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Fish availability in supermarkets and fish markets in New Jersey

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Abstract

There is considerable interest in fish consumption, contaminant loads in edible fish, and the risk from consuming fish. Both the benefits and the risks from eating fish are publicized. Most of this attention has focused on recreational anglers and self-caught fish, although the vast majority of fish that people eat are purchased from commercial sources: fish markets and supermarkets. We examined the availability of fish in supermarkets and specialty fish markets in New Jersey, including three regions of the state in communities with high and low per capita incomes (upscale vs. downscale neighborhoods). We were particularly interested in examining whether consumers could determine what type of fish they were buying and whether it was farm-raised or wild. Flounder and salmon were the most commonly available fish, followed by bluefish and tilapia. There were few significant differences in the availability of fish as a function of region. Fish were equally available in fish markets and supermarkets, although snappers were more available in fish markets. The most common fish (found in over 60% of stores) were equally available in upscale and downscale neighborhood stores. However, there were some significant differences in less common fish; butterfish, croaker, monkfish, porgy, and whiting were more available in downscale markets, and halibut, sole, and swordfish were more available in upscale markets. Information available to consumers on labels varied markedly: (1) most labels were generic but some indicated species (e.g., Spanish vs. Boston mackerel, Chilean vs. Black sea bass, mako vs. black-tip shark, rainbow vs. steelhead trout); (2) in many cases, labels indicated whether catfish or salmon were farmed or wild, but usually that information was lacking; (3) sometimes, the labels indicated the location where fish were caught (salmon); and (4) sometimes, there was information on both species and type (e.g., farm/wild for salmon). In most cases, labels gave only a fish name and price. Consumers would be able to make more informed choices if the provenance of fish was clearly stated. State agencies might improve information available to consumers by providing distributors and markets with guidelines about the types of information necessary for consumers to make informed decisions about the fish they eat. When asked, counter staff often could not answer where fish originated from. Finally, there should be partnerships between government agencies responsible for public health, risk assessors, and consumers to ascertain the types of information consumers want and to provide the best available information to consumers.

Keywords: Fish consumption; Risk; Human health; Commercial fish

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1. Introduction

Recently, considerable attention has been devoted to the possible human health risk from consuming fish, particularly self-caught fish (Stern, 1993; Lacerda et al., 1994; Lange et al., 1994; ASTDR, 1996; Burger et al., 2001). There are numerous fish advisories which might prompt consumers to choose among different types of fish. Fish are an important source of protein, and fishing is a popular pastime in many places in the world (Toth and Brown, 1997; Burger et al., 1992, 1993; Burger, 2002), including some urban areas (Burger et al., 1999, 2001; Ramos and Crain, 2001). Despite the interest in self-caught fish, little attention has been directed at fish that are commercially available in supermarkets and fish stores, the source of fish for most Americans.

Recently, the U.S. 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 limit their fish consumption, should avoid eating four types of marine fish—shark, swordfish, king mackerel, and tilefish—and should limit their consumption of all other fish to just 12 ounces per week (FDA, 2001). The main responsibility for protecting human health lies with state agencies, which deal with the potential for adverse health effects from eating fish by issuing consumption advisories, but most do not provide information on the potential risk from consuming fish purchased commercially in supermarkets or fish stores (Burger and Gochfeld, 2004). The number of fish advisories due to chemicals, such as mercury and PCBs, has increased in the U.S. over the last several years (EPA, 2002).

Although intended to be reassuring, the recent FDA (2001, 2003) advisories have raised concern about the safety of fish available in supermarkets. Because most people obtain their fish from markets and supermarkets, it is important to know what fish are available and whether consumers have the appropriate information to make informed decisions about the risk from eating fish. In this paper, we examine the commercial availability of fish in New Jersey as a function of store type (supermarket or specialty fish market), region (north, central, south), and economic status (upscale vs. downscale towns, based on per capita income). We were particularly interested in whether people could ascertain the species of fish they were buying, whether availability varied among regions of the state, and whether consumers could determine if a fish was wild-caught or farm-raised. We tested the null hypothesis that there would be no differences as a function of these variables. We also collected data on fish availability from fish markets along the shore, where we expected a greater diversity in types of fish due to local commercial and "grey market" fish landings.

It is important for people to have information about the types of fish available in relation to potential contaminant levels so that they can make informed choices. Fish provide Omega-3 (n-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, contaminant levels are sufficiently high in some fish to cause adverse human health effects in people consuming large amounts of fish (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).

2. Methods

Our overall research design was to survey fish markets and supermarkets throughout New Jersey (north, central, south) and also along the shore, in upscale and downscale towns, in July through October 2003. We defined upscale as above the median per capita income for that region and downscale as below the median per capita income, and we used the U.S. Census Bureau (2000) data for per capita income. We sampled at least two fish markets and two supermarkets in both downscale and upscale towns within each of the three regions of the state. Supermarkets are

stores selling a range of food and other grocery items, and fish markets sold primarily fish. Only fish markets were available along the shore and were mainly in shore communities with a high rate of summer residents. We selected one upscale and one downscale town in each of the three regions and then developed a list of supermarkets and fish markets in each town from New Jersey's Seafood and Fish Index Page http://www.ipindex.com/New%20Jersey/NJseafood.html). We oversampled in the southern and northern part of the state because the stores had less diversity than in central New Jersey. We kept the sample sizes from upscale/downscale and fish markets/supermarkets balanced. Because we collected data only from July through October, seasonality may affect availability of fish in some regions of New Jersey.

At each market, we recorded all fish that were present in the fish counter display (not canned fish or packaged frozen fish). All information provided on the label was noted; for some species, this referred to wild or farm-raised or the country of origin. This information addressed the issue of whether people can know if the fish they select is wild and from a given region. Because one of our key objectives was to examine the information available to the public concerning the fish they select, following our survey we asked the clerk behind the counter if they knew where the fish came from and whether they were

Table 1
List of common species which occurred in at least 15% of the markets sampled in New Jersey

Fish	Scientific name	Trophic level	All New Jersey	Upscale	Downscale	χ^2 (p) Kruskal–Wallis
Number of markets			57	28	29	
Number of fish species			113	87	63	4.7 (0.03)
Mean number of fish/market			13.1 ± 1	13.5 ± 1	12.7 ± 1	0.02 (NS)
Common Fish (by %)						
Bluefish	*Pomatomus saltatrix*	Invert/Piscivore	82.5%	82.1%	82.8%	0.0006 (NS)
Butterfish	*Peprilus triacanthus*	Jellyfish/Plankton	26.3%	7.1%	44.8%	7.69 (0.006)
Catfish	*Ictalurus punctatus*	Small Invert/Piscivore	52.6%	57.1%	48.3%	0.21 (NS)
Cod	*Gadus morhua*	Invert/Piscivore	38.6%	35.7%	41.4%	0.12 (NS)
Scrod	*Gadus morhua*	Invert/Piscivore	19.3%	14.3%	24.1%	0.72 (NS)
Croaker	*Micropogonias undulatus*	Invert/Piscivore	35.1%	14.3%	55.2%	6.79 (0.009)
Flounder	*Pleuronectes americanus*	Invert/Piscivore	89.5%	89.3%	89.7%	0.0002 (NS)
Grouper	*Epinephelus morio*	Invert/Piscivore	24.6%	28.6%	20.7%	0.36 (NS)
Halibut	*Hippoglossus stenolepis*	Large Invert/Piscivore	24.6%	42.9%	6.9%	7.50 (0.006)
Mackerel	*Scomber scombrus*	Small Invert/Piscivore	17.5%	17.9%	17.2%	0.003 (NS)
Mahi mahi	*Coryphaena hippurus*	Large Invert/Piscivore	26.3%	35.7%	17.2%	1.85 (NS)
Monkfish	*Lophius americanus*	Piscivore	17.5%	3.6%	31.0%	6.12 (0.01)
Perch	*Sebastes marinus*	Invert/Piscivore	21.1%	17.9%	24.1%	0.27 (NS)
Porgy	*Stenotomus chrysops*	Small Invert/Piscivore	33.3%	14.3%	51.7%	5.99 (0.01)
Salmon	*Salmo salar*	Invert/Piscivore	89.5%	92.9%	86.2%	0.07 (NS)
Sea bass	*Centropristis striata*	Invert/Piscivore	45.6%	57.1%	34.5%	1.60 (NS)
Blacktip shark	*Carcharhinus limbatus*	Top predator	1.8%	0.0%	3.4%	
Mako shark	*Isurus oxyrinchus*	Top predator	12.3%	21.4%	3.4%	3.8 (0.05)
Snapper	(family) *Lutjanidae*	Invert/Piscivore	57.9%	64.3%	51.7%	0.39 (NS)
Sole	(family) *Pleuronectidae*	Small Invert	24.6%	39.3%	10.3%	4.86 (0.03)
Spot	*Leiostomus xanthurus*	Small Invert	28.1%	17.9%	37.9%	2.04 (NS)
Swordfish	*Xiphias gladius*	Top predator	56.1%	78.6%	34.5%	4.93 (0.02)
Tilapia	*Oreochromis* spp.	Small Invert/Herbivore	75.4%	75.0%	75.9%	0.001 (NS)
Trout	(family) *Salmonidae*	Invert/Piscivore	29.8%	35.7%	24.1%	0.64 (NS)
Tuna	*Thunnus* spp.	Piscivore	75.4%	85.7%	65.5%	0.77 (NS)
Whiting	*Merluccius* spp.	Small Invert/Piscivore	42.1%	17.9%	65.5%	7.68 (0.006)

Scientific names are given, in some cases, only to the family level. The designation "spp." indicates that several species in a genus may be represented.
All trophic level information is from http://www.fishbase.org/search.cfm.

wild-caught or farm-raised. We examined information in two ways: (1) identification of the species of fish sold under a given label and (2) detailed information for those species where more information was given. This included bass, catfish, cod, flounder, mackerel, perch, pompano, salmon, sea bass, shark, snapper, tilapia, trout, and whiting. All scientific names for commonly sold fish are given in Table 1 and are not repeated in the text. In some cases, we identified the whole fish by keys and texts in hand while we looked at the fish.

We used Kruskal–Wallis tests to test for differences as functions of location, store types, and economic status (SAS, 1995a,b). For the price comparisons, we used a two-tailed sign test, using normal approximation to the binomial (Siegel, 1956). We accepted $P<0.05$ as significant. Multiple regression procedures were used to determine if region, type, or scale (or interactions between variables) contributed to explaining the variations in the number of fish species/market (PROC GLM, SAS, 1995a,b). 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 collinearly are entered only if they add independently to explaining the variation.

3. Results

3.1. Availability

Twenty-five nominal types of fish were present in at least 15% of the 57 markets sampled in New Jersey (Table 1). Only nine types (in most cases, species) of fish were found in over half of the markets in New Jersey (Fig. 1). Flounder and salmon (seldom identified to species) were the most common fish, followed by bluefish and tilapia. Several fish were found in only one store (and are not included in the tables or in further analyses), including blue marlin *Makaira nigricans*, blowfish *Lagocephalus lunaris*, corvina *Cynoscion parvipinnis*, cuttlefish *Sepia officinalis*, galongong *Decapterus* spp., hake *Merluccius bilinearis*, opah *Lampris guttatus*, scup *Stenotomus chrysops*, shad *Alosa sapidissima*, and wahoo *Acanthocybium solander*.

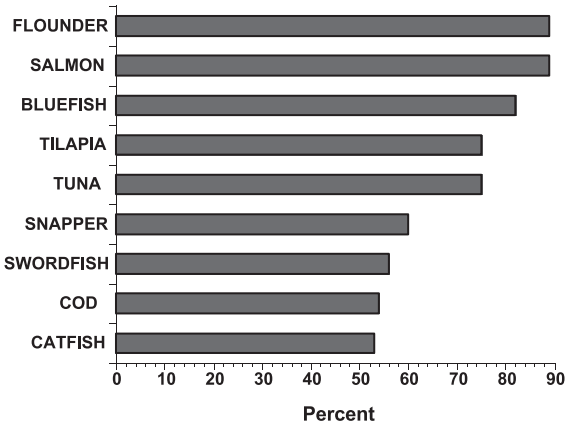

Fig. 1. Common species found in fish markets and supermarkets in New Jersey. Shown are percent of markets where they occurred.

In general, there were no significant differences in the availability of particular fish species as a function of region. That is, a given species was found in a similar percent of stores in all regions of the state with one exception: butterfish were more common in the north ($X^2=6.37$, $P<0.04$). Surprisingly, fish were equally available in fish markets and supermarkets, although snappers were more available in fish markets (78%) compared to supermarkets (32%, $X^2=5.16$, $P<0.02$).

The most common fish, those found in over 60% of the stores, were equally available in upscale and downscale neighborhood stores (Table 1). However, there were some significant differences; butterfish, croaker, monkfish, porgy, and whiting were more available in downscale markets, and halibut, sole, and swordfish were more available in upscale markets (Table 1). Thus, there were more differences with respect to local economies than to the region of the state or type of market.

There were no significant regional differences in the mean number of fish species available in stores ($X^2=2.84$). The average number of different fish per store varied between 10.4 (along the shore) to 15.6 (central New Jersey). Similarly, there were no differences between fish markets and supermarkets ($X^2=1.7$). However, in central and southern New Jersey, upscale stores had significantly more kinds of fish than downscale stores ($X^2=6.16$, $P<0.01$), but in north Jersey, downscale stores averaged twice as many different kinds of fish ($X^2=10.6$, $P<0.001$).

Table 2
Information provided to customers in New Jersey markets about types of fish

Fish species	Scientific name	Supermarket (%)	Fish market (%)	X^2 (p)
Bass				
Striped	*Morone saxatilis*		60	
White	*Morone saxatilis*		20	
Striped (Hybrid)	*Morone saxatilis* × *Morone chrysops*	100		
Slippery (Tautog)	*Tautoga onitis*		20	
Catfish				
No designation		63	73	2.02 (NS)
Cajun (refers to seasoning)		8	20	0.03 (NS)
Farm-raised	*Ictalurus punctatus*		7	
Nuggets		29		
Mackerel				
No designation (Atlantic?)	*Scomber scombrus*	80	80	0.12 (NS)
Boston	*Sarda sarda*	20		
Spanish	*Scomberomorus maculatus*		20	
Salmon				
No designation		21		
Alaskan		8		
Atlantic	*Salmo salar*	37	43	2.04 (NS)
Baby		3		
Cooper			4	
Farm-raised	*Salmo salar*	23	8	6.44 (0.01)
King	*Oncorhynchus tshawytscha*		8	
Maine			4	
Organic		5		
Smoked			4	
Steelhead (Rainbow trout)	*Oncorhynchus mykiss*		4	
Sushi Grade			4	
Wild		3	13	0.58 (NS)
Wild king	*Oncorhynchus tshawytscha*		4	
Wild sockeye	*Oncorhynchus nerka*		4	
Sea bass				
No designation		33	30	0.41 (NS)
Black	*Centropristis striata*		10	
Chilean	*Dissostichus eleginoides*	67	60	0.81 (NS)
Shark				
No designation		50	20	2.65 (NS)
Blacktip	*Carcharhinus limbatus*	12		
Mako	*Isurus oxyrinchus*	38	80	0.003 (NS)
Snapper				
No designation		30		
Baby		10		
Blue (juvenile bluefish?)			16	
Red	*Lutjanus campechanus*	60	81	8.19 (0.004)
Yellowtail	*Ocyurus chrysurus*		3	

(continued on next page)

Table 2 (*continued*)

Fish species	Scientific name	Supermarket (%)	Fish market (%)	X^2 (p)
Sole				
No designation		67	60	1.90 (NS)
Dover	*Mircostomus pacificus*	11		
Gray	*Glyptocephalus cynoglossus*	22	20	0.63 (NS)
Lemon	*Microstomus kitt*		20	
Tilapia				
No designation	*Oreochromis* spp.	100	95	2.03 (NS)
Costa Rican	*Oreochromis* spp.		5	
Trout				
No designation		18		
Lake	*Salvelinus namaycush*		14	
Rainbow	*Oncorhynchus mykiss*	55	86	0.18 (NS)
Sea	*Cynoscion nebulosus* or *regalis*	9		
Steelhead	*Oncorhynchus mykiss*	18		
Tuna				
Baby		5		
Bigeye	*Thunnus obesus*		4	
Yellowfin	*Thunnus albacares*	95	96	0.05 (NS)
Whiting				
No designation	*Merluccius* spp.	91	77	0.31 (NS)
King (Kingfish)	*Menticirrhus americanus*	9	8	0.031 (NS)
Smoked			15	

Given is the percent of either supermarkets or fish markets (of the total) that provided that kind of information on their labels. NS = not significant.

The latter reflects an inclusion of more local species of ethnic interest (i.e., porgys, butterfish). The best model explaining the variation in the number of fish species/market explained 65% of the variability in terms of region ($F = 3.8$, $P < 0.02$) and region X type (downscale/upscale, $F = 25.9$, $P < 0.0001$).

3.2. Knowledge about the fish

In general, people working at the fish counters did not have any more information than was provided on the labels, even in the specialty fish markets. As is clear from Table 2, there was more information about some fish than others. Some fish had no additional information because there was none required. For example, there is only one species of bluefish, and they are only acquired from the wild. For other fish, the species designation was never given (e.g., flounder could be two different species).

Several points need to be made:

1. sometimes, the labels indicated that the fish were actually different species (i.e., mackerel, sea bass, shark; Table 2);
2. sometimes, the labels indicated that the fish were farm-raised but did not indicate if other species in their display were wild-caught (catfish, salmon);
3. sometimes, the designations indicated the location where fish were caught (salmon); and
4. sometimes, there was a combination of information (salmon, Table 2).

Even with additional information, the provenance of a fish was difficult to identify precisely (e.g., Atlantic Salmon may refer to its catch location or to the fact that farm-raised salmon is also called Atlantic Salmon). In general, slightly more information was available in fish markets compared to supermarkets (Table 2). For example, in 21% of the supermarkets, salmon was listed without any other designation,

whereas in all the fish markets, salmon had a descriptor, either for species or whether it was farm-raised.

3.3. Price

Finally, for 35 species of fish where comparisons were possible from downscale and upscale stores, the average price/lb of fish was less in downscale markets ($Z = 31.5$, $P < 0.0001$). The average price/lb was cheaper in supermarkets than in fish markets for 33 of 42 comparisons ($Z = 32.5$, $P < 0.0004$). Thus, the same species of fish is cheapest in downscale supermarkets compared to others.

4. Discussion

4.1. Availability

The null hypothesis of no regional difference in the availability of fish throughout the state generally was accepted (except for butterfish). However, overall diversity of fish species differed by region. The only difference between fish markets and supermarkets overall was for snappers. This should make risk assessment for commercial fish easier on a statewide basis. There were, however, several significant differences in the availability between upscale and downscale markets; butterfish, croaker, monkfish, porgy, and whiting were more available in downscale markets and halibut, sole, and swordfish were more available in upscale markets. These data indicate that for the consumer, most kinds of fish are generally available within each geographical region, but they might have to frequent both upscale and downscale markets to buy a diversity of fish. Thus, risk communicators might need to target information to people in these two sectors because fish availability differed in upscale/downscale stores. One unexpected finding was that the variety of fish available was not greater at shore fish markets compared to markets elsewhere in the state. We had expected that markets located along the shore would have access to locally caught fish. It should be noted that we visited markets from late July until late October, and availability of types of fish may differ at other times of the year.

One important aspect is whether fish that are low in contaminants are equally available to people in different regions of the state. There were few differences by either region or by type of store, people in all parts of the state could find a variety of fish. Fish that are generally low in contaminants are flounder, salmon, and tilapia, three of the four fish that were found in the most stores (see Fig. 1). While salmon is generally considered low in contaminants, recent work has suggested that farm-raised salmon may have higher levels of PCBs than wild-caught salmon because they are fed fish meal (which may be high in contaminants, Hites et al., 2004).

4.2. Knowledge about fish availability

The more surprising finding was the differences in the information provided for commonly eaten fish, such as catfish, salmon, sea bass, and snapper. In many markets, a consumer could not determine whether fish were farm-raised or wild-caught and in most cases could not tell where they came from. Many labels are idiosyncratic, for example, ‘‘cooper salmon’’ and ‘‘baby snapper’’. Some of the common names for fish actually refer to more than one species.

There are at least two aspects that pose a problem for the consumer: (1) some common names under which fish are sold can include several species (e.g., salmon), and (2) some fish are called one thing when they are really another (i.e., red snapper). Recently, Consumer Reports (2003) noted that only 5 of 11 samples labelled ‘‘red snapper’’ in supermarkets were actually red snappers. There are several species of salmon, yet half of the 51 stores carrying salmon did not list either the source (farm or wild) or the species.

For other species, there was no disagreement in the species, but the source location was unknown. For example, there is only one species of bluefish, but consumers could not tell whether it was caught locally or not. Because bluefish are highly migratory, catch location will not indicate mercury exposure, except over a large geographical region.

Knowledge about fish availability is key to consumers making informed decisions about reducing their own health risks from contaminants and for preserving fish populations. For example, knowing salmon are wild-caught may aid in reducing organochlorine contaminants (Hites et al., 2004) and know-

ing wild-caught salmon came from Alaska (rather than elsewhere) may aid in reducing the impacts to salmon populations that are more at risk (Monterey Bay Aquarium, 2004).

4.3. Fish availability and risk

Most attention regarding the health risks from consuming contaminated fish has focused on contaminant levels in fish, consumption rates, and potential risk (see references in introduction). However, for purposes of risk communication and advisories for targeted audiences (such as pregnant women), it is essential to know the availability of fish locally and to address these specific fish. This is the first step in selecting which species to test for contaminants so that consumption advice can be positive (“eat these”) rather than solely negative (“avoid these”). Communicating risks to a target audience is an important aspect of risk communication (Reinert et al., 1991; Velicer and Knuth, 1994; Connelly et al., 1996; Burger, 2000; Burger and Waishwell, 2001). The data presented in this paper suggest that because fish are equally available in all regions of the state, risk assessors can conduct statewide risk assessments. However, targeted information on risk may need to be developed differently for upscale/downscale neighborhoods (and markets) because there were differences in availability in these types of markets.

If knowledgeable consumers are to select fish with low levels of mercury or other contaminants, they must know both which types and species of fish have high levels and where they come from. While top level predatory fish generally have higher levels of contaminants than herbivores (refer to Table 1), individuals of the same species can vary in their contaminant levels depending upon where they lived (i.e., a fish living in a polluted bay will acquire higher contaminant loads than one living in a pristine bay). For example, contaminant levels are higher in Raritan Bay in northern New Jersey than in southern New Jersey, so that locally caught flounder might differ in contaminant levels. While there is a wide range of commercial fish available to customers in New Jersey within each geographical region, the information provided to consumers on the exact species of fish they are buying, whether the fish are farm-raised or wild-caught and the location of wild-caught fish is often lacking. It took us several days of visiting stores, purchasing whole fish we could use for identification, and using keys to identify some of the species.

We suggest that markets selling fish should make the following information available to customers: species, farm-raised or wild, and locale where caught. State agencies might improve the information available to consumers by providing distributors and markets with guidelines about the types of information necessary for consumers to make informed decisions about the fish they eat. Finally, there should be partnerships between government agencies responsible for public health, risk assessors, and consumers to ascertain the types of information consumers want and to provide the best available information to consumers (Ebert, 1996).

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References

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

Anderson PD, Wiener JB. Eating fish. In: Graham JD, Wiener JB, editors. Risk Versus Risk: Tradeoffs in Protecting Health

and the Environment. Cambridge (MA): Harvard University Press; 1995; p. 104–124.
Buck GM, Vena JE, Schisterman EF, Dmochowski J, Mendola P, Sever LE, et al. Parental consumption of contaminated sport fish from Lake Ontario and predicted fecundability. Epidemiol 2000; 11:383–8.
Burger J. Consumption advisories and compliance: the fishing public and the deamplification of risk. J Environ Plan Manag 2000; 43:471–88.
Burger J. Consumption patterns and why people fish. Environ Res 2002;90:125–35.
Burger J, Gochfeld M. Mercury in canned tuna: white versus light and temporal variation. Environ Res. 2004;94 [in press].
Burger J, Waishwell L. Are we reaching the target audience? Evaluation of a fish fact sheet. Sci Total Environ 2001;227: 77–86.
Burger J, Cooper K, Gochfeld M. Exposure assessment for heavy metal ingestion from a sport fish in Puerto Rico: estimating risk for local fishermen. J Toxicol Environ Health 1992;36: 355–65.
Burger J, Staine K, Gochfeld M. Fishing in contaminated waters: knowledge and risk perception of hazards by fishermen in New York City. J Toxicol Environ Health 1993;39:95–105.
Burger J, Pflugh KK, Lurig L, von Hagen LA, von Hagen SA. Fishing in urban New Jersey: ethnicity affects information sources, perception, and compliance. Risk Anal 1999;19:217–29.
Burger J, Gaines KF, Gochfeld M. Ethnic differences in risk from mercury among Savannah River fishermen. Risk Anal 2001;21: 533–44.
Connelly NA, Knuth BA, Brown TL. Sportfish consumption patterns of Lake Ontario anglers and the relationship to health advisories. North Am J Fish Manage 1996;6:90–101.
Consumer Reports. American's fish: fair or foul? 2003. http://www.consumerreports.org/special/consumerInteret/Reports/0102fis0.html.
Daviglus M, Sheeshka J, Murkin E. Health benefits from eating fish. Comments Toxicol 2002;8:345–74.
Ebert ES. Fish consumption and human health: developing partnerships between risk assessors and resource managers. Am Fish Soc Symp 1996;16:261–70.
Environmental Protection Agency (EPA). Update: national listing of fish and wildlife consumption advisories. Cincinnati, Ohio, U.S. Environmental Protection Agency; 2002. Available at http://vysiwyg//104/http//www.epa.gov/ost/fish/advisories/general.html.
Food and Drug Administration (FDA). FDA consumer advisory; 2001. http://www.fda.gov/bbs/topics/news/2004/NEW1038.html [accessed 1 March 2001].
Food and Drug Administration (FDA). FDA consumer advisory; 2003. http://www.ipindex.com/listing.lasso [accessed 1 February 2004].
Guallar E., Sanz-Gallardo M.I., van't Veer P., Bode P., Aro A., Gomez-Aracena J., et al. Heavy metals and myocardial infarction study group: mercury, fish oils, and the risk of myocardial infarction. New Engl. J. Med. 2002;347:1747–1754.
Hightower JM, Moore D. Mercury levels in high-end consumers of fish. Environ Health Perspect 2003;111:604–8.
Hites RA, Foran JA, Carpenter DO, Hamilton MC, Knuth BA, Schwager SJ. Global assessment of organic contaminants in farmed salmon. Science 2004;303:226–9.
Institute of Medicine (IOM) Seafood Safety. Washington (DC): National Academy Press; 1991.
Jacobson JL, Jacobson SW. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. New Engl J Med 1996;335:783–9.
Lacerda LD, Bidone ED, Giumaraes AF, Pfeiffer WC. Mercury concentrations in fish from the Itacaiunas–Parauapebas River System. Carajas region. Amazon Ann Acad Bras Sci 1994;66: 373–9.
Lange TR, Royals HE, Connor LL. Mercury accumulation in largemouth bass (*Micropterus salmoides*) in a Florida lake. Arch Environ Contam Toxicol 1994;27:466–71.
Monterey Bay Aquarium. Seafood watch; 2004. http://www.mbayaq.org/cr/seafoodwatch.asp.
NRC (National Research Council). Toxicological effects of methylmercury. Washington (DC): National Academy Press; 2000.
Patterson J. Introduction—comparative dietary risk: balance the risks and benefits of fish consumption. Comments Toxicol 2002;8:337–44.
Ramos AM, Crain EF. Potential health risks of recreational fishing in New York City. Ambul Pedriatr 2001;1:252–5.
Reinert RE, Knuth BA, Kamrin MA, Stober QJ. Risk assessment, risk management, and fish consumption advisories in the United States. Fish 1991;16:5–12.
Schantz SL. Developmental neurotoxicity of PCBs in humans: what do we know and where do we go from here? Neurotoxicol Teratol 1996;18:217–27.
Siegel S. Non-parametric statistics. New York (NY): McGraw-Hill; 1956.
Sparks P, Shepherd R. Public perceptions of the potential hazards associated with food production: an empirical study. Risk Anal 1994;14:799–808.
Statistical Analysis System (SAS). SAS Users' Guide. Cary: Statistical Institute; 1995a.
Statistical Analysis System (SAS). SAS Users' Guide. Cary, North Carolina: Statistical Institute; 1995b.
Stern AH. Re-evaluation of the reference dose for methylmercury and assessment of current exposure levels. Risk Anal 1993;13: 355–64.
Toth Jr JF, Brown RB. Racial and gender meanings of why people participate in recreational fishing. Leis Sci 1997;19:129–46.
Velicer CM, Knuth BA. Communicating contaminant risks from sport-caught fish: the importance of target audience assessment. Risk Anal 1994;14:833–41.