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Mercury exposure in two coastal communities of the Bay of Fundy, Canada

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Abstract

There is a rising global concern with regard to mercury (Hg) exposure among coastal populations. Two communities on the Bay of Fundy (New Brunswick, Canada) were assessed by hair monitoring and dietary methods. Average concentration of total Hg in hair was 0.70 ± 0.55 mg/kg ($N = 91$) at Grand Manan and 0.42 ± 0.15 mg/kg ($N = 52$) at St. Andrews/St. Stephen. Average daily consumption of fresh fish and shellfish was 50 ± 40 g/day for Grand Manan and 19 ± 19 g/day for St. Andrews/St. Stephen. Average daily total Hg intake estimated from the food frequency and 24-h recall questionnaires was 0.05 ± 0.04 μg Hg/kg bw/day at Grand Manan and 0.03 ± 0.04 μg Hg/kg bw/day at St. Andrews/St. Stephen. A significant correlation ($r = 0.47$, $P = 0.002$) between Hg intake and hair was observed for Grand Manan. Low Hg intakes and body burden can be attributed to the low Hg levels found in the species commonly consumed: haddock, canned tuna, lobster, and pollock (all below 0.2 μg/g wet weight). The results showed that Hg exposure in these Canadian coastal communities is low; fish with higher levels of Hg (shark, tuna, swordfish, pickerel, and bass) are not consumed locally.

Keywords: Mercury; Exposure assessment; Seafood; Hair; Community

1. Introduction

The threat of environmental mercury (Hg) exposure to human health has been known for over five decades following the consumption of Hg-contaminated fish in Japan (Harada, 1995) and of contaminated grain in Iraq (Bakir et al., 1973). Because fish is the primary source of Hg among the general population, communities that rely on fish intake for daily nutrient sustenance are often thought to be at risk of chronic high exposure to methylmercury (MeHg) (Grandjean et al., 1997, 1992). Based on the findings that prenatal exposure to MeHg leads to significant behavioral effects during infant development, the World Health Organization (WHO) reduced the MeHg provisional tolerable daily intake from 0.47 to 0.23 μg/kg bw/day (Joint FAO/WHO Expert Committee on Food Additives (JECFA), 2003). The immediate consequence of the JECFA recommendation is to raise the question of the safety of intake of large predatory marine fish (JECFA, 2003).

In view of the nutritional, social, cultural, and economic benefits incurred from fish consumption (JECFA, 2003; Frooi and Secher, 2002; Chan and Receveur, 2000; Groff and Gropper, 1999; Egeland and Middaugh, 1997; Kuhnlein and Receveur, 1996), it is important to balance the risks and benefits in the risk management process.

The Bay of Fundy, spanning the shores of the provinces of New Brunswick and Nova Scotia, Canada

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and the State of Maine, USA, provides a wealth of resources to its communities. However, the consumption patterns of the local inhabitants and the mercury levels found in the fish locally consumed have yet to be documented; thus exposure to Hg remains unidentified. In addition, the eastern Canadian provinces account for 2800 kg or 25% of the current total Canadian Hg emissions (Pilgrim et al., 2000), which may be an important contributor to local Hg deposition to the Bay of Fundy.

The Passamaquoddy (People of the Dawn) First Nations originated from southern New Brunswick and the state of Maine with their territory ranging past the US/Canada border. The Passamaquoddies living on the reserves in Maine (Sipayik and Indian Township) still practice traditional hunting (moose, deer, bear, and harbor porpoise) and fishing. However, with the restrictions of the border crossing and lack of recognition from the Canadian government, those living in the region of St. Andrews/St. Stephen, New Brunswick, Canada (Fig. 1) have slowly abandoned their traditional lifestyle (Hugh Akagi, Chief of Passamaquoddy, St. Andrews, New Brunswick, personal communication).

Offshore, an island called Grand Manan (Fig. 1) is also home to people with Passamaquoddy heritage. The first residents of the island were Passamaquoddy but with the arrival of the Loyalists toward the end of the 18th century, most of the current 2675 residents are descendants of the United Empire Loyalists (Municipality and Land Housing, unpublished draft report). Only recently have about 150 Grand Mananers been granted official recognition as being descendants (Hugh Akagi, personal communication). Despite the declining fish stocks, particularly the ground fish (cod, haddock, and pollock), the chief livelihood of Grand Mananers remains fishing and lobstering. Since the early 1990s, salmon farming has increased as the traditional fishery declined.

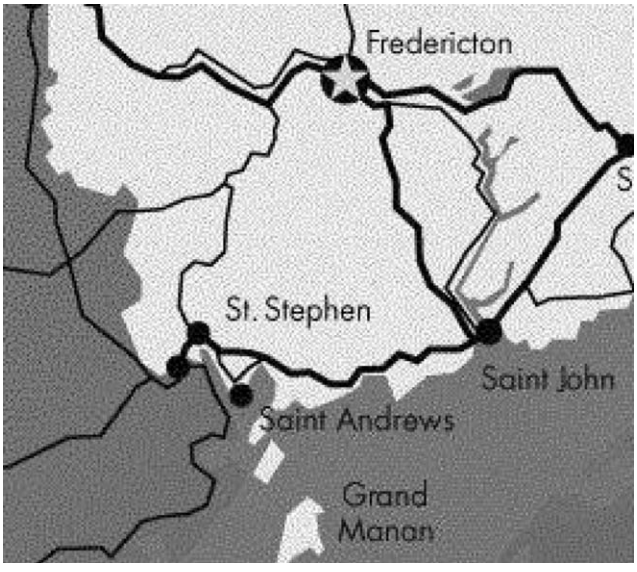

Fig. 1. Location of field sites (St. Andrews/St. Stephen and Grand Manan).

The objective of this study was to characterize the risk of Hg exposure in Passamaquoddy and non-Passamaquoddy from Grand Manan and the region of St. Andrews/St. Stephen, New Brunswick, Canada by determining Hg levels in hair and using dietary questionnaires to identify the main sources of Hg.

2. Material and methods

The project was approved by the ethics committee of the Faculty of Agriculture and Environmental Sciences, McGill University. A research agreement was drafted and signed by community representatives and researchers on March 1, 2002. Workshops with the communities were held in April and May 2002 to prepare description of the local food systems and identify key species and their preparation methods.

Interviews were completed between June and July 2002 by two trained community members (one from St. Stephen/St. Andrews and one from Grand Manan). The interviews included a 24-h recall, food frequency and sociocultural questionnaires, and collection of a sample of scalp hair. Individual signed informed consent was obtained from each participant and a coding system was developed to ensure individual confidentiality. Inclusion criteria comprised male and female adults over 18 years with permanent residence in St. Andrews/St. Stephen and Grand Manan (at least 1 year) and written consent. All non-residents of the community, all with refusal of consent, and all unwilling to participate were excluded. Convenience sampling was used to recruit the participants of the St. Stephen/St. Andrews area and random sampling at Grand Manan.

Dietary intake was assessed with one 24-h recall and a food frequency questionnaire (FFQ). The FFQ was divided into the past four seasons (spring 2002, winter 2002, fall 2001, and summer 2001) and further divided into several categories: fish (whole or filet and with or without skin), shellfish (refer Table 3 for list of local fish included in the questionnaire), canned fish (tuna, salmon, herring, and sardine), and canned shellfish (clam, crab, lobster, mussel, shrimp, oyster). The questionnaires were developed based on a review of the literature, other related studies (Chan et al., 1999; deGonzague et al., 1999), and small workshops with community representatives. The questionnaires were pilot tested on community representatives and were found to be culturally acceptable. Below is an excerpt of the FFQ. The participants were first asked to identify whether the item was consumed, whether it was locally caught or from the market, and whether it was eaten

whole/filet with or without skin. To facilitate the recall, frequency of consumption in each season was warranted beginning with spring 2002 and working backward to summer 2001. Two trained community members (one from Grand Manan and one from St. Andrews/St. Stephen) conducted the interviews which included the three questionnaires and collection of a sample of hair.

Example of FFQ questionnaire layout:

	Spring	Winter	Fall	Summer	Caught	Market
Mackerel						
Yes	No				☐	☐
Whole	(W/ or W/O skin)					
Filet	(W/ or W/O skin)					

The hair collection procedure for Hg analysis has been established by the First Nations and Inuit Health Lab of Health Canada (Bigras, 1998). Briefly, a 2.5-mm bundle of hair was isolated and cut from the occipital region, ensuring minimum damage to the participants' aesthetics. The hair was placed in a polyethylene bag and fastened with two staples near the scalp end. Polyethylene bags are used as they do not affect Hg levels in hair.

Total Hg in the hair was analyzed at Health Canada's First Nation and Inuit Health laboratory in Ottawa, Canada. Each hair strand was cut into 1-cm sequential segments beginning at the scalp and up to a maximum of 14 cm, sufficient to overlap the yearly FFQ. Total Hg was determined using a method developed by Farant et al. (1981). The hair was digested using 2 mL of 45% sodium hydroxide and 1 mL 1% L-cysteine. Cold vapor atomic absorption spectrometry (CVAAS) was conducted with an Hg UV monitor (Model 1235, Laboratory Data Control, Riviera Beach, FL). Stannous chloride–cadmium chloride solution was used to determine total Hg and stannous chloride to determine inorganic Hg. Detection limit for total Hg was 0.4 mg/kg and it was 0.3 mg/kg for inorganic Hg. Inorganic Hg was consistently under the detection limit even when total Hg was above 3 mg/kg, thus it was not a significant contributor. In this paper, only total Hg is used in the statistical analysis.

Quality control (precision and accuracy) of the results was ensured with the use of human hair standard reference material obtained from the Hair Hg Interlaboratory Comparison Program, Health Canada, Ottawa, Canada. Levels below detection limit were assigned a random number between zero and the detection limit for statistical analysis.

Total Hg was measured on local store-bought fish and shellfish and on species collected in collaboration with local fishermen (refer Table 3 for details of each local species collected and measured). Canned fish and shellfish with Hg measurements included tuna, salmon, clam, and crab. Canned items that were included in the questionnaire (see above) but for which we did not measure Hg were allotted the same value as that of the freshly caught species. For can tuna, the Food and Drug Administration (FDA, 2001) value of 0.17 mg/kg was used to compute intake. Total mercury in fish was determined as follows. A subsample of 0.1 g was predigested overnight in 10 mL of a 7:3 mixture of nitric and sulfuric acid. The digestion was complete after being heated for 4 h at 90 °C. For fish samples, a certified reference material DORM (National Research Council of Canada, Ottawa) was used with each digestion batch to measure the effectiveness of the digestion. Analysis for total Hg content was performed using double gold trap CVAAS, with a Tekran 2600 analyzer that has a detection limit of 0.5 ng/L.

Intake of total Hg (μg/kg body weight/day; hereafter μg Hg/kg bw/day) for each individual was calculated based on the intake of each fish and shellfish reported in the spring FFQ—March, April, May 2002. Portion size of each species was extracted from the 24-h recall. When a particular species was not recalled, an average portion size (85 g for women and 127 g for men) was assigned (Canada Food Guide, 2000). A total of 46 market and locally available fish and shellfish items were included in the FFQ. Most of the species were not recalled by St. Andrews/St. Stephen participants and when recalled the sample size equaled 2 at best. To avoid bias, each species was assigned the average portion size in this community. For Grand Manan, 35% of the 46 items of the FFQ were reported on the 24-h recall. These included flounder, herring, haddock, pollock, salmon, can tuna, can salmon, can herring, can sardine, clam, lobster, mussel, scallop, and can clam.

The frequency and amount of each species were combined to obtain grams of food per season, which was multiplied by the amount of total Hg concentration (mg/kg) in each food item and divided by 90 to obtain daily Total Hg intake. The daily Total Hg intake for each participant was further divided by the individual's reported weight in kilograms to obtain μg Hg/kg bw/day

which may be compared to established intake guidelines such as the JECFA.

The 24-h recalls were entered and analyzed using the CANDAT 97 nutrient analysis package (Godin Ltd., London, Ontario, Canada). The FFQ was entered in Microsoft Office 10 Excel 2000. All data were imported and analyzed with the statistical software package SAS version 8 (Cary, NC, 2000).

Characteristics of the communities and fish consumption habits were explored using descriptive statistics. Distribution of the dependent variable (hair Hg) was skewed using a value of 4.26 and a kurtosis index of 25.9, indicating heaviness of the right tail. Thus, gender (male and female) and age group (19–29; 30–39; 40–49; 50–64; 65+ years) comparisons for total Hg in hair were assessed using ANOVA on the log-normal distribution. Intake comparisons were assessed with ANOVA as the assumptions of normality, homoscedasticity, and linearity were met. Correlation analysis was performed to examine the association between log Hg levels in hair and dietary intake parameters. All P values below the 0.05α level were considered significant. On Grand Manan, one male did not provide hair and another male did not complete the questionnaires. One female was removed from the intake analysis due to implausible intake of fish and shellfish. For spring 2002, with 90 days in the season, her total frequency of fish and shellfish intake alone was 286 times (not counting intake of market foods). Outlier influence diagnostics revealed an elevated leverage (hi) of 0.470 compared to 0.017 mean for the population.

3. Results

Fifty-two individuals (29 men and 23 women) from St. Andrews/St. Stephen and 92 adults (38 men and 54 women) from Grand Manan participated in the study. At St. Andrews/St. Stephen and Grand Manan, 95% and 62% response rates, respectively, were obtained. Of the 57 Grand Mananers who did not participate, 30 did not return our call, 13 claimed to be summer residents (i.e., not permanent residents), 10 were refusals, and four died.

In total, 926 (384 from St. Andrews/St. Stephen and 542 from Grand Manan) hair segments were analyzed from the 143 participants. Average total Hg concentration for St. Andrews/St. Stephen was 0.42 ± 0.15 mg of total mercury/kg of hair (mg/kg) ($N = 52$) and this was 0.70 ± 0.55 mg/kg ($N = 91$) for Grand Manan. Averages were computed using the highest Hg segment from each individual. Figs. 2 and 3 classify these results by age group and gender.

At Grand Manan, there was no significant difference between age groups for both men ($P = 0.33$) and women ($P = 0.46$). In addition, there was no statistical difference between men and women pooled for all ages ($P = 0.67$). At St. Andrews/St. Stephen, no significant difference was found among age groups for both men ($P = 0.64$) and women ($P = 0.98$). When pooling all age groups, a significant difference was detected between men and women ($P = 0.001$) with women having more elevated mean mercury hair content (0.49 ± 0.12 versus 0.37 ± 0.14 mg/kg).

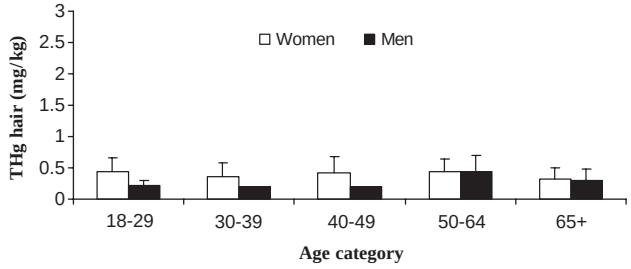

Fig. 2. Mean and standard deviation of total Hg in hair categorized by age and gender for St. Andrews/St. Stephen.

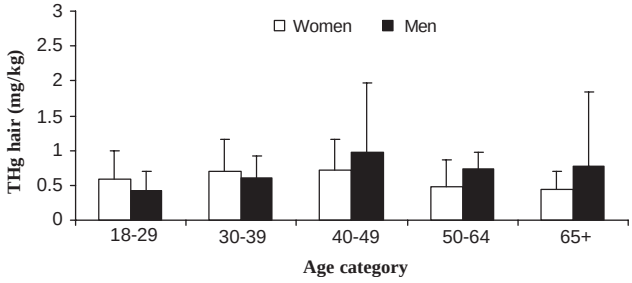

Fig. 3. Mean and standard deviation of total Hg in hair categorized by age and gender for Grand Manan.

Based on the spring 2002 dietary questionnaire, average daily total Hg intake estimated from the food frequency and 24-h recall questionnaires was 0.05 ± 0.04 μg Hg/kg bw/day at Grand Manan and 0.03 ± 0.04 μg Hg/kg bw/day at St. Andrews/St. Stephen. Figs. 4 and 5 categorize mean and standard deviation of Hg intake by gender and age group for spring 2002. At Grand Manan, no significant difference in Hg intake between age groups for both men ($P = 0.61$) and women ($P = 0.30$) was observed. When pooling all age groups, intake was also not significantly different between men and women ($P = 0.90$). At St. Stephen/St. Andrews, intake did not differ between age group for either men ($P = 0.30$) or women ($P = 0.413$). However, when all ages were pooled, mean Hg intake for men (0.04 ± 0.04 μg Hg/kg bw/day) was significantly higher ($P = 0.02$) than that of women (0.02 ± 0.02 μg Hg/kg bw/day). Tables 1 and 2 list the top 10 sources of Hg (μg of Hg per day in each season) for each community. The list was generated by multiplying the amount of each species by the amount of total Hg concentration (mg/kg) in each food item and dividing by 90 to obtain daily Total Hg intake. Then, average intake

for each species was calculated for the community and the species were ranked by descending order. Total Hg of the main contributing foods include haddock (0.05 mg/kg), canned tuna (0.17 mg/kg), lobster (0.18 mg/kg), pollock (0.03 mg/kg), and lake trout (0.22 mg/kg). Table 3 provides additional data for total Hg concentration of the local fish and shellfish.

Correlation analysis was performed between daily intake as μg total Hg per day and Hg concentration in hair for the spring at Grand Manan. Correlation analysis was not performed for St. Andrews/St. Stephen as 41 of 52 participants had levels below the detection limit for the spring months. Since hair collection took place in June and July 2002 and the length of hair of the participants varied from 1 to 14 cm, the first segments would correspond to at least 1 of the spring months (March, April, May 2002), assuming that hair grows on average approximately 1 cm per month. To ensure maximum inclusion of participants in the correlation, body burden and intake data were limited to spring 2002. A significant correlation ($r = 0.30$, $P = 0.005$) was noted between the highest Hg segment and the intake in the spring. When limiting the data to those above the 0.40-mg/kg detection level in hair, the coefficient was increased to 0.47 ($P = 0.002$) (Fig. 6).

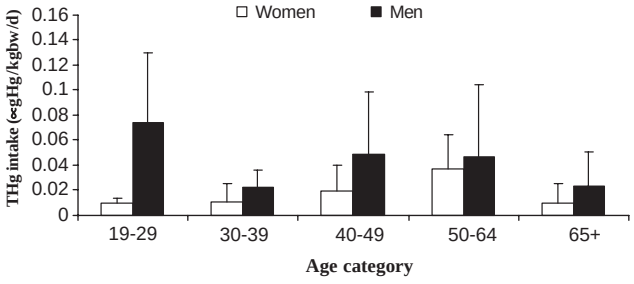

Fig. 4. Mean and standard deviation of Hg intake (μg Hg/kg bw/day) in spring 2002 categorized by age and gender for St. Andrews/St. Stephen.

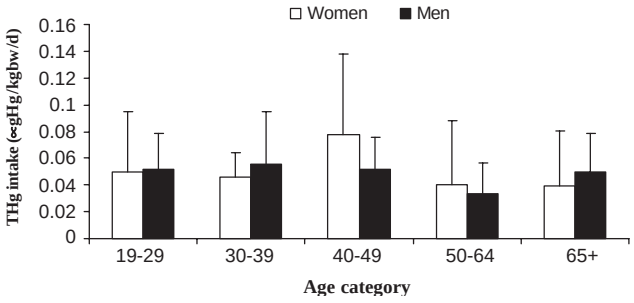

Fig. 5. Mean and standard deviation of Hg intake (μg Hg/kg bw/day) in spring 2002 categorized by age and gender for Grand Manan.

4. Discussion

Hair monitoring and estimated Hg intakes showed that exposure in both communities is below Health Canada (1999) and JECFA (2003) guidelines. Mercury body burden, fish consumption, mercury intake, levels in fish, and assessment limitations will be discussed sequentially.

Mean arithmetic concentrations of total Hg in hair were 0.70 mg/kg for Grand Manan and 0.42 for St. Andrews/St. Stephen. These levels fall below the 6-mg/kg "increasing risk" level established by Health Canada (1999). Given that Grand Manan is considered a fishing community with its chief livelihood being fishing and lobstering, average concentration for the community was low. Body burden measurements in other coastal communities such as the Seychelles and the Faroe islands showed much larger maternal hair Hg with averages of 15.3 and 12.0 mg/kg, respectively (Agency for Toxic Substances and Disease Registry (ATSDR), 1999). The types and amounts of fish and shellfish consumed are different and will be discussed later.

Average marine fish consumption on Grand Manan was 32 g/day with haddock and pollock accounting for 25 g/day of the intake. Shellfish was also consumed at an average rate of 18 g/day and canned fish at 12 g/day.

Table 1
Top 10 sources of mercury intake (average ± standard deviation (SD) μg of mercury per day each season) at St. Andrews/St. Stephen

Spring		Winter		Fall		Summer	
Species	Average ± SD	Species	Average ± SD	Species	Average ± SD	Species	Average ± SD
Can tuna	1.56 ± 2.77	Can tuna	1.60 ± 2.77	Can tuna	1.44 ± 2.71	Can tuna	1.82 ± 3.18
Lobster	0.26 ± 0.44	Haddock	0.22 ± 0.30	Haddock	0.19 ± 0.26	Haddock	0.27 ± 0.38
Trout	0.24 ± 1.07	Trout	0.18 ± 1.06	Trout	0.16 ± 1.06	Lobster	0.23 ± 0.37
Haddock	0.23 ± 0.29	Lobster	0.13 ± 0.29	Lobster	0.16 ± 0.31	Trout	0.21 ± 1.07
Can salmon	0.11 ± 0.38	Can sardine	0.08 ± 0.35	Can sardine	0.08 ± 0.35	Can salmon	0.12 ± 0.47
Can sardine	0.08 ± 0.35	Can herring	0.08 ± 0.26	Can herring	0.07 ± 0.26	Halibut	0.10 ± 0.35
Halibut	0.07 ± 0.31	Tuna	0.07 ± 0.30	Can salmon	0.07 ± 0.23	Salmon	0.08 ± 0.26
Can herring	0.06 ± 0.21	Can salmon	0.07 ± 0.23	Halibut	0.06 ± 0.29	Can herring	0.08 ± 0.26
Salmon	0.05 ± 0.11	Halibut	0.07 ± 0.30	Tuna	0.06 ± 0.24	Can sardine	0.08 ± 0.35
Tuna	0.05 ± 0.23	Salmon	0.04 ± 0.11	Salmon	0.05 ± 0.12	Mackerel	0.06 ± 0.19

Table 2
Top 10 sources of mercury intake (average ± standard deviation (SD) μg of mercury per day each season) at Grand Manan

Spring		Winter		Fall		Summer	
Species	Average ± SD	Species	Average ± SD	Species	Average ± SD	Species	Average ± SD
Haddock	0.94 ± 1.25	Haddock	1.02 ± 1.23	Haddock	1.18 ± 1.44	Haddock	1.12 ± 1.55
Lobster	0.91 ± 1.59	Lobster	0.90 ± 1.62	Lobster	0.92 ± 1.73	Can tuna	0.82 ± 0.96
Can tuna	0.88 ± 1.03	Can tuna	0.87 ± 1.01	Can tuna	0.85 ± 0.99	Lobster	0.32 ± 0.82
Trout	0.27 ± 0.61	Can sardine	0.25 ± 0.51	Can sardine	0.24 ± 0.50	Pollock	0.28 ± 0.34
Can sardine	0.22 ± 0.50	Pollock	0.25 ± 0.31	Pollock	0.24 ± 0.31	Halibut	0.23 ± 0.83
Pollock	0.22 ± 0.30	Scallop	0.13 ± 0.16	Can salmon	0.12 ± 0.20	Can sardine	0.21 ± 0.50
Can salmon	0.13 ± 0.20	Can salmon	0.12 ± 0.20	Scallop	0.09 ± 0.16	Mackerel	0.20 ± 0.46
Scallop	0.10 ± 0.16	Shrimp	0.07 ± 0.14	Mackerel	0.08 ± 0.32	Can salmon	0.11 ± 0.19
Salmon	0.09 ± 0.30	Salmon	0.06 ± 0.18	Shrimp	0.07 ± 0.14	Trout	0.10 ± 0.33
Shrimp	0.06 ± 0.13	Halibut	0.06 ± 0.41	Halibut	0.07 ± 0.41	Salmon	0.09 ± 0.29

Table 3
Total Hg (mg/kg wet weight) in consumed seafood

	Average	Range	Count
Fresh fish			
Alewife	0.02	0.02–0.02	1
Bass	0.38	0.11–0.82	12
Cod	0.03	0.01–0.18	20
Flounder	0.03	0.002–0.04	15
Haddock	0.05	0.02–0.10	5
Halibut[a]	0.23	0.02–0.63	29
Herring/sardine	0.02	0.01–0.02	7
Mackerel[b]	0.06	0.05–0.07	6
Pickerel	0.29	0.21–0.38	2
Pollock	0.03	0.01–0.04	6
Salmon	0.05	0.01–0.09	6
Shad	0.10	0.04–0.16	2
Shark	0.13	0.12–0.14	2
Smelt	0.04	0.04–0.04	1
Swordfish[a]	1.00	0.10–3.22	598
Trout	0.22	0.11–0.52	21
Tuna[a]	0.32	ND–1.30	191
Perch	0.25	0.05–0.52	26
Shellfish			
Clam	0.01	0.004–0.01	4
Crab	0.02	0.01–0.06	9
Lobster	0.18	0.03–0.32	6
Mussel	0.02	0.01–0.04	32
Periwinkle	0.02	0.004–0.17	28
Scallop	0.02	0.02–0.02	1
Shrimp	0.03	0.02–0.07	4
Snail	0.10	0.02–0.36	7

[a]Data provided by US Food and Drug Administration, http://vm.cfsan.fda.gov/~frf/sea-mehg.html.
[b]Data provided by the Canadian Food Inspection Agency, www.inspection.ca.

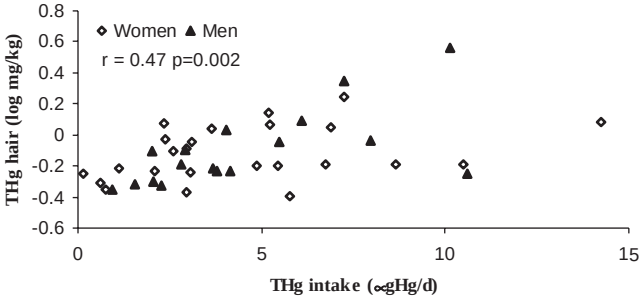

Fig. 6. Correlation between the highest total Hg segment above the 0.4 mg/kg detection limit and the intake as μg Hg/day in spring 2002.

These intake levels are similar to those reported for US anglers at 15–37 g/day (Rupp et al., 1980) but lower than the 92-g/day intake of Spanish male adults (Llobet et al., 2003) and the 72 g/day at marine fish intake of Faroe Islands adults (Grandjean et al., 1992). At St. Andrews/St. Stephen, average marine fish intake was lower at 10 g/day with 5.6 g/day attributed to haddock and pollock. Average shellfish consumption was less at 8.6 g/day but canned fish was highest at 13 g/day consumed. St. Andrews/St. Stephen followed similar patterns as the general US population with a marine fish intake at 8.8 g/day (Rupp et al., 1980).

Average Hg intake (as μg/day) at Grand Manan was 6.8 (including fresh and market fish and shellfish), which is lower than the results from the Spanish study where Hg intake ranged from 16.5 μg/day in children to 21.2 μg/day in male adults (Llobet et al., 2003). Low levels of Hg found in the species consumed explain low intakes, which in turn explain the low total Hg in hair. The greatest contributor for Grand Mananers is haddock which averages 0.05 mg/kg total Hg. Canned tuna (0.17 mg/kg) is the top contributor for those of St. Andrews/St. Stephen. Mercury levels in the consumed fish are similar to those in other groundfish such as halibut (0.25 mg/kg) and flounder (0.09 mg/kg) from San Fransisco markets (Hightower and Moore, 2003) and hake (0.37 mg/kg) and mackerel (0.15 mg/kg) from the Adriatic Sea (Juresa and Blanusa, 2003). In addition, levels for the top four Hg contributors are similar to

those published by the US FDA (2001): haddock (0.17 mg/kg), canned tuna (0.17 mg/kg), lobster (0.31 mg/kg), and pollock (0.2 mg/kg). Marine fish with elevated Hg levels such as shark, tuna, and swordfish are not consumed by these communities, nor are local predatory freshwater fish such as pickerel and bass.

Mercury intake (μg Hg/kg bw/day) was not significantly different between age groups in both communities, but men of St. Andrews/St. Stephen had significantly higher intake than the women of the same area even though the women's body burden was significantly higher. In this study, the individuals reported their weight, thus introducing a potential bias to the estimated intake. In addition, our questionnaire did not differentiate intake of the various types of canned tuna. This is particularly important given the recent data showing the average Hg of that light tuna (skipjack variety with average Hg of 0.118 mg/kg) is approximately 3.5 times lower than that of white tuna (albacore variety with average Hg of 0.407 mg/kg) (Burger and Gochfeld, 2004). Future consumption studies should distinguish between intake of white and light can tuna as using the mean of 0.17 mg/kg from the FDA may over- or underestimate Hg intake in populations where can tuna is the main contributing Hg source. Finally total Hg, not MeHg, in fish and shellfish was incorporated in the intake equation, which would overestimate MeHg intake since the proportion of MeHg in shellfish is variable and may be as low as 10% of total Hg (Bloom, 1992). Despite these limitations, intakes in both communities are below the WHO guidelines of 0.23 μg MeHg/kg body per day. Our data concord with the estimates from the total diet studies of Health Canada, which ranged from 0.012 μg Hg/kg bw/day for females over 65 years old to 0.062 μg Hg/kg bw/day for 0–1-month-old infants Dabeka et al. (2003).

The focused FFQ coupled with one 24-h recall (to obtain portion sizes) was deemed relevant to estimate the frequency and amount of each fish and seafood species consumed over the past 12 months. The benefits of the FFQ are that it is easy and quick to complete with low respondent burden as compared to other dietary assessment methods (Gibson, 1990). Although this method may have been less accurate and precise in comparison to other methods, it is justified because our goal was not to determine nutrient status or obtain a detailed dietary history. Tran et al. (2004) have recently shown that the combined food frequency data from the National Health and Nutrition Examination Survey and 24-h recall data from the Continuing Survey of Food Intake by Individuals is suited to estimate long-term dietary exposure to MeHg.

Dietary instruments (questionnaires) as a measure of exposure to Hg have been only recently validated. MacIntosh et al. (1997) evaluated the usefulness of a food frequency and a food composition questionnaire to estimate intake of dietary MeHg. Results obtained from a semiquantitative FFQ were compared to Hg levels found in toenails. A ranked correlation coefficient of 0.35 supported the view that use of diet instruments as an indicator for Hg intake is adequate. Results from two additional studies from Japan (Nagawaka, 1995) and Sweden (Svensson et al., 1995) obtained similar coefficients. In our study, comparing the highest Hg segment in the spring 2002 with intake, as defined as micrograms of mercury per spring, a correlation coefficient of 0.47 was obtained. This suggests that estimating Hg levels in hair using the focused FFQ coupled with the 24-h recall is reliable.

This is the first study investigating Hg body burden in human populations living along the Bay of Fundy. Even though fish and shellfish are the primary sources of Hg, the species commonly consumed locally contain low levels of Hg.

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