MERCURY LEVELS IN HAIR OF COASTAL ALABAMA ANGLERS AND RESIDENTS

FULL REPORT

KIMBERLY WARNER
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Introduction

Mercury is a potent neurotoxin that accumulates in fish in the form of methylmercury. Most people's exposure to mercury comes from consuming fish. Certain large predatory fish accumulate the most mercury and Federal and State agencies warn anglers and sensitive consumers on which fish to avoid or that should be eaten less frequently. Because the developing fetus and young children are most vulnerable to mercury's toxic effects, mercury advisories for recreational fish in many states will list separate consumption advice for women and kids in this sensitive group as opposed to all others. However, many anglers may also be vulnerable to mercury exposure since they are likely to consume above average amounts of fish.

The northern Gulf of Mexico receives some of the highest mercury deposition in the U.S. A number of popular Gulf sport fish, such as ling (cobia), Spanish mackerel, amberjack, and blackfin tuna, as well as king mackerel, were found to have relatively high mercury levels in an Oceana survey the previous year[1]. However, only king mackerel presently carries a fish consumption advisory in coastal Alabama. Seafood consumption levels among those surveyed were also found to be higher than the national average, which may place anglers and coastal residents at higher risk from mercury exposure. Fortunately, many of the fish monitored were relatively low in mercury. Knowing which fish are lower in mercury may help people who eat a lot of recreational or commercial fish derive the benefits of fish consumption while minimizing risks from mercury.

For those who were concerned or curious about their mercury exposure, and as a follow-up to our fish testing, Oceana offered free mercury hair tests at the 2006 Alabama Deep Sea Fishing Rodeo held in Dauphin Island, AL, July 21-23. Announcements about the testing event were reported in the media prior to the event and participation was voluntary. Anglers were targeted due to their purported higher levels of fish consumption, but other interested attendees were tested as well. The goal of this study was to provide confidential information on personal mercury levels to those interested and to help characterize seafood consumption and mercury exposure in Gulf anglers and residents.

Findings

Hair mercury levels

Sixty five people, including Rodeo anglers (35) and their family members (8), had their hair tested for mercury; 46 were male and 19 were female. Hair mercury concentrations ranged from 0.02-4.05 mg/Kg or parts per million (ppm) (Table 1). As a group, Rodeo anglers had the highest average concentration (0.93) and females the lowest (0.55).

Table 1. Hair mercury levels in Alabama and the U.S.

Group	Mean	Median	Min	Max	% > 1	n	# fish servings/mo. mean	Source
	ppm (mg/Kg)							
Rodeo, Northern Gulf								This study
All	0.80	0.65	0.02	4.05	29.0	65	5.60	
Angler	0.93	0.67	0.09	4.05	37.0	35	5.80	
Angler and family	0.86	0.60	0.09	4.05	33.0	43	5.80	
Non angler/family	0.69	0.67	0.02	1.94	23.0	22	5.30	
Male	0.91	0.66	0.07	4.05	37.0	46	5.86	
Female	0.55	0.37	0.02	1.44	10.5	19	5.05	
Shoals area north AL								Oceana data, 2005
All	0.12	0.09	0.01	0.62	0	59	3.80	
Male	0.11	0.09	0.02	0.62	0	28		
Female	0.12	0.11	0.01	0.48	0	31		
Mobile, AL and Gulf								Mobile Register 2001
All	2.79	2.34	0.12	11.10	78.5	65		
Male	3.07	2.42	0.45	11.10	85.1	47		
Female	2.06	1.42	0.12	5.96	61.1	18		
NHANES								McDowell 2004
Female (16-49)	0.47	0.19				1726		

The National Academy of Science and US EPA set a *reference dose* for methylmercury that is equal to 1 part per million (ppm) in hair. Most of the mercury in human hair exists as methylmercury[2]. This reference dose is the methylmercury level in the human body that is reasonably expected to cause no harm and is protective of all people. In this study, 10.5% of females exceeded this level, as did 37% of Rodeo anglers and males.

Fish and shellfish consumption

All participants in this survey consumed fish[3]. All except two of these also consumed shellfish. The largest group of people ate around 10 monthly 6 oz seafood (fish and shellfish) servings, close to the average of 9.7 (or 55 g/d) (Fig. 1A). This is roughly 3-4 times estimated national averages (13-20 g/d).[4] On the other hand, most of those surveyed ate 8 or more servings of fish, while the average number of monthly fish servings was 5.6 (or 31.8 g/d) (Fig 1B). This is a

conservative estimate, since the highest category of fish or shellfish consumption on the survey that people could choose was 8 or more servings per month.

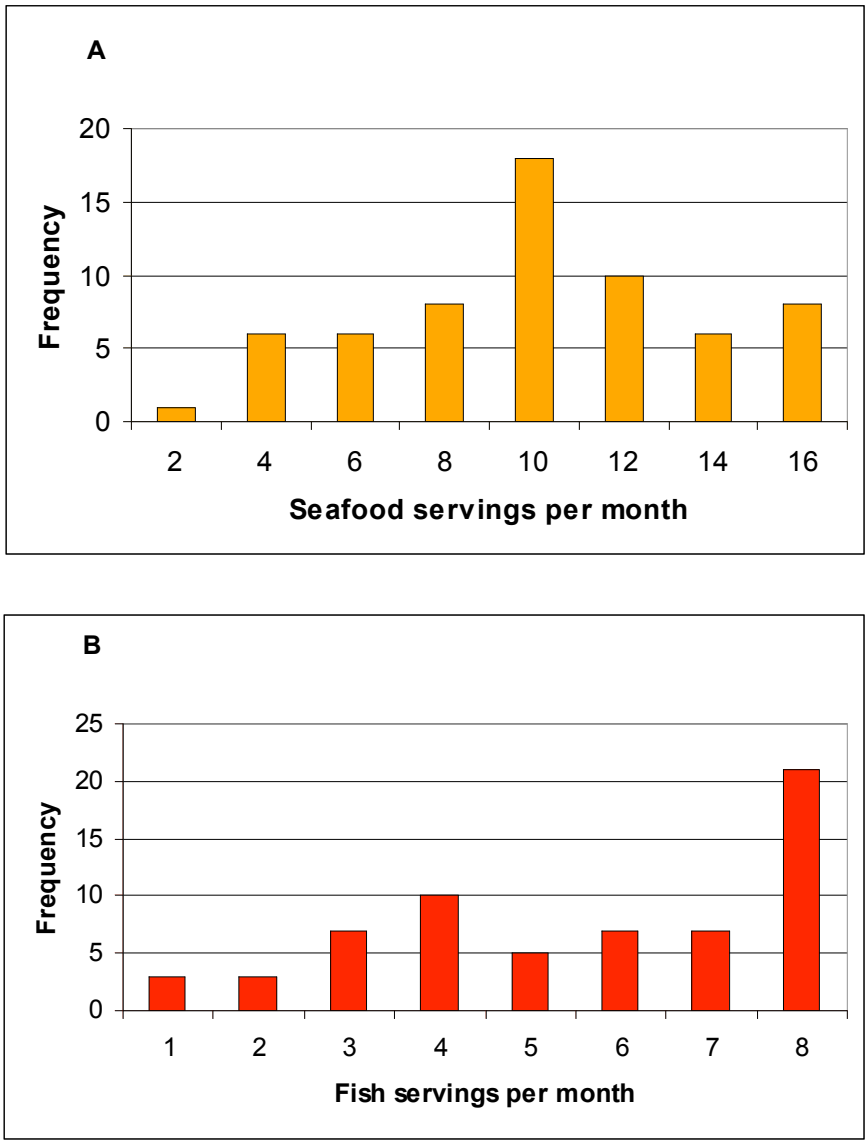

Figure 1. Distribution of (A) seafood (fish and shellfish) and (B) fish consumption rates

Seafood that ranked as most consumed were red snapper, flounder, and grouper (Fig. 2).[5] Red snapper, flounder and grouper were also in the top four choices from our previous survey of Rodeo attendees, but yellowfin tuna ranked as the second most popular in the previous survey.[6] King mackerel, a fish with a mercury advisory both in the Gulf and nationally, ranked much higher in preference among these anglers then it did in the previous survey of Rodeo attendees, where it ranked as one of the least consumed.

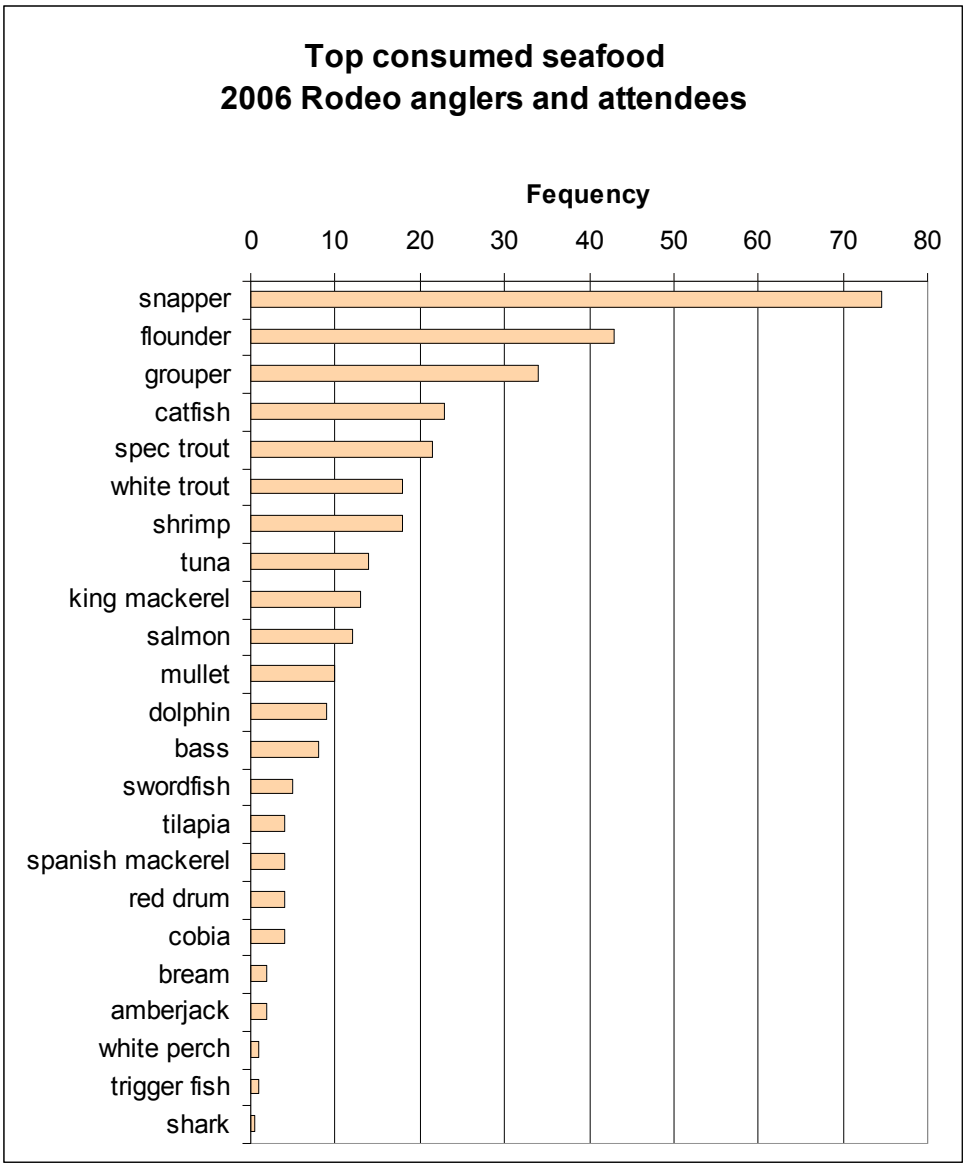

Figure 2. Top consumed seafood surveyed at 2006 Rodeo

Influence of amount and type of fish eaten on hair mercury levels

Hair mercury levels were significantly ($p < 0.0001$) and positively associated with the total number of fish servings per month (Fig. 3), but not total shellfish or total seafood servings. As is clear in Figure 3, there is quite a bit of variability in this relationship. For example, people who said they ate 8 or more servings of fish per month had hair mercury levels that ranged from 0.09 to greater than 4 ppm. Those with the lowest levels consumed low mercury fish, such as flounder and catfish. The person with the highest mercury level (4 ppm) listed Spanish and king mackerel as the most frequently consumed fish, both of which are high in mercury.[7]

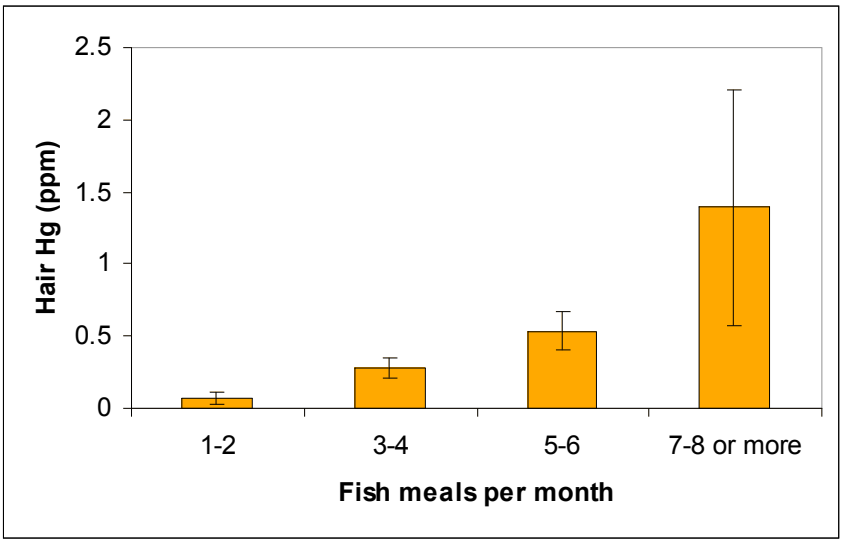

Figure 3. Hair mercury levels in relation to fish consumption rate. Error bars represent one standard deviation of the mean.

This influence of mercury levels in the top consumed fish was quantified and then shown to be positively associated with hair mercury ($p < 0.0001$). The product of these two factors (fish mercury levels and total number of fish servings) explained roughly 50% of the variability in hair mercury levels ($p < 0.0001$) (Fig. 4).

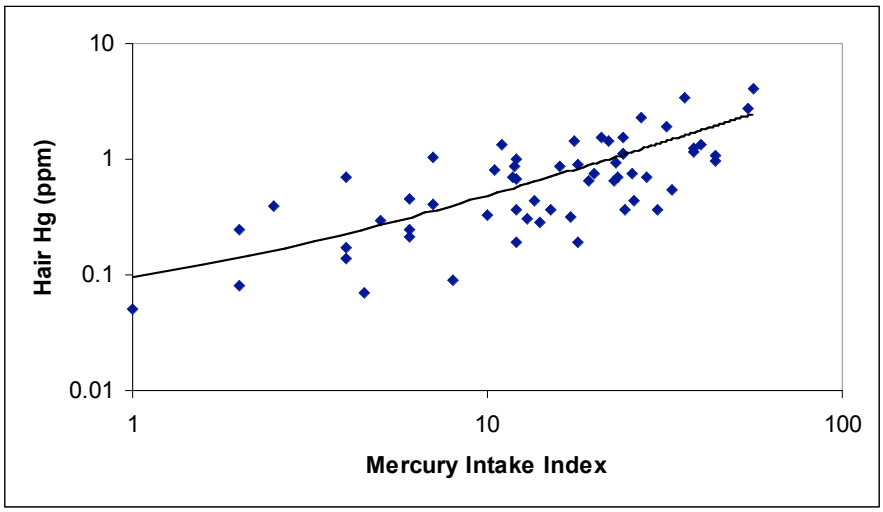

Figure 4. Hair mercury levels as a function of a mercury intake index, defined as the product of the fish consumption rate and fish mercury levels (see Methods).

Some people reported symptoms of mercury exposure

Fifteen participants (23%) reported one or more symptom of mercury toxicity listed on the survey. Numbness or tingling in extremities, memory problems, and headache, were the most reported symptoms. Three participants had been told by their doctors that they had a problem with their nervous system. There was no correlation between mercury levels and reported symptoms, however.

National and regional data comparisons

The data collected in this study were compared to other national and regional data of mercury exposure to help interpret these results. These data sources were from the National Health and Nutrition Examination Surveys (NHANES), a northern Gulf of Mexico survey conducted by the Mobile Register, and an Oceana sponsored study in northern Alabama.

There are no national figures on typical mercury levels in the US population as a whole. The only randomly generated mercury exposure data that are believed to be representative of a segment of the US population are found in the NHANES studies conducted by the federal government. NHANES mercury exposure data only cover women of child bearing age and children, however. Other reported studies of hair mercury levels in the US, including this one, are from segments of the population who choose to have their hair sampled for mercury. This self selection results in data that are not representative of the general US population, but may give insight into regional mercury exposure in segments of the population who are more concerned about this health issue.

The 1999-2000 NHANES data for hair mercury concentrations in women of child bearing age and children in the United States[8] were used as a comparison to female hair levels in this study. The reported median of females in this study was nearly twice that of women who participated in the NHANES study (Table 1). However, the percentage of females who exceeded the EPA reference dose was similar between this study (10%) and the national study of exposure (5-10%).[9]

Another study of hair mercury levels in Mobile, AL and the northern Gulf region was conducted by the Mobile Register in 2001.[10] In that survey, most of the people tested said they ate predator fish on a regular basis. These types of fish generally carry the most mercury. Perhaps for that reason, the range (0.12-11.10 ppm) and average level of hair mercury (2.79 ppm) were particularly high, and significantly higher than in the present study (T-test; $p < 0.0001$)(Table 1).

Oceana also sponsored mercury hair testing in the Shoals area of northern AL in 2005. In this region no one had hair mercury levels above 1 ppm (Table 1). The median mercury level in northern AL was 4 times lower than the median in this study (Fig. 5A). The top consumed fish reported in the north Alabama survey were catfish, salmon, and cod, all of which are very low in mercury (6 times lower than the top consumed Rodeo fish) (Fig. 5B). This population also ate less fish, overall or self-caught, with the average number of fish servings nearly half that of the coastal residents.

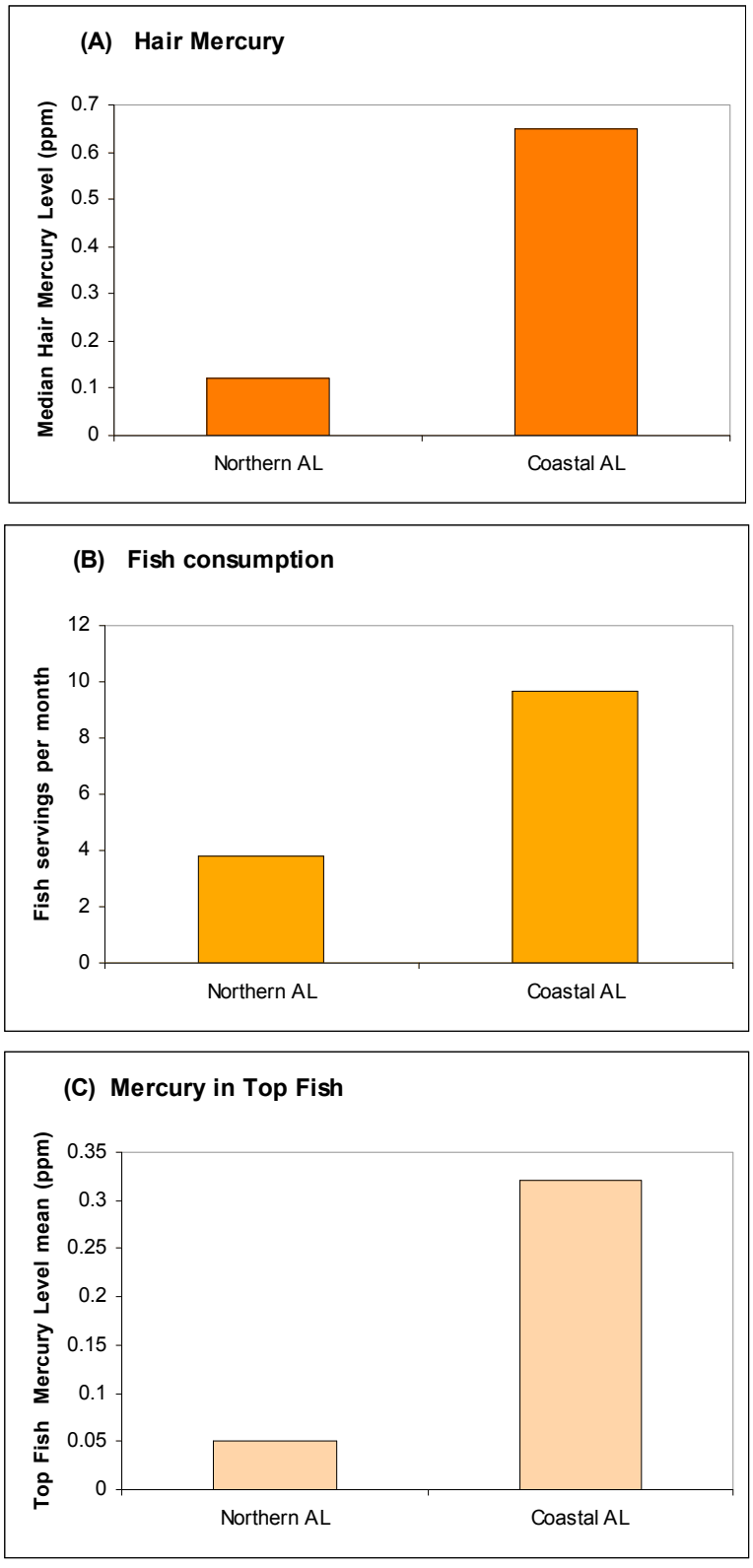

Figure 5. (A) Median hair mercury levels, (B) comparative fish consumption rates and (C) mercury levels in top consumed fish in Northern and Coastal Alabama

Discussion

The finding of higher mercury exposure in Alabama coastal residents compared to northern areas is consistent with a pattern observed nationally. A recent analysis of the latest NHANES data on blood mercury levels in women of child bearing age in the US revealed that those residing in coastal counties had higher levels of blood mercury than inland residents.[11] These relationships appear reasonable due to the greater availability and variety of fish in coastal areas, in general.

Previous monitoring of hair mercury levels in Gulf residents in 2001 showed much higher levels than those found in this study. This could be attributed to several factors. One factor may be that mercury levels in northern Gulf residents are actually lower now than they were 5 years ago, due to increased media attention to mercury levels in Gulf fish and residents that resulted in changes in the types of fish eaten. On the other hand, this survey may simply have missed many of the people who presently eat more high mercury fish.

From this and previous monitoring it appears that Gulf and Alabama residents, on average, eat more fish and shellfish than nationally. Higher levels of fish consumption are promoted by many health studies. What is clear from this and other studies is that one consequence of higher fish consumption may be higher mercury exposure, especially if one chooses fish higher in mercury. Importantly, this study also shows that, by choosing low mercury fish, one can have a very high fish consumption rate and still maintain mercury levels below recommended levels. But what are the implications of higher mercury exposure for anglers, their families, and coastal residents?

Research on the effects of mercury suggests there is good reason to limit exposure. For women of child-bearing age, mercury can be passed on to a developing fetus at its most sensitive stage posing neurological risks to the child. For children, mercury can affect the development of the nervous system. While fish consumption is often encouraged to increase gestation in pregnancy and bolster developing children's neurodevelopment, high mercury exposure in mothers may lead to very preterm delivery[12] and counter beneficial effects for children's neurodevelopment[13]

For adult men, there is emerging evidence that elevated mercury levels (hair mercury greater than 2 ppm) may cause an increased risk of cardiovascular disease.[14] While older adults are urged to eat more fish in order to protect against heart disease (e.g. American Heart Association recommendations), research also suggests that high mercury levels in some fish may counteract some of the heart protective benefits.[15]

Certainly some individuals will be more sensitive to mercury effects than others. A recent study reported mercury poisoning resulting in visual loss in a British male with mercury levels a little over 2 times the EPA mercury reference dose.[16] This individual reported consuming 10-12 fish meals per week, most of which were red snapper from the Caribbean.

Studies such as these led the National Academies Institute of Medicine to conclude that:

"For both child neurodevelopment and adult cardiovascular health, emerging evidence suggests that the health benefits of seafood consumption are greater among individuals whose body burden of methylmercury is lower".[17]

In other words, in order to derive all the benefits of fish consumption, it is important to know which sport or commercial fish are high in mercury and to heed advisories.

Fortunately there is a wide variety of fish available in the Gulf and many species are lower in mercury, as outlined in "*What's on the Hook*?, Oceana's fish testing report. Anyone concerned about their mercury level should talk to their doctor and follow his or her recommendation. Anglers and others who want to lower their level of mercury may choose to eat fish lower in mercury and avoid or limit those that are higher in mercury.

Acknowledgments

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Methods

Participants were asked to first sign a consent form and then complete a 3 page survey. The survey, designed by the testing laboratory, consisted of questions on demographics, fish and shellfish consumption and preferences, and other potential sources of mercury exposure. Questions on whether anyone had any medical symptoms attributed to mercury exposure by their doctors were added by Oceana. These symptoms were hand tremors, numbness or tingling in extremities, loss of coordination, memory problems, blurred vision, headaches, and Parkinson's disease. Assistance was offered in explaining questions and filling out the survey. Answers depended on recall and no effort was made to control for recall bias. Not all participants answered every question. The response rate ranged from 86-100% and averaged 95%. Before leaving, all participants were given or offered a list of Rodeo fish and their average mercury levels, as determined in the previous year's testing.

Participants were asked to give a small bunch of hair strands for testing. Hair was collected primarily from the back and sides of the head near the scalp and trimmed to 1-2 inches, if longer. Hair closest to the scalp gives the most recent exposure, reflecting mercury exposure approximately one month prior.[18] Hair was weighed to provide a 0.5 gram sample and placed into plastic bags. The hair sample, consent form and survey were sent to the Environmental Quality Institute, Asheville, NC, for analysis. Each participant was notified confidentially of their own personal result by the testing lab. Oceana obtained anonymous results from the survey and associated hair mercury levels, with demographic information, other than gender, omitted.

Statistical Tests: Linear and multiple regression, ANOVA, and differences in sample means were performed in Excel and SAS Stat View. Most participants (59) specified the types of fish or shellfish they consumed most often. Some listed only one type, but most listed their top 3 choices. To evaluate dietary mercury intake and how this may influence hair mercury levels, each fish species listed as a top choice was assigned to one of five numeric categories based on its average mercury level, using Oceana data for Gulf fish[19] and FDA data[20] for other fish and shellfish. These categories were numbered 1 through 5, with number 5 representing fish with the highest mercury levels (> 1 ppm). Since the number of servings of top ranked fish was not given, weights were assigned to the top three listed. Various weighting factors were evaluated to examine how they affected the significance of statistical tests. All weighting schemes evaluated resulted in significant outcomes, so a 4, 2, 1 weighting scheme was chosen. This assumed that the top ranked fish was eaten twice as often as the second ranked fish which was consumed twice as often as the third ranked fish. The same assumptions and weighting scheme was assigned to a ranking of seafood preferences. The residuals of the number of fish servings and hair mercury levels were not normally distributed, so the logarithm of these variables was also used in statistical tests. The sum of the weighted mercury ranks of the top 3 fish was then used to evaluate mercury intake with hair mercury as the dependent variable. A *mercury index*, defined as the product of this mercury intake value and the total number of fish servings, was also used in linear regression analyses, while both variables were evaluated in a multiple regression model.

Endnotes

[1]Warner, K and J. Savitz. 2006 "What's on the Hook? Mercury Levels and Fish Consumption Surveyed at a Gulf of Mexico Fishing Rodeo" Oceana, Washington, DC; URL: http://www.oceana.org/fileadmin/oceana/uploads/mercury/rodeo/RodeoreportFINAL.pdf
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[5] It was assumed that of the top three seafood items listed, the first choice was consumed twice as often as the second, which was consumed twice as often as the third. These same assumptions and weights were used in further statistical analyses (see Methods)
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[7] Ibid
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