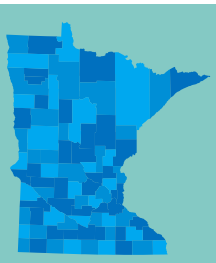
Fish consumption

November 2022

Interim fish consumption rate for women of childbearing age

Water quality criteria – Minn. R. chs. 7050 and 7052

MINNESOTA POLLUTION CONTROL AGENCY



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- Updated description of appropriate fish types considered
- Made a few formatting edits

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Executive summary

Site-specific Water Quality criteria (WQC) can be developed based on human health-based water quality standards (HH-WQS) methods in Minnesota Rule chapters (Minn. R. chs.) 7050 and 7052. WQC are a tool under the Clean Water Act for addressing pollutants in Minnesota's fish and water that lack numeric standards in rule. Updated and new WQC are needed for perfluorooctanoate (PFOA), perfluorooctane sulfonate (PFOS), and possibly other per- and polyfluoroalkyl substances (PFAS). The Minnesota Department of Health (MDH) characterizes both chemicals as having Developmental Health Endpoints (MDH 2017a and 2019b), so appropriate fish consumption rates (FCR) are needed for women of childbearing age (WCBA)—the subpopulation of fish consumers whose exposure to fish pollutants is directly proportional to prenatal through postnatal exposure and susceptibility of their infants to adverse or toxic effects.

The HH-WQS methods include a default FCR for adults, but this rate was not based on data specific to WCBA; the HH-WQS technical support document stated that if a pollutant affects development and prenatal to postnatal (gestational to lactational) exposure is relevant to the toxicity profile of the pollutant, the Minnesota Pollution Control Agency (MPCA) would review available fish consumption survey and exposure data to determine if the default adult FCR[1] was representative of WCBA, or if an alternative rate was needed (MPCA 2017). In addition, many surveys find that about 40% of WCBA are not familiar with fish consumption advice−outreach designed specifically for avoiding excess exposure to fish pollutants (MDH 2012 and Connelly et al. 2012 and 2017); therefore, having accurate and reliable FCR to develop HH-WQS, institutional controls, or cleanup goals for fish and water pollutants is crucial to protecting fish consumers' health. PFOS in particular is a pollutant of concern to WCBA, because it can accumulate to high concentrations in fish species lower on the food chain. These species are typically recommended for frequent consumption by women and those who are pregnant or are considering pregnancy because fish are a source of essential nutrients and lipids, with these species also being lower in mercury and polychlorinated biphenyls (PCB).

The MPCA default FCR (adult and child) reflect upper percentile freshwater-caught fish consumption rates and patterns of consumption by trophic level[2]. MPCA recognizes the cultural importance and popularity of fishing warrants a high level of protection for Minnesota's fish consumers (MPCA 2017). The U.S. Environmental Protection Agency's (EPA) Office of Water also sets guidance and publishes national default FCR for states and tribes to develop water quality criteria and standards based on requirements of the Clean Water Act Section 304(a), including ensuring protection for high-end freshwater consumers who want to catch and eat

EPA default fish consumption rates

In 2014, EPA published a new review of national data collected by the Centers for Disease Control and Prevention (CDC) through the National Health and Nutrition Examination Survey (NHANES) on fish and shellfish consumption (see Table 1). This dataset provided the basis to develop a default FCR for the United States' general population for use in updating national 304(a) criteria for human health (USEPA 2014). The default rate—the 90th percentile for adult men and women—was 22.0 g/d. The report also includes FCR by narrower demographics and fish and shellfish types. However, this EPA analysis, unlike past, did not use individual body weights and did not calculate values for WCBA based on ethnicity/race.

[1] The adult FCR (default) is 0.43 g/kg-d (30 grams of fish consumed per day using 70 kg average adult body weight).
[2] MPCA's FCR assume 74% of fish consumed are in trophic level 4 (typical predator species, like walleye, bass, trout, and northern pike) and 26% are in trophic level 3 (includes bottom feeders and pan fish, like carp, catfish, bluegill sunfish, perch, crappie, and lake herring).

freshwater or estuarine fish or shellfish anywhere in the United States (see sidebar).

Using the best available and reliable data for this limited review to meet MPCA and EPA's protective goals for HH-WQS, an interim FCR for WCBA (FCR_{WCBA}) of 66 g/d and 70 kg bodyweight[3] (0.94 g/kg-d or 0.00094 kg/kg-d) will be applied to account for reasonable maximum exposure[4] to WCBA (ages 16 to 50) in Minnesota that consume freshwater fish. This FCR is based on the MDH *Fish are Important for Superior Health* (FISH) survey of North Shore Minnesotans (see, Table 1) and also reflects similar rates found in other surveys of Minnesotan WCBA (see Table 2: MPCA Eco Experience 2014, 2015). The detailed FISH survey was conducted in a clinical setting with trained health professionals supporting accurate data collection from almost 500 Minnesotan WCBA (MDH 2017b). This FCR will be an interim rate used in WQC for pollutants characterized as developmental toxicants to ensure reasonable maximum protection from adverse health effects for babies whose mothers eat fish and shellfish as part of a healthy and balanced diet.

Methods and EPA Clean Water Act National Guidance

The methods to develop Class 2 numeric, water quality criteria or standards to protect human health (HH-WQS) are found in Minn. R. 7050.0217 to 7050.0219 for statewide application and Minn. R. 7052.0110 for the Lake Superior Basin. Based on the HH-WQS methods and the supporting guidance, *Human Health-based Water Quality Standards Technical Support Document* (MPCA 2017), development of an intake rate for fish consumption considers a breadth of readily available and reliable data and guidance from the EPA. The EPA's Office of Water publishes national default intake rates for states and tribes to develop water quality criteria and standards based on requirements of the Clean Water Act Section 304(a) (see previous sidebar). However, EPA recommends the use of local, state, or regional data in a state's HH-WQS, to more accurately capture fish consumption patterns, particularly related to fish caught for recreational or subsistence purposes by subpopulations of consumers with cultural, racial/ethnic, or socioeconomic differences, and local fishing habitats (freshwater vs. estuarine/marine) that can differ from broad national surveys (USEPA 2016). EPA's most recent guidance states:

> "EPA recommends that states and authorized tribes consider developing criteria to protect highly exposed population groups and use local or regional data in place of a default value as more representative of their target population group(s). The preferred hierarchy is: (1) use of local data; (2) use of data reflecting similar geography/ population groups; (3) use of data from national surveys; and (4) use of EPA's default consumption rates." (USEPA 2014)

Minnesota's HH-WQS methods define intake rates based on the route of exposure (ingestion, inhalation, dermal contact) and express the amount of a media taken in, on a per body weight and daily basis, for a specified duration (Minn. R. 7050.0218, subp. 3. FF). Two defaults FCR are included in the methods (MPCA 2017):

[3] While EPA has recommended use of a higher body weight from NHANES for developing water quality criteria or standards (USEPA 2015)—the latest NHANES would suggest use of a 74 kg body weight (average age-adjusted from 16 to 50 from Table 8-5, USEPA 2011)—this rate is not specific to fish consumers and use of the standard 70 kg body weight is the standard assumption used for assigning a portion size of 227 g to fish meals.

[4] In the EPA's human health guidance for Superfund sites, reasonable maximum exposure (RME) is defined as the highest exposure that is reasonably expected to occur at a site. The estimate considers current and future exposure scenarios (USEPA 1989).

FCR_{adult} = fish consumption intake rate of 0.00043 kg/kg-d based on 0.030 kg/day of amount of fish consumed per day and 70 kg adult body weight or rate may be chemical-specific with sufficient data, and

FCR_{child} = 0.00086 kg/kg-d for application for children age group of 1 through 5, or when needed to address more children's age groups, such as with linear carcinogens and Age-Dependent Adjustment Factors (ADAF), these rates were developed: $FCR_{0<2}$ = 0.00086 kg/kg-d and $FCR_{2 \text{ to } < 16}$ = 0.00055 kg/kg-d.

The MPCA developed these rates to reflect upper percentile freshwater-caught fish consumption rates from regional survey results. The MPCA has established that the cultural importance and popularity of fishing warrants a higher level of protection for Minnesota's fish consumers (MPCA 2017). The adult FCR, however, was not based on data specific to women of childbearing age (WCBA); most recently, WCBA or women or those who are or plan to become pregnant, are defined as ages 13 to 50 (USEPA 2014). The HH-WQS method guidance document states that if a pollutant affects development and *in utero* exposure is relevant to the toxicity profile of the pollutant, MPCA would review available survey and exposure data to ensure the adult FCR is representative of WCBA (MPCA 2017). WCBA are considered an important subpopulation of fish consumers, because their environmental pollutant exposure directly influences fetal development, growth, and health outcomes, and thus, have had a significant amount of study and outreach related to their patterns of fish and shellfish consumption (USEPA and FDA 2017).

The most recent EPA guidance directs states and tribes to develop FCR that account for all freshwater fish, and estuarine fish and shellfish consumption (USEPA 2013a). EPA's broad goal is to ensure most people (based on upper percentile intake rates, typically at 90th percentile) eating caught-fish and shellfish can consume them in any US waters, based on their typical consumption rates and still maintain total exposure to bioaccumulative pollutants below adverse risk levels. EPA accounts for consumption of marine fish only in the relative source contribution (RSC) factor (USEPA 2013a and 2015). The MPCA HH-WQS methods were developed based on freshwater fish consumption rates only, with estuarine fish, shellfish, and marine fish consumption all included in the RSC. However, like EPA's objective for public health protection, MPCA's FCR need to use the best data to protect high-end freshwater fish consumers across Minnesota. The presence of a bioaccumulative pollutant in different trophic levels of fish also needs to be factored into final FCR and RSC (i.e., lack of presence of a pollutant in fish by trophic level or shellfish should be considered). Evaluation of these two exposure parameters is conducted specifically based on the best available data for WCBA and the pollutant under review for HH-WQS.

The development of site-specific Water Quality Criteria (WQC) based on the methods in Minn. R. 7050.0217 to 7050.0219 are relevant for addressing pollutants in fish and water that lack listed numeric standards in Minn. R. 7050.0222. Updated and new WQC are needed for perfluorooctanoate(PFOA), perfluorooctane sulfonate (PFOS), and possibly other poly- and perfluoroalkyl substances (PFAS). Because the Minnesota Department of Health (MDH) has characterized both chemicals as having *Developmental Health Endpoints* (MDH 2017a and 2019b), a review of readily available data on FCR for WCBA was conducted. The main goals of this limited review is to determine if 0.00043 kg/kg-d (0.43 g/kg-d) reflects an upper percentile FCR for this subpopulation of fish consumers. MPCA programs need WQC for decision-making; more in-depth review will take more time in order to obtain and fully analyze additional survey data for more complete statistics and to consult with Minnesota Tribal (both the Fond du Lac and Grand Portage Bands of Lake Superior Chippewa have water quality standards and FCR) and other subsistence freshwater fish-eating communities for additional information prior to any future FCR or numeric standards for fish pollutants are adopted into rule.

Surveys on fish consumption by women of childbearing age

The main sources of readily available and reliable fish consumption datasets are from surveys conducted since 2000 by or in cooperation with the MDH or from the Centers for Disease Control and Prevention's (CDC) National Health and Nutrition Examination Survey (NHANES)(Table 1). These studies represent the most recent and comprehensive evaluations of fish consumption data for WCBA in Minnesota and Great Lakes Region, and nation, respectively. Supplementary information reviewed in Table 2 includes a 2005 University of Minnesota report to the Minnesota Department of Natural Resources (DNR)[5], unpublished surveys for the MPCA of visitors to the Eco Experience Building at the Minnesota State Fair in 2014 and 2015, and two subsistence population studies: 2014 Fond du Lac community biomonitoring and 2017 University of Wisconsin-Madison survey[5]. An earlier study of WCBA and Tribal Community— Benson and co-authors (2001), also known as the Energy and Environmental Research Center study —was also included because of extensive review by EPA in the 2011 *Exposure Factors Handbook* and other publications as summarized in MPCA 2017.

Like most foods, people may regularly consume fish and shellfish, but few people eat these foods every day. The intermittent nature of food consumption, as compared to drinking water consumption that occurs daily, is addressed in how fish consumption surveys are designed and the results analyzed (USEPA 2011 and 2014). Intermittent food consumption is statistically modeled into daily rates (grams per day) depending on the way the survey reported people's consumption. Most surveys on fish consumption ask about number of meals eaten over a defined timeframe and may specifically evaluate timeframes shorter than or up to a year. For example, the MDH *Fish are Important for Superior Health* (FISH) survey asked about usual, seasonal consumption, because research has found people tend to eat more freshwater caught-fish in the open-water fishing season, and annual consumption (MDH 2017b). The NHANES survey uses a standardized survey method to ask about food, water, and beverage consumption on two separate days in a three to ten-day window (USEPA 2014). The survey is extremely well designed and comprehensive; there are also biological samples collected to evaluate environmental chemical exposure and health status. The National Cancer Institute (NCI) published an in-depth and well-tested statistical model in 2005 to develop "usual" consumption rates (UCR). The EPA's Office of Water Methods are based on NCI's model and were used to develop the national default FCR for use in HH-WQS (USEPA 2014). However, EPA guidance continues to place a higher weight on local to regional FCR data over national defaults when states or tribes derive water quality standards. The exact methods used by NCI and EPA are time and resource intensive, so to-date, have been rarely used outside of the EPA's 2014 report to evaluate NHANES survey data on fish and shellfish consumption.

A key finding from review of the surveys summarized in Table 1 is that most WCBA eat some fish and shellfish, whether or not they have a fishing license (74% in NHANES surveys, 100% in Great Lakes Regional diary survey). Surveys of fish consumers regularly categorize the fish consumed by the type of fish (finfish or shellfish); whether the fish were caught or purchased (store or restaurant); and habitat of the fish (marine, estuarine, or freshwater). Based on the general population of fish and shellfish consumers from national surveys, purchased marine fish[6] often accounts for about half of the total fish

[5] Studies recommended for review by the Minnesota DNR.

[6] For more information on habitat apportionment fish and shellfish, see USEPA 2014.

consumed, with the combined freshwater, estuarine, and shellfish making up the other half. Freshwater caught- or purchased-fish tends to account for the smallest portion of total fish and shellfish consumed and is often equal to or slightly less than consumption of estuarine fish and shellfish (caught or purchased)[7]. However, when datasets are available to characterize fish consumption by habitat for upper percentile freshwater fish consumers, the relative comparisons can differ. The Connelly et al. 2017, MDH with Turyk 2017, and Cusack et al. 2017 survey results determined that freshwater caught-fish (plus purchased when recorded) can be as high as 30 to almost 50% of the total amount of fish consumed. More information on this topic is covered in a later section, *Further Discussions*.

A high percentage of women surveyed in Minnesota eat freshwater, caught-fish, from 41 to 83% depending on the survey, with the highest percentage being for WCBA on Minnesota's North Shore (see Tables 1 and 2). Many of these surveys also evaluate understanding and behaviors around fish consumption advice (FCA), with the goal being to have all fish consumers eating fish and shellfish that are low in mercury and other contaminants to attain the most health benefits. Overall, the surveys find that about 40% of WCBA are not familiar with FCA (MDH 2012 and Connelly et al. 2012 and 2017). Therefore, having a reliable FCR to develop HH-WQS or clean-up goals for fish and water pollutants is very important: even if control measures can take years to reduce pollutants below these levels. Exceedance and identification of impairment status of these regulatory values under the Clean Water Act provide important context to the extent of pollution problems and help with implementation of institutional controls and best management practices to protect public health.

Standard serving or portion sizes

The serving or portion size used most often as a baseline for the surveys and in fish consumption advice (FCA) is a half-pound or 8-ounce (oz.) portion of uncooked fish or shellfish (USEPA 2000b). This is often equally referred to as a 6 oz. piece of cooked fish in survey questions (subtracts moisture and lipid loss in preparation). Converting these amounts to grams equals 227 or 170 grams, respectively. When considered in grams per day based on the threshold of one meal per week (used in FCA), the amounts are 32.4 and 24.3 g/day. FCA scales serving size to body weight and so pairs the 8 oz. or 227 g serving size with 150 lb. (70 kg) body weight (MDH 2018a). The MPCA"s default adult FCR is calculated using 30 g/day (210 g/week) also paired with an average adult body weight of 70 kg for the final rate of 0.43 g/kg-d.

As summarized in Table 1, the types of datasets and statistics used to evaluate FCR for WCBA varied. The key elements from these available and reliable surveys for the purpose of developing a fish consumption rate for WCBA included:

- Targeting freshwater caught-fish consumers: Minnesotan and Great Lakes WCBA that have fishing licenses, and more broadly, WCBA that may or may not fishing licenses, but were pregnant or just gave birth

[7] Based on the EPA's assignment of regularly consumed fish and shellfish by habitat, most estuarine species eaten are shellfish (shrimp, crab, mussels, and clams). In surveys, shrimp is often found to be one of the most frequently consumed purchased fish or shellfish. Shrimp is thought to have been chosen as a replacement for canned tuna by some consumers because of extensive outreach recommending increasing consumption of lower mercury seafood in place of high mercury fish species, like tuna. Few estuarine fish are consumed, except tilapia, which is assigned 50% to estuarine and 50% to marine habitats. Most studies do not ask specifically about tilapia consumption but do about shellfish. Using data that records shellfish consumption is a reasonable and reliable estimate of total estuarine fish and shellfish consumption.

- Capturing information for a large number of Caucasian WCBA, both in state, regional, and national surveys
- Providing some quantitative, but also significant qualitative data to consider ethnic differences in fish consumption rates for Native American, Asian, Hispanic/Latina, and African American WCBA
- Categorizing fish and shellfish consumed
- Providing estimates of portion sizes for fish and shellfish meals

Some general limitations in the surveys relate to:

- No survey had the specific objective of defining high-end freshwater caught-fish consumers in Minnesota
- Data specific to WCBA across Minnesota's racial/ethnic minorities, socioeconomic status, or regional cultural differences in fishing habits and freshwater and total fish consumption
- Participant's body weight with consistent estimates of portion size
- Complete recording of categories of fish and shellfish consumed (not all asked about self-caught or freshwater purchased, such as walleye eaten in restaurants, or freshwater species)

Further discussions: addressing uncertainties in available survey data

As previously described, for some subpopulations of fish consumers, caught-fish can comprise a higher amount of total fish consumed. Surveys often ask racial or ethnic identity, because of relationships to patterns of fish consumption that can differ between Caucasians (non-Hispanic white) and other groups (USEPA 2016). Of the key datasets with complete data and evaluation by fish and shellfish categories, national evaluations using NHANES can provide statistics for a comparison of WCBA by race/ethnicity. One such evaluation of WCBA using NHANES provides more quantitative data on upper percentile FCR, Cusack et al. 2017. In this study, upper percentiles were calculated based on race (personal communication). Their methods for calculating FCR are defensible, but did differ from the USEPA 2014 report, which has developed a research-based statistical method specifically to support development of WQS based on the NCI "gold-standard" model for evaluating the data collected in NHANES to develop UFCR. The Cusack et al. finding offers important context about the upper-percentile consumption of total fish and shellfish by habitat: African American and "Other" race, including Asians and Native American, WCBA consumed more freshwater fish-meals than Caucasian, Mexican American, and other Hispanic WCBA. When considering shellfish consumption, participants categorized as "Other" race had the highest number of shellfish meals consumed per person.

Of the Minnesota and Great Lakes Regional studies, the MDH *Minnesota Family Environmental Exposure Tracking* (MN FEET) study provides some information on racial/ethnic differences in total fish and shellfish consumption, but not by habitat or source (caught or purchased), due to problems with the survey instrument (Personal communication Nelson and Lindstrom 2018). Consistent with the NHANES surveys, Asian, African American, and Latina women in the Minneapolis/St. Paul Metropolitan area ate much higher amounts of total fish and shellfish than Caucasian women. The other Minnesota or Great Lakes surveys either did not report results by race/ethnicity (MDH FISH study, which did include Native American women) or had a very small number of women that were non-white. The study with Fond du Lac Tribal members was informative for FCA, but because the tribal community had not fished walleye from Lake Mille Lacs that year, the study does not provide reliable information for UFCR.

Other demographic factors can also influence the amount and type of fish or shellfish consumed by WCBA: age, socioeconomic status, and regional culture or traditions related to fishing (USEPA 2016). On

the national level, EPA published information on fish consumption by some of these factors based on NHANES (USEPA 2014).

Supporting information: Benefits of eating fish

While risk assessment primarily uses exposure information that represents or estimates population characteristics, such as upper percentile FCR, average body weight, etc., when public health protection is prioritized and statistical survey data are limited, other information can become more relevant for policy decisions. For example, detailed evaluations of WCBA and their fish consumption patterns has led to important outreach by MDH, Federal agencies, and health organization (American Heart Association) to highly recommend WCBA eat more fish than usually consumed. Eating fish and shellfish low in mercury and other contaminants has multiple health benefits, including for brain and nervous system development in babies and cardiovascular function in adults. The EPA, Food and Drug Administration (FDA), and United State Department of Agriculture (USDA) recommend that women who are or may become pregnant not just limit their intake of certain fish species, but actually eat two to three 4 oz. servings per week or approximately 8 to 12 oz. (uncooked)[8] of fish and shellfish low in mercury (USDA 2015, USEPA and FDA 2017). The American College of Cardiology with the American Heart Association recommend women consume two 3.5 oz. servings (as consumed or in cooked weights)[9] of fish per week (ACC/AHA 2013) because fish and shellfish have important essential fatty acids and other nutrients that are not readily available in other proteins, foods, or supplements.

In the development of a FCR for WCBA, it is also important to consider state-specific information on recommended fish species for consumption. MDH's statewide fish consumption advice for sensitive populations (children and WCBA) recommend weekly consumption of crappie, sunfish (such as bluegill), and yellow perch (MDH 2018a). This advice is based on fish species with lower statewide average mercury concentrations. Younger, smaller fish and species lower on the food chain accumulate less mercury. However, MPCA studies on fish find that these same species can have significant accumulation of PFOS (MPCA 2018b). Therefore, it is reasonable that the WQC for PFOS ensure that this sensitive population should at least be able to consume fish based on statewide advice after remediation and pollution reduction measures.

Conclusion: Interim fish consumption rate for women of childbearing age (FCR_{WCBA})

All the survey data available provide sufficient information for an interim freshwater caught FCR for WCBA. The datasets cover information on Minnesotan and Great Lakes WCBA with fishing licenses and other subpopulations of women that might eat more fish and shellfish, either for subsistence or cultural reasons (North Shore Minnesotans, including local Native Americans, and urban minorities) to use in HH-WQS. The most relevant and reliable survey data came from the *MDH Fish are Important for Superior Health* (FISH) survey and Great Lakes WCBA diary survey (Connelly et al. 2017). While these surveys did not directly recruit high-end freshwater fish consumers, they did include reasonable representative samples of Minnesota and Great Lakes WCBA, respectively, who consume freshwater fish and other fish and shellfish.

The MDH FISH and Great Lakes WCBA diary surveys had many strengths. The Great Lakes WCBA diary survey specifically targeted women ages 18 to 48 who had fishing licenses and lived in Minnesota and seven other states bordering the Great Lakes. The diary study included regular and consistent tracking of

[8] Eight to twelve ounces of fish and/or shellfish consumed a week is equivalent to 227 to 340.2 g/week or 32.4 to 48.6 g/d.

[9] In uncooked weights, seven ounces equates to 9.33 ounces or 265 g/week or 37.9 g/d.

all fish and shellfish consumed with estimates of portion size. The results of this survey found women participating (95% Caucasian) consumed less than 30 g/d (20.7 g/d at the 90th percentile) of total freshwater fish based on the reported portion size. The average portion size was 157-166 g for caught fish. In comparison, the MDH FISH survey, which exclusively involved WCBA (ages 16 to 50) residing on the North Shore of Minnesota, their upper percentile freshwater fish consumption was much higher at 66.2 g/d. The FISH study statistics were based on the standards portion size of 227 g paired with the number of freshwater fish meals eaten to avoid the association of portion size with body weight: a standard average body weight (70 kg) is applied to the final FCR. Based on actual estimates of portion size by participants (assumed to be as prepared), the average portion was only slightly less at 214 g (adjusted to uncooked or raw, 265 g).

The higher amount of fish eaten in the FISH study is consistent with the fact that study participants include Native American WCBA. Based on data from NHANES (USEPA 2014), there is also evidence that non-Caucasian youth, women of any age, and men eat more freshwater fish and shellfish than Caucasians; therefore, while the Connelly et al. (2017) diary study provides a robust estimate of an upper percentile amount of freshwater fish consumed by Caucasian WCBA with fishing licenses, this amount and dataset may not represent freshwater fish consumption for WCBA of other Minnesotan local or regional cultural or racial/ethnic consumption patterns. MDH MN FEET survey, the only Minnesota survey with data on non-Caucasian fish consumption patterns (East African, Asian, and Latina WCBA) only had reliable results for total fish and shellfish consumption (Personal communication Nelson and Lindstrom 2018). If you assume the highest proportion of their total consumption being attributed to freshwater fish at 50%, then the highest 90th percentile value would be for East African WCBA approximately 48.7 g/d.

The MPCA is committed to ensuring environmental justice in our work to protect all Minnesotans (MPCA 2018a). MPCA has a published a story map of areas of concern in the state where the number of people of color exceed 50% and/or more than 40% of the households have a household income of less than 185% of the federal poverty level. This information and others, such as from national census survey data (Statistical Atlas 2018), is important to updating and applying exposure rates in HH-WQS, in this case for fish consumption patterns for WCBA of different cultural, ethnic, and economic backgrounds. In addition, the overarching goal of FCR are to ensure any freshwater fish consumer in Minnesota or regionally can eat caught-fish in any waterbody and maintain their total exposure to fish contaminants below adverse health effect thresholds, and so consider the data available from the North Shore and other Minnesota and Great Lakes Regional surveys applicable for statewide application (USEPA 2013a and 2014).

To meet the EPA and MPCA's protective goals for HH-WQS, by making the best use of the available and reliable data, a FCR for WCBA of 66 g/d and 70 kg bodyweight[10] (0.94 g/kg-d or 0.00094 kg/kg-d) will be applied to account for reasonable high-end exposures[11] to WCBA in Minnesota based on reliable and available data from MDH FISH survey of North Shore Minnesotans. The age range for this rate will be

[10] EPA has recommended use of higher body weight from NHANES for developing criteria or standards (USEPA 2015). The latest NHANES would suggest use of a 74 kg body weight (average age-adjusted from 16 to 50 from Table 8-5, USEPA 2011), but this not specific to fish consumers and use of the standard 70 kg body weight is the assumption used for assigning a meal 227 g to not double-count portion size and weight in the survey statistics.

[11] In the EPA's human health guidance for Superfund sites, reasonable maximum exposure (RME) is defined as the highest exposure that is reasonably expected to occur at a site. The estimate considers current and future exposure scenarios (USEPA 1989).

16 to 50 years old, since the key surveys did not include girls younger than 16. A previous review of MPCA of children's fish intake found on a per body weight basis, combined freshwater fish consumption for females and males older than 6 was similar to the adult rate of 0.43 g/kg-d, also supporting an application of this interim FCR to an age range of 16 to 50. This detailed survey was conducted in a clinical setting with trained health professionals supporting accurate data collection on almost 500 Minnesotan WCBA (MDH 2017b). The weight of evidence of the available data also support use of this interim FCR_{WCBA}:

- Additional Minnesota-specific survey data point to higher freshwater fish consumption intake for some Minnesotan WCBA (MDH MN FEET survey from Table 1; MPCA Eco Experience Surveys and Benson 2001 from Table 2)
- Other reliable surveys have rates that are both lower and higher (see Tables 1 and 2)
- None of the available surveys specifically targeted high-end fish consumers, so that subpopulation may be underrepresented in the available data
- At a minimum, species of fish typically low in mercury (crappie, bluegill sunfish, and yellow perch), should be consumable at the statewide MDH FCA of one meal per week (32.4 g/d or 0.46 g/kg-d with 70 kg body weight) in PFAS contaminated waters
- Based on recommended consumption amounts for WCBA to obtain the greatest health benefits to developing babies, the rate of 12-ounces per week of total fish/shellfish equates to 48.6 g/d or 0.69 g/kg-d with 70 kg body weight, even if most WCBA are not currently eating that much freshwater fish, it is reasonable from a public health perspective to ensure fish are available in amounts that do not result in health effects to the mother or her child from industrial pollution
- And future updates to FCR in HH-WQS methods in rule need to also consider adding in estuarine fish and shellfish consumption, thereby also increasing the existing rates

Table 1 Key findings published on regional fish consumption patterns

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information (*D-discrete values based on questions of number of meals eaten per time frame and use of 227 g for portion size;* *C- continuous data based on refined measures of portion size and could include use of participants' body weight*)
Minnesota Survey: MN FEET (Urban study of women of childbearing age and exposure to mercury, lead, and cadmium) **MDH (J. Nelson and W. Lindstrom) 2018b and 2019a**	Biomonitoring survey of pregnant women (777) using certain Health Partners and West Side Community Health Services Clinics in Hennepin, Ramsey, and Washington Counties from 2015 to 2017. The women included Caucasian, Asian (75% Hmong), East African (mostly Somali), and Latina ethnicities from ages 16 to 45.	The women completed a survey prior to delivery of their babies. Because mercury is a target environmental chemical they were asked questions about fish and shellfish consumption. The online survey was available in multiple languages and 53% of the women chose the English survey with the remaining 47% taking the survey in Somali, Hmong, or Spanish. An error in the survey meant not all the questions on fish consumption were answered as planned, so information is only accurate for the total fish and shellfish and tuna consumption results. • In general, eighty percent of the participants ate some fish or shellfish (no specific recall window was used). • Based on the four ethnicities, East African women had a higher percentage of nonconsumers than average (32.9%). • The highest consumption category of > 2 meals per week had the highest percentage of consumers in this category for Asian women at 19.6% and lowest for Caucasian women at 10.2%. The relationship to mercury exposure in the women's babies, those with the highest cord blood concentrations, was associated with ethnicity (Asian) and number of meals per month of high mercury fish species. This finding is important for mercury exposure because the type of fish eaten, not just the amount, can be an equally important factor in WCBA exposure to fish pollutants.	*D* Based on consumers only of total fish and shellfish for WCBA, the following statistics by ethnicity (N) are for mean, medians, 80th, and 90th percentiles: Asian (120): 36.4, 22.4, 64.9, and 64.9 g/d Caucasian (185): 28.5, 32.4, 22.4, and 64.9 g/d East African (55): 53.2, 32.4, 64.9, and 97.3 g/d Latina (263): 31.9,32.4, 48.6, and 64.9 g/d In addition, percentage of women by ethnicity that ate 2 or more meals of fish and/or shellfish per week are 23, 12.4, 22, and 17.5%, respectively.
Minnesota Survey: PFC	Biomonitoring studies included long-term and new residents in Oakdale,	The 2010 and 2014 studies included a few questions about local fishing:	Not available.

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information (*D-discrete values based on questions of number of meals eaten per time frame and use of 227 g for portion size;* *C- continuous data based on refined measures of portion size and could include use of participants' body weight*)
Biomonitoring-East Metro **MDH (J. Nelson) 2017**	Lake Elmo, and Cottage Grove have been conducted in 2008, 2010, and 2014.	• How often did you eat fish or shellfish caught from lakes and rivers in the East Metro area? (2010, 2014 new residents only) • If yes, which lakes/rivers? (2010, 2014 new residents only) • If yes, what types of fish did you eat? (2010 only) Because of the small numbers of participants that had eaten local fish in each of the two years questioned, 7 and 2.4%, respectively, the results were not evaluated further.	
Great Lakes Regional Survey: MDH-GLRI Grant, WCBA **Connelly et al. 2017 (HDRU 16-3, version 2 report plus journal articles) on WCBA diary study and additional statistics from N. Connelly 2018**	In 2014, Women (1,395) of childbearing age (18 to 48- maximum age recruited to not exceed 50 at end of two-year study) participated in a diary study. They lived in a county bordering the Great Lakes (Minnesota was one of 8 states) and had a fishing license. Most of the women (95%) were Caucasian. The statistics reported included all participants and were not presented by race.	The range of total fishmeals during the study was 1 to 92, so 100% of the women ate some fish. In addition, 53% of the women ate sport-caught fish. For each meal reported, participants recorded whether the fish was purchased (at a store or restaurant) or sport-caught (i.e., fish caught by you or someone else), the species eaten, the portion size (assumed cooked), and (for sport-caught fish) where the fish was caught. In terms of percent of meals, Minnesota had the highest percent of sport-caught meals at 30%, with 70% purchased. Table 1 in the study report to MDH breaks out the fish species purchased for all women in the study: top was shellfish at 30.4%; the other estuarine species reported was tilapia (considered 0.5 estuarine) at 5.5%. For marine salmon ranked 2nd at 13.6%, with canned "light" tuna 3rd and canned "white" tuna 5th at 9.7 and 7.6%, respectively.	*C* The portion size reported for sport-caught fish was larger than purchased fish. Table 1 in Connelly 2016 showed the range of average portion size to be 157-166 g for sport-caught fish. When evaluating all participants and all fish consumed during the 16 weeks of year one, the results found that 80th percentile was 29.9 g/day (Table 3 in Connelly 2016; based on estimates of cooked portion size); ninetieth and 95th percentiles when 4 oz. portions were used to represent portion sizes less than the picture, 38.4 and 46.0 g/d, respectively. Additional statistics provided reliable, regional estimates for upper percentile amounts of fish and shellfish eaten by categories (90th and 95th %)in g/d as consumed:

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information (*D-discrete values based on questions of number of meals eaten per time frame and use of 227 g for portion size;* *C- continuous data based on refined measures of portion size and could include use of participants' body weight*)
	GL Diary study only contacted women in English, with 95% of the study participants being Caucasian-study said though only 22 women were not eligible to participate due to language barriers) The report to MDH also included a special Minnesota survey of 16 additional WCBA from Northern Minnesota (Appendix B).	Cod, fish sticks/fast food fish sandwiches, fresh tuna and other purchased fish were ranked next highest. Data presented on average consumers found: in Appendix B, Table B-3 the regular participants compared to a special survey of WCBA in Northern Minnesota not recruited based on purchase of a fishing license, the number of average sport-caught meals over the 16-weeks was 4.4 and 4.9 compared to 10.0 and 7.1 for number of purchased meals over study; average percent of sport-caught was 32.5 and 33.7% for diary participants and special study, respectively. Table B-4 shows that 26% of purchased fish were shellfish. Providing an estimate of amounts eaten in sport-caught plus estuarine as accounting for almost 60% of fish eaten. In Table E4 for WI/MN the percentage of meals with portion sizes > 6 oz. is 25% for sport-caught and 9.8% for purchased. Overall, about 14% of meals, the participants indicated their portion size was larger than the picture; the authors assumed they ate 8 oz. (227 grams) assumed cooked weight.	Freshwater, caught: 11.6 and 16.7 Freshwater, purchased: 1.5 and 3.0 Shellfish+estuarine: 12.2 and 16.7 Total freshwater (caught+purchased) and shellfish: 20.7 and 26.3 Marine: 23.7 and 29.4 Rates of exceedance of state fish consumption guidelines, which include sport-caught fish, were much higher than for purchased fish. One-quarter of WCBA exceeded the state guidelines, with rates as high as 41% exceeding the guidelines in Minnesota. Excess consumption of walleye was most often the reason for advice exceedance (Appendix F). Note: Modeled information reported on in the report based on demographic information found that older, highly educated, non-white women without children living at home averaged 1.5 fish meals/week. However, the published data did not include specific statistics for non-white participants.
Minnesota Survey: MDH FISH	*Fish are Important to Superior Health* (FISH) study of 499 WCBA (16 to 50) using clinics in the	Ninety-six percent of participants had eaten fish in the last 3 months.	*D (Estimates of portion size not use in statistics)* In Table 6 of the technical report, the number of participants that ate portion sizes of 4 oz. (palm-size)/meal is included. That information showed

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information (*D-discrete values based on questions of number of meals eaten per time frame and use of 227 g for portion size;* *C- continuous data based on refined measures of portion size and could include use of participants' body weight*)
MDH and Mary Turyk, MDH 2017b and additional statistics from P. McCann 2017-18	Grand Portage area and Cook county. Study team included Sawtooth Mountain Clinic (SMC), Grand Portage Health Service (GPHS), North Shore Health (NSH), Grand Portage Band of Lake Superior Chippewa Trust Lands, and the Minnesota Department of Health (MDH). The study ran from June 2014 to July 2015. Race was not included in the demographics presented per study design. (MDH FISH used local trained health professionals to administer survey.)	Summary information stated 73% of women ate sport-caught fish from Lake Superior (a higher percentage than most surveys that include WCBA). Meals of fish that were caught, not purchased, comprised 35% of total fishmeals. Table 4 in Technical Report provides mean and maximum number of fishmeals eaten per species in the 3-month window; walleye, lake herring, and whitefish ranked fourth to sixth most consumed meals after canned tuna, shellfish, and salmon. Note: Walleye was asked about separately from source (purchased or caught) so could be purchased and not from Minnesota waters. Sixty percent of participants ate two or more palm-sized portions (est. 4 oz. or greater) of fish. Local fish consumption, especially of lake trout, showed an association with elevated blood mercury.	differences in average blood mercury as the number of portions increased. In addition, using this information the estimated average cooked, portion size based on recall for any fish or shellfish was 214 g. Additional statistics provided the best estimates for upper percentile amounts of fish and shellfish eaten by categories (80^{th} and 90^{th} %)in g/d as consumed based on the standard meal size of 227 g to avoid double-counting association with body weight as not recorded in this survey: Freshwater (didn't designate as caught or purchased): 41.2 and 66.2 Shellfish: 15.0 and 22.5 Total freshwater and shellfish: 54 and 81 Marine: 42.4 and 59.5 This survey also has the additional strengths of being very detailed and administered by trained, local health professionals.
Great Lakes Regional Survey: MDH-GLRI Grant;	Study involved licensed anglers from Great Lakes States (except Ohio)	Women under age 50 reported eating more purchased fish than did men or older women, but not more sport-caught fish. Canned tuna consumption was higher among women under age 50 compared to other groups.	The survey asked about meals, but not portion size.

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information (*D-discrete values based on questions of number of meals eaten per time frame and use of 227 g for portion size;* *C- continuous data based on refined measures of portion size and could include use of participants' body weight*)
urban population **Connelly et al. 2012**	In 2011, 1,712 people completed the survey. Only 10% were WCBA; however, all participants provided information on WCBA and children living in their households. Of the respondents, 38.8% had WCBA in their household and 21.3% had children. Ninety-four percent of respondents were white (most non-Hispanic). There were less than two percent for Native Americans, black/African, or Asian/Pacific Islander and 4% other (not reported specifically for WCBA).	Table 29- About 0.6% of WCBA ate over one meal a week over the past year of caught-fish (9.6% ate 13-52); 3.3% ate over one meal a week of purchased fish (25.7% at 13-52). Table 29 shows women < 50 ate most meals of walleye, bass, crappie, bluegill/sunfish and northern pike for caught fish. Women aged 15 to 49 living in the household with the responding angler appeared to eat approximately the same number of sport-caught fishmeals as the angler (5.1 vs. 5.9 meals) based on average number of meals in a year. Children living in households with anglers consumed similar numbers of sport-caught fishmeals as women under age 50 also living in those households (4.8 vs. 5.1 meals). However, differences by state showed that the majority of children living in New York did not consume any sport-caught fish, whereas in Minnesota over 80% of these children ate at least one meal in the past year (Table 31). Children ate fewer purchased fishmeals than women under age 50 living in the household or responding anglers (mean 8.9 vs. 11.3 and 15.1 meals).	Report did not specifically provide quantitative data for just women of childbearing age to determine upper percentile FCRs.
Minnesota Survey (New Mothers): **MDH 2012 and additional**	Women (1,045) residing in Minnesota who gave birth in May 2004 (No demographics associated with results.)	Eighty-seven percent of the women had eaten fish or shellfish in the last year. The categories used in the survey were canned tuna, shellfish, sport-caught, and other.	*D* Information published was not sufficient to calculate how many meals were sport-caught or sport-caught plus shellfish. The survey also did not ask about portion size.

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statistics from P. McCann		Forty-one percent reported eating at least one meal of sport-caught fish. Sixty-two percent of the women had eaten shellfish in the previous year (note: for species eaten and assigned the estuarine habitat, shellfish composes the main fish in this category). Based on the categories, the estimated percent of women eating marine meals was 78% for canned tuna, 60% for frozen fish, and in the "other" group, salmon ranked the highest.	The 95th percentile of total fish plus shellfish meals eaten per month was 7.0. Based on using a standard 8 oz. or 227 g meal size, in grams per day, the 90th and 95th percentile for total fish and shellfish consumption were estimated at 37 and 45 g/d, respectively (based on 1,028 participants).
National Survey: **USEPA 2014**	Estimated Fish Consumption Rates for the U. S. Population and Selected Subpopulations (NHANES 2003-2010) The sample sizes for WCBA consuming any fish were 1,919 and 1,421 for freshwater and estuarine fish.	The NHANES survey uses details methods and food models to get accurate information on food consumption and other information. For fish consumption, all fish (finfish and shellfish) consumed from all sources is rigorously evaluated. The new analyses in this report has a new statistical approach/model to determine usual fish consumption rates based on the two-day recall survey protocol of NHANES. The EPA Method was based on one developed by the National Cancer Institute. A weakness to this analyses is publishing statistics only in g/d and not by individual body weight. More accurate estimates of intake rates would include each participant's body weight with food frequency and amounts.	*C* EPA has updated the default fish consumption rate to 22 grams per day. This rate represents the 90th percentile consumption rate of freshwater and estuarine fish for the U.S. adult population 21 years of age and older, based on NHANES data from 2003 to 2010 (USEPA 2014). EPA guidance also states though that local-regional data be used in place of the national default FCRs and special subpopulations of high fish consumers or biological sensitivity need to be protected. When data are limited to assess high-end subsistence consumers, EPA recommends 99th percentiles from general population studies. Using the tables in the fish consumption report, WCBA (13-49, in raw weight g/d) has usual fish consumption rates for freshwater and estuarine

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		The survey uses different years of NHANES data than the most recent EPA Exposure Factors Handbook (2011) with body weights used in national water quality criteria.	fish of 15.8 g/d at the 90th percentile, 29.5 g/d at 95th, and 46.6 g/d at 99th (Table E-7). This rate includes WCBA of all races; other statistics shown by race did not include WCBA. For freshwater finfish and shellfish for usual fish consumption rates for WCBA were 3.8, 8.5 and 38.4 g/d for the 90th, 95th, and 99th percentiles, respectively (Table E-4). In addition, the usual fish consumption rates for marine fish was 25.3, 34, and 55.5 g/d for the same percentiles (Table E-2). Statistics for males and female adults (age > 21) by race, the "other" category that includes Native Americans and Asians, was the highest at 44.5 and 62.3 g/d at the 90th and 95th percentiles, for total freshwater and estuarine fish intake(Table E-7); where men are reported for fish consumption rates they tend to be higher than women. The other racial groups were only slightly above 30 g/d in the 95th percentile. The highest amount for the freshwater total was 24.3 and 49.5 g/d for 90th and 95th percentiles for adults of "other" race (includes men and women). Based on Table 5 shellfish is included in the totals for total, freshwater and estuarine, and marine

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information (*D-discrete values based on questions of number of meals eaten per time frame and use of 227 g for portion size;* *C- continuous data based on refined measures of portion size and could include use of participants' body weight*)
			fish. Statistics are also available that separate finfish from shellfish.
National Survey: **Birch et al. 2014**	Trends in blood mercury concentrations and fish consumption among U.S. women of reproductive age, NHANES, 1999–2010 Study used data from 30-day fish recall data with estimates of portion from the 2-day survey questions. They used different statistics from EPA 2014; however, their results did include evaluation of WCBA (16-49) by racial categories. When comparing total fish consumption in 30-days by racial category the sample numbers are: Caucasian - 4043 African American - 2230 Mexican American - 2589 Other Hispanic - 751 Other Race - 474		*C* When comparing total fish consumption over 30-days at the 90th percentile by racial category -- g/d based on dividing reported monthly total fish consumption by 30: Caucasian - 22.5 g/d African American - 24.7 Mexican American - 21.7 Other Hispanic - 25.2 Other Race - 35.5 Data were not presented based on habitat apportionment.

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information (*D-discrete values based on questions of number of meals eaten per time frame and use of 227 g for portion size;* *C- continuous data based on refined measures of portion size and could include use of participants' body weight*)
National Survey: **Cusack et al. 2017**	Regional and temporal trends in blood mercury concentrations and fish consumption in women of child bearing Age in the united states using NHANES data from 1999–2010 Study used data from 30-day fish recall data and different statistics from EPA 2014, but evaluated WCBA (16-49) by racial categories.	Study determined 74-77% of WCBA ate some fish or shellfish, with more WCBA eating more in later cycles of the NHANES survey.	*D* Upper percentile fish consumption over 30-days averages by racial category (personal communication with author 10-20-17): Data show sample number (N) and 90th and 95th percentile number of meals for freshwater, followed by shellfish and marine with habitat categories also presented as a percentage of total fish and shellfish consumed: • African American -2253- 2, 5, 4 and 3, 7, 6 (freshwater 15 and 16%; freshwater plus shellfish 54 and 53% of total, respectively) • Mexican American - 2605- 0, 4, 2 and 1, 5, 3 (0 and 8%, 50 and 50%) • Other Hispanic - 762- 0, 4, 4 and 1, 7, 5 (0 and 36%, 6 and 44%) • Other Race - 477 -2, 7, 7 and 3, 11, 10 (10.5 and 47%, 10.7 and 50%) • Caucasian-4087 - 0, 4, 4 and 1, 7, 5 (0 and 36%, 6 and 44%)

Supplementary Information

Besides the key published studies summarized in Table 1, the MPCA considered other available data in reviewing FCRs for WCBA. That information is found in Table 2. For example, the MPCA conducted surveys of Minnesota caught-fish consumption from people vising the Eco Experience at the Minnesota State Fair. The survey, conducted on a single day in 2014 and 2015, included WCBA. These datasets are not as recent or reliable as those reviewed in Table 1, but offer some additional context to the key studies.

Table 2: Supplementary Information

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information
Minnesota/North Dakota Survey: The 2001 Benson et al. survey was conducted in Minnesota and North Dakota and evaluated in a number of papers and reports from USEPA (USEPA 2011 and 2013b and summarized in MPCA 2017).	The survey targeted Minnesota and North Dakota residents with fishing licenses, members of Tribal communities, and new mothers, as well as, the general population. It was conducted in Fall 2000. Statistical approaches for *usual* consumption rates have changed since this study was published by EPA. In addition, the study had a small response rate. The information is included because it was referenced in MPCA 2017.	EPA has presented information on mean and upper percentiles of FCRs and fish species consumed by a number of factors (e.g., age, ethnicity, gender, and income). The most relevant presentation of the survey data are in the context of freshwater caught rates. EPA had determined the rates for the average and 95th percentile from all the consumers surveyed, including children, in Minnesota were 14 g/d and 37 g/d, respectively (USEPA 2011). Information on estuarine and marine fish consumption were not included in MPCA 2017. Table E-149 in USEPA 2013b shows habitat amounts by all participants (consumers, uncooked): • Based on comparing at the 75th and 90th percentiles freshwater fish accounted for about 47% of total and estuarine only 9-10% of total.	*C* Where EPA provided results by age ranges from the general population survey, the 90th and 95th percentiles for sport-caught was 14.0 and 24.9 g/d and purchased fish was 49.3 and 78.8 g/d for females ages 15 to 44, respectively. (USEPA, 2011, Table 10-84). In another USEPA report on these surveys, WCBA consumers-only in Minnesota for total fish in uncooked rates (in USEPA 2013,Table E-143): • Ages 15-44, 0.42 and 0.67 g/kg-d for 75th and 90th percentiles, respectively.) For relative comparisons to other groups evaluated in the survey, as provided in USEPA 2013b (Table E-180, note: heading says "as consumed", but this was an error previously confirmed by Dr. Moya by personal communication in 2013, and values are "uncooked"): Female (all ages) in subpopulations for total fish consumed (consumers): • Native American 0.39 and 0.78 g/kg-d for the 75th and 90th percentiles, respectively. • Anglers 0.47 and 0.96 g/kg-d • New mothers 0.58 and 1.39 g/kg-d • General 0.50 and 0.93 g/kg-d

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information
Minnesota Survey: Statewide Angler Survey:2003-4 **Schroeder and Fulton with MN Department of Natural Resources (2005)**	2,276 men and women with Minnesota fishing licenses in 2003-4 were surveyed in 2004-5. Women comprised about 16% of the responses (Table I-1). Published information was combined for males and females, but the author provided information for women only (March 13, 2018). Data are available to analyze responses for 378 Caucasian WCBA.	Eighty-three percent of the women surveyed had eaten freshwater, caught fish in the last year. An important part of the survey was to evaluate differences by regional residence. The state was divided into five regions. The questions covered many aspects of fishing, including questions on freshwater fish species caught and eaten and other types of fish and shellfish consumed. The number of women who also recorded their regional residence was only 152, so no valid information was available to look at difference in number of caught-fish eaten. Three hundred-sixty WCBA ate Minnesota-caught fish in the previous year. The average number of meals was 20.93 (std. dev. 46.62) and the median was 10.00. Examining the number of Minnesota caught-fish eaten in a year, about 8% of the women ate over 50 fish (or about one fish per week). Questions on average number of meals for month included, store- or restaurant-purchased fish and shellfish, and high mercury species consumption: tuna, halibut, shark, and swordfish. Means were highest for canned tuna (1.72), followed by purchased in a store (1.54) or restaurant (1.07), with very few women consuming other fish. The survey asked how many days in the past year were spent fishing for any or specific species of Minnesota fish. WCBA fished most	Could not be accurately calculated based on the available information.

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information
		days for any species (71), followed by walleye (61), sunfish (50), pike (38), largemouth bass (33), yellow perch/rainbow trout (13), sauger (11) and the remaining species are less than 10.	
Minnesota Survey: Minnesota State Fair, Eco Experience Building 2014, 2015: **Dr. Christie Manning, Macalaster College and Dr. Elise Amel, University of St. Thomas**	People leaving the Eco Experience building. Surveyed males and females over age 18. WCBA (18-50) included 168 (Caucasian) and 15 (other races, including Asian, Hispanic, African American/Caucasian) in 2014. In 2015 101 (Caucasian) and 15 (other race, including Native American and Asian in 2015	Questions only pertained to Minnesota-caught fish consumed over the summer. (18-50) in 2014: Caucasian consuming caught-fish was 49% and other races was 53%. Total number of fish consumers was 87. Ten respondents (11% of all WCBA eating MN fish) ate 2 or more meals a week, with a range in portion sizes from 1 to 3. Thirty-four respondents (38%) ate two or more palm-sized portions (est. 8 oz. or greater) of fish per meal. Average portion was estimated at 163 g. (18-50) in 2015: Forty-six percent of Caucasian WCBA said yes and 13% identify as other races consumed caught-fish. Total number of fish consumers was 47. Six respondents (12.5% of all WCBA eating MN fish) ate 2 or more meals a week, with a range in portion sizes from <1 to 3. Twenty-four respondents (50%) ate two or more palm-sized portions of fish per meal. Average portion size was estimated at 192 g.	*D* Based on estimating amounts of Minnesota, caught fish (other categories were not surveyed), where responses of less than one meal per week were assigned a value of 0.5 meal per week with portions assigned as 227 g per meal, the results for 80th and 90th percentiles were 32 and 65 g/d each year. *C* In 2015, the survey also asked for participants to provide their body weight. Of the 35 WCBA that recorded their weights an estimate of fish consumption based on their portion sizes was also analyzed. Based on estimating amounts of Minnesota, caught fish consumed, responses of less than one meal per week were assigned a value of 0.5 meal per week and less than one 4 oz. (113.4 g) palm-size portion was assigned a value of 2 oz. or 57 g, with the remaining responses used as reported. The results for 80th and 90th percentiles were 0.35 and 0.89 g/kg-d. As in both datasets, the higher percentile was influenced more by the WCBA eating the highest number of meals or estimated portions per week.
Minnesota Survey:	Survey was conducted in 2013 with support and on	Results for all participants men and women:	From the report: "In general, participants who ate larger amounts of fish that contain greater

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information
Fond du Lac Human Services Division, Community Health Services Department; MDH 2014 **As stated in the report, The FDL Band did not net from Lake Mille Lacs in spring 2013. Typically, this harvest is shared widely in the community. If participants ate less fish or less from Minnesota waters than usual, the study's mercury results are likely lower than they might have been if netting occurred. Due to the lack of this regular community event the freshwater fish consumption rates are likely to be underestimated.**	Fond du Lac Tribal members to assess fish consumption and other factors related to biomonitoring of contaminants. Approximately 98 Native American WCBA participated. Limited results were published related to fish consumption in the *Community Report for Cadmium, Lead, and Mercury*.	More tribal members (89%) reported they ate fish purchased from a store or restaurant compared to 52% who ate fish that they, or someone they knew, caught. About one half (49%) ate fish from both sources. Thirty-three percent of all participants ate four or more fish meals per month Shrimp and canned tuna were the most popular. Walleye was the most popular fish that was caught by a participant or someone they knew. Total consumption of walleye was likely underestimated because the usual Tribal harvest of Lake Mille Lacs did not occur that spring.	amounts of mercury had more mercury in their blood. For example, women ate greater amounts of fish known to have higher amounts of mercury during the summer months and the amount of mercury in blood samples collected in the summer also increased (see results for women in Figure 8). Fortunately, all results were below the Level of Health Concern for mercury."
Great Lakes Regional Survey (no Minnesota participants): **Stevens et al. 2017 and 2018**	Men and women Hmong, African American, and Caucasian people fishing in Madison, WI. Personal interviews with 144 anglers in 2015 included 24 women and 10 WCBA. The information is included	The surveys included questions on numbers of meals annually of freshwater-caught species with estimates of portion size by body weight and sharing of meals with woman and children in the family. The study also examined mercury exposure and advice understanding. The authors found some important differences in fish consumption between the three ethnicities: each group had statistically different	Data are not available.

Survey	Population Surveyed	Consumption of fish and shellfish categories	Upper Percentile Information
	because the dataset for the men and these few women provide some context for non-White, Midwest urban fishing patterns.	average fish consumption rates of 26.3 g/d for white men, 44.5 g/d for Hmong men, and 80.7 g/d for African American men. African American and Hmong fishermen were also more likely to share caught fish with their family and children. They also ate more parts of the fish than fillets. From the women directly surveyed only 10 were between the ages of 18 and 50 and ate caught fish. Their average annual fish consumption was 55.17 g/d (n=10); among ethnic groups African Americans consumed on average 89.90 g/d(n=5),Hmong Americans 30.99 g/d (n=3), and Whites 4.59 g/d (n=2).	
Great Lakes Regional Survey (no Minnesota participants): **Connelly et al. 2017 (report plus journal articles)**	A diary study of urban populations (MI, NY, PA) with fishing licenses in 204to 2015 included women 18 years and older (approximately 230); however, quantitative data were either by all participants or very limited by sex or race.	Diary participants completed the same information as the survey of only WCBA. Table 3 had some data presented by demographics (none exactly for WCBA) Females consumed 15% meals were sport-caught (males were 20%) For ages, under 59 about 20% of fish meals were sport-caught. Non-white participants ate about 24% of their meals from sport-caught and whites were 19% (significantly different) Table G-4 shows again shellfish was the highest category consumed of purchased fish at 28% on average.	No quantitative data were provided for upper percentiles. The study did find advisory exceedance was higher for women, non-whites, and older anglers. Note: the mean grams of total fish consumed per day was 25.1-26.8 (depending on the assumptions made about portion size) was higher than the mean from the WCBA diary study.

Supporting documents

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