUI, the BPAC requested that muskrat or turtle be analyzed for chemicals of concern due to the local consumption of these meats. The MDEQ funded the collection and analysis of eight samples of muskrat from this area. This health consultation evaluates the potential public health risks from eating St. Clair River AOC muskrat muscle meat based on lab results from this small convenience sample.

Discussion

Exposure Pathway

In the 1986, 56 percent of Walpole Island's First Nation households reported eating muskrat muscle. In 1987, muskrat muscle was analyzed and found to have organochlorine contamination from St. Clair River AOC sources. A plausible completed exposure pathway exists between St. Clair River AOC chemical contaminants and people who eat St. Clair River AOC muskrat meat.

[3] Washington Department of Fish & Wildlife. Living with wildlife. http://www.wdfw.wa.gov/living/muskrats.html

Chemical Concentrations

A total of 13 muskrat were obtained from trappers harvesting in the lower portion the St. Clair River around Harsens and Walpole Islands (Figure 1). Muskrat muscle tissue was removed, homogenized, and analyzed as six muscle tissue samples with one to four individual muskrats included in each sample. Harsens Island samples had 3 or 4 muskrats per composite sample; Walpole Island muskrat were analyzed as individual muscle samples. Each sample was analyzed for a standard suite of persistent, bioaccumulative chemicals that are evaluated in fish tissue (Appendix A). Five chemicals were detected in one or more of the muscle samples (Appendix A).

Toxicological Assessment

The muskrat muscle analytical dataset is limited due to the small number of samples and convenience-sample collection methods used to acquire the muskrats.
This limitation means the dataset cannot necessarily be considered representative of the contamination levels in the population of muskrat from the St. Clair River AOC.

MDCH conducted a reasonable worst-case toxicological assessment based on the maximum detected concentration of each chemical. Chemicals not detected in the muscle tissue were assumed to be zero and no further evaluation was done. This is consistent with the data analysis approach used in the Michigan Fish Consumption Advisory Program[2]. Chemicals not detected in the muscle tissue were aldrin, dieldrin, lindane, heptachlor, heptachlor epoxide, heptachlorostyrene, hexachlorostyrene, mirex, polybrominated biphenyls, pentachlorostyrene, chlorinated terphynyls, total chlordane, and toxaphene (Appendix A).

Five chemicals [hexachlorobenzene, octachlorostyrene (OCS), total dichlorodiphenyltrichloroethane (DDT), total mercury, and total polychlorinated biphenyls (PCBs)] were detected in one or more muskrat muscle samples. Agency for Toxic Substances and Disease Registry (ATSDR) or EPA chemical potency values were used in this evaluation. No potency value for OCS is provided by ATSDR or EPA. MDCH conducted an internet search for documented OCS potency values; however none were found. An EPA website mentions a non-cancer value from Health Canada, but no documentation was found to support this value. OCS was detected in one of the six samples just above the limit of detection (1 nanogram per gram). OCS was detected in the same sample as PCBs, and PCBs often determine the highest risk estimates. MDCH did not pursue further evaluation of OCS.

Based on estimated non-cancer and upper-bound excess cancer risk of the four remaining chemicals, MDCH calculated the number of servings per month of muskrat muscle the public can consume without increasing their risk of chronic disease. These estimates are based on the individual class of chemicals: no cumulative or mixture

toxicity risks are calculated. The risk estimates are considered protective of the most sensitive life-stage or individual in the population.

A hazard quotient (HQ) is the amount of a chemical a person is exposed to, divided by the amount of the chemical that is *not* expected to cause health effects (non-cancer toxicity values). Examples of non-cancer toxicity values are minimal risk levels or reference doses. These values are amounts of chemical that are not expected to cause health effects for anyone, even if they are exposed to that chemical daily for a lifetime.

- If the non-cancer risk is less than 1.0, a person is exposed to less than the non-cancer toxicity value. No further evaluation of this exposure is needed.
- If the non-cancer risk is 1.0, a person is exposed to the non-cancer toxicity value. No further evaluation of this exposure is needed.
- If the non-cancer risk is greater than 1.0, a person is exposed to more than the non-cancer toxicity value. This does not automatically mean that people will have health effects, but that the exposure should be reviewed further as exposure to a larger amount of chemical is occurring.

Cancer risk (CR) values represent the theoretical number of people that may develop cancer from exposure to these chemicals. A higher than normal risk of cancer is a theoretical cancer risk greater than the typically used range of one individual in 10,000 to one individual in 1,000,000.

Meal serving size is based on body weight, such that an 80- kilograms (kg) person's serving size is an 8-ounce (oz) portion and a 40-kg person's serving size is 4-oz. Meal sizes can be adjusted by 1-oz per 10 kg of body weight. Risk estimates were not calculated beyond sixteen servings per month (192 servings per year).

Table 1. Cancer risk (CR) and non-cancer risk [hazard quotient (HQ)] for the maximum detected concentration in muskrat muscle collected from the St. Clair River Area of Concern (AOC).

Chemical	Servings per Month	HQ	CR
Hexachlorobenzene	16	0.01	1.2E-06
Octachlorostyrene	--	--	--
Total DDT	16	0.01	1.0E-06
Total Mercury	16	0.29	--
Total PCBs	2	0.72	2.9E-05

Hexachlorobenzene (HCB)

People who were exposed to high levels of HCB had changes in their liver and thyroid function. Experimental animal studies confirm that the liver, kidney, and endocrine glands are primary sites for HCB toxicity[4]. The non-cancer potency value for HCB is based on rodent studies that reported dose-dependent tissue changes in the liver and kidneys. The cancer potency value is based on liver tumor formation.

HCB was detected in two of the six samples; both samples were composites made up of muscle from 3-4 muskrat harvested around Harsens Island. Cancer and non-cancer risks were minimal at a consumption rate of 16 serving per month (Table 1).

Total mercury

Long-term human exposure to low-levels of methylmercury most often occurs from periodic consumption of methylmercury-contaminated fish. Methylmercury exposure prior to birth (as a result of the mother's intake before and during pregnancy) has been correlated with neurological effects in children[5]. Methylmercury can affect autonomic nervous system function and cardiovascular function in adults. Experimental animal studies report reduced immune system function. The non-cancer potency value is based on human prenatal exposure and measures of early-age neurological function. Methylmercury has not been identified as a carcinogen.

Total mercury – assumed to be in the form of methylmercury – was quantified in all muskrat muscle samples. The non-cancer risk due to methylmercury was minimal at the consumption rate of 16 serving per month (Table 1).

Total DDT

Long-term human exposure to low-levels of DDT and its metabolites has been associated with reproductive, developmental, and endocrine effects (e.g., increased risk of type 2 diabetes)[6]. Experimental rodent studies found liver changes at the cellular

[4] Agency for Toxic Substances and Disease Registry (ATSDR). 2013. Toxicological profile for Hexachlorobenzene. *(Draft for Public Comment)* Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=627&tid=115

[5] MDCH 2009. Technical Support Document for a Methylmercury Reference Dose as a Basis for Fish Consumption Screening Values (FCSVs). http://www.michigan.gov/documents/mdch/MDCH_Methylmercury_Reference_Dose_HC_9-10-2009_382034_7.pdf

[6] MDCH 2012. Technical Support Document for DDT, DDD, and DDE Reference Dose (RfD) as the Basis for Michigan Fish Consumption Screening Values (FCSVs). http://www.michigan.gov/documents/mdch/DDT_LHC_FCSV_2012_10_21_402648_7.pdf

level. DDT and its metabolites are probable human carcinogens based on experimental rodent studies. The cancer and non-cancer potency values are based on dose-response liver effects observed in experimental animal studies.

Total DDT, which is the sum of DDT and its metabolites, was detected in two of the Harsens Island composite samples. Cancer and non-cancer risks were minimal at a consumption rate of 16 serving per month (Table 1).

Total PCBs

Eighty-three individual PCB congeners are measured by the MDCH Analytical Laboratory for the total PCB concentrations. People's PCB exposure typically comes from eating foods contaminated with a mixture of PCBs. Associations between human PCB exposure and the occurrence of diabetes, immune system dysfunction, thyroid dysfunction, cardiovascular disease, neurodevelopmental effects in children, memory decrements in adults, and impaired reproductive system function have been reported in observational epidemiology studies[7]. Experimental animal studies report similar toxicity endpoints. PCBs are considered carcinogens based on animal studies.

PCBs were detected in one Harsens Island composite sample. The total PCB concentration was 77 ppb wet-weight with approximately 31 PCB congeners detected in this sample. MDCH does not know if only one or more than one of the four muskrat used in the composite sample were contaminated with PCBs. The maximum individual total PCB muskrat muscle concentration is not discernable from a composite sample. Based on the available data, cancer and non-cancer risk were minimal at a consumption rate of 2 serving per month (24 per year) (Table 1).

Conclusions

MDCH concludes that mercury and organochlorine chemicals from the St. Clair River AOC can accumulate to measureable amounts in muskrat muscle meat. It is unclear why the organochlorine measurements were found only in Harsens Island composite samples, but it may be because fewer muskrat were sampled from Walpole Island. The maximum concentration for each detected compound, except for total PCBs, represents a minimal public health risk at 192 servings per year for 78 years of consumption.

[7] MDCH 2012. Technical Support Document for Polychlorinated Biphenyl Reference Dose (RfD) as a Basis for Fish Consumption Screening Values (FCSVs). http://www.michigan.gov/documents/mdch/MDCH_PCB_Fish_Consumption_Protocol_2012_401298_7.pdf

The data suggest that PCB concentrations in muskrat muscle can reach at least 77 ppb and that around 31 PCB congeners can be detected in the meat. Due to the use of composites, the maximum individual PCB concentration is unknown. It is unclear why only one of the six muscle tissue samples had measurable amounts of PCBs. However, eating 24 servings per year of muskrat meat containing 77 ppb of PCBs for 78 years is not expected to result in a human health risk.

Based on past reports, a completed exposure pathway exists between the St. Clair River AOC chemical contaminants and consumers of muskrat muscle from that region[1]. This assessment is limited to the results of this dataset, and extrapolation of these results is not recommended due to the small number of samples, sample collection methods, and use of composites. MDCH cannot determine if unlimited consumption of muskrat muscle could harm people's health.

Recommendations

1. MDCH recommends this health consultation be provided to the BPAC for their consideration.
2. MDCH recommends working with BPAC to develop outreach materials discussing the findings if requested.

Public Health Action Plan

1. MDCH will provide this health consultation to the BPAC for their consideration.
2. MDCH will work with the BPAC to develop outreach materials discussing the findings if requested.

Figure 1. Location of Harsens and Walpole Islands.

Appendix A. Analytical chemistry results for the six muskrat muscle samples collected from the Harsens and Walpole Islands region within the St. Clair River Area of Concern.

Table A-1. Number of analyses, percentage of chemical detections per analyte, limit of detection and maximum detected concentration for muskrat muscle samples from the Harsens and Walpole Islands region within the St. Clair River Area of Concern.

Chemical	Number of Samples	Percentage of Detections	Limit of Detection	Maximum concentration
			ppm	*ppm*
Aldrin	6	0	0.001	--
Dieldrin	6	0	0.005	--
gamma-BHC (Lindane)	6	0	0.002	--
Heptachlor	6	0	0.001	--
Heptachlor Epoxide	6	0	0.002	--
Heptachlorostyrene	6	0	0.001	--
Hexachlorobenzene	6	33%	0.001	0.0005
Hexachlorostyrene	6	0	0.001	--
Mercury	6	100%	0.001	0.0190
Mirex	6	0	0.001	--
Octachlorostyrene	6	17%	0.001	0.0011
Polybrominated Biphenyls	6	0	0.003	--
Pentachlorostyrene	6	0	0.001	--
Terphynyls	6	0	0.250	--
Total Chlordane	6	0	0.001	--
Total DDT	6	33%	0.001	0.0020
Total PCBs	6	17%	0.001	0.0772
Toxaphene	6	0	0.050	--

Table A-2. Descriptive information for each muskrat muscle sample.

Sample Number	Number of Muskrats per Sample	Location	Collection Date	Species	Percent Fat
1	3	Harsens Island	03-Jan-13	Muskrat	4.83
2	3	Harsens Island	03-Jan-13	Muskrat	2.91
3	4	Harsens Island	03-Jan-13	Muskrat	2.98
4	1	Walpole Island	04-Feb-13	Muskrat	3.11
5	1	Walpole Island	04-Feb-13	Muskrat	0.59
6	1	Walpole Island	04-Feb-13	Muskrat	21.44

Table A-3. Analytical chemistry results for six muskrat muscle samples collected from the Harsens and Walpole Islands region within the St. Clair River Area of Concern.

Chemical	Sample Number					
	1	2	3	4	5	6
Aldrin	0.00025*	0.00025*	0.00025*	0.0013*	0.00025*	0.0011*
Dieldrin	0.0012*	0.0012*	0.0012*	0.0012*	0.0012*	0.0054*
gamma-BHC	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
Heptachlor	0.00025*	0.00025*	0.00025*	0.0013*	0.00025*	0.0011*
Heptachlor Epoxide	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
Heptachlorostyrene	0.0005*	0.0005*	0.0005*	0.0013*	0.0005*	0.0011*
Hexachlorobenzene	0.00025*	0.0003	0.0005	0.00025*	0.00025*	0.0011*
Hexachlorostyrene	0.0005*	0.0005*	0.0005*	0.0013*	0.0005*	0.0011*
Mercury	0.0034	0.0039	0.0044	0.0027	0.0014	0.0190
Mirex	0.00025*	0.00025*	0.00025*	0.0013*	0.0005*	0.0011*
Octachlorostyrene	0.00025*	0.00025*	0.0006	0.00025*	0.00025*	0.0011*
Pentachlorostyrene	0.0005*	0.0005*	0.0005*	0.0013*	0.0005*	0.0011*
Polybrominated Biphenyls	0.0005*	0.0005*	0.0005*	0.0027*	0.0005*	0.0021*
Terphynyls	0.250*	0.250*	0.250*	0.250*	0.250*	0.250*
Total Chlordane	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
alpha-Chlordane	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
cis-Nonachlor	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
trans-Nonachlor	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
gamma-Chlordane	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
Oxychlordane	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
Total DDT	0.0010	0.001*	0.0020	0.001*	0.001*	0.001*
2,4'-DDD	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
2,4'-DDT	0.0005*	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
4,4'-DDD	0.0001*	0.0005*	0.0001*	0.0001*	0.0001*	0.0043*
4,4'-DDE	0.0001*	0.0001*	0.0016	0.0001*	0.0001*	0.0043*
4,4'-DDT	0.0009	0.0005*	0.0005*	0.0005*	0.0005*	0.0021*
Total PCBs	0.001*	0.001*	0.0772	0.001*	0.001*	0.001*
Toxaphene	0.050*	0.050*	0.050*	0.050*	0.050*	0.050*

* Detection limit; no amount of analyte was quantified above this amount.