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Role of self-caught fish in total fish consumption rates for recreational fishermen: Average consumption for some species exceeds allowable intake

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Abstract

Studies of fish consumption focus on recreational or subsistence fishing, on awareness and adherence to advisories, consumption patterns, and contaminants in fish. Yet the general public obtains their fish from commercial sources. In this paper I examine fish consumption patterns of recreational fishermen in New Jersey to determine: 1) consumption rates for self-caught fish and for other fish, 2) meals consumed per year, 3) average meal size, and average daily intake of mercury, and 4) variations in these parameters for commonly-consumed fish, and different methods of computing intake. Over 300 people were interviewed at fishing sites and fishing clubs along the New Jersey shore. Consumption patterns of anglers varied by species of fish. From 2 to 90 % of the anglers ate the different fish species, and between 9 and 75 % gave fish away to family or friends. Self-caught fish made up 7 to 92 % of fish diets. On average, self-caught fish were eaten for only 2 to 6 months of the year, whereas other fish (commercial or restaurant) were eaten up to 10 months a year. Anglers consumed from 5 to 36 meals of different fish a year, which resulted in intake of mercury ranging from 0.01 to 0.22 ug/kg/day. Average intake of Mako shark, swordfish, and tuna (sushi, canned tuna, self-caught tuna) exceeded the U.S. Environmental Protection Agency's oral, chronic reference dose for mercury of 0.1 ug/kg/day. However, computing intake using consumption for the highest month results in average mercury intake exceeding the reference dose for striped bass and bluefish as well. These data, and the variability in consumption patterns, have implications for risk assessors, risk managers, and health professionals.

Keywords

risk; fish consumption; mercury, U.S. EPA's Rfd

Introduction

Persistent contaminants, such as mercury and polychlorinated biphenyls (PCBs), are among the environmental contaminants that remain from mining, industrial, military, transportation, and agricultural activities. Many of these chemicals bioaccumulate in organisms and can bioamplify as they move up the food chain, reaching concentrations that have deleterious effects on organisms and the predators that eat them (ATSDR 1999; NRC 2000). Mercury enters the environment as elemental mercury, is converted to methylmercury by bacteria, and is then bioaccumulated up the food chain (Fitzgerald and Mason 1996; Downs et al. 1998). Consumption of fish, shellfish and other seafood is the primary source of some

contaminants in people (IOM, 2006), especially methylmercury (Stern 1993; EPA 1997a,b; Rice et al. 2000; Stern et al. 2004) and PCBs (ATSDR 1996, 2000). Seafood consumption is increasing in many parts of the World (NOAA 2004), particularly for coastal communities.

Determining the effect of contaminants on humans requires site specific information on contaminant levels and consumption patterns (Burger et al. 1992, 1999a, 2001a; IOM 2006). Consumption varies among regions (Imm et al. 2007), and even within a given area, fish consumption varies markedly as a function of ethnicity, age, income, and other factors (Garcia-Closas et al. 1993; Connelly et al. 1996; Buck et al., 2000; Burger et al., 2001a,b; Nahab et al. 2011). Average consumption rates of specific ethnic groups may be many times higher than for the general population, particularly for tribal, low-income, or subsistence populations (Judd et al. 2004) where environmental justice is an issue (Bullard 1994; EPA 1994, 2002, 2009; Burger and Gochfeld 2011a; Gochfeld and Burger 2011). Further, consumption patterns are often high for coastal residents who fish for saltwater fish (Burger and Gochfeld 2009). Consumption patterns are usually reported for all self-caught fish (not for specific fish), or for specific fish species (those favored or with high contaminant levels). That is, most consumption studies either examine consumption of one species of fish or shellfish (e.g. Burger et al. 1992; Weintraub and Birnbaum 2008; Pflugh et al. 2011), or of consumption generally (Dougherty et al. 2000; Lincoln et al. 2011), but not for a wide range of fish species.

Consumption patterns have been determined for the general population (e.g. Carrington and Bolger 2003), or for particular populations with high levels of consumption (e.g. ethnic groups, low-income, subsistence fishers, Burger and Gochfeld 2011a). In the former case, the fish consumed are mainly commercial fish (Rice et al. 2000), and in the latter case, the fish are usually self-caught. Fish consumption patterns for recreational fishers who might be obtaining their fish both from commercial sources and self-caught fish are seldom examined. The relationship between self-caught fish and commercial fish, and between possible exposure and subsequent risk, from these two different sources remains unclear.

In this paper I examine fish consumption patterns for anglers along the entire New Jersey shore. I was interested in the following questions: 1) How does frequency of consumption of different fish species vary among the fishing population, 2) How many months do people eat specific fish species, and how many meals do they consume per month of each fish species, 3) What is the relationship between consumption patterns for self-caught and commercial fish, and 4) What is the average intake of each species. The average intake of mercury for each fish species was examined using site-specific data on mercury (Burger and Gochfeld, 2011b). Of particular interest was the relationship between self-caught and commercial fish, and between methods of computing intake. Anglers and those present at fishing sites were interviewed to examine people who might be high-end consumers of saltwater fish. 316 people were interviewed in 2010 and 2011. This paper addresses the need for data on the role of both self-caught and commercial fish in diets (Burger and Gochfeld 2006), especially in the selection of fish consumption estimates for risk assessment (Ebert et al. 1994; EPA 1998).

Self-reported fish consumption is the usual method of determining exposure, and Jaarvinen et al. (1993) found that dietary histories are reproducible and acceptable. Considerable attention devoted to the approaches and questions asked on consumption recall studies have contributed to realistic data (EPA 1998), including the use of fish models to estimate size of fish meals (Burger et al. 1999a). Consumption histories have been validated by other methods, including biomarkers (contaminants in tissues). Mercury concentrations in human hair reflects fish intake; a study of hair from 13 countries showed that mercury levels increased with increasing fish consumption (Airey 1983). Similarly, both fish consumption

by history, and mercury intake, are positively associated with mercury levels in hair (Johnsson et al. 2004; Schoeman et al. 2010; Freire et al. 2010), including in pregnant women (Xue et al. 2007). There is also a significant correlation between mercury levels in blood and mercury intake by fish consumption (Knobeloch et al. 2005, 2006), between mercury levels in blood and in hair (Dorea et al. 2005), and between mercury levels in blood and in the occipital cortex (Bjorkman et al. 2007). There is a strong correlation between mercury in cord tissue and mercury in cord blood (Sakamoto et al. 2007), the strongest biomarker for fetal exposure (Budtz-Jorgensen et al. 2000).

Methods

Subjects

316 people were interviewed who were present or angling at several locations from Sandy Hook to Cape May, including fishing tournaments, fishing sites, and fishing clubs, on weekdays and on weekends. Subjects were interviewed with an approved Rutgers University Protocol (E95-082).

Survey Protocol

Subjects were interviewed individually while they fished or watched at fishing sites. All anglers at a site were interviewed, so no subject selection was required. Interviewers identified themselves from Rutgers University, asked subjects if they would participate in an interview about fish consumption patterns, and told them it would take 20-30 min. Some interviews required more time when people wanted to ask questions or discuss fishing. Refusal rate was low (< 5 %), mainly because people were sitting, watching fishing poles, and enjoyed talking about fishing. Demographic questions were deferred until the end of the survey.

The questionnaire was divided into sections on demographics, fishing behavior, self-caught fish, other fish consumption (fish purchased, or eaten in restaurants or fast food places), and meal size. Information on all species of fish included (by fish species): do you eat them, how many months do you eat them, average number of meals/week, and do you give any away. Average meal size was solicited by showing a model of fillets. The list of fish species was derived from previous studies of fish in New Jersey, and on mercury levels in these fish (Burger, 2002; Burger et al., 1999b; Burger and Gochfeld 2005, 2011b, 2012). The list contained 15 species of saltwater fish that are caught in New Jersey, three additional commercial species (swordfish, tuna, salmon), and places for additional fish. Three types of tuna (canned tuna, tuna sushi, and other tuna) were distinguished. Some fish species can be self-caught, or purchased in stores, restaurants or sushi bars (e.g. tuna, bluefish, striped bass).

Consumption rates were determined as ug/Kg/day, using two methods: 1) intake for the year (average per day), and 2) intake for highest month (usually in summer). This latter method was used because the risk to pregnant women depends upon their highest exposure during critical neurodevelopmental periods, and is not necessarily exposure averaged over a year. Consumption rate was a function of number of meals per month X meal size X number of months they consumed the fish, computed for both self-caught and other fish. Intake was computed for mercury, using data from Burger and Gochfeld (2011b), and compared to the U.S. Environmental Protection Agency's (EPA) oral reference dose for mercury of 0.1 ug/kg/day. Total mercury was measured; in most fish, 90% or more of mercury is methylmercury (Lansens et al. 1991; Jewett et al. 2003).

Analysis

Non-parametric statistics (Chi square test) were used because they require no assumptions about the distribution of data, and are thus less likely to make Type I errors (SAS 2005). The Kruskal-Wallis Chi Square test has 95 % the power of ANOVA (Siegel, 1956). A probability level of 0.05 was accepted as significance.

Results

Demographics

Demographics of those interviewed are as follows: mean income was \$87,500 $\pm$ \$4,700, mean age was 52.5 $\pm$ 0.8 years, and 91 % self-identified as Caucasian (5 % African, rest mainly Asian). 90 % of those interviewed were male and they engaged in saltwater fishing 89 % of their fishing time. In nearly all cases, anglers indicated that if they ate the fish, their spouses and children did also.

Consumption rates and mercury intake on a yearly basis

Overall, the percent of anglers who ate each fish species varied by fish species or type, and ranged from 2 % (sand shark) to 90 % (flounder, Table 1, Fig. 1). The percent of the total sample that ate each type of fish is also shown; the percent varied and some fish were eaten mainly when self-caught, and others were mainly eaten from commercial sources (Table 1). There is little relationship between angler consumption overall, and mean mercury levels (Fig. 1).

The percent of fish that is self-caught, by species or type, also varied depending upon how it was calculated (Table 1). One of the questions on the form asked – what percent of fish of these species that you eat is self-caught? (this value is shown as ‘one question’ on Table 1). The actual percent for each person was calculated using their consumption information (meal/month X months they eat) for each type (self-caught and other). The estimates were remarkably similar, providing an internal validity check. In addition, the % self-caught using the mean values was calculated and is given in Table 2 for the number of meals of each type. This gives a much lower value because the values were calculated on the basis of only those who ate each type of fish. In other words, some people ate only self-caught fish, and their % consumption would thus be 100 % (but then they were NOT included in the values presented in Table 2).

Many anglers also give away some of their fish (Table 1), including fish that they caught elsewhere (e.g. salmon), they fished far off the New Jersey shore (e.g. swordfish), or that they purchased (e.g. canned tuna fish). Some anglers mentioned that they gave away fish that were high in mercury, such as striped bass or bluefish. Others mentioned that they gave away some of the large fish (e.g. large tuna caught far offshore).

Consumption rates, a function of number of meals per month, number of months each fish type was eaten, and meal size, varied by fish species (Table 2). The highest consumption rates (meals consumed/year) were for canned tuna, flounder, tuna sushi, fresh tuna, and salmon, followed by striped bass, tautog, dolphin, and black sea bass. This mix clearly indicates that both commercial and recreational fish figure heavily in total fish consumption for this population.

Since both the number of meals/month, and number of months/year each fish was consumed varied, the average number of grams of each fish species consumed/year varied by fish species, and the mercury intake for a 70 kg person varied (Table 2). When consumption is computed as a yearly average, only 5 fish species (types) exceeded the EPA’s mercury Rfd

of 0.1 ug/kg/day, including mako shark, swordfish, and tuna (self-caught as well as canned and in sushi, Fig. 2)

Consumption rates and intake in the month of maximum consumption

Consumption rates were also computed for the month with the highest rates of both self-caught and other fish. Consumption and intake from mercury varied significantly by species (Table 3, Fig. 2). Using this method, striped bass and blue fish exceeded the EPA's Rfd for mercury, in addition to the species (types) given for the yearly method calculated above. Striped bass and bluefish were among the most frequently consumed fish (Fig. 1).

Discussion

Methodological issues

There are a number of methodological issues with this study (and any consumption study) that include: 1) recall bias, 2) biased sample, 3) questionnaire issues and 4) contradictory information. There is some recall bias, but many studies have shown that recall interviews are an acceptable method of obtaining such information (Smith 1993; Jarvinen et al. 1993; EPA 1998), and that consumption rates correspond to internal biomarkers for humans, including mercury levels in blood and other internal tissues (references in introduction).

The sample was intentionally biased as anglers were selected because they might be expected to have higher consumption rates of fish than the general public. I wanted to assess the role of self-caught fish in fish diets of fish consumers. Thus, the conclusions relate to the anglers interviewed. However, saltwater fishing is a popular pastime all along the Jersey shore (Burger and Gochfeld 2011b, 2012), as well as along much of the Atlantic shore from Maine to Florida. It is thus important to understand whether anglers are mainly eating fish they catch, or other fish as well. Average consumption rates of specific ethnic groups may be many times higher than for the general population, particularly for tribal, low-income, or subsistence populations (Judd et al. 2004) where environmental justice is an issue (Bullard 1994, EPA 1994, 2002, 2009a). One of the objectives of this study was to examine fish consumption rates, but also to integrate the importance of self-caught with commercial fish for anglers who might be expected to be at the high end of fish consumption.

The subjects were provided with a list of fish species, but this list was generated from past studies in New Jersey of both recreational and commercial fish (Burger et al., 2004, 2005; Burger and Gochfeld 2011b), although subjects could add fish if they desired. The fish species that subjects added were mainly commercial species, such as tilapia, cod, and halibut.

Any survey that relies on interviewing people in public usually has a problem with the time required to do the survey. However, this was less of a problem in this study because: 1) interviewers at fishing clubs were there by invitation, and club members were part of the research project to understand mercury in fish, and they were interested in the findings and in contributing, and 2) when people were interviewed, they were mainly standing around watching fishing poles, waiting for a bite. People who were not fishing were usually eager to participate, and those who were fishing appreciated the break.

While the number of meals/month is standard information for surveys (EPA 1998), few people ask how many months people fish. Rather, studies usually assume people fish during the fishing months, and compute consumption rates accordingly. I had expected people would eat some fish all year (e.g. salmon), but averages were less than 12 months. These lead to considerations that people may well eat more self-caught fish in some months (and little or none in other months), and in other months eat mainly store/restaurant fish. Two

endpoints were computed: a yearly consumption rate, and a highest month consumption rate. Thus, the computation for the number of meals consumed per year includes all sources of meals (for each fish species).

There was one check on consistency among subjects – we asked them the percent of self-caught fish they ate at the beginning of the survey, and we later used their consumption information to compute the percent of self-caught fish they ate. These numbers were consistent.

Consumption patterns: Types of fish consumed, gifts, and mercury

Not all subjects ate all species of fish; the fish most frequently eaten were flounder, striped bass, tuna (not canned), black sea bass, and bluefish, followed by canned tuna and salmon. It was not surprising that they ate fish that can be caught off the New Jersey shore.

A relatively large number of anglers gave away fish to friends and family. This suggests that risk assessors and managers need to consider the relatively large role of gifts of fish to others when examining the risk from contaminants. While the importance of gifts of fish has been recognized for Native Americans, and those from southern cultures (Toth and Brown 1997), it has not been generally acknowledged for saltwater anglers in the northeast. It was also clear that anglers were giving away fish that they bought (tuna sushi), caught in northwestern U.S. (salmon), or caught out in the ocean (swordfish). The extent of fish-gift giving has not been recognized as a potential exposure; recipients of gifts were not identified in this study, but bears examination.

Role of self-caught fish in total fish consumption

People make choices about the kinds of protein they eat, whether plant or animal, and if animal, what kinds. From 1909 to 1980, consumption of protein (beef, poultry, fish, pork) increased in the United States (Welsh and Marston 1982), and from 1990 to 1998 the consumption of beef declined and poultry increased (Cattle and Beef Industry, 1999). Estimated mean fish consumption for fish for the U.S. population was 15.65 gr/person/day (late 1990s, Jacobs et al. 1998), but has increased since then (Moya 2004; Moya et al. 2010).

In this study, the major objective was to determine the role of self-caught fish in the total fish consumption diet of saltwater anglers, who might be expected to consume more self-caught fish than the general public, and who might be expected to have a high proportion be self-caught. This aspect is seldom examined, although Burger (2000) and Burger et al. (2002) did so for anglers in South Carolina. The percent of fish meals that were self-caught increased with the mean monthly meal rate for both men and women (Burger 2000). For men and women who ate more than 10 fish meals per month, 90 % was self-caught (Burger 2000). There were ethnic differences; blacks ate significantly more self-caught fish than did whites (mean of 171 g vs. 39 g/day).

In the present study, the relative percent of fish that was self-caught varied by fish species. For many subjects, self-caught fish made up a high proportion of their fish diet, and there was little relationship to the amount of mercury in fish. This indicates that they are unaware of the mercury in fish (or mercury hazards), or that they decided to ignore it. In either case, the data indicate a need for increasing knowledge within this high fish consumption community.

Importance of method of computing intake

Intake is normally computed as average mercury consumed per body kg/day. This method averages exposure for a given time period, such as a year. Intake was computed using this

method (Table 2), as well as consumption for the highest month because of the recognition that anglers may well eat more self-caught fish in the summer (they may continue to eat commercial fish, Table 3). The second method results in higher mercury intake rates for most fish species/types, compared to a yearly rate (Fig. 2). These results suggest that scientists need to carefully define the parameters of fish consumption and fish intake, risk assessors need to be aware of these differences, and risk managers need to be aware that angler fish consumption patterns are not consistent throughout the year.

These inconsistencies have implications for exposure to contaminants, and are especially important for high-risk populations, such as pregnant women and young children. While EPA's Rfd has built-in protective assumptions, averaging intake rates from angler populations minimizes the potential risk to developing fetuses because a pregnant woman may actually eat much more fish for several summer months. Her exposure, and that of her baby, is not the yearly average, but is much higher. Women who eat shark, swordfish, tuna, striped bass and bluefish may eat fish with consistently high levels of mercury. That is, when anglers catch a large tuna they may eat it for many meals in a two to three week period, or freeze it and continue to eat it. In addition, the usual methods of risk assessment do not take into account the potential effect of a large, single meal with very high mercury levels. Thus, a pregnant woman could eat one (or two) meals with very high mercury levels, which may have adverse effects on the developing fetus (Ginsberg and Toal 2000). Likewise, anglers that catch large striped bass or bluefish may have a catch that is entirely composed of large fish because such species often travel in same-aged (same-size) schools. Further, anglers often prefer to catch large fish, which have the highest mercury levels (Lange et al. 1994), including striped bass and bluefish (Burger and Gochfeld 2011b). Thus, there are many reasons to assume that mercury levels in fish, and consumption rates of these fish, vary greatly during the year.

Risk balancing

Fishing is fun and fish are a healthy food, but they contain contaminants that are detrimental, particularly to developing fetuses (IOM, 1991 2006). The important role fish and fishing play in local cultures cannot be ignored (Toth and Brown 1997; Burger et al. 2007; Dawson et al. 2008). Yet, people have to make a choice of which fish to eat, and how much to eat (Burger et al. 2005), which involves balancing risks and benefits (Gochfeld and Burger 2005; Mozaffarian and Rimm 2006).

Fish provide omega-3 (n-3) fatty acids that reduce cholesterol levels and incidences of heart disease, stroke, and pre-term delivery (Patterson 2002; Albert et al. 2002; Pounis et al. 2008). Even modest fish consumption (1 serving fish/week) is associated with lower risk of cardiovascular disease (Hu et al. 2005; Virtanen et al. 2008). A positive relationship between consumption of fish with high n-3 fatty acids and mortality from prostate cancer (Szymanski et al. 2010), as well as a lower likelihood of high hostility in young adults (Iribarren et al. 2004), has been demonstrated.

Contaminant levels in some fish are sufficiently high to cause adverse human health effects, making it necessary to consider both the risks and benefits (Gochfeld and Burger 2005). Adverse effects from contaminants in fish include counteracting cardioprotective effects (Guallar et al. 2002), damaging unborn babies and young children (Iso and Rexrode 2001; Olsen and Secher 2002; Moya 2004), and adversely affecting adult behavior and physiology (Hightower and Moore 2003; Hites et al. 2004). There is a positive relationship between mercury and polychlorinated biphenyl (PCB) levels in fish, fish consumption by pregnant women, and deficits in neurobehavioral development in children (Schantz 1996; NRC 2000; Schantz et al. 2003; Axelrad et al. 2007), and with a decline in fecundity (Buck et al. 2000). There is indications that maternal fish consumption may be more highly associated with

birth defects for male offspring than female offspring (Mendola et al. 2005). Generally, there is a positive relationship between mercury levels in people and fish consumption (Knobeloch et al. 2005).

Subjects in the present study ate a wide range of fish, although the percent of the population that ate each kind of fish varied, but was not related to mercury levels (e.g. Fig. 1)). Further, the percent who gave fish away to family and friends was not related to their consumption or to mercury levels (Fig. 1 and Table 1). Bluefish, for example, are relatively high in mercury (0.35 ppm), were eaten by 43 % of the subjects, and 64 % of these people gave some away. Salmon, eaten by 39 % of the subjects, was given away by only 9 %. Salmon, which is not fished in New Jersey (but NJ fishermen fished it from elsewhere), was frozen for later consumption, is highly prized, and is not routinely given away. Ling and Mako shark, not preferred eating species according to people interviewed, were eaten by about 20 % of the sample, but over 50 % of gave some away, presumably to friends who liked them or knew how to cook them. These data clearly show there is selection in the fish species people eat, but their choices are not necessarily related to mercury levels.

There are many implications of this study for risk assessment, risk management, and health management. Risk assessors need that anglers consume both recreational and commercial fish, meal size varies by fish species, self-caught fish are not eaten in every month, commercial fish are not eaten in every month, the importance of self-caught and commercial fish varies by fish species (and individual preferences), and mercury varies by species. Scientists need to be aware that the consumption patterns vary in different months, and the dates of surveys need to be carefully documented.

Risk managers need to consider that anglers vary in their fishing practices, fish preferences, consumption preferences, and fish they give away. Managers also need to remember that anglers go fishing for many different reasons besides obtaining fish to eat, including recreation, relaxation, reducing stress, being with children, and enjoying the outdoors (Burger 2002). All of these, in addition to mercury levels in fish, must be considered in any risk management or communication strategy. Health professionals need to consider that people eat much more fish during the summer, and if pregnant, the potential risk from mercury is thus higher at these times. While the data apply to the population studied, the overall implications are that consumption patterns vary greatly over the year, that the relative proportion of self-caught fish varies over the year, and that since mercury varies markedly in different fish and seasons, the risk from mercury to high-risk populations varies as well.

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Figure 1. Relationship between percent of New Jersey saltwater anglers consuming each type of fish, the role of self-caught fish, and mean mercury levels. The mean and standard error are shown for mercury levels.

Figure 2.

Intake levels computed for yearly averages, and for the highest month of consumption. The dotted line equals the U.S. EPA's reference dose for mercury.

Table 1

Percent of New Jersey anglers surveyed that consume each fish type. For each fish type we asked subjects what percent of each fish they was self caught, and we also calculated the percent that was self-caught from information they provided on meals eaten/month and months they ate each fish type.

Common Name	Scientific Name	% who eat (overall) (N=321)	% who eat (Self-caught) (N=321)	% who eat (Commercial) (N=321)	% who give fish away (N=321)	% of fish that is self caught (one question)	% of fish that is self caught (Calculated for each survey)
Flounder	<i>Paralichthys dentatus</i> ^a	90%	75%	36%	51%	72.8 ± 2.2	74.6 ± 2.3
Striped Bass	<i>Morone saxatilis</i>	72%	57%	6%	52%	87.1 ± 1.9	92.7 ± 1.7
Tuna (not canned or sushi)	<i>Thunnus</i> sp. ^b	54%	29%	25%	46%	58.7 ± 3.5	58.3 ± 4.0
Black Sea Bass	<i>Centropomus striata</i>	53%	42%	6%	50%	88.0 ± 2.3	87.5 ± 2.7
Bluefish	<i>Pomatomus saltatrix</i>	43%	36%	4%	64%	84.9 ± 2.6	90.2 ± 2.6
Tuna fish (canned)	<i>Thunnus</i> sp.	41%	2%	33%	6%	7.0 ± 2.3	9.0 ± 2.9
Salmon	<i>Salmo</i> sp. or <i>Oncorhynchus</i> sp.	39%	5%	30%	9%	12.4 ± 3.0	13.9 ± 3.9
Weakfish	<i>Cynoscion regalis</i>	38%	30%	6%	54%	86.2 ± 2.7	92.3 ± 2.6
Tautog	<i>Tautoga onitis</i>	33%	27%	2%	51%	92.7 ± 2.4	95.9 ± 2.0
Dolphin	<i>Coryphaena hippurus</i>	30%	14%	10%	42%	67.2 ± 4.6	70.6 ± 5.8
Tuna Sushi	<i>Thunnus</i> sp.	26%	3%	19%	14%	19.3 ± 4.3	20.9 ± 5.2
Ling	<i>Molva molva</i>	21%	16%	2%	59%	92.2 ± 3.2	94.6 ± 3.0
Mako Shark	<i>Isurus oxyrinchus</i>	20%	12%	3%	53%	82.2 ± 4.6	86.7 ± 5.0
Swordfish	<i>Xiphias gladius</i>	19%	5%	11%	15%	30.0 ± 6.3	37.9 ± 8.1
Snapper	<i>Lutjanus</i> sp.	13%	8%	4%	55%	68.0 ± 7.1	71.0 ± 7.8
Kingfish	<i>Menticirrhus saxatilis</i>	13%	8%	1%	44%	91.0 ± 4.4	88.0 ± 5.9
Blowfish	<i>Sphoeroides maculatus</i>	11%	6%	2%	38%	88.2 ± 5.9	82.5 ± 7.9
Eel	<i>Anguilla rostrata</i>	5%	2%	1%	58%	72.5 ± 14.2	77.7 ± 11.3
Sand Shark	<i>Mustelus canis</i>	2%	1%	0%	75%	100 ± 0.0	100.0 ± 0.0

^aMost New Jersey anglers target Fluke (*Paralichthys dentatus*), however Winter Flounder (*Pseudopleuronectes americanus*) and Windowpane (*Scophthalmus aquosus*) are also common. Mercury results are for Fluke.

^bYellowfin Tuna (*Thunnus albacares*), Bluefin Tuna (*Thunnus thynnus*), and Albacore (*Thunnus alalunga*) are all caught in New Jersey.

Table 2

Average exposure of New Jersey anglers. Shown are the meals per month, number of months per year fish are consumed, and average meal size, as well as grams consumed and average intake of mercury.

Common Name	Self Caught Fish (for those who eat self caught)		Other than Self-Caught (Restaurant or Store Bought)		Average meal Size (ounces)	Average total meals per year	Average meal Size (grams)	Average grams per year	Mean Mercury (ug/g)	Intake/ 70 kg body wgt ug/kg/day
	# of months/ year you eat	Average # meals/month	# of months/ year you eat	Average # meals/month						
Flounder	5.9 ± 0.2	3.9 ± 0.2	8.9 ± 0.4	3.2 ± 0.3	8.9 ± 0.3	31.1	253 ± 7.4	7884	0.14 ^a	0.04
Striped Bass	5.3 ± 0.2	3.2 ± 0.2	8.3 ± 1.1	2.0 ± 0.4	10.0 ± 0.8	18.9	285 ± 22.1	5374	0.39	0.08
Tuna (not canned or sushi)	5.7 ± 0.4	3.6 ± 0.4	8.3 ± 0.5	2.3 ± 0.3	9.0 ± 0.3	25.0	254 ± 8.2	6338	0.52 ^b	0.13
Black Sea Bass	5.1 ± 0.3	3.1 ± 0.2	9.9 ± 0.8	2.3 ± 0.6	9.7 ± 0.5	17.9	276 ± 12.8	4930	0.16	0.03
Bluefish	4.5 ± 0.3	3.1 ± 0.3	8.1 ± 1.3	4.2 ± 1.0	9.8 ± 0.8	16.4	278 ± 23.2	4560	0.35	0.06
Tuna fish (canned)	5.3 ± 1.4	2.0 ± 0.6	10.8 ± 0.3	3.2 ± 0.3	5.7 ± 0.2	35.8	161 ± 5.1	5765	0.52	0.12
Salmon	4.1 ± 0.8	3.1 ± 0.8	8.6 ± 0.5	2.2 ± 0.2	8.5 ± 0.3	21.5	240 ± 8.2	5166	0.03	0.01
Weakfish	4.6 ± 0.3	3.2 ± 0.4	6.4 ± 1.2	2.2 ± 0.4	9.5 ± 0.3	15.2	270 ± 9.6	4108	0.15	0.02
Tautog	5.1 ± 0.4	2.9 ± 0.3	9.4 ± 1.4	2.4 ± 0.7	9.1 ± 0.4	18.0	259 ± 11.3	4667	0.20	0.04
Dolphin	4.9 ± 0.5	3.1 ± 0.5	6.9 ± 0.8	2.0 ± 0.5	9.4 ± 0.4	18.3	268 ± 12.2	4906	0.17	0.03
Tuna Sushi	5.8 ± 0.9	7.4 ± 2.7	9.1 ± 0.6	2.5 ± 0.3	8.2 ± 0.6	29.8	232 ± 16.2	6899	0.52	0.14
Ling	5.5 ± 0.6	2.5 ± 0.3	7.0 ± 2.1	1.8 ± 0.6	10.1 ± 0.6	13.6	285 ± 15.6	3878	0.04	0.01
Mako Shark	4.1 ± 0.6	2.8 ± 0.4	3.9 ± 1.3	1.6 ± 0.4	9.0 ± 0.5	12.0	255 ± 12.8	3070	1.83	0.22
Swordfish	5.6 ± 1.1	1.9 ± 0.6	6.8 ± 0.8	1.7 ± 0.5	8.4 ± 0.4	14.9	237 ± 11.6	3532	1.40	0.19
Snapper	5.9 ± 0.8	3.0 ± 0.5	7.2 ± 1.5	1.7 ± 0.3	9.5 ± 0.8	17.8	269 ± 22.4	4799	0.20	0.04
Kingfish	4.4 ± 0.6	2.1 ± 0.2	8.7 ± 2.9	3.3 ± 0.7	9.2 ± 0.8	14.1	261 ± 22.1	3674	0.15	0.02
Blowfish	3.9 ± 0.7	1.9 ± 0.3	6.0 ± 2.3	2.2 ± 0.7	8.9 ± 0.8	10.1	252 ± 22.4	2536	0.07	0.01
Eel	4.3 ± 1.3	2.8 ± 0.5	5.7 ± 2.7	2.8 ± 0.8	9.1 ± 1.6	16.4	259 ± 43.9	4250		
Sand Shark	2.0 ± 0.6	2.0 ± 1.0			5.5 ± 2.5	5.0	156 ± 70.9	780	0.47	0.01

^aMercury results are for Fluke.

^bMercury results are for Bluefin Tuna.

Table 3

Highest exposure given mean levels of consumption per month. These data are assuming overlap of eating self-caught and fish from other sources. Species given in order of highest frequency of consumption.

Common Name	Average # meals for overlap / month (self-caught & other)	Average meal Size (grams)	Average grams per day	Mean Mercury ppm (ug/g)	Mean Hg Intake ug/day	Intake/70 kg body wgt ug/kg/day	Hazard quotient
Flounder	4.8 ± 0.3	253 ± 7.4	40.8	0.14	5.67	0.08	0.81
Striped Bass	3.2 ± 0.2	285 ± 22.1	30.6	0.39	12.01	0.17	1.72
Tuna (not canned or sushi)	3.7 ± 0.3	254 ± 8.2	30.9	0.52	16.18	0.23	2.31
Black Sea Bass	3.3 ± 0.2	276 ± 12.8	30.1	0.16	4.94	0.07	0.71
Bluefish	3.4 ± 0.3	278 ± 23.2	31.7	0.35	11.14	0.16	1.59
Tuna fish (canned)	3.1 ± 0.3	161 ± 5.1	16.9	0.52	8.83	0.13	1.26
Salmon	2.4 ± 0.2	240 ± 8.2	19.0	0.03	0.57	0.01	0.08
Weakfish	3.4 ± 0.4	270 ± 9.6	30.1	0.15	4.61	0.07	0.66
Tautog	2.9 ± 0.3	259 ± 11.3	25.2	0.20	5.01	0.07	0.72
Dolphin	3.2 ± 0.4	268 ± 12.2	28.5	0.17	4.89	0.07	0.70
Tuna Sushi	3.4 ± 0.5	232 ± 16.2	26.1	0.52	13.65	0.20	1.95
Ling	2.5 ± 0.3	285 ± 15.6	23.9	0.04	0.89	0.01	0.13
Mako Shark	2.8 ± 0.4	255 ± 12.8	24.0	1.83	44.04	0.63	6.29
Swordfish	1.9 ± 0.4	237 ± 11.6	15.3	1.40	21.43	0.31	3.06
Snapper	2.9 ± 0.4	269 ± 22.4	25.8	0.20	5.15	0.07	0.74
Kingfish	2.3 ± 0.3	261 ± 22.1	20.1	0.15	3.05	0.04	0.44
Blowfish	2.3 ± 0.4	252 ± 22.4	19.1	0.07	1.41	0.02	0.20
Eel	3.0 ± 0.7	259 ± 43.9	25.9				
Sand Shark	2.0 ± 1.0	156 ± 70.9	10.4	0.47	4.89	0.01	0.10