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Body burdens of mercury in lower Hudson River area anglers

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Abstract

The Hudson River has been a federally designated Superfund site for over 20 years. Discharges of industrial waste and of treated and untreated sewage and atmospheric deposition have introduced mercury and other persistent pollutants to the Hudson River ecosystem. Despite New York and New Jersey health advisories, many local anglers and their family members continue to consume fish caught from the river. To evaluate associations between body burden of mercury and local fish consumption, we conducted a cross-sectional study of 191 anglers recruited from piers and fishing clubs. Participants were administered a questionnaire to obtain information on local fish consumption, and 65% (124 individuals) provided a blood sample used to determine mercury levels. Mercury levels ranged from below the limit of detection (0.75 ng/mL) to 24.0 ng/mL. Participants who reported eating locally caught fish had significantly higher levels of mercury (mean (M) = 2.4 ng/mL, standard error (SE) = 1.2) than anglers who never ate locally caught fish (M = 1.3 ng/mL, SE = 1.1). A positive dose–response pattern was also observed, where participants who reported eating locally caught fish more than once a week had higher mercury levels (M = 2.6 ng/mL, SE = 1.1) than anglers eating fish less frequently (M = 2.0 ng/mL, SE = 1.2) or never at all (M = 1.3 ng/mL, SE = 1.1). These findings indicate that consumption of fish caught from the lower Hudson River area is a route of human exposure to mercury for the angling community.

Keywords: Mercury; Human; Fish consumption; Anglers; Hudson river

1. Introduction

Mercury is a ubiquitous environmental contaminant. Emissions of inorganic mercury to the atmosphere, derived primarily from coal combustion and waste incineration (US EPA, 1998), contribute significantly to global atmospheric loading (Lindqvist, 1994) and lead to enhanced atmospheric deposition of mercury in the vicinity of combustion sources (Mason et al., 1994) and in more distant locales. An additional source of mercury to natural water systems such as the lower Hudson River and the adjacent New York–New Jersey (NY–NJ) harbor complex is direct input from industrial establishments and discharge of municipal wastes. Inorganic mercury that reaches sediments of rivers, lakes, and oceans can be biologically transformed to methylmercury, an environmentally persistent neurotoxic compound capable of bioaccumulation in the marine food web (Gilmour et al., 1992; Krabbenhoft et al., 1995; Fitzgerald et al., 1998).

Methylmercury is a potent neurotoxicant, especially to the developing brain of the fetus. The neurotoxic effects of methylmercury were first documented in the 1950s when the population of Minamata City, Japan was exposed to high levels of methylmercury through contaminated fish consumption (Harada, 1978, 1995). Clinical observations of Iraqi children, accidentally exposed to high levels of methylmercury through grain contamination, also showed neurological deficits, especially in infants (Amin-zaki et al., 1978). Studies designed to investigate the human health effects of mercury exposure at lower doses have been underway for the past several decades. In a study undertaken in the Faroe Islands fetal exposure to methylmercury from maternal fish consumption has been shown to be associated with neurological deficits in offspring that persist at least through the teen years (Amin-zaki et al.,

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1978; Murata et al., 2004; Steuerwald et al., 2000). A study undertaken in New Zealand has shown a similar association (Crump et al., 1998). However, data collected from children residing in the Republic of Seychelles have shown little evidence of an association between neurological development in children and maternal mercury exposure (Davidson et al., 1998; Myers et al., 2000, 2003). Based on a critical analysis of these studies, The National Academy of Sciences has concluded that methylmercury is a fetal neurotoxicant even at low levels of exposure and that the harmful health effects associated with methylmercury exposure for pregnant women outweigh the potential benefits of omega-3 fatty acids and other nutrients from fish consumption (Keiding et al., 2003; Landrigan and Goldman, 2003; Lyketsos, 2003; NAS, 2000). Other researchers have shown that exposure to mercury-contaminated fish may carry a risk of cardiovascular complications for men also and the development of a reference dose based on these outcomes has been suggested (Guallar et al., 2002; Stern, 2005). Currently, the reference dose for mercury consumption set by federal agencies is 0.1 μg/kg of body weight per day (US EPA, 2003) with a recommended resting state of 5.8 ng Hg/ml blood (NAS, 2000). The New York State Department of Health recommends that no person should eat more than one meal of fish per week from the lower Hudson River area or any of the state's freshwaters (NYSDOH, 2005).

A positive relationship between fish consumption and human body burdens of mercury has been found in fish-eating populations worldwide (Grandjean et al., 1992; Kosatsky et al. 2000; Evens et al., 2001; Bjornberg et al., 2003; Myers et al., 2003; Schober et al., 2003). In the United States, a recent study using data from 1709 women from the National Health and Nutrition Examination Survey (NHANES) found that in 1999–2000 mean blood levels of mercury were higher for women who reported eating both commercial fish and shellfish in the previous 30 days (1.7 ng/mL) than for women who never ate any (0.4 ng/mL) (Schober et al., 2003). Blood levels of mercury in US angling populations have been reported to be as high as 2.2 ng/mL for people living near the Great Lakes area and 4.4 ng/mL for Chippewa Indians living near the Wisconsin Lake (Peterson et al., 1994; Anderson et al., 1998). The levels of mercury found in these US populations are similar to those reported for Swedish (4.0 ng/mL) and Canadian (3.0 ng/mL) anglers (Svensson et al., 1995; Kosatsky et al., 2000).

A previous study of anglers in the Newark (New Jersey) Harbor complex area found that nearly 70% of anglers studied ate locally caught fish or crabs at least once a month during the fishing season, with 8–25% consuming more than 1.5 kg/month (Burger, 2002). A related study found that, in a survey of anglers in the same area, while 60% of those surveyed were aware of New Jersey State fishing advisories, 62% of respondents were unaware of specific health effects associated with the consumption of locally caught fish and shellfish (Pflugh et al., 1999).

Although studies in various locales have shown associations between fish consumption and elevated methylmercury exposure, to date, no comprehensive studies of anglers in the lower Hudson River area documenting the human body burdens of the environmental chemicals found in locally caught fish have been published. Since the Hudson River is a Superfund site with elevated levels of mercury in sediments and fish, this study was designed to evaluate the association between local fish intake and blood levels of mercury in humans and to document the persistence of mercury in the lower Hudson River area ecosystem.

2. Materials and methods

2.1. Study participants and sampling

During the summer and fall fishing seasons from 2001 to 2004, we conducted a cross-sectional study among urban anglers in the lower Hudson River and adjacent NY–NJ harbor complex. Anglers were recruited on fishing piers (in Elizabeth, Englewood Cliffs, and Bayonne, NJ; in West Harlem, New York City and at Canarsie Pier in Brooklyn, NY) and at fishing clubs (in Ridgefield Park, NJ; in Staten Island, NY) (Fig. 1). A typical recruitment event was staffed by the principal investigator, a research coordinator, a certified phlebotomist, and two additional trained interviewers. During questionnaire-based interviews participants were asked questions on their fishing practices, consumption patterns, and demographic parameters. In addition, participants provided information on the frequency and amount of intake for the following species: American eel, blackfish, bluefish, blue crab, clam and mussel, flounder, fluke, striped bass, tommy cod, weakfish, white catfish, white perch, and general commercial fish. One hundred and ninety-one anglers participated in the study between 2001 and 2004. One hundred forty-nine (78%) of the participants provided blood samples and 126 of these had sufficient whole blood for mercury analysis (Table 1). However, because body mass index (BMI) or age was not available for 2 participants the final data set includes 124 anglers. A comparison of anglers providing whole-blood samples and those who did not found very few differences between the two groups, except that blood donors (a) were slightly younger (mean age (in years) = 52 versus mean age = 54) and (b) reported ever eating their local catch more frequently (84% versus 72%).

2.2. Analytical techniques

Whole-blood samples (10 mL) were collected using venipuncture, stored at −20 °C and analyzed for total mercury content using a UV-absorptiometer (Mercury Monitor 1235, Laboratory of Data Control, Milton Roy, FL) at the University of Rochester. Methods for this analysis have been described in detail elsewhere (Magos and Clarkson, 1972). The limit of detection (LOD) was 0.75 ng/mL. Seronorm (Sero AS, Norway) was used as an external standard prior to sample analysis. A mean value of 8.0 ng/mL was observed, which is in close agreement with the mean value (8.2 ± 0.9 ng/mL) reported by the manufacturer. Unidentified replicate samples were also analyzed for quality assurance.

2.3. Statistics

Consumption of local fish by respondents was measured based on self-reported intake. First, a dichotomous variable was created where anglers reporting eating any of the species of fish at any frequency were categorized as "eating locally caught fish" and respondents reporting not eating any species of fish were categorized as "not eating locally caught fish." Second, a categorical variable was created where average frequency of fish intake was measured by summing the weighted frequency of reported intake across species of fish, using the following

Fig. 1. Lower Hudson River Area.

Table 1
Recruitment of participants by site

Site location	State	Year	Participants (N)	Biosamples collected (No., %)
Staten Island	NY	2001	45	35 (78)
Canarsie Pier	NY	2002, 2004	48	46 (96)
Harlem (New York City)	NY	2002	25	15 (60)
Bayonne	NJ	2003	15	5 (33)
Elizabeth	NJ	2003	22	14 (64)
Englewood Cliffs	NJ	2003	11	7 (64)
Ridgefield Park	NJ	2003	25	25 (100)
Total			191	149 (78)

weights: "no meals per month" = 0, "<1 per month" = 0.05, "1 per month" = 0.25, "2–3 times per month" = 0.50, "1 per week" = 1, "2–3 times per week" = 2.5, "4–5 times per week" = 4.5, and "6 times per week or more" = 6. Individuals were then categorized based on their summed weights as having eaten locally caught fish: (a) never, (b) less than 1 per week, or (c) greater than or equal to 1 per week. Generalized linear models

Table 2
Demographic and fish intake characteristics of anglers

Characterisitics	No local fish intake ($n=20$) No. (%)	Any local fish intake ($n=104$) No. (%)
Race/ethnicity (%)		
White	11 (55)	64 (62)
African American	5 (25)	21 (20)
Hispanic	3 (15)	15 (14)
Other	1 (5)	3 (3)
Not reported	0 (0)	1 (1)
Male (%)	17 (85)	89 (86)
Total yearly household income (%)		
<$30, 000	9 (45)	28 (27)
$30,000–49,999	4 (20)	22 (21)
>$50,000	6 (30)	39 (38)
Not reported	1 (5)	15 (14)
Completed years of education		
⩽12	11 (55)	56 (54)
>12	9 (45)	48 (46)
Age, years (mean, SD)	60 (16)	50 (14)
BMI (mean, SD)	33 (6)	30 (5)
Reported intake of commercial fish	16 (80)	86 (83)
Reported intake of any (%)		
Fluke		81 (78)
Striped bass		76 (73)
Blue fish		67 (64)
Flounder		65 (62)
Weak fish		60 (58)
Black fish		49 (47)
Blue crab		44 (42)
American eel		21 (20)
Clams or mussels		20 (19)
White perch		14 (13)
Tommy cod		10 (10)
White catfish		9 (9)
Respondents who share their Catch with others (%)	13 (68)	69 (67)

Table 3
Geometric mean concentration of blood mercury levels by study population characteristics ($n=124$)

	Mean[a] (SE)[b]	P-value[c]
Total population	2.2 (1.1)	
Race/ethnicity		
Non-Hispanic White	2.3 (1.1)	*ref.*
Black	1.6 (1.2)	0.082
Hispanic	2.0 (1.2)	0.540
Other	4.2 (1.5)	0.176
Gender		
Men	2.3 (1.2)	0.190
Women	1.7 (1.2)	*ref.*
Yearly household income		
<$30,000	1.8 (1.2)	*ref.*
$30,000–$49,999	2.0 (1.2)	0.692
> $50,000	2.4 (1.1)	0.167
Not reported	3.0 (1.2)	0.071
Completed years of education		
⩽12	1.9 (1.1)	0.050
>12	2.6 (1.1)	*ref.*
Age		
18–29	1.5 (1.4)	0.202
30–49	2.2 (1.1)	0.920
⩾50	2.3 (1.1)	*ref.*
Body mass index		
<25	1.5 (1.2)	0.059
25–29.99	2.5 (1.2)	0.619
⩾30	2.3 (1.1)	*ref.*
Commercial fish consumption		
Yes	2.1 (1.1)	*ref.*
No	2.3 (1.3)	0.7693

[a]Geometric mean.
[b]Geometric standard error.
[c]*P*-values presented against reference group "*ref*".

were used to adjust for age (years), BMI (weight in kg/height in meters^2), race, household income, commercial fish consumption (yes/no), gender, and categories of educational attainment (Table 2). Categorical variables were created for age and BMI for the purpose of stratifying mercury levels by these factors (Table 3). Samples having mercury concentrations below the LOD were coded with the LOD divided by the square root of 2, and, because the mercury values were positively skewed, geometric means and standard errors were calculated utilizing log transformations. All analyses were conducted using SAS software (version 9.1.2 for Windows; SAS Institute Inc., Cary, NC).

3. Results

A comparison of the anglers reporting any versus no local fish consumption shows that the majority of the anglers (84%) eat their catch (Table 2). Compared to nonconsumers, a greater proportion of anglers who reported eating locally caught fish were White (62% versus 55%) and had annual incomes greater than $50,000 (38% versus 30%). Although educational attainment was similar and both groups were predominantly male, anglers who ate their local catch were younger (mean age = 50 years versus mean age = 60 years) and had slightly lower BMIs (BMI = 30 versus BMI = 33). The three most commonly eaten fish were fluke, striped bass, and bluefish. A majority of both consumers (83%) and nonconsumers (80%) of locally caught fish reported eating commercially purchased fish. Two thirds of all anglers reported sharing their catch with others. Fish consumption patterns analyzed by race show that 85% of White, 81% of Black, and 83% of Hispanic participants ate locally caught fish, while 89% of White, 88% of Black, and 56% of Hispanic participants reported eating commercial fish (data not shown).

The mean blood mercury concentration for the study population was 2.2 ng/mL (SE = 1.1) (Table 3). Slight differences in concentrations of mercury were observed by

Table 4
Geometric mean concentration of blood mercury levels by reported fish intake

	Crude				Adjusted[a]		
	n[b]	Mean[c] (SE)[d]	Difference	P-value	Mean[c] (SE)[d]	Difference	P-value
Never versus any local fish intake							
Never	20	1.3 (1.2)	0	*ref.*	1.5 (1.4)	0	*ref.*
Any fish intake	104	2.4 (1.1)	1.1	0.011	3.2 (1.3)	1.7	0.002
Average frequency per week[e]							
Never	20	1.3 (1.2)	0	*ref.*	1.5 (1.4)	0	*ref.*
Any fish $\leqslant$ once per week	31	2.0 (1.2)	0.70	0.149	3.0 (1.3)	1.5	0.024
Any fish $>$ once per week	73	2.6 (1.1)	1.30	0.005	3.3 (1.3)	1.8	0.002

[a]Model adjusted for race, gender, income, education, commercial fish consumption, age, and BMI.
[b]n is the number of participants.
[c]Geometric mean.
[d]Geometric standard error.
[e]P-values presented against reference dose (never eats local fish).

educational attainment and body mass index in unadjusted models. Higher levels of mercury were observed among anglers with higher educational attainment (>12 years: $M = 2.6$, $SE = 1.1$ versus education level $\leqslant 12$ years: $M = 1.9$, $SE = 1.1$) and larger body mass (BMI $\geqslant 30$: $M = 2.3$, $SE = 1.1$; BMI 25–29.9: $M = 2.5$, $SE = 1.2$; and BMI <25: $M = 1.5$, $SE = 1.2$) although differences were not always statistically significant at an alpha of 0.05.

Table 4 presents the crude and adjusted mean concentrations of mercury for anglers stratified by frequency of local fish consumption. The mean level of mercury for anglers reporting eating their catch was significantly higher ($M = 2.4$, $SE = 1.1$) than for noneaters ($M = 1.3$, $SE = 1.2$). When comparing frequency of local fish eaten per week, anglers who reported eating fish more than once a week had the highest concentration of mercury ($M = 2.6$, $SE = 1.1$) compared to anglers who report consuming their local catch less than or equal to once a week ($M = 2.0$, $SE = 1.2$) and those reporting eating no local fish ($M = 1.3$, $SE = 1.2$). These associations persisted after adjustment for race, gender, income, education, commercial fish consumption, age, and BMI.

4. Discussion

In this study we found a positive association between body burden of mercury and consumption of fish caught from the lower Hudson River area by anglers. Higher levels of mercury were observed among anglers consuming their local catch compared to anglers who reported not eating locally caught fish. Further stratification by frequency revealed that anglers consuming fish more than once a week had higher mercury levels than those consuming fish less than or equal to once a week. These findings indicate that consumption from the lower Hudson River area is a route of exposure for local anglers.

The high frequency of anglers consuming their catch and the observation that most anglers were male are consistent with the findings of other researchers in the area (Pflugh et al., 1999; Ramos and Crain, 2001; Corburn, 2002). Ethnic characteristics of participants are also similar to other studies. For example, anglers from the State of New Jersey have previously been found to be predominantly White (Pflugh et al., 1999). Anglers from Manhattan and Brooklyn have been found to be predominantly Hispanic and Black (Ramos and Crain, 2001; Corburn, 2002), although in our study we sought areas where minority groups might be fishing.

While this study identifies fish as a source of mercury exposure to Hudson River area anglers, we realize that it is limited by a few important factors. First, we did not thoroughly investigate the impact of eating non-locally-caught fish. For example, recent studies have identified potential exposures from canned tuna (Burger and Gochfeld, 2004; Table 4) and fresh ahi tuna and commercial swordfish (Hightower and Moore, 2003). However, while 82% of the study population reported commercial fish consumption, a relationship between frequency of commercial fish intake and blood mercury levels was not observed (Table 3). Although we did not inquire specifically about canned tuna or fresh predatory fish consumption, we attempted to address this issue by asking about commercial fish consumption in our questionnaire and adjusting for it in our statistical model. This question asked specifically about "meals of fish or crabs that are *NOT caught in local waters*" (emphasis present in questionnaire) including "supermarket, fish market or other fish or crabs." A second potential limitation in our data is that, although it is recognized that certain species of fish may contain higher levels of mercury than others, species-specific dietary analysis was not possible because of the collinear nature of these data, where 92% of local fish eaters reported intake of a variety of fish species. Third, we attempted to correct for occupational exposure by asking if the participant "…ever had a job or hobby…" working with mercury. While 13 participants responded affirmatively, corresponding descriptions of exposures demonstrated that participants may have overestimated their exposure. For example, one participant responded that a job as a phlebotomist may have been an exposure route, while another considered a thermometer in a fish tank a possible source. An additional potential limitation is that we could not determine response rates because of the passive recruitment methods employed. The population at each site was dynamic, changing over the course of the day. For instance, participants called local fishing friends to come to the site and participate, which further complicates determining a denominator for a response rate. In general, however, most people present at each pier opted to participate in the interview process, even if they did not provide a blood sample. Participation was slightly less successful at the fishing clubs. Finally, we did not assess other factors that could possibly have led to elevated body burdens of mercury, such as dental amalgams or religious uses of mercury.

Despite the limitations of the study, differences in body burdens were observed between consumers and nonconsumers of locally caught fish. While most respondents reported eating multiple species of fish, striped bass and bluefish were among the most frequently consumed (Table 2). In the New York contaminant database, these species of fish are among the top three in mean mercury level (NYSDEC, 2004; Table 5). Based on mercury fluxes and levels in sediments, the NY–NJ harbor area could be expected to have higher than national average levels of mercury both in fish and in consumers of local fish. In a survey of fine-grained sediment samples from 175 coastal and estuarine sites throughout the nation, the six highest mercury concentrations were all found in the NY–NJ harbor area (NOAA, 1988). In more recent studies (Kroenke, 2003; Bopp, unpublished data), the atmospheric flux of mercury to this area was determined to be among the highest ever reported, and direct inputs of mercury to the NY–NJ harbor were found to be significantly greater

Table 5
Reported mercury concentrations (ppm, wet weight)

Species[a]	Mean	Median	Min	Max	No. of samples
NY–NJ harbor, 1993[b]					
Striped bass	0.34	0.28	0.05	1.25	82
Blackfish (Tautog)	0.30	0.24	0.07	0.75	19
Bluefish	0.24	0.22	<0.05	0.72	57
American eel	0.14	0.08	<0.05	0.54	17
White perch	0.18	0.19	<0.05	0.49	17
Weakfish	0.17	0.14	<0.05	0.49	13
Atlantic tomcod	0.15	0.13	<0.05	0.43	10
Fluke (summer flounder)	0.10	0.09	0.05	0.26	19
Blue crab	0.13	0.12	<0.05	0.23	22
Winter flounder	0.05	<0.05	<0.05	0.18	21
Clams and blue mussels	<0.05	<0.05	<0.05	0.12	17
NY–NJ harbor, 1999–2000[c]					
Striped bass	0.28	0.21	0.09	1.91	74
American eel	0.34	0.32	0.12	0.56	17
White perch	0.30	0.27	0.02	0.93	104
Blue crab	0.15	0.14	0.04	0.30	32
Winter flounder	0.05	0.04	0.01	0.14	66
Clams and blue mussels	0.03	0.03	0.01	0.06	9
NJ State and US Commercial Fish					
Bluefish[d] (FDA market survey)	0.31	0.30	0.14	0.63	22
Bluefish[e] (NJ market survey)	0.30	NR[f]	0.01	0.76	53
Tuna (canned, albacore, FDA)[d]	0.35	0.34	<0.01	0.85	179
Tuna (canned, albacore, NJ)[g]	0.41	0.37	NR	1.00	123
Weakfish[d]	0.25	0.16	<0.01	0.74	27
Flounder[e]	0.05	NR	<0.01	0.14	55

[a]Some species designations differ slightly from those used in the questionnaire (Table 1).

[b]Data from the NYSDEC Biota Contaminant Database (NYSDEC, 2004).Values reported are for fillets except for clams and blue mussels (soft parts), blue crab (muscle), and American eel (whole fish minus head, viscera and skin). For samples below the detection limit, a value of 0.025 ppm (half the detection limit) was assumed.

[c]Data from the Contaminant Assessment and Reduction Project (CARP, 2005).Values reported are for fillets (striped bass and winter flounder), soft parts (clams and blue mussels), muscle (blue crab), whole fish minus head and viscera (white perch), and whole fish minus head, viscera and skin (American eel).

[d]Bluefish data from FDA Surveys 2002–2003; Weakfish and Tuna data from FDA Surveys 1990–2003 (CFASAN, 2004).

[e]NJ market study data from Burger et al. (2005).

[f]NJ market study data from Burger and Gochfeld (2004).

[g]NR, not reported.

than the atmospheric flux. It is noteworthy that the exceptionally high mercury fluxes and levels in sediments of the NY–NJ harbor area do not seem to be reflected in the limited amount of comparable data on mercury in fish. For instance for bluefish and weakfish the mean mercury levels in US commercial fish in national and local New Jersey market basket surveys (CFASAN, 2004) were actually slightly higher than those in NY–NJ harbor samples reported by NYSDEC (NYSDEC, 2004; Burger et al., 2005; Table 5). These observations underscore the possibility that commercial fresh and canned fish may be important sources of exposure and suggest that, despite exceptionally high fluxes of total mercury to the NY–NJ harbor, relatively inefficient transformation to methylmercury and subsequent bioaccumulation may limit exposure from local fish consumption.

Unadjusted blood mercury levels of fish eaters in our study were higher than those reported among the US national sample of women who ate fish and shellfish ($M = 2.4$ ng/mL versus $M = 1.7$ ng/ml, respectively) (Schober et al., 2003). However, levels were similar to those seen in other angling populations, even though differences exist in species and contamination levels of locally caught fish from other regions. For instance, anglers in the Lake Ontario region have mean mercury levels of 2.2 ng/mL for sport-fish eaters and 1.5 ng/mL for noneaters (Cole et al., 2004). However, the mean level of mercury among Hudson River fish consumers was lower than that in some other non-US fishing populations. For example, frequent fish consumers in Montreal had mean blood mercury levels of 3.0 ng/mL (Kosatsky et al., 2000), and Swedish fishermen have mercury levels of 4.0 ng/mL compared to a reference population that had a mean level of 1.8 ng/mL and consumed one less meal per week of local fish (Svensson et al., 1995). While mercury levels in these studies were highest for frequent eaters of locally caught fish, in none of these studies did group levels exceed the only "safe" baseline level recommended by a federal agency, 5.8 ng/mL. This level was calculated to prevent adverse neurological and developmental effects to infants exposed in utero (NAS, 2000).

Concern arises from the fact that the majority of anglers surveyed, including those who do not eat ever their catch, reported sharing it with family, friends, and acquaintances. Specifically, 38% of this study population reported giving locally caught fish to women of childbearing age and 15% gave fish to children, populations identified as sensitive to mercury exposure. These findings are consistent with those of Bienenfield et al. (2003) who reported that, among participants of the Women Infants and Children program in the East Harlem area of New York City, 11% of study participants reported eating fish caught from local waters. While this study identifies an important route of exposure to mercury for anglers in the lower Hudson River area, continued monitoring of local and commercial fish consumption will be necessary to address body burdens and associated health risks to these more sensitive populations and the community at large.

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