Letter Health Consultation

Interim Consumption Screening Values for Total Selenium

GOOSE LAKE SELENIUM

LANSING, MICHIGAN

Prepared by:
Michigan Department of Community Health

MARCH 10, 2011

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

LETTER HEALTH CONSULTATION

Interim Consumption Screening Values for Total Selenium

GOOSE LAKE SELENIUM

LANSING, MICHIGAN

Prepared By:

Michigan Department of Community Health
Under Cooperative Agreement with
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

STATE OF MICHIGAN
DEPARTMENT OF COMMUNITY HEALTH
LANSING

JENNIFER M. GRANHOLM
GOVERNOR

JANET OLSZEWSKI
DIRECTOR

Date: June 30, 2010

To: Dennis Bush, Toxicologist Manager, Water Toxics Unit
Department of Natural Resources and Environment - Water Bureau
525 West Allegan, Lansing, MI

From: Kory J. Groetsch, Toxicologist

Re: Interim fish consumption screening values for total selenium

Per your request, this letter provides interim fish consumption screening values for total selenium. The impetus for these screening values is the Michigan Department of Natural Resources and Environment (DNRE)[1] finding of elevated selenium concentrations in fish fillets from Goose Lake[2]. The Michigan Department of Community Health will work with DNRE to implement selenium screening values through the Michigan Fish Consumption Advisory Program.

Interim fish consumption screening values for total selenium are:

Meal Category	Total meals per year	Selenium Fish Consumption Screening Values µg/g wet weight[3]
No Restrictions	not applicable	less than or equal to (≤) 2.5
One meal per week	52	greater than (>) 2.5 to ≤ 7.4
One meal per month	12	> 7.4 to ≤ 32
Six meals per year	6	> 32 to ≤ 64
Do not Eat	0	> 64

Background

Goose Lake (Marquette County) is a large lake with minimal housing structures (surface area: 450 acres, deepest depth: less than 16 feet). It is approximately 4, 6, and 8 miles from the cities of Palmer (population 449), Negaunee (population 4,576), and Ishpeming ((population 6,686), respectively. Ninety-eight percent of these populations self-reported in the 2000 census as being "white", with between 1-3 percent reporting as American Indian or Native Alaskan, and all other

[1] Michigan Department of Natural Resources (DNR) and Department of Environmental Quality (DEQ) were combined into the single Department of Natural Resources and Environment in January 2010.
[2] MDEQ 2009. An assessment of environmental selenium levels around Empire and Tilden Mines in Marquette County Michigan. by the Selenium Monitoring Work Group. Lansing, MI MI/DEQ/WB-09/038 http://www.michigan.gov/documents/deq/wb-swas-selenium-report_287994_7.pdf
[3] micrograms of selenium per gram of wet weight of fish fillet

races/ethnic groups reporting at less than 1 percent. DNRE field notes confirm the lake is used by local anglers.

In 2002, the lake experienced "severe nuisance conditions" due to algal blooms as a result of excessive nutrients that likely are caused by human activity.[4] Goose Lake receives water from Partridge Creek that currently follows a manmade path through the storm-water sewers of the city of Negaunee, then flowing through an abandoned iron mine settling basin, and a manmade rock tunnel before emptying into Goose Lake. Partridge Creek also receives water from a second iron mine settling basin that is used by the Empire Iron Mine for storm-water discharge. The severe nuisance conditions are more likely to occur during the late summer (i.e., August) as compared with spring (i.e., May).[5]

The previously cited assessment conducted by the DNRE reported elevated selenium concentrations in water, sediment, whole fish, and other aquatic biota several miles downstream of the local iron mining operations. Fish fillet concentrations from Goose Lake were elevated and are the impetus for conducting this MI Department of Community Health/Agency for Toxic Substances and Disease Registry (ATSDR) Letter Health Consultation.

Environmental Contamination

Two species of fish, northern pike (pelagic carnivore) and white sucker (benthic insectivore) were collected from Goose Lake (Marquette County) and uncooked fillets were analyzed for selenium (see Attachment A). The northern pike and white sucker mean concentrations of selenium were 9.5 micrograms per gram (µg/g) and 12 µg/g, respectively. The median concentrations were slightly higher at 10 µg/g and 12 µg/g, respectively (Table 1). Selenium concentrations did not increase with fish length. In addition, northern pike were collected from Schweitzer Reservoir (Marquette County), an impoundment of Schweitzer Creek. Schweitzer Reservoir is approximately 5 miles south of Ishpeming and receives run-off from surrounding mine tailings basins. Selenium concentrations in the fillets from northern pike (Schweitzer Reservoir) were less than half the Goose Lake northern pike selenium concentrations (Table 1 and Attachment B).

The commonly reported average concentration of total selenium in fish tissue is approximately 0.5 µg/g.[6,7,8] A recent survey was conducted by the U.S. Fish and Wildlife Service in which they analyzed whole fish (N= 315) for selenium from 109 locations nationwide (geometric mean: 0.42

[4] Michigan Department of Environmental Quality – Water Division. 2003. Preliminary Investigation of Goose Lake. May 15. author Lindsey Villa. MI/DEQ/WD-03/081

[5] Michigan Department of Environmental Quality. 2003. Goose Lake Nutrient Study (Marquette County, Michigan). Prepared by White Water Associates, Inc., Amasa, MI 49903. December 31. MI/DEQ/WD-04/013. DEQ contact Sarah Walsh.

[6] Lowe TP, May TW, Brumbaugh WG, et al. 1985. National contaminant biomonitoring program: Concentrations of seven elements in freshwater fish, 1978-1981. Arch Environ Contam Toxicol 14:363-388.

[7] May TW, McKinney GL. 1981. Cadmium, lead, mercury, arsenic, and selenium concentrations in freshwater fish, 1976-1977 National Pesticide Monitoring Program. Pestic Monit J 15:14-38.

[8] Ohlendorf HM, Lowe RW, Kelly PR, et al. 1986b. Selenium and heavy metals in San Francisco Bay diving ducks. J Wildl Manage 50:64-71.

ppm; 85th percentile: 0.73 ppm; max: 2.3 ppm).[9] Whole fish selenium concentrations would likely over estimate the fillet concentration, based on a study that reported selenium was higher in visceral tissue (25–35 ppm wet weight) than in muscle tissue (6–11 ppm wet weight).[10]

Table 1. Mean, standard deviation (SD), median, minimum, and maximum concentrations (µg/g wet weight) for northern pike and white sucker fillets from Goose Lake and Schweitzer Reservoir (Marquette County).

Species	Sample Size	Mean ± SD	Median	Min	Max
		µg/g	µg/g	µg/g	µg/g
Goose Lake					
Northern Pike	10	9.5 ± 2.4	10	5.0	12.2
White Sucker	10	12 ± 1.3	12	9.1	13.1
Schweitzer Reservoir					
Northern Pike	4	1.9 ± 0.3	1.9	1.7	2.4

Human Exposure

Goose Lake is a large lake that has public boat access. It is located near three communities totaling over 11,000 people. According to DNRE field notes from 2008, a local resident stated to DNRE he had been fishing Goose Lake for 60 years. West et al. (1993)[11] reported that the mean amount of sport fish eaten by Michigan anglers is 16.7 grams per day (g/d) [95% CI 15.3-18.1 g/d], with the total mean fish consumption by Michigan anglers of 26.6 g/d [95% CI: 24.9-28.2].

Selenium is an essential nutrient and is commonly found in the United States (US) food supply.[12] The National Academies' Institute of Medicine (IOM) Recommended Dietary Allowance (RDA) for selenium varies by age and ranges from 20-55 µg/day (Table 2). The RDA represents an amount of selenium a person should ingest every day to avoid selenium deficiency. The IOM's Tolerable Upper Intake Level (UL) varies by age and the intakes range from 90 to 400 µg/day (Table 2). The UL represents the amount of selenium a person could ingest every day and not suffer any adverse effects. Consumption of selenium that exceeds the RDA but not the UL does not imply beneficial effects. According to the Centers for Disease Control and Prevention the

[9] Schmitt CJ, Brumbaugh WG. 1990. National contaminant biomonitoring program: Concentrations of arsenic, cadmium, copper, lead, mercury, selenium, and zinc in U.S freshwater fish, 1976-1984. Arch Environ Contam Toxicol 19(5):731-747.
[10] Ohlendorf HM, Hoffman DJ, Saiki MK, et al. 1986. Embryonic mortality and abnormalities of aquatic birds: Apparent impacts. Sci Total Environ 52:49-63.
[11] West et al. 1993. 1991-92 Michigan Sport Anglers Fish Consumption Study. Final report to the Michigan Great Lakes Protection Fund. Michigan Department of Natural Resources. University of Michigan. School of Natural Resources, Natural Resource Sociology Research Lab. Technical Report # 6.
[12] Agency for Toxic Substances and Disease Registry (ATSDR). 2003. Toxicological profile for Selenium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

mean daily intake of selenium by the US population is 114 µg/day and does differ by age (Table 3).[13] For people 16 to 69 years old (i.e., most of the adult range for the fish consumption advisory) the average is 122 µg/day, which is 31 percent of the adult UL. These CDC estimates of daily dietary intake of selenium are more than twice the RDA, but well below the UL.

The third National Health and Nutrition Examination Survey (NHANES III) that covered 1988 to 1994 reported that the mean serum selenium concentration in the U.S. population was 124.75 micrograms per liter (µg/L) (sample size of 18,292).[14]

[13] Department of Health and Human Services (DHHS). 2002. Dietary intake of macronutrients, micronutrients, and other dietary constituents: United States, 1988-94. Data from the National Health Examination Survey, the National Health and Nutrition Examination Surveys, and the Hispanic Health and Nutrition Examination Survey. Haysville, Maryland: Department of Health and Human Services.

[14] Department of Health and Human Services, Centers for Disease Control and Prevention. 1997. Third National Health and Nutrition Examination Survey. 1988-1994.

Table 2. National Academies of Science's dietary reference intakes for selenium.

Age Ranges	Recommended Daily Allowance µg/day	Tolerable Upper Intake Level µg/day
1 – 3 years	20	90
4 – 8 years	30	150
9 – 13 years	40	280
14 – 70 and over	55	400

Table 3. Selenium dietary intake (µg/day) by age for the total U.S. population, 1988-1994.

Age Ranges	Sample Size	Mean ± SEM[15] µg/day	Median µg/day
2 – 11 months	1,620	28 ± 0.6	23
1 – 2 years	2,310	62 ± 0.9	58
3 – 5 years	2,941	79 ± 1.3	74
6 – 11 years	3,134	96 ± 1.7	87
12 – 15 years	1,599	108 ± 3.0	97
16 – 19 years	1,522	126 ± 3.4	111
20 – 29 years	3,400	131 ± 2.1	113
30 – 39 years	3,238	130 ± 2.8	113
40 – 49 years	2,503	125 ± 2.8	111
50 – 59 years	1,799	117 ± 2.4	104
60 – 69 years	2,208	107 ± 2.1	94
70 – 79 years	1,678	96 ± 1.8	86
80 years and over	1,153	86 ± 1.9	78
Total Combined	29,105	114 ± 1.1	99

Toxicological Overview

Selenium can be a component of organic molecules or be found in various elemental states. In fish tissue 15-35 percent of total selenium is selenate (Se VI), and 55-80 percent of the total selenium is Se VI, selenite (Se IV), and selenide (Se-II).[16] Variation in effective dose by the chemical species does exist, however, most studies only report total selenium concentrations. The health effects from exposure to various forms of dietary selenium are not expected to be greatly different.[17]

[15] SEM: standard error of the mean.
[16] Cappon CJ and Smith JC. 1981. Mercury and Selenium Content and Chemical Form in Fish Muscle. Arch. Environm. Contam. Toxicol. 10:305-319.
[17] Agency for Toxic Substances and Disease Registry (ATSDR). 2003. Toxicological profile for Selenium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Selenium is an essential nutrient that is part of a variety of selenoproteins. Selenium is found in several forms of glutathione peroxidase, which plays a role in protecting cells from oxidative damage. Selenium also is part of the three types of deiodinases which convert thyroxine to triiodothyronine. It is found in thioredoxin reductase that catalyses the NADPH-dependent reduction thioredoxin (a redox protein).[14] Selenoproteins are part of the sperm capsule and may also be necessary for muscle metabolism.[18] Selenoproteins have been found to have both cancer preventing and promoting properties.[19] A randomized, double-blinded clinical control study of selenium supplements (200 μg/day) on skin cancer resulted in no significant reduction in risk, however, in secondary analyses, overall mortality, cancer incidence, lung cancer incidence, prostate cancer incidence, and colorectal cancer were significantly reduced in the selenium treatment group.[20] Selenium may have therapeutic value when given by a clinician to patients with certain types of cancer.[21]

Based on the ATSDR *Toxicological Profile for Selenium*, observational and experimental human studies have indicated that elevated selenium exposure is associated with changes in body function and certain negative health outcomes.[17] Endpoints that correlate with increasing selenium exposure over weeks or months are decreased white blood cell counts[22] and reduced concentrations of thyroid stimulating hormone or thyroxine.[23,24] Chronically exposed populations ingesting elevated levels of selenium have been reported to have clinical symptoms that can be observed during a physical examination including skin discoloration, skin lesions, brittle hair and nails, morphological alterations in finger nails, mottled tooth enamel, and prevalence of chronic arthritis.[17, 25,26,27,28] Blood draws found delayed clotting of blood in more highly exposed

[18] Brown KM, Arthur JR. 2001. Selenium, selenoproteins and human health: a review. Public Health Nutr. 4(2B):593-9.
[19] Hatfield DL, Yoo MH, Carlson BA, Gladyshev VN. 2009. Selenoproteins that function in cancer prevention and promotion. Biochim Biophys Acta. 1790(11):1541-5.
[20] Clark LC, Combs GF Jr, Turnbull BW et al. 1996. Effects of selenium supplementation for cancer prevention in patients with carcinoma of the skin. A randomized controlled trial. Nutritional Prevention of Cancer Study Group. JAMA. 276(24):1957-63.
[21] Micke O, Schomburg L, Buentzel J, Kisters K, Muecke R. 2009. Selenium in oncology: from chemistry to clinics. Molecules. 14(10):3975-88.
[22] Hawkes WC, Kelley DS, Taylor PC. 2001. The effects of dietary selenium on the immune system in healthy men. Biol Trace Elem Res 81:189-213.
[23] Duffield AJ, Thomson CD, Hill KE, et al. 1999. An estimation of selenium requirements for New Zealanders. Am J Clin Nutr 70:896-903.
[24] Hagmar L, Persson-Moschos M, Ckesson B, et al. 1998. Plasma levels of selenium, selenoprotein P and glutathione peroxidase and their correlations to fish intake and serum levels of thyrotropin and thyroid hormones: A study on Latvian fish consumers. Eur J Clin Nutr 52:796-800.
[25] Yang G, Wang S, Zhou R, et al. 1983. Endemic selenium intoxication of humans in China. Am J Clin Nutr 37:872-881.
[26] Yang G, Yin S, Zhou R, et al. 1989a. Studies of safe maximal daily dietary Se-intake in a seleniferous area in China. II. Relation between Se-intake and the manifestation of clinical signs and certain biochemical alterations in blood and urine [published erratum appears in J Trace Elem Electrolytes Health Dis 3(4):250.] J Trace Elem Electrolytes Health Dis 3(3):123-130.
[27] Yang G, Zhou R, Yin S, et al. 1989b. Studies of safe maximal daily dietary selenium intake in a seleniferous area in China. I. Selenium intake and tissue selenium levels of the inhabitants. J Trace Elem Electrolytes Health Dis 3(2):77-87.
[28] Yang G, Zhou R. 1994. Further observations on the human maximum safe dietary selenium intake in a seleniferous area of China. J Trace Elem Electrolytes Health Dis 8:159-165.

individuals. The Yang et al. studies describe Chinese populations that experienced differing selenium exposures from contact with local soils and consumption of local food (Table 4).

Table 4. Exposure categories for each Chinese population described by the Yang studies.

Exposure Categories Se Intake by Region	**Mean ± Standard Error**	
	Se Dietary Intake Estimates mg/kg/day[29]	**Se in Whole Blood mg/L[30]**
Low	0.0012±0.00009	0.16±0.00
Medium	0.0037±0.0004	0.35±0.02
High	0.025±0.001	1.51±0.05

The Yang et al. studies of clinical outcomes are the basis for the 1991 US EPA oral reference dose (RfD) ((0.005 milligrams per kilogram per day (mg/kg/day)) and the 2003 ATSDR chronic minimal risk level (0.005 mg/kg/day). The US EPA RfD is based on the 1989 publication[26] and the ATSDR minimal risk level (MRL) is based on the 1994 publication.[28] Both agencies identified the no observable adverse effects level (NOAEL) for this study as 0.015 mg/kg/day and the lowest observable adverse effect level (LOAEL) of 0.023 mg/kg/day and both applied an uncertainty factor of three to the NOAEL to calculate the final RfD and MRL.[17,31] The uncertainty factor was included to be protective of the most sensitive individuals. Among the more highly exposed Chinese village populations, selenosis occurred in about half the people within those villages. Patients diagnosed as having selenosis in the Yang studies were based on one of three sets of fingernail criteria (as described by Yang et al. 1989a):

1. Fingernail disease is ongoing or has occurred repeatedly over years, or
2. Symmetric thickening and stratifying of fingernails with one or more of the following:
    a. history of severe hair or nail loss,
    b. deformed or brittle fingernails,
    c. distinct transverse or longitudinal ridges on the wall of the nails,
    d. presence of a white area at the base of the nail wall,
    e. frequent breaking down of brow with itchiness of the shaded skin, or
3. Presence of four of the fingernail descriptions above (a-e).

The study population includes 349 adults and 54 children. The exact numbers were not reported. Although the number of diagnosed individuals is not precisely stated, six individuals were diagnosed according to criteria 1 and at least 36% of the study population were diagnosed based on criteria 2. Five patients were reported to have long-persisting, distinct clinical signs and a measured, elevated blood selenium concentration. No children under the age of 12 years were diagnosed with selenosis.

Both agencies reference a second cross-sectional observational study of 142 adults from South Dakota as supporting the Yang studies and the calculation of the US EPA RfD and the ATDR MRL.[32] In this supporting study, 78 subjects were enrolled the first year with 49 individuals

[29] milligrams per kilogram per day
[30] milligrams per liter
[31] US. EPA 1991. Integrated Risk Information System. Selenium. http://www.epa.gov/ncea/iris/subst/0472.htm
[32] Longnecker, M.P., P.R. Taylor, O.A. Levander et al. 1991. Selenium in diet, blood, and toenails in relation to human health in a seleniferous area. Am. J. Clin. Nutr. 53: 1288-1294.

randomly selected and 29 individuals chosen based on the likeliness of having an elevated selenium exposure. In the second year, an additional 64 individuals were enrolled based on having a serum blood selenium concentration greater than 165 µg/L. All participants were medically examined for common clinical symptoms of selenium poisoning. Physical examination focused on dermatologic and neurologic examinations. For example, signs of interest included muscle weakness, asymmetrical reflexes, hyperreflexia, abnormal sensory examination, dermatitis, and nail loss or markings. Approximately half the participants had a selenium intake greater than 200 µg/day with 12 individuals having greater than 400 µg/day. No clinical symptoms from the physical exam correlated with selenium concentrations.

Clinical symptoms that can be observed during a physical exam may not be the only adverse effects that elevated chronic selenium exposures can cause. Due to the expected benefits of selenium supplements, experimental studies in the form of clinical trials have been reported in the literature since the establishment of either the RfD or MRL. The Nutritional Prevention of Cancer Trial (1983–1996) was a randomized clinical trial (N=1,312), during which the treatment group received a selenium supplement (200 µg/day) for 7.7 years for the purpose of studying if selenium is chemoprotective for skin cancer.[33] Researchers conducted a secondary analysis to determine if selenium was beneficial in reducing the incidence of diabetes. Instead, selenium supplements were found to increase the risk of diabetes such that the incidence of diabetes in the study was 12.6 cases per 1000 person-years for those receiving selenium supplements compared to 8.4 cases per 1000 person-years in the control population [hazard ratio: 1.55; 95% CI, 1.03 to 2.33]. A significant dose-response (P: 0.038) across tertiles of baseline plasma selenium levels was observed with the top tertile having statistically significant increased risk for type 2 diabetes [hazard ratio: 2.70; CI, 1.30 to 5.61].

A second randomized, placebo-controlled selenium supplement (200 µg/day) trial was conducted with 35,533 men from the US, Canada, and Puerto Rico (*Selenium and Vitamin E Cancer Prevention Trial (SELECT))* and lasted 5.5 years.[34] The study was designed to determine the effect of selenium or vitamin E on the incidence of prostate cancer. The study found no beneficial effect of selenium supplements on reducing the incidence of prostate cancer. The study did find a suggestive, although non-significant, relative risk of 1.07 for type 2 diabetes mellitus (99% CL: 0.94-1.22, p=0.16).

Two of the National Health and Nutrition Examination Surveys (US nationally representative cross-sectional observational study design) found significant positive associations between increased selenium concentrations in blood and the prevalence of diabetes. The 1988-1994 (N=8,876 adults) study reported an adjusted odds ratio of 1.57 [95% CI: 1.16 –2.13] for selenium levels being positively associated with increased prevalence diabetes.[35] The 2003-2004 (N= 917

[33] Stranges S, Marshall JR, Natarajan R. et al. 2007. Effects of Long-Term Selenium Supplementation on the Incidence of Type 2 Diabetes A Randomized Trial. Ann Intern Med. 147:217-223.

[34] Lippman SM, Klein EA, Goodman PJ et al. 2009. Effect of Selenium and Vitamin E on Risk of Prostate Cancer and Other Cancers The Selenium and Vitamin E Cancer Prevention Trial (SELECT) JAMA. 301(1):39-51.

[35] Bleys J, Navas-Acien A, Guallar E. 2007. Serum selenium and diabetes in U.S. adults. Diabetes Care 30:829–834.

adults) study reported adjusted odds ratio of 7.64 (95% CI: 3.34–17.46) for diabetes comparing the highest quartile of serum selenium (≥ 147 µg/L) with the lowest (< 124 µg/L).[36]

In healthy individuals with selenium sufficient diets, increasing selenium exposure may either have no added benefit or contribute to negative health outcomes. The use of selenium supplements to treat certain types of cancer or other illnesses should only be done under the care of a physician.

Interim Fish Consumption Screening Value Calculation

MDCH used the US EPA RfD/ATSDR MRL of 0.005 mg/kg/d to calculate fish tissue concentrations that would not be expected to result in adverse health effects when eaten regularly. Given both the risks and benefits of selenium related to cancer, no cancer slope factor for selenium is reported by the US EPA.

The screening value calculation uses the following equation:

$$(RfD*BW*RSC*AT)/(EF*ED*IR) = FCSV \qquad \text{Eq. 1}$$

where

RfD:	0.005 mg/kg/day
Body Weight (BW):	70 kg
Relative Source Contribution (RSC):	0.69 unitless
Averaging Time (AT):	1,825 days
Exposure Frequency (EF):	52 meals per year 12 meals per year 6 meals per year
Exposure Duration (ED):	5 years
Ingestion Rate (IR):	0.23 kg
Fish Consumption Screening Value:	ppm (see Table 5)

The body weight is for an adult and is not specific to gender.[37] The relative source contribution is calculated based on people ages 16 to 69 years that had an average selenium intake of 122 µg/day, which is 31 percent of the adult UL (1 – 0.31 = 0.69). Averaging time and exposure duration are set to five years.[38] The ingestion rate is eight ounces (0.23 kg) of fish weighed prior to cooking. MDCH has selected the meal frequencies to match the current Michigan fish consumption advisory structure. The no restriction meal category represents three or more meals per week.

---

[36] Laclaustra M, Navas-Acien A, Stranges S, et al. 2009. Serum Selenium Concentrations and Diabetes in U.S. Adults: National Health and Nutrition Examination Survey (NHANES) 2003–2004. Environmental Health Perspectives. 17(9): 1409-1413

[37] Please note that while these interim screening values were calculated for adults, values for children would be similar as a child's smaller portion size offsets the smaller body weight. Interim screening values may be replaced by values specifically for children or women of childbearing age as MDCH updates its risk assessment practices for fish consumption advisories.

[38] Exposure duration does not affect the screening value because it cancels with averaging time.

Table 5. Interim fish consumption screening values for total selenium.

Meal Category	Total meals per year	Selenium Fish Consumption Screening Values µg/g wet weight[39]
No Restrictions	not applicable	less than or equal to (≤) 2.5
One meal per week	52	greater than (>) 2.5 to ≤ 7.4
One meal per month	12	> 7.4 to ≤ 32
Six meals per year	6	> 32 to ≤ 64
Do not Eat	0	> 64

These FCSV are considered interim and may be updated based on changes to the fish consumption advisory program or more recent scientific literature.

Uncertainties

The following uncertainties may result in either an under or over estimate of risk and are provided to allow a better understanding of the limits of the screening values.

1. The specific chemical speciation of selenium is not reported in most studies. The toxicological differences between chemical forms of selenium are not well described and can not be accounted for in a risk assessment.

2. The reference dose is based on clinically observable symptoms. A few recent publications suggest that less easily observed clinical outcomes may occur at chronic exposures less than the reference dose. However, the available information is limited on these recent findings and not sufficient to warrant a revision of the current reference dose.

3. Although the screening values are established to be protective of the public, it is not possible to unequivocally state that any single screening value is absolutely safe for everyone.

Conclusions

Fish fillets harvested from Goose Lake (Marquette County) have elevated selenium concentrations. Selenium should be included in the Michigan Fish Consumption Advisory Program and the Goose Lake fish fillet samples need to be assessed within that program.

Public Health Action

MDCH will incorporate these selenium FCSVs into the Michigan Fish Consumption Advisory Program and selenium fish consumption advisories will be first issued in 2010 as appropriate.

[39] micrograms of selenium per gram of wet weight of fish fillet

Attachment A
Fillet selenium concentrations and descriptive information for each fish collected from Goose Lake.

Species (number)	Sex	Length cm	Weight g	Selenium µg/g
Northern Pike				
1	M	55.0	1250	8.0
2	F	57.1	1410	6.5
3	F	57.5	1340	11.2
4	F	57.6	1300	12.2
5	M	59.4	1560	11.9
6	M	61.0	1560	11.6
7	M	62.0	1600	8.8
8	M	64.0	1600	9.8
9	F	63.6	1900	10.5
10	-	68.4	2160	5.0
White Sucker				
1	F	36.5	520	12.3
2	F	36.0	600	13.1
3	M	39.1	840	12.0
4	M	41.4	730	13.3
5	F	40.6	920	9.1
6	F	42.0	940	12.2
7	F	43.0	920	11.0
8	M	46.2	1230	12.1
9	F	48.4	1340	10.6
10	F	50.2	1540	11.2

Attachment B
Fillet selenium concentrations and descriptive information for each fish collected from Schweitzer Reservoir.

Species (number)	Sex	Length cm	Weight g	Selenium µg/g
Northern Pike				
1	M	44.4	550	1.7
2	M	48.1	640	1.9
3	F	48.6	810	1.9
4	M	76.9	2680	2.4

Certification

The Michigan Department of Community Health prepared this Health Consultation, Goose Lake Selenium, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). At the time this Health Consultation was written, it was in accordance with the approved methodologies and procedures. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

for AY

Team Leader, Cooperative Agreement Team, CAPEB, DHAC, ATSDR