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Fishing, fish consumption, and knowledge about advisories in college students and others in central New Jersey

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Abstract

Risks to humans and other organisms from consuming fish have become a national concern. Over the past 3 years there have been a number of national advisories regarding saltwater fish. Although information on fishing, consumption patterns, and public knowledge about advisories has been examined for at-risk populations, there is little information about the latter for a general population. Overall knowledge about advisories, ratings for information about the risks and benefits of eating fish, and the relationship between fishing, consumption patterns, and knowledge about advisories was examined in a sample of 180 college students and others residing in central New Jersey, USA. The null hypothesis of no differences in fishing, consumption, and knowledge about advisories as a function of age, gender, ethnicity, and education was tested. A significantly higher proportion of men fished compared to women, and significantly fewer Blacks and Asians fished than did Whites or Hispanics. More Asians who fished did so in salt water, compared to others. There were no gender differences in consumption patterns, and few age or ethnic differences, mainly due to low sample sizes in some ethnic groups. Significantly fewer young people and fewer Asians ate fish compared to others. Overall, more people knew about the benefits of eating fish than the risks. Half as many people had heard about advisories concerning tuna, and less than a third knew about advisories concerning shark and swordfish than had heard general warnings. There were no gender differences in knowing about advisories, but there were several ethnic differences: a lower percentage of Asians generally knew that there were advisories, and fewer Blacks knew that there were benefits from eating fish than others. People in the age group 21–45 years were less aware of both the benefits and the risks from eating fish compared to older people. These data suggest that risk managers need to target younger people for information about the risks and benefits of consuming fish, particularly given that this is the population that will become pregnant over the next few years. Contrary to some previous research, subjects trusted family, friends, and other fishermen less for knowledge about the risks and benefits of fish consumption than other sources, such as doctors, governmental officials, and university professors. Even with this limited sample size, it is clear that people have heard more about the benefits of fish consumption than the risks, and a relatively low percentage have heard about the recent US Food and Drug Administration warnings about swordfish and shark.

Keywords: Fishing; Fish consumption; Warnings; Advisories; FDA; Credibility; Trust; New Jersey

1. Introduction

Considerable attention in the media has been devoted to the benefits of consuming fish, as well as to the possible health risk, particularly for self-caught fish (Stern, 1993; Lacerda et al., 1994; Lange et al., 1994; Burger et al., 2001). Fish are an important source of protein, and fishing is a popular pastime in many places

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in the world (Toth and Brown, 1997; Burger et al., 1992, 1993; Burger, 2002), including in some urban areas (Burger et al., 1999a, 2001; Ramos and Crain, 2001). Fish provide Omega-3 fatty acids that reduce cholesterol levels and the incidence of heart disease, stroke, and preterm delivery (Anderson and Wiener, 1995; Daviglus et al., 2002; Patterson, 2002). However, for people consuming large amounts of fish, contaminant levels are sufficiently high in some fish to cause adverse human health effects (ATSDR, 1996; IOM, 1991; Hightower and Moore, 2003; Hites et al., 2004), including counteracting the cardioprotective effects (Guallar et al., 2002) and damaging developing fetuses and young children. 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 (IOM, 1991; Sparks and Shepherd, 1994; Jacobson and Jacobson, 1996; Schantz, 1996; NRC, 2000). There is also a decline in fecundity in women who consume large quantities of contaminated fish from Lake Ontario (Buck et al., 2000).

State and federal agencies can respond to potential health risks from contaminants in fish by issuing consumption advisories, or, in rare cases, making it against the law to fish in certain waters (Burger et al., 1999a). Since the primary responsibility for protecting human health lies with state agencies, it is mainly the states that issue advisories, but most do not provide information on the potential risk from consuming fish purchased commercially in markets or fish stores. The number of state fish advisories due to chemicals, such as mercury and PCBs, has increased in the USA over the last several years (EPA, 2002). Most state agencies distribute fish consumption guidance with fishing licenses, which are usually required only for freshwater fish (Reinert et al., 1991; Burger and Gochfeld, 1991; Burger et al., 1992, 1993, 1999a, b; Velicer and Knuth, 1994; Knuth, 1995; Burger, 2000a). State agencies, however, deal only to a limited extent with the potential risk from consuming fish purchased commercially in supermarkets or fish stores and do not normally issue advisories for these fish or for saltwater fish (exceptions are Maine and Minnesota).

Recently the US Food and Drug Administration (FDA, 2001, 2003) issued a series of consumption advisories based on methylmercury that suggested that pregnant women and women of childbearing age who may become pregnant should (1) limit their fish consumption, (2) avoid eating four types of marine fish: shark, swordfish, king mackerel, and tilefish, and (3) limit their consumption of all other fish to just 12 oz per week (FDA, 2001). Although intended to be reassuring, the FDA advisories have raised concern about the safety of fish available in markets. Despite the interest in self-caught fish, little attention has been directed at fish that are commercially caught (Burger, 2000a). Changes in consumption behavior are possible only if people are aware of the warnings and benefits. Despite the fact that there is literature on the awareness of fish advisories for at-risk populations, little is known about knowledge among the non-fishing public about the risks of fish consumption.

In this paper I examine fishing behavior, fish consumption, and knowledge about the risks and benefits of fish consumption among college students and others (up to 78 years old) surveyed in central New Jersey, USA. I test the null hypotheses that (1) there were no differences in fishing behavior, fish consumption, and knowledge about the risks and benefits of fish consumption as a function of age, gender, education, and ethnicity and (2) there were no differences in the trust of different information sources. My main objective was to determine whether students and others were aware of recent warnings about fish consumption and whether there were ethnic differences in the percentage of people who had heard about the risks or benefits from fish consumption. All attempts to understand and model risk (e.g., Carrington and Bolger, 2002), and to reduce the potential risks from contaminant exposure in fish, will be ineffective if the risk communication aspect is ignored. This paper is intended to serve as a pilot study to suggest hypotheses that address our understanding of public perceptions of both the risks and the benefits of fish consumption.

2. Study population, materials, and methods

The overall protocol was to interview people ($N = 180$) in central New Jersey, including college students and adults ranging in age from 18 to 78 years. The survey population included college students as well as university employees who were selected randomly from the population working at Rutgers University (including maintenance, staff, and faculty) and other adults selected from surrounding communities (and interviewed at supermarkets). Only three people declined to be interviewed (they were busy trying to finish shopping). While this represents a convenience sample, the intent of the study is to begin to understand whether people are aware of recent fish consumption advisories and whether they are aware of both the benefits and the risks of fish consumption. People were approached, told that this was a survey from Rutgers University and that all answers were confidential (they did not give us their names), and were asked the questions.

Information on the questionnaire included demographics (age, sex, ethnicity, years of school, income, and occupation), fishing behavior (whether people fished, saltwater fishing, number of times/year), consumption (meals per week of different kinds of fish),

knowledge about the risks and benefits of fish consumption, the kinds of warnings heard, and a rating of trust for information about benefits and risks of fish consumption (where 1 = no trust and 5 = trust completely). Other questions dealt with the kinds of information they had about warnings and who issued the warnings. The questionnaire required about 20 min to complete.

The demographics of the subjects indicated a wide range in age, education, income, and ethnicity (see Table 1). Only 7% of subjects had no college experience. The sample population self-identified as 9% Hispanic, 12% Black, 27% Asian, and 46% White, and the rest did not self-identify. For New Jersey generally, people identify their ethnicity as 13% Black, 13% Hispanic, 6% Asian, and 66% White (US Census Bureau, 2004). Thus, in this study the sample had more Asians than was reported for New Jersey generally (in 2000)—some of this is due to increases in the Asian population over the last 5 years in New Jersey, and some is due to a higher population of Asians in the University and in central New Jersey.

Mean values with standard errors and ranges are given in the text. Variables were compared using the non-parametric Kruskal–Wallis analysis of variance (PROC NPAR1WAY in SAS with Wilcoxon option). This yields a χ^2 statistic, comparing distributions of responses by different independent variables (SAS, 1995). Multiple regression procedures were used to determine if source (i.e., doctor, federal official, state official, and others), ethnicity, income, gender, age, or education (or interactions between variables) contributed to explaining the variations in trust scores (PROC GLM, SAS, 1995). The procedure adds the variable that contributes the most to the R^2, then adds the next variable that increases the R^2 the most, continuing until all significant variables are added. Thus variables that vary colinearly are entered only if they add independently to explaining the variation.

3. Results

3.1. Fishing behavior

Significantly more men than women fished, and they fished more times per year (Table 2). There were no age-related differences in the percentage of people that fished, but older people who fished, fished more days per year than others. A significantly higher proportion of Hispanics fished than others, and a lower proportion of Blacks fished than did others. There were no ethnic differences in number of days fished per year (Table 2).

Table 1
Fishing and consumption behavior of people surveyed in New Jersey ($N = 180$)

	Mean ± SE	Range	Percentage
Age (years)	34.4 ± 1.18	18–78	
Income (thousands of dollars)	39.2 ± 3.63	0–100	
Gender (women)			58
Education			
Less than high school			3
High school graduate			4
Currently enrolled in college			41
Completed some college			6
College graduate			27
Graduate-level education			19
Fishing			
% fish			24
Number of times fish per year[a]	6.53 ± 1.51	0.1–40	
% fish in salt water[a]			53
Monthly consumption (*for everyone*)			
% who eat fish			86
Number of meals of self-caught fish	0.27 ± 0.11	0–8.7	
Number of meals of fish in restaurants	2.69 ± 0.32	0–22	
Number of meals of store-bought fish	5.02 ± 0.43	0–30	
Number of meals with meats	26.0 ± 1.92	0–91	
Monthly consumption (*for those who eat fish, N = 151*)			
Number of meals of self-caught fish	0.32 ± 0.12	0–8.7	
Number of meals of fish in restaurants	3.12 ± 0.36	0–22	
Number of meals of store-bought fish	5.84 ± 0.46	0–30	
Number of meals with meats	27.4 ± 2.01	0–91	

[a]Only for those who fish.

Table 2
Fishing behavior of people surveyed ($N=180$)

	N	% fish	Number of times fish per year[a]	% fish in salt water[a]
Overall	180	24	6.53±1.51	53
Gender				
Male	80	34	6.94±1.61	49
Female	100	17	5.75±3.22	58
$P^2(p)$		6.83 (0.009)	3.10 (0.08)	NS
Age (years)				
Under 21	52	24	2.39±13.2	43
22–45	61	27	7.6±2.4	51
Over 45	58	17	11.3±4.7	66
$P^2(p)$		NS	5.66 (0.06)	NS
Ethnicity				
White	84	30	6.3±1.74	48
Black	22	9	27.5±12.5	38
Hispanic	16	25	5.7±3.3	25
Asian	49	16	2.9±1	93
$P^2(p)$		7.80 (0.05)	NS	7.20 (0.07)

Given are means±standard error. NS, not significant. Sample sizes may not add up to 174 if some people did not answer a particular demographic question.
[a]Only for those who fish.

There were no gender or age-related differences in the percentage of time fished in salt water compared to fresh water. However, more Asians fished in salt water compared to others (Table 2).

3.2. Fish consumption

Overall consumption patterns are shown in Table 1. Only 3% of fish meals were from self-caught fish, 34% were eaten in restaurants, and 63% were fish bought in stores and cooked at home. When fish and meat diets are examined, fish account for 25% of the meals (self-caught fish are less than 1% of total meals).

Consumption patterns generally did not vary as a function of age, gender, ethnicity, and education, but there were some differences. The same percentage of men and women ate fish, but fewer people under 21 years of age (73%) ate fish compared to older people (over 90%, $\chi^2 = 9.14$, $P<0.01$). Further, 22- to 45-year-olds ate more total meals of fish than others ($\chi^2 = 7.74$, $P<0.02$). There were no ethnic- and gender-related differences in fish consumption patterns, mainly due to small sample sizes within some ethnic groups.

3.3. Knowledge

One objective of the study was to understand whether people had heard about the benefits and risks from consuming fish. Overall, more people had heard about the benefits than had heard about the risks (Fig. 1). Fewer had heard about the risks from consuming canned tuna, and far fewer had heard about the FDA's warnings about shark and swordfish. There were no gender and few age-related differences in the understanding of the risks and benefits from consuming fish. However, significantly fewer 21- to 45-year-olds had heard about the benefits of eating fish ($\chi^2 = 8.23$, $P<0.006$) and the risks from eating fish ($\chi^2 = 8.46$, $P<0.007$), but significantly more of the under-21-year-olds had heard warnings about freshwater fish than others ($\chi^2 = 18.7$, $P<0.005$). There were also ethnic differences: significantly fewer Blacks had heard about the benefits of eating fish ($\chi^2 = 6.99$, $P<0.05$), and significantly fewer Asians had heard about the risks from eating fish than others ($\chi^2 = 20.5$, $P<0.0001$, Fig. 2).

When asked who they trust for information about health benefits and risks from eating fish, 34% of the variation was explained by source (e.g., doctors, officials, others; $F = 35.6$, $P<0.0001$). Doctors were rated the highest, followed by governmental officials (Fig. 3). Friends were rated the lowest. There were almost no differences in ratings as a function of gender, age, or ethnicity. However, Blacks rated university professors lower as a source of information (mean of 2.77+0.19) than did Whites (mean of 3.57±0.12, $\chi^2 = 13.9$, $P<0.007$).

4. Discussion

The data in this study examine the relationship between fishing and fish consumption and between fish consumption and knowledge about the risks and

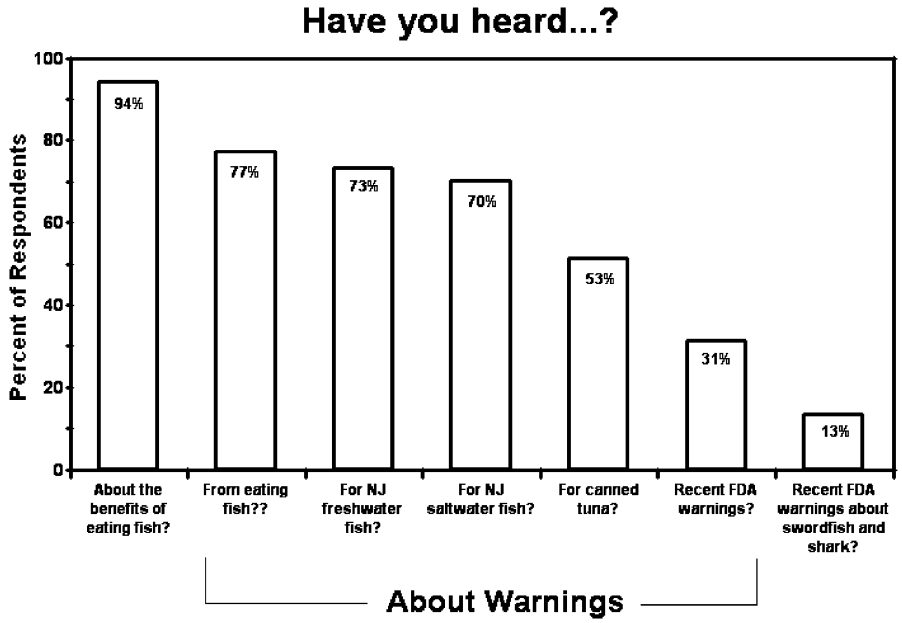

Fig. 1. Percentage of people who have heard about the benefits and risks of fish consumption.

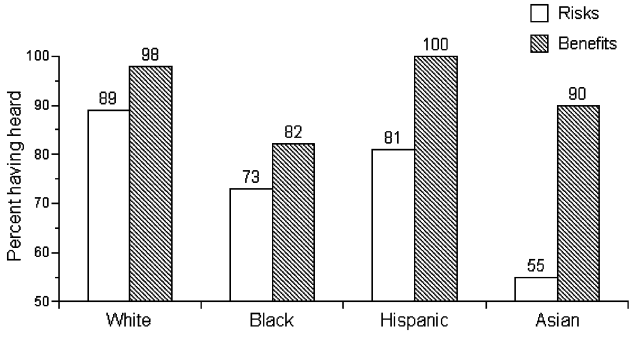

Fig. 2. Percentage of subjects having heard of the benefits or risks of consuming fish, regardless of the species or types (freshwater, saltwater). The actual percentage is shown above each bar.

benefits of fish consumption. While there were few differences as a function of demographics, the differences were significant in terms of knowledge about the risks and benefits and in the knowledge base. These aspects are discussed below.

4.1. Fish consumption

For many years federal and state agencies and scientists have concentrated on understanding the relationship between fishing behavior and consumption, leading to risk calculations for self-caught fish, mainly from fresh waters. Only recently has attention been focused on the commercially available fish that forms the bulk of the fish consumed in the United States (Burger et al., 2002; Hightower and Moore, 2003) or to saltwater fish. The data in this paper indicated that half of the self-caught fish was derived from salt water, rather than fresh water, suggesting that this component of the contaminant risk from fish should be examined in detail, especially for coastal states. Coastal states should consider conducting the same range of studies on contaminant levels in self-caught saltwater fish as they do for freshwater fish, leading to potential advisories for fish with high levels of contaminants.

Most of the subjects in this study ate commercial fish obtained either from markets or in restaurants. Ninety-seven percent of the fish consumed was not self-caught, which was higher than the amount of non-self-caught fish eaten by sportsmen in the state of South Carolina (USA), where self-caught fish accounted for over 30% of the fish diet (Burger, 2000b). In South Carolina, consumers at the high end of the consumption spectrum ate a higher proportion of self-caught fish than those who ate small quantities of fish (low-end consumers). Thus, for the New Jersey population and for most of the South Carolina population, the risk from contaminants in commercial fish bears extensive examination. While the FDA (2001, 2003) has recently issued warnings about commercial fish, the advice is limited to only a few species and does not indicate the fish that are generally low in contaminants. That there is a potential risk from consuming some species of commercial fish is clear from the FDA's issuance of advisories, from high levels of PCBs in fish thought to be low in contaminants, and from health effects from fish (FDA, 2001, 2003; Hightower and Moore, 2003; Hites et al., 2004; Burger and Gochfeld, 2004).

A high proportion of the population examined ate fish, even though fish only accounted for about a quarter

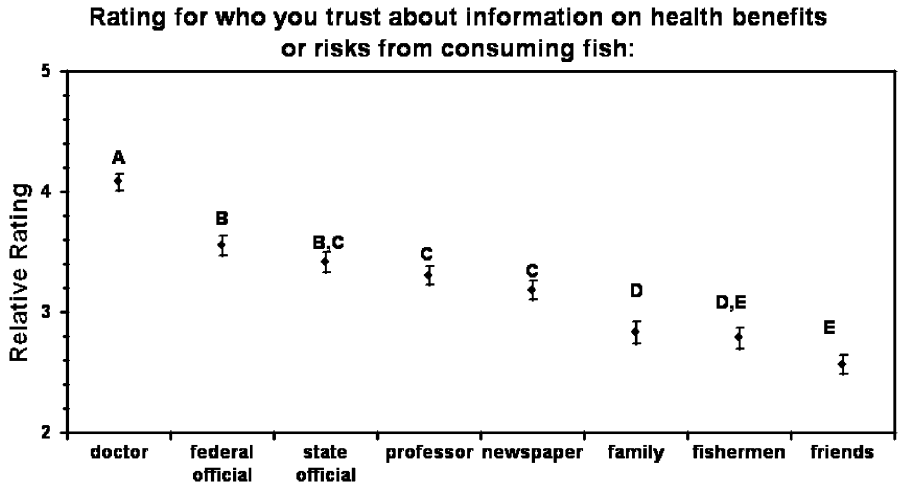

Fig. 3. Relative ratings for "How would you rate your trust in these people for information on the health risks and benefits of eating fish?" Scale is 1, lowest degree of trust, to 5, highest degree. Letters that are different reflect significant differences.

of all meals. There were no age, gender, or ethnic differences in patterns of fish meal consumption, due mainly to small sample sizes in some ethnic groups. Such differences have been identified in many studies of fish consumption among high-end fish consumers (Burger et al., 1999a, b). There were very-high-end consumers of fish in every demographic group.

Finally, most consumption advisories deal with patterns of consumption (so many meals or amounts of fish/week or month) for high-end consumers (Hightower and Moore, 2003). However, concern exists for single fish meals that might have excessive amounts of mercury (over 2 ppm), which could harm developing fetuses (Ginsberg and Toal, 2000). This aspect also bears further examination.

4.2. Knowledge and risk

For people to make informed decisions about eating fish based on the potential risks and benefits, they must know and believe this information (Burger, 2000a, 2002; Jardine, 2003). Such information did not appear to be universally available in the study population. A higher percentage of people had heard about the benefits from eating fish compared to the risks. Risk information was generally higher for self-caught fish than for commercial fishes (such as canned tuna, swordfish, or shark). We found this surprising since the FDA has issued several advisories over the previous 2 years that have been available on their web page (FDA, 2001) and that were reported in the media.

An adequate knowledge base is the first step to making informed decisions. It does not ensure any changes in behavior (switches in diet), but without knowledge, informed decisions cannot be made. Differences in the knowledge base that arise as a function of age, gender, or ethnicity are problematic and should be addressed with a targeted risk-communication strategy (Velicer and Knuth, 1994; Burger and Waishwell, 2001; Jardine, 2003; Burger et al., 2003). Potential recipients of such information will receive both targeted advisories and general information available from the media (e.g., Consumer Reports, 2003). In this study, Blacks were less aware of the benefits and Asians were less aware of the risks of consuming fish. Discrepancies in the awareness of advisories has been noted in a number of studies (Knuth, 1995; Connelly et al., 1996; Tilden et al., 1997; Burger et al., 1999a, b, 2001).

Even if people have heard about the benefits or risks from consuming fish, they need to believe them, which involves trust (Burger, 2000a; Jardine, 2003). In the present study there were significant differences in trust among possible information sources; friends, family, and fishermen were less trusted than other sources. This is contrary to data from urban New Jersey fishermen, who tended to rely on family and friends for such information (Pflugh et al., 1999). The subjects in this study had attained a higher level of education than people in the previous study and had higher incomes than those in the previous study, which might account for the differences in trust. Taken together, these studies indicate that risk communicators should target their outreach efforts to different sources, notably doctors and governmental officials, as well as family and friends.

Finally, there is a politicization of consumption advisories that is troubling. There are several aspects of the problem that have become politicized, including the agencies issuing the advisories, the potential for dissonance between agencies (Burger, 2000a), and the shift of responsibility for exposure from protective environmental federal agencies to individuals themselves (Halkier, 1999). People who develop advisories seem to make choices that depend on policy rather than science, suggesting that uniformity among governmental

jurisdictions is difficult (Kamrin and Fischer, 1999; Burger et al., 2000). Indeed, there are often differences in the consumption advisories neighboring states issue for the same adjoining river or other body of water (Burger et al., 1999a, b; Kamrin and Fischer, 1999). This suggests that advisories must be a partnership between those issuing the advisories and the public (Ebert 1996; Tilden et al., 1997; Burger, 2000a). Differences also exist in the information base that is provided. For example, the recent FDA advisory on tuna (FDA, 2003) was less explicit than published data on mercury in tuna (Burger and Gochfeld, 2004). These political aspects of advice for fish consumers are transmitted to the public via the media, making uniformity, or at least consistency in the contaminant information and risk, essential to changing public perceptions and thus consumption behavior.

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References

Anderson, P.D., Wiener, J.B., 1995. Eating fish. In: Graham, J.D., Wiener, J.B. (Eds.), Risk Versus Risk: Tradeoffs in Protecting Health and the Environment. Harvard University Press, Cambridge, MA, USA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1996. Mercury awareness for the public. Hazard. Subst. Public Health 6, 4–5.

Buck, G.M., Vena, J.E., Schisterman, E.F., Dmochowski, J., Mendola, P., Sever, L.E., Fitgerald, E., Kostyniak, P., Greizerstein, H., Olson, J., 2000. Parental consumption of contaminated sport fish from Lake Ontario and predicted fecundability. Epidemiology 11, 383–388.

Burger, J., 2000a. Consumption advisories and compliance: the fishing public and the deamplification of risk. J. Environ. Plann. Manage. 43, 471–488.

Burger, J., 2000b. Gender differences in meal patterns: role of self-caught dish and wild game in meat and fish diets. Environ. Res. 83, 140–149.

Burger, J., 2002. Consumption patterns and why people fish. Environ. Res. 90, 125–135.

Burger, J., Gochfeld, M., 1991. Fishing a superfund site: dissonance and risk perception of environmental hazards by fishermen in Puerto Rico. Risk Anal. 11, 268–277.

Burger, J., Waishwell, L., 2001. Are we reaching the target audience: evaluation of a fish fact sheet. Sci. Total Environ. 277, 77–86.

Burger, J., Gochfeld, M., 2004. Mercury in canned tuna: white versus light and temporal variation. Environ. Res. 96, 239–249.

Burger, J., Cooper, K., Gochfeld, M., 1992. Exposure assessment for heavy metal ingestion from a sport fish in Puerto Rico: estimating risk for local fishermen. J. Toxicol. Environ. Health 36, 355–365.

Burger, J., Staine, K., Gochfeld, M., 1993. Fishing in contaminated waters: knowledge and risk perception of hazards by fishermen in New York City. J. Toxicol. Environ. Health 39, 95–105.

Burger, J., Pflugh, K.K., Lurig, L., von Hagen, L.A., von Hagen, S.A., 1999a. Fishing in urban New Jersey: ethnicity affects information sources, perception, and compliance. Risk Anal. 19, 217–229.

Burger, J., Stephens, W., Boring, C.S., Kuklinski, M., Gibbons, J.W., Gochfeld, M., 1999b. Factors in exposure assessment: ethnic and socioeconomic differences in fishing and consumption of fish caught along the Savannah River. Risk Anal. 19, 427–438.

Burger, J., Gochfeld, M., McGrath, L.F., Powers, C.W., Waishwell, L., Warren, C., Goldstein, B.D., 2000. Science, policy, stakeholders, and fish consumption advisories: developing a fish fact sheet for the Savannah River. Environ. Manage. 27, 501–514.

Burger, J., Gaines, K.F., Gochfeld, M., 2001. Ethnic differences in risk from mercury among Savannah River fishermen. Risk Anal. 21, 533–544.

Burger, J., Boring, S., Dixon, C., Lord, C., McMahon, M., Ramos, R., Shukla, S., Jeitner, C., Gochfeld, M., 2002. Exposure of South Carolinians to commercial meats and fish within their meat and fish diet. Sci. Total Environ. 287, 71–81.

Burger, J., McDermott, M.H., Chess, C., Bochenek, E., Perez-Lugo, M., Pflugh, K.K., 2003. Evaluating risk communication about fish consumption advisories: efficacy of a brochure versus a classroom lesson in Spanish and English. Risk Anal. 23, 781–803.

Carrington, C.D., Bolger, M.P., 2002. An exposure assessment for methylmercury from seafood for consumers in the United States. Risk Anal. 22, 689–699.

Connelly, N.A., Knuth, B.A., Brown, T.L., 1996. Sportfish consumption patterns of Lake Ontario anglers and the relationship to health advisories. North Am. J. Fish. Manage. 16, 90–101.

Consumer Reports, 2003. American's fish: fair or foul? Available from URL: http://www.consumerreports.org/special/consumerInteret/Reports/0102fis0.html

Daviglus, M., Sheeshka, J., Murkin, E., 2002. Health benefits from eating fish. Commun. Toxicol. 8, 345–374.

Ebert, E.S., 1996. Fish consumption and human health: developing partnerships between risk assessors and resource managers. Am. Fish. Soc. Symp. 16, 261–270.

Environmental Protection Agency (EPA), 2002. Update: National Listing of Fish and Wildlife Consumption Advisories. US EPA, Cincinnati, OH, USA, available from URL: vysiwyg//104/http://www.epa.gov/ost/fish/advisories/general.html

Food and Drug Administration (FDA), 2001. FDA Consumer Advisory. Available from URL: http://www.fda.gov/bbs/topics/ANSWERS/2000/advisory.html

Food and Drug Administration (FDA), 2003. FDA Consumer Advisory. Available from URL: http://www.fda.gov/bbs/topics/ANSWERS/2000/advisory.html

Ginsberg, G.L., Toal, B.F., 2000. Development of a single-meal fish consumption advisory for methylmercury. Risk Anal. 20, 41–47.

Guallar, E., Sanz-Gallardo, M.I., van't Veer, P., Bode, P., Aro, A., Gomez-Aracena, J., Kark, J.D., Riemersma, R.A., Martin-Moreno, J.M., Kok, F.J., 2002. Heavy Metals and Myocardial Infarction Study Group: Mercury, fish oils, and the risk of myocardial infarction. N. Engl. J. Med. 347, 1747–1754.

Halkier, B., 1999. Consequences of the politicization of consumption: the example of environmentally friendly consumption practices. J. Environ. Policy Plann. 1, 25–41.

Hightower, J.M., Moore, D., 2003. Mercury levels in high-end consumers of fish. Environ. Health Perspect. 111, 604–608.

Hites, R.A., Foran, J.A., Carpenter, D.O., Hamilton, M.C., Knuth, B.A., Schwager, S.J., 2004. Global assessment of organic contaminants in farmed salmon. Science 303, 226–229.

Institute of Medicine (IOM), 1991. Seafood Safety. National Academy Press, Washington, DC.

Jacobson, J.L., Jacobson, S.W., 1996. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. N. Engl. J. Med. 335, 783–789.

Jardine, C.G., 2003. Development of a public participation and communication protocol for establishing fish consumption advisories. Risk Anal. 23, 461–471.

Kamrin, M.A., Fischer, L.J., 1999. Current status of sport fish consumption advisories for PCBs in the Great Lakes. Regul. Toxicol. Pharmacol. 29, 175–181.

Knuth, B., 1995. Fish consumption health advisories: who heeds the advice? Great Lakes Res. Rev. 1, 36–40.

Lacerda, L.D., Bidone, E.D., Giumaraes, A.F., Pfeiffer, W.C., 1994. Mercury concentrations in fish from the Itacaiunas–Parauapebas River System, Carajas region. Amazon Ann. Acad. Braz. Sci. 66, 373–379.

Lange, T.R., Royals, H.E., Connor, L.L., 1994. Mercury accumulation in largemouth bass (*Micropterus salmoides*) in a Florida lake. Arch. Environ. Contam. Toxicol. 27, 466–471.

National Research Council (NRC), 2000. Toxicological Effects of Methylmerury. National Academy Press, Washington, DC.

Patterson, J., 2002. Introduction—comparative dietary risk: balance the risks and benefits of fish consumption. Commun. Toxicol. 8, 337–344.

Pflugh, K.K., Lurig, L., vonHagen, L.A., vonHagen, S., Burger, J., 1999. Urban angler's perceptions of risk from contaminated fish. Sci. Total Environ. 228, 203–218.

Ramos, A.M., Crain, E.F., 2001. Potential health risks of recreational fishing in New York City. Ambul. Pediatr. 1, 252–255.

Reinert, R.E., Knuth, B.A., Kamrin, M.A., Stober, Q.J., 1991. Risk assessment, risk management, and fish consumption advisories in the United States. Fish 16, 5–12.

Statistical Analysis System (SAS), 1995. SAS Users' Guide. SAS Institute, Cary, NC, USA.

Schantz, S.L., 1996. Developmental neurotoxicity of PCBs in humans: what do we know and where do we go from here? Neurotoxicol. Teratol. 18, 217–227.

Sparks, P., Shepherd, R., 1994. Public perceptions of the potential hazards associated with food production: an empirical study. Risk Anal. 14, 799–808.

Stern, A.H., 1993. Re-evaluation of the reference dose for methylmercury and assessment of current exposure levels. Risk Anal. 13, 355–364.

Tilden, J., Hanrahan, L., Anderson, H., Palit, C., Olson, J., MacKenzie, W., The Great Lakes Sport Fish Consortium, 1997. Health advisories for consumers of Great Lakes sport fish: is the message being received? Environ. Health Perspect. 105, 1360–1365.

Toth Jr., J.F., Brown, R.B., 1997. Racial and gender meanings of why people participate in recreational fishing. Leisure Sci. 19, 129–146.

US Census Bureau, 2004. New Jersey Quick Facts. Available from URL: http://quickfacts.census.gov/qfd/states/34000.html

Velicer, C.M., Knuth, B.A., 1994. Communicating contaminant risks from sport-caught fish: the importance of target audience assessment. Risk Anal. 14, 833–841.