Fish Consumption and Advisory Awareness in the Great Lakes Basin

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Consumption advisories for sport-caught fish were first issued by Great Lakes (GL) states during the 1970s. These advisories were based on findings from investigations of the methylmercury poisonings that had occurred in Minamata, Japan, and on fish tissue analysis. Since that time, researchers have discovered that a variety of other persistent environmental contaminants, including PCBs (polychlorinated biphenyls), DDT (dichlorodiphenyltrichloroethane), and polybrominated diphenyl ethers, had found their way into the aquatic food chain and might pose a risk to frequent consumers of large, predatory fish. Currently, health departments and/or state environmental agencies in 48 states issue consumption guidelines for local sport-caught fish—fish that is caught and not purchased.

The recent methylmercury reference dose revision from 0.5 µg/kg/day to 0.1 µg/kg/day triggered states to review their sport-fish advisories and federal agencies to assess the need for a commercial fish advisory. In 2004 the U.S. Environmental Protection Agency (EPA) and the U.S. Food and Drug Administration (FDA) jointly issued consumption advice for commercial fish that was intended to protect women of childbearing age and young children against the neurodevelopmental effects of methylmercury. It became apparent to some states that there was a need for a holistic methylmercury fish consumption advisory that combined advice for local sport-caught fish and commercial fish. Up until this time sport-caught fish advisories largely ignored exposures from commercial fish. Current advisories are intended to assist anglers and consumers of commercial fish in selecting fish low in chemical contaminants as part of a healthy, balanced diet.

In 2001 an estimated 1.85 million fishermen purchased licenses to fish on the Great Lakes (U.S. Department of the Interior 2002). Although this figure reflects an almost 30% decline from 2.55 million in 1991, GL sport fishing continues to be a popular recreational activity for many families. Frequent ingestion of fish from these lakes has been associated with higher body burdens of PCBs, DDT, and DDE (dichlorodiphenyltrichloroethylene) (Anderson et al. 1998; Fiore et al. 1989; Humphrey 1983; Schwartz et al. 1983; Sonzogni et al. 1991; Tilden et al. 1997). These persistent contaminants accumulate in the body over time and increase the risk of a variety of health problems such as liver disease (Yu et al. 1997), reproductive (Dar et al. 1992; Weiskopf et al. 2003) and neurologic problems (Rogan and Gladen 1992), endocrine changes (Brathen et al. 2004; Persky et al. 2001), and developmental delays (Jacobson et al. 1990; Jacobson et al. 1986; Kimbrough and Krouskas 2003; Longnecker et al. 1997; Tilson and Kodavanti 1998). PCBs, DDT, and DDE have been classified as probable human carcinogens by the U.S. EPA, and sport-fish consumption has recently been associated with an increased risk of breast cancer among young, premenopausal women (McElroy et al. 2004).

Prenatal exposure to methylmercury has been associated with subtle learning delays and blood pressure changes (Grandjean et al. 1998; Sorensen et al. 1999). Methylmercury exposure during adulthood has recently been linked to higher rates of cardiovascular disease and acute myocardial infarction (Guallar et al. 2002; Salonen et al. 1995).

Until the early 1990s sport-fish consumption advisories were developed independently by each state. Development of these advisories may have been based on policy considerations as well as science. This led to confusion because neighboring states often provided different advice for the same, shared body of water. This situation was confusing for anglers and may have reduced confidence in the advisories. At the direction of the Council of Great Lakes Governors, the states that border the Great Lakes (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin) developed a protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (Anderson et al. 1993). That 1993 advisory protocol provides information on the health benefits of fish; adverse effects of contaminants; recommended quantity, frequency, and types of fish to consume; recommended fishing locations; and preparation methods that can be used to reduce exposure to bioaccumulative contaminants such as PCBs and DDE (Anderson et al. 1993).

In 1991 the Great Lakes Sport Fish Consortium of health departments in six of the eight GL states (Michigan and Pennsylvania were not members of the original consortium) was formed and received competitive funding from the Agency for Toxic Substances and Disease Registries. In 1993–1994 the consortium conducted a random-digit-dial telephone survey of 8,306 residents of the eight GL states to evaluate their total fish and GL sport-fish consumption habits, define at-risk subpopulations, and assess the effectiveness of state-issued consumption advisories. Households were selected by a computerized random-digit-dial system, and an adult was then randomly
selected among those in each household. The survey found that 50% of consumers of GL sport-caught fish were aware of the consumption advisory issued by their state of residence (Tilden et al. 1997). Awareness rates varied by gender and race and were lowest among women and minorities. Those results prompted a reevaluation of GL sport-caught fish advisory programs. Previously, information was targeted almost exclusively to anglers who were predominantly male, but in recognition that advice was not reaching women or minorities, the consortium expanded program outreach materials specifically to include materials targeted to women of childbearing age. Although the focus of the consortium was on PCB and DDE in GL fish, each state also provided consumption advice for fish caught from inland lakes and rivers based on PCB and methylmercury fish tissue levels.

Between June 2001 and June 2002 the consortium conducted a follow-up randomized telephone survey of 4,106 adults to evaluate changes in awareness and fish consumption patterns among residents of these states. In this article we summarize findings from that survey and changes that occurred between the 1993 and 2001 surveys.

Materials and Methods

Between June 2001 and June 2002 a population-based, random-digit-dial telephone survey of adults (≥18 years of age) residing in Indiana, Illinois, Minnesota, Michigan, New York, Ohio, Pennsylvania, and Wisconsin was conducted by the Wisconsin Survey Research Laboratory (Madison, Wisconsin). This study was designed as a follow-up to the 1993–1994 study conducted in these states and involved 4,106 adults who were randomly selected from each household. Although the same basic survey instrument was used as a follow-up to the original survey, a new random sample among adult residents of these states was drawn. The total sample size was nearly half that of the original 1993–1994 study because of funding restraints. The overall Conference of American Survey Research Organizations (CASRO) response rate was 56% (CASRO 1982).

Trained telephone interviewers used standardized questionnaires to collect information on demographic characteristics and fish consumption during the preceding 12 months. Respondents were asked about their fish consumption habits in a stepwise pattern. Those who included fish in their diets were asked about sport-caught fish ingestion, specifically, any fish not purchased that was caught by the respondent or by someone else and given to the respondent. Fish purchased at a restaurant or store did not qualify as sport caught. Sport-caught fish consumers were asked about GL sport-caught fish intake, and consumers of GL sport-caught fish were asked about advisory awareness. GL sport-caught fish included fish caught in the mouths of rivers that feed into the Great Lakes. Because of the popularity of tuna in the U.S. diet and recent concerns regarding tuna as a source of mercury exposure, this survey also included a series of questions about tuna (any type) consumption, which the original 1993–1994 survey did not include. Consumers of “commercial fish only” were defined as fish consumers who reported eating no sport-caught fish in the previous 12 months. In this article commercial fish includes any type of tuna. However, where tuna is specifically referenced, it refers only to this type of commercial fish and no other.

Statistical analysis of prevalence estimates, odds ratios, and chi-square and t-tests were conducted using SAS statistical software (version 9.1 for Windows; SAS Institute Inc., Cary, NC). Survey data were weighted before analysis to reflect state-specific selection probability for each household and adjusted for the number of telephone lines serving the residence using 2000 Census data. Data from each state were weighted to reflect the population age (four age groups were used) and gender distribution.

### Table 1. Fish consumption patterns among Great Lakes Basin residents.

| Demographic characteristic | % Weighted population that consumes: |
|----------------------------|-------------------------------------|
| Age (years)                | Any type of fish | Tuna | Sport-caught fish | GL sport fish |
| 18–34                      | 77 | 59 | 19 | 7 |
| 35–44                      | 88 | 74 | 29 | 10 |
| ≥ 45                       | 87 | 73 | 22 | 6 |
| Gender                     |                           |     |                  |
| Male                       | 85 | 66 | 26 | 8 |
| Female                     | 83 | 72 | 19 | 6 |
| Race                       |                           |     |                  |
| White                      | 85 | 71 | 23 | 7 |
| Black                      | 84 | 60 | 19 | 10 |
| Other/unknown              | 78 | 59 | 15 | 4 |
| Education                  |                           |     |                  |
| Less than high school      | 72 | 54 | 22 | 7 |
| High school graduate       | 80 | 64 | 23 | 7 |
| Some college               | 87 | 72 | 24 | 8 |
| College graduate           | 90 | 77 | 20 | 7 |
| Household income ($)       |                           |     |                  |
| < 15,000                   | 71 | 54 | 14 | 4 |
| 15,000–24,999              | 86 | 66 | 22 | 5 |
| 25,000–34,999              | 84 | 69 | 23 | 6 |
| 35,000–49,999              | 88 | 69 | 24 | 8 |
| ≥ 50,000                   | 89 | 77 | 26 | 9 |
| Unknown                    | 81 | 66 | 18 | 5 |
| State                      |                           |     |                  |
| Illinois                   | 86 | 68 | 24 | 5 |
| Indiana                    | 80 | 64 | 21 | 4 |
| Michigan                   | 82 | 68 | 25 | 16 |
| Minnesota                  | 84 | 69 | 44 | 8 |
| New York                   | 85 | 75 | 15 | 3 |
| Ohio                       | 83 | 62 | 21 | 12 |
| Pennsylvania               | 87 | 71 | 16 | 3 |
| Wisconsin                  | 87 | 70 | 39 | 10 |
| Total                      | 4,106 (100%)              | 84% | 69% | 22% | 7% |

Percentages within groups may not total 100% because of rounding error. Percentages are based on weighted data. There were missing values for state, age, and education demographics because of partial completion of survey or refusal.

### Table 2. Fish consumption and average number of fish meals by type of fish eaten.

| Type of fish consumed | No. of respondents | % Who consume | Average no. of fish meals per year | Average no. of tuna meals per year |
|-----------------------|--------------------|---------------|-----------------------------------|-----------------------------------|
| Commercial fish only  | 2,442              | 63            | 44                                | 28                                |
| Non-GL sport fish (may include commercial fish) | 685 | 15 | 46 | 22 |
| GL sport fish (may include commercial and/or non-GL sport fish) | 299 | 7 | 53 | 35 |
| None                  | 628                | 16            | 0                                 | 0                                 |

Percentages and averages are based on weighted data. Average number of fish meals per year is calculated based on any and all types of fish, including tuna.
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Fish consumption. On the basis of weighting of the survey data, > 80% of the adults living in this region had eaten some type of fish during the previous 12 months. Most of the population consumed only commercial fish (any type of fish purchased and not caught; Table 2). Nearly 70% specifically reported consumption of canned or fresh tuna, revealing the popularity of this type of commercial fish (Table 1). Fewer than one quarter (22%) had eaten any sport-caught fish, and only 7% (~4.2-million residents) had eaten fish that were caught from one of the Great Lakes.

Although the percentage of men and women who consume fish (any type) was nearly the same (~85% vs. 83%, respectively), men were more likely to eat sport-caught fish (p < 0.0001) and GL sport-caught fish (p = 0.0064) than were women. Conversely, women were more likely to have ingested tuna than were men (p < 0.0001). Regardless of whether the fish was commercial or sport caught, consumption prevalence was positively correlated with household income (p-values < 0.0001). Consumption prevalences for “any type of fish” and tuna were correlated with education (p < 0.0001); however, sport-caught fish and GL sport-caught fish consumption prevalences were not correlated with educational attainment. The percentage of residents who included fish and sport-caught fish in their diets varied from state to state.

Consumption of any type of fish ranged from 80% among Indiana residents to 87% among residents of Wisconsin. Sport-caught fish consumption was much more common in the Midwest than in the eastern states, ranging from 44% in Minnesota and 39% in Wisconsin to 15% in New York and 16% in Pennsylvania (Table 1).

Although the sample was too small to support extensive analysis by race or ethnicity, overall fish consumption rates were similar among black and white adults and lower among other/unknown races. This difference was statistically significant between white adults and those of other or unknown races (p < 0.0002). White residents were significantly more likely than black residents and residents of other/unknown races to have consumed tuna (p < 0.01) or sport-caught fish (p < 0.05). Adults reporting other/unknown races were significantly less likely to eat GL sport fish than were white or black adults (p < 0.05).

As shown in Table 2, most adults in these states (63%) consumed commercial fish but had not eaten any sport-caught fish during the 12-month recall period. This did not differ significantly from the 1993–1994 study (62%).

Among those who ate fish, the average number of meals eaten (from all sources) ranged from 44/4/year among those who consumed only commercial fish to 53/year among those who had eaten sport-caught fish from the Great Lakes. Based on a t-test of the means of the log of the number of fish meals per year, the consumption rates reported by consumers of “commercial fish only” were significantly lower than those who included “GL sport-caught fish” in their diets (p = 0.044). Although the difference in means for these two fish consumer groups was less in the 1993–1994 study (46 meals/year vs. 48 meals/year), this difference also proved statistically significant when conducting a t-test of means of the logs (p = 0.0007). There was, however, no statistically significant difference across time periods.

For those who ate GL sport-caught fish, the average number of GL sport-fish meals consumed per year was 13. This consumption rate was higher among men than among women (14 vs. 11, respectively), but the difference was not statistically significant.

Most respondents who consumed GL sport-caught fish did so fewer than 12 times a year (range, 1–126). Depending on the type and size of the fish consumed, this rate is likely to comply with most GL fish consumption advisories. As shown in Figure 1, a small percentage of the men (10%) and women (3%) in this group ate GL fish > 35 times a year, or about 3 times a month (this gender difference was not statistically significant). Among men in this high-consumption group did not change significantly over this period.

As shown in Table 3, most adults who live in the GL states eat fish up to once a week (52 meals/year). Table 4 provides demographic descriptors and population estimates for people who consume fish more than twice a week. This subgroup comprises a high-risk population for exposure to PCBs, methylmercury, and other persistent contaminants found in

| Demographic characteristic | n | Population estimate | Weighted (%) |
|----------------------------|---|---------------------|-------------|
| Age years                  |   |                     |             |
| 18–34                      | 39 | 641,000             | 23          |
| 25–44                      | 33 | 490,000             | 18          |
| ≥ 45                       | 112| 1,011,000           | 58          |
| Gender                     |   |                     |             |
| Male                       | 81 | 1,342,000           | 47          |
| Female                     | 109| 1,513,000           | 53          |
| Education                  |   |                     |             |
| Less than high school      | 13 | 219,000             | 8           |
| High school graduate       | 38 | 589,000             | 21          |
| Some college               | 45 | 803,000             | 28          |
| College graduate           | 93 | 1,223,000           | 43          |
| Household income ($)       |   |                     |             |
| < 15,000                   | 19 | 276,000             | 10          |
| 15,000–24,999              | 25 | 345,000             | 12          |
| 25,000–34,999              | 19 | 233,000             | 8           |
| 35,000–49,999              | 22 | 377,000             | 13          |
| ≥ 50,000                   | 76 | 1,162,000           | 41          |
| Unknown                    | 29 | 471,000             | 17          |
| State                      |   |                     |             |
| Illinois                   | 24 | 376,000             | 13          |
| Indiana                    | 19 | 161,000             | 6           |
| Michigan                   | 24 | 324,000             | 11          |
| Minnesota                  | 14 | 107,000             | 4           |
| New York                   | 46 | 1,054,000           | 37          |
| Ohio                       | 23 | 352,000             | 12          |
| Pennsylvania               | 22 | 342,000             | 12          |
| Wisconsin                  | 18 | 140,000             | 5           |
| Type of consumer            |   |                     |             |
| Commercial only            | 132| 2,034,000           | 73          |
| Sport fish (non-GL)        | 30 | 425,000             | 15          |
| GL sport fish              | 25 | 343,000             | 12          |
| Total                      | 190| 2,895,000           | 100         |

Consumption of more than two fish meals per week exceeds the U.S. EPA/U.S. FDA recommended amount. There were missing values for education and age demographics because of partial completion of survey or refusal. Type of consumer categories match those of Table 2 and are mutually exclusive.
large, predatory fish. As shown in Table 4, > 2.8 million residents fall into this subgroup. Most were female, college educated, and ≥ 45 years of age. People reporting a household income > $50,000/year were more likely to fall into this category than were those with lower incomes. Residents of New York were three times more likely to fall into this high-intake subgroup than were residents of any other state and approximately eight times more likely than residents of Wisconsin and Minnesota. Fifty-one percent of these high-intake individuals are tuna at least once a week.

Advisory awareness. All GL states have issued consumption advisories for GL fish. Approximately half of adults who consumed fish from the Great Lakes were aware of the health advisory that had been issued by their state health department (Table 5). This awareness rate had not changed since the 1993–1994 survey. On the basis of multivariate logistic regression analysis, advisory awareness varied significantly (p < 0.05) by gender, black/white race, and fish consumption rate (Table 6). Whites were > 6 times more likely to be aware of their state’s advisory than blacks and men were four times more likely to be aware than women. Also, advisory awareness was positively associated with annual fish consumption rates.

Most GL fish consumers who were aware of the advisories issued by their state complied with them. Compliance rates for the types and sizes of fish that were safe to eat, preparation methods, and fishing locations ranged from 63 to 77%. The least popular recommendation was the restriction on the amount of fish that should be eaten in a given time period. Compliance with this guideline was only 52% (Table 7).

Discussion

Although persistent, bioaccumulative contami-
nants in the Great Lakes Basin continue to be a public health concern, our survey results indi-
cate that sport fishing in these lakes remains a popular activity. According to the survey results, 7% of adults living in the GL states had eaten at least one meal of GL sport fish during the previous 12 months. This percentage corre-
sponds to an estimated population of 4.2 mil-
lion adult residents in these states. Compared

with national dietary estimates, residents of these states appear to consume more fish than do people living in other regions. Including residents who did not eat fish, our study revealed an average fish consumption rate of 38 meals/year. The U.S. Department of Agriculture 1994–1996 and 1998 Continuing Survey of Food Intakes by Individuals found that the average number of fish meals (grams per day converted to 6-oz prepared fish meals per year) consumed by adults ≥ 18 years of age was approximately 32/year (U.S. EPA 2002).

Comparison of responses to our 1993–1994 and 2001–2002 surveys indicates that fish con-
sumption rates and awareness prevalence have remained stable over this time period. As in
1993–1994, the 2001–2002 study suggests that most GL sport-fish consumers choose to
eat fish that are low in contaminants, such as perch, smelt, and walleye.

Findings from this survey suggest that sig-
nificant exposure to GL contaminants from fish is limited to a small subpopulation of avid

Table 5. Advisory awareness among GL sport-fish consumers.

| Demographic characteristic | 2001–2002 | 1993–1994 |
|---------------------------|-----------|-----------|
| Age (years)               | n % Aware | n % Aware |
| 18–24                     | 73 38     | 217 49    |
| 35–44                     | 93 56     | 190 56    |
| ≥ 45                      | 131 52    | 276 49    |
| Race                      |           |           |
| White                     | 258 55    | 638 53    |
| Black                     | 24 15     | 38 23     |
| Gender                    |           |           |
| Male                      | 153 65    | 355 60    |
| Female                    | 146 30    | 337 38    |
| Education                 |           |           |
| Less than high school     | 25 33     | 50 33     |
| High school graduate      | 91 50     | 278 50    |
| Some college              | 86 55     | 195 50    |
| College graduate          | 97 48     | 185 61    |
| Consumption               |           |           |
| 0–5 meals/year            | 107 41    | 291 45    |
| 6–23 meals/year           | 135 57    | 248 53    |
| ≥ 24 meals/year           | 34 70     | 120 61    |
| Total                     | 299 49    | 692 51    |

Percentages are based on weighted data. Statistics not provided for other races because of small sample sizes.

Table 6. Multivariate logistic regression model for advisory awareness among GL sport-fish consumers.

| Demographic characteristic | 2001–2002 | 1993–1994 |
|---------------------------|-----------|-----------|
| Race                      |          | Odds ratio |
| Gender                    |          | (95% confidence interval) |
| Black                     | Referent |
| White                     | 66 (2.0–21.5) |
| Female                    | Referent |
| Male                      | 40 (2.3–7.1) |
| Fish consumption           |          |           |
| < 6 meals/year            | Referent |
| ≥ 6–23 meals/year         | 2.3 (1.3–4.1) |
| ≥ 24 meals/year           | 5.0 (1.7–14.6) |

All odds ratios reported in table were statistically significant at p < 0.05 level. Regression calculated using weighted data. Statistics are not provided for other races because of small sample sizes.

Table 7. Self-reported compliance with advisories.

| Advisory component         | n % Always complying |
|---------------------------|----------------------|
| Cooking/cleaning methods   | 81 77                |
| Consumption frequency     | 92 52                |
| Fish species and size      | 65 63                |
| Fishing locations          | 57 71                |

Percentages are based on weighted data. n = number of GL sport-fish consumers who reported awareness of each guideline.
not allow for extensive analysis by race because of the small number of minorities who reported consumption of GL sport fish. Additional research focusing on minority populations or oversampling areas with larger minority populations is needed.

Comparisons of advisory awareness versus state of residence were not made because only a small number of respondents in each state had consumed GL sport-caught fish during the period of our study.

The need to educate the adult population about persistent toxins present in some commercial fish is evident from these survey data. Not only do most of the adult population of these GL states consume only commercial fish (63%), but also, most people in our survey who exceeded the U.S. EPA/U.S. FDA recommendation of no more than two fish meals per week consumed only commercial fish. Conversely, most of the outreach that has been conducted in these states has been targeted at licensed anglers and their families. State-issued brochures are often specific to local species and water bodies. Written advisory information, such as fishing regulation booklets and advisory brochures, has been distributed primarily to recreational fishermen and health care providers. Until recently, very little information has been available to the general public regarding contaminant levels in fish that are sold in restaurants, fish markets, and grocery stores. Although contaminant levels vary greatly among fish depending on their diets, age, and habitat, most dietary guidance has encouraged fish consumption as a healthy alternative to red meats, and advisories have limited consumption restrictions to a few highly contaminated species such as shark and swordfish. As a result, many consumers assume that all other fish is safe for unlimited consumption. Few realize that frequent, prolonged consumption of canned tuna and other predator species can lead to a high body burden of methylmercury. The U.S. FDA has published a website with methylmercury levels in commercial fish and shellfish (U.S. FDA 2004).

Those with the highest levels include king mackerel, shark, swordfish, and tilefish (all close to or above 1 ppm, except king mackerel at 0.73 ppm). Other commercial fish that have average methylmercury levels above 0.5 ppm include grouper and orange roughy. Average levels in canned albacore tuna and fresh/frozen tuna are 0.35–0.38 ppm, respectively. According to recent research conducted by Hites et al. (2004), total PCBs, dioxins, toxaphene, and dieldrin levels were significantly higher in farm-raised salmon than in wild salmon. This finding is significant because more than half the salmon sold in Northern Europe, Chile, Canada, and the United States is farm raised.

Advisories that focus only on sport-caught fish miss much of the fish-consuming population. Based on our survey, > 2 million residents of the Great Lakes Basin who eat only commercial fish eat enough commercial fish to exceed safety guidelines for exposure to a variety of persistent, bioaccumulative pollutants.

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