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A framework and information needs for the management of the risks from consumption of self-caught fish

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Abstract

Governmental agencies deal with the potential risk from consuming fish contaminated with toxic chemicals by issuing fish consumption advisories. Yet such advisories are often ignored by the general public, who continue to fish and consume self-caught fish that are the subject of advisories and are from contaminated waters. Further, people are often unaware of specific warnings (which species to avoid, who is vulnerable, when they are vulnerable). In this paper we propose a more inclusive framework for examining consumption behavior of self-caught fish and identify information needs for effective communication. We include not only the usual variables that are used for calculating risk from fish consumption (meal frequency, meal size, contaminant levels) but also other aspects of behavior that contribute to risk. These include attitudes (trust, risk aversion, environmental concerns), behavior (sources of information, cultural mores, personal preferences), exposure (physical proximity, ingestion rates, bioavailability, target tissues), contaminant levels, individual host differences, and hazards (levels of contaminants). We suggest that attitudes and behavior shape risk as much as exposure and hazards and that all four of these factors must be considered in risk management. Factors such as gender, age, pregnancy status, and nutrition all influence who is at risk, while other consumption factors affect these at-risk populations, including meals/week, meal size, cooking method, fish species and sizes eaten, and years of fish consumption. Similarly, contaminant levels in fish vary by fish species, fish size and age, part of the fish, and collection location. Elucidating the risk to individual consumers involves integrating this range of factors, and managing the risk likewise involves incorporating these factors. We suggest that development of appropriate advisories and compliance with advisories will occur only if managers, risk assessors, and public policy makers consider this whole range of factors and not just the traditional fish consumption rate (often underestimated) and contaminant levels in fish (often undersampled). Merely informing the public of contaminant levels or the risk from contaminants will not ensure a public that has enough information to make informed decision, or to be in compliance with consumption advisories, or to effect changes in consumption behavior where public health is at risk.

Keywords: Fish; Consumption; Consumption advisories; Contaminants; Mercury; PCBs; Health benefits; Risk assessment; Risk management; Risk perception; Risk/benefit balancing

1. Introduction

Fishing is a popular pastime in both urban and rural areas of the United States and throughout the world (Toth and Brown, 1997; Burger et al., 1992, 1993, 1999a, 2001a, b; Ramos and Crain, 2001; Burger, 2002a). Angling not only provides fish and shellfish to eat but also confers a range of other social benefits that include interacting with family and friends, participating in fish fries, getting away from the stresses of urban life, and communing with nature (Fleming et al., 1995; Toth and Brown, 1997; Burger, 2002a). Increasing attention to health and nutrition has increased the public's consumption of fish, even among

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those who never fish themselves (NOAA, 2004). In the United States there has been a general upward trend in seafood consumption since the 1960s, despite an increase in price (relative to meat). The trend has waxed with nutrition advice and waned with hazard advisories (FAO, 1998) but continues to increase, now exceeding 7.4 kg/capita per year (NOAA, 2004).

Over the past decade health professionals have devoted considerable attention to elucidating the benefits and risks from consuming fish, particularly for self-caught fish (Lange et al., 1994; Anderson and Wiener, 1995; Egeland and Middaugh, 1997, 1998; Burger et al., 2001a; Gochfeld and Burger, 2005). Fish are a healthy source of protein, provide omega-3 (n-3) fatty acids that are generally accepted to reduce cholesterol levels, and reduce the incidence of heart disease, stroke, and preterm delivery (Anderson and Wiener, 1995; Daviglus et al., 2002; Patterson, 2002; Hu et al., 2002; Albert et al., 2002), although Garcia-Closas et al. (1993) did not find a negative association between fish consumption and ischemic heart disease mortality. Further, Iribarren et al. (2004) showed a positive relationship between consumption of fish with high n-3 fatty acids and a lower likelihood of high hostility in young adults.

However, contaminant levels in some fish are sufficiently high to potentially cause adverse human health effects, including counteracting the cardioprotective effects (Guallar et al., 2002), damaging unborn babies and young children (Neuringer et al., 1994; ATSDR, 1996; IOM, 1991; Lonky et al., 1996; Iso and Rexrode, 2001; Nestel, 2001; Olsen and Secher, 2002; Consumer Reports, 2003; Moya, 2004), and adversely affecting adult behavior and physiology (Hightower and Moore, 2003; Hites et al., 2004). There are positive relationships 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; Schantz et al., 2003). There is a decline in fecundity in women who consume large quantities of contaminated fish from Lake Ontario (Buck et al., 2000). There is also a suggestion that mercury affects blood pressure (Vupputuri et al., 2005). Generally, there is a positive relationship between mercury levels in people and fish consumption (Knobeloch et al., 2005; Johnsson et al., 2005). The extensive discussion about what the "safe" level of exposure is may be partly political and is surely controversial (Stern, 1993; NRC, 2000; Stern et al., 2004). The role of occasional peak exposures versus chronic lower level exposures to methylmercury, for example, requires close attention, and it may also be essential to develop single-meal fish consumption advisories, especially for fish species high in methylmercury (Ginsberg and Toal, 2000).

The risk to humans from contaminants in fish can be addressed by reducing contaminant levels in fish, by reducing consumption of fish with high contaminant burdens, or both. Reducing the input of contaminants into aquatic systems ultimately reduces the levels in fish, but there is a lag time. In the Everglades of Florida reductions in mercury inputs were evident in declines in mercury in fish tissue within 8 years (SFWMD, 2004), but in other places decreases have been much slower. Reducing contaminants in aquatic ecosystems requires a concerted regulatory effort on a regional scale. New Jersey regulations reducing emissions from garbage incinerators have been very effective in controlling a major source (NJ Mercury Task Force, 2001). On the other hand, in the northeastern part of North America, atmospheric transport of mercury, mainly from coal-fired powerplants in the midwestern states, is deemed a major controllable input (NESCAUM, 1998; NJ Mercury Task Force, 2001). The Environmental Protection Agency's Clear Skies initiative relies heavily on emission trading but does not take full effect until 2018 (USEPA, 2003). Ultimately, however, it is the responsibility of governments to reduce contaminants in the environment so that fish consumption advisories are no longer necessary.

The other approach to risk reduction is to shift the burden from environmental protection to personal behavior (Jakus et al., 1997; Halkier, 1999), to issue consumption advisories, and to assume that personal behavior will change accordingly. State, federal, and tribal agencies have responded to potential health risks from contaminants in fish by issuing consumption advisories. Yet compliance with such advisories is sometimes low, leading to questions about the efficacy of such advisories as a public health policy (Connelly and Knuth, 1998; Burger, 2000a; Jardine, 2003). However, one study from Newark Bay (NJ) reported that Hispanic fishermen showed a willingness to change their consumption behavior when presented with clear risk information (Burger et al., 1999a, Pflugh et al., 1999), and another study reported a decline in fish consumption among pregnant women following a federal mercury advisory issued in January 2001 (Oken et al., 2003). However, we found that, although many people in our study population in New Jersey had heard about warnings concerning tuna, less than a third knew about advisories concerning shark and swordfish and most did not have specific information about the basis for such warnings (Burger, 2005; Burger and Gochfeld, in press).

In this paper we review the issuing of consumption advisories, compare angler compliance and knowledge about such advisories from several of our studies, and propose a framework for information needs necessary to integrate several aspects of fishing, fish consumption, and risk. We suggest that public health officials will not change personal behavior with regard to fish consumption unless they take a multifaceted approach to managing the risks. Further, we suggest that issuing consumption advisories alone is not sufficient to allow people to make informed decisions about their health in relation to fish consumption. This paper is intended to provide a broad framework for state agencies and the public to think about a holistic

approach to advisories and providing the public with sufficient information to make decisions about fish consumption. It suggests the types of site-specific information that are required, including fishing behavior, consumption behavior, contaminant levels, knowledge, and the reasons for going fishing. While some of this information is being used by some states, it is not generally used consistently across states because site-specific information is often not available.

2. Consumption advisories

The number of state fish advisories due to chemicals, such as mercury and PCBs, has increased in the United States over the past 2 decades and has increased by 125% since 1993 (US EPA, 2004). Such an increase could be due to increases in the number of health assessments, enhanced screening programs, lower detection levels, changing standards, or increases in contamination. Wyoming and Alaska are the only states in the United States without fish consumption advisories (US EPA, 2004). Alaska has taken a strong antiadvisory stance, supported by the state epidemiologists, that nutritional benefits of fish outweigh the risks, especially for subsistence fishers (Egeland and Middaugh, 1997). Most states only issue advisories, but some states have closed particular lakes, estuaries, or other habitats to fishing or allow only catch-and-release fishing (Pflugh et al., 1999). Many states distribute fish consumption guidance with fishing licenses, which in most states are 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). This form of distribution leaves out two very important user groups: saltwater anglers (which includes estuaries) and Native American groups (who do not need to purchase fishing licenses). State advisories may be updated annually and under most conditions do not command much media attention.

The US Food and Drug Administration (US FDA, 2001, 2003) issued consumption advisories based on methylmercury which advised pregnant women and women of childbearing age who may become pregnant to entirely avoid eating four types of marine fish (shark, swordfish, king mackerel, tilefish) and limit their consumption of all other fish to just 12 oz per week (US FDA, 2001). This was recently amended to add that people should "mix up the types of fish and shellfish you eat, and do not eat the same type of fish or shellfish more than once a week" (US FDA, 2004). Advisories for tuna, particularly canned tuna, remain controversial (Burger and Gochfeld, 2004), and there is little advice and few advisories for fish available commercially (Burger et al., 2004, 2005), although the FDA advisory does indicate that white tuna has higher mercury than light tuna (US FDA, 2004). The FDA advice is for both commercial and self-caught fish, whereas most state advisories relate only to self-caught fish (although this is gradually changing). This paper, however, is directed toward self-caught fish, rather than commercial fish.

3. Angler knowledge and compliance

While consumers might limit fish consumption or choose among different kinds of fish based on consumption advisories and media warnings, there is a rich literature indicating that this is not always the case (Reinert et al., 1991; Velicer and Knuth, 1994; Knuth, 1995; Burger, 2000a; Jardine, 2003; Knuth et al., 2003). In many cases, people are aware of the advisories but choose to ignore them. The public consistently underrates or ignores risks which are voluntary and familiar (Slovic, 1987; Kasperson et al., 1988; Burger, 2000a) and continues to fish in contaminated waters (Belton et al., 1986; Burger and Gochfeld, 1991; Anderson and Wiener, 1995; Ebert, 1996; Reinert et al., 1996; Knuth et al., 2003). It should be noted that there is also the risk that people will react to the advisories by no longer eating fish, which in itself has public health implications because fish are such a good source of nutrients and protein. The nutritional advice about the health benefits of eating fish conflicts with advisories. However, people sometimes heed the warnings. For example, Weihe et al. (2005) reported a decrease in whale consumption (and subsequently in hair mercury levels) by Faroe Island women following the issuing of extensive whale consumption advisories for pregnant women.

Awareness of warnings is sometimes ethnically related. In a South Carolina study population, only 42% of Blacks had heard warnings about freshwater fish, compared to 65% for Whites (Burger et al., 1999b). In an on-going study in the Newark Bay Complex, 70% of Whites were aware of warnings, whereas this was only 60% for Blacks and 35% for Hispanics and Latinos (Burger et al., 1999a). That is, some people had not heard any warning despite the fact that they were fishing for the species under advisories. Similarly, consumption patterns often vary ethnically, with Native Americans and minorities consuming more fish than whites (Harris and Harper, 1997; Jacobs et al., 1998; Burger et al., 1999a, b, 2001a).

The dissonance between knowledge of fish consumption advisories and compliance led Burger (2000a) to propose that the deamplification of risk occurs for hazards that are familiar and enjoyable, such as fishing and fish consumption from contaminated waters. Kasperson et al. (1988) proposed a dichotomy of amplification and deamplification of risk that they largely applied to the amplification of risks associated with hazardous wastes. Unlike the amplification of risk, the deamplification of risk from fishing in the face of consumption advisories is partly legitimized by the actions of some governmental agencies and by society at large. In general, wildlife agencies are encouraging fishing, stocking fish, and issuing fishing licenses, while public health agencies may be discouraging some types of fish consumption among some target populations. Burger (2000a) suggested that a variety of economic benefits and

social institutions lead to a discounting of consumption advisories and that the delayed nature of adverse health effects allows for further disregard by the public. For fishing, there is a discrepancy between the scientist's and the regulator's views of the risk from eating some fish and that of the general public; the public views eating such fish as less serious than does the scientist (Burger, 2000a). Fish and fishing are familiar and voluntary, and there is no basis for dread.

Several authors have noted that people do not find voluntary and familiar risks to be "dangerous" (Slovic, 1987; Kasperson et al., 1988).

4. Consumption patterns, knowledge of advisories, and compliance: data from our studies

Over the past 20 years we have examined fishing behavior, consumption patterns, and compliance in study populations in Puerto Rico (Burger et al., 1992), New Jersey (Burger et al., 1999a, 2005; Pflugh et al., 1999), New York (Burger et al., 1993, 2003a, b), South Carolina (Burger et al., 1999b, 2001a–c), and Tennessee (Campbell et al., 2002; Burger and Campbell, in press). All areas were under fish consumption advisories, although the contaminant of concern varied. Among fishing respondents in past studies, people consume an average of over two meals per month (Fig. 1) and may average over one meal per week (South Carolina, Blacks, Burger et al., 1999b).

Depending upon the study location, from 20% to 90% of the people interviewed have heard some warnings about fish safety (Fig. 2). However, there is often a disparity between the percentage of people who have heard warnings and that of those who think that the fish are safe to eat. Thus, in respondents from Arthur Kill (NJ), 60% had heard warnings, yet 61% still thought that the fish were safe to eat. In Puerto Rico, nearly 90% of those interviewed had heard the warnings, and over 90% still believed that the fish were safe to eat. Thus there is a dissonance between their awareness of fish consumption advisories and their belief in the safety of the fish. These data were all taken using the same general questions, by the same interviewers, using the same methodology (an advantage of comparative studies by the same research group).

For the study populations examined, there is a relatively high agreement between the percentage of people who believe that the fish are safe to eat and the percentage of

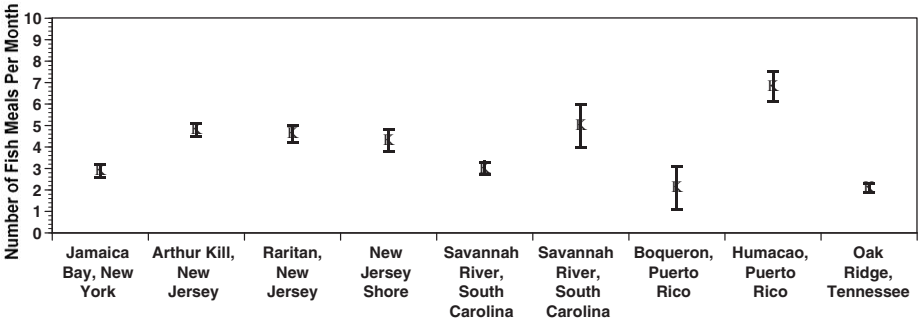

Fig. 1. Number of fish meals consumed per month for several studies conducted in study sites in Puerto Rico (Burger et al., 1992), New Jersey (Burger et al., 1999a, 2005; Pflugh et al., 1999), New York (Burger et al., 1993, 2003), South Carolina (Burger et al., 1999b, 2001a–c), and Tennessee (Campbell et al., 2002; Burger and Campbell, in press). For South Carolina, the high value is for Blacks, and the lower value is for White fishermen.

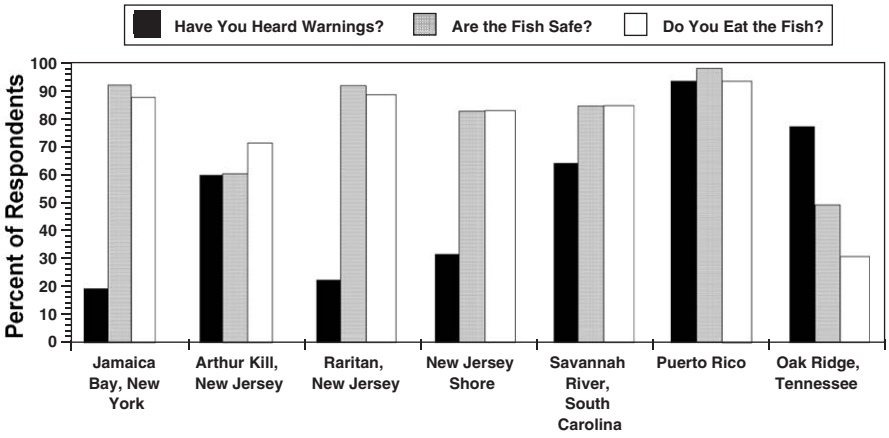

Fig. 2. Relationship between having "heard warnings about any fish from the study site", belief that "all fish are safe to eat" from these waters, and whether fish are eaten. Data sources shown in Fig. 1 legend.

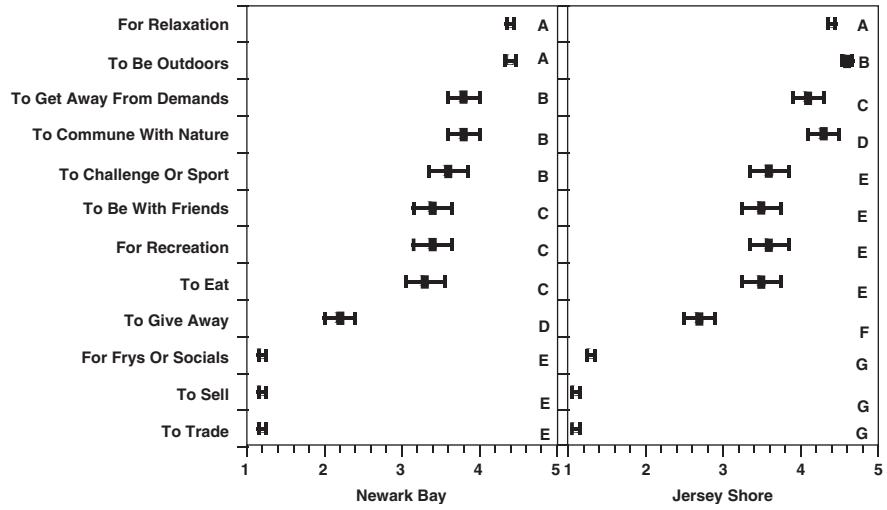

Fig. 3. Relative rating (1 = not important, 5 = very important) for why people fish in Newark Bay (Burger, 2002a, b) and New Jersey shore (Burger, unpublished data). Given are means ± SE. Letters that are different reflect significant differences (Duncan multiple range test). The bottom five reasons relate to catching fish.

those who eat the fish (Fig. 2). In general, people who believe that the fish are safe to eat, eat their self-caught fish. The largest discrepancy was in Oak Ridge (Tennessee), where fewer people ate the fish than thought that the fish were safe to eat (Fig. 2).

Information about consumption advisories is not uniform or complete, even for professionals who might be expected to be aware of the details of advisories, the causes for such advisories, and what fish to avoid or use. Burger et al. (2004) reported that, although most captains of charter and party fishing boats were aware of advisories, most were unaware of the specific chemicals or fish to avoid. For example, only 24% mentioned mercury as a problem, 35% mentioned PCBs, and far fewer knew which species of fish should be avoided. These data suggest that there should be a targeted educational program to provide information to influential people, such as marina owners, bait shop workers, and boat captains who take people out fishing daily, to enable them to provide such information to their clients. Such a campaign would be possible since boats are normally licensed by individual states.

The discrepancy between knowledge of consumption advisories and compliance suggests that other factors in addition to contaminant levels are influencing fish consumption. In a study of anglers in New Jersey people were asked to rate (on a scale of 1 [low] to 5 [most preferred]) the importance of different factors in their decision to go fishing (Burger, 2002a). The choices given were derived from an open-ended question—Why do you fish? There was remarkable agreement among anglers interviewed in Newark Bay and along the New Jersey shore (which generally had higher mean income and education levels; Fig. 3). Overall, people went fishing to relax, be outdoors, get away from demands, and commune with nature; catching fish to eat was rated lower than many other factors. These data, and those of Toth and Brown (1997), suggest that obtaining fish to eat is only one of many reasons for going fishing. If this is the case generally, then site-specific data will aid risk managers in tailoring the fish consumption advisory information for their regions or states.

Additionally, a distinction should be made between fishing and fish consumption for recreationally caught fish. From Fig. 2 it is clear that anywhere from 25% to nearly 100% of the people who fish eat their fish, regardless of whether there are consumption warnings and of whether the warnings are about the fish species that they are catching. It should also be noted that many people who do not go fishing may eat recreationally caught fish given to them by friends and family (Toth and Brown, 1997; Burger, 2000b, 2002b). Finally, the role of recreationally caught (or subsistence) fish relative to commercially available fish needs to be examined in different populations. In a general population in South Carolina, people consuming the most fish ate a higher proportion of self-caught fish than did people consuming less fish overall (Burger, 2000b). Nearly all of the fish eaten by people who ate an average of over 10 fish meals/month was from wild or self-caught fish (Burger, 2000b). This relationship may well vary in different parts of the country, but this needs to be examined elsewhere.

5. Discussion

5.1. Willingness to change consumption behavior

Appropriate changes in behavior in response to consumption are possible only if people have knowledge of the nature of the risks (levels of contaminants in different species and sizes of fish) and to whom they apply, not just

an awareness of a warning. Studies of fish consumption by anglers may overestimate fish consumption when the consumption rates from these studies are applied to the general public, see Tran et al. (2004). However, they do reflect exposure of the high-end fishing public.

Despite the fact that there is a substantial literature on awareness of fish advisories for at-risk populations, little about knowledge among the general public about the benefits and risks of fish consumption is known. However, people do not necessarily respond similarly to positive and negative information (Liu et al., 1998), suggesting that considerable thought should go into how to present contaminants data. Liu et al. (1998) found that people respond more quickly to negative media coverage than to positive information. The effect of negative coverage was reduced by positive information relative to consumption benefits, and people returned to eating fish.

Knuth et al. (2003) showed that people would change their behavior if they were presented with risk/risk and risk/benefit information about fish consumption. Their study described the health benefits and risks from consuming fish, rather than relying on general knowledge. However, four studies about consumption advisories suggest that people might change their consumption behavior with appropriate, target-based information aimed at their life style: (1) Pflugh et al. (1999) reported that anglers in the New York/New Jersey harbor estuary would change their fish consumption behavior when given specific information about the risks to unborn babies and children, (2) Burger et al. (2003a) reported that 62–70% of pregnant women (or women with young children) who had received training in the risks and benefits of fish consumption at a Women, Infants, and Children Center in New Jersey said that they would change the species of fish that they eat or their methods of cooking them, (3) Oken et al. (2003) reported a decline in fish consumption among pregnant women following a federal mercury advisory issued in January 2001, and (4) Weihe et al. (2005) reported a decrease in whale consumption by Faroe Island women following an in-depth study of the Faroes and the issuing of extensive whale consumption advisories for pregnant women.

Yet the general public seems unaware of the specific FDA advisories and of the specific reasons for the warnings (Burger, 2005; Burger and Gochfeld, in press). A study among Norwegian women reported that improvements in the supply of high-quality fish (and fish products) that satisfy the desires of children, health-oriented family members, and convenience-oriented consumers would increase fish consumption (Trondsen et al., 2003). The above studies suggest that social factors should be integrated into a risk management strategy. That is, fish (or fish products) that satisfy these goals, while minimizing contaminant exposure, might have the greatest chance of being successful in commercial markets. Taken together, these papers provide evidence that people might change their consumption behavior when provided with detailed and adequate information about the populations at risk and the causes for the risk if the advice acknowledges the cultural and health benefits of fish consumption.

One of the factors often cited for a failure to change consumption patterns is economic hardship. That is, fish are a cheap source of protein, and asking people to switch to store-bought meat will impose an economic cost. This assumption bears examination in a number of different communities. In our New Jersey commercial fish study, fish were often as expensive as meat (Burger et al., 2005), with fish fillets more than twice as costly per unit weight as beef. Further, Burger and Campbell (in press) found that in a fishing community in Oak Ridge it was upscale, higher-income people who consumed the most fish, and this agreed with the California findings of Hightower and Moore (2003). Further, Duhaime et al. (2004) found that encouraging dietary changes among the Inuit of Nunavik Island (Canada) showed that replacement of contaminated foods with store-bought meat did not significantly affect households budgets and had even less of an effect if contaminated foods were replaced with other types of regional game. Finally, it should be noted that people could replace some fish with either other fish, other subsistence foods, or with "western foods," in the case of aboriginal communities. That is, in many northern and Aleut communities people might not have access to store-bought fish or meat and might simply substitute other subsistence foods. This aspect requires additional study.

Jardine (2003; Jardine et al., 2003) suggested that public participation in the establishment of fish consumption advisories would greatly improve not only the advisories themselves but also public participation and therefore compliance. She established 14 guiding principles for public participation that listed the inclusion of community needs and values into the advisory process in a timely fashion, in a collegial fashion, and with transparency. She also noted the importance of having balanced risk communication that includes both the benefits and the risks of fish consumption.

5.2. Framework for information needs to integrate fishing behavior, fish consumption, risk, and risk management

The information provided in the above sections indicates that, although there have been minor changes in understanding and behavior concerning fish consumption, there is still a disparity in knowledge, beliefs, and actions. There are clear health benefits for consuming fish for people of all ages, including developing fetuses and young children (see references in introduction). From a public health perspective, the task is not to discourage consumption of fish but to increase the positive benefits from fish consumption, while reducing the risk from contaminants. Few states, however, provide information on the contaminants, protein levels, and omega-3-fatty-acid content of fish (Michigan is an exception, see Sidhu, 2003). State advisories or brochures could provide tables that provide

information on a range of contaminants (PCBs, mercury) and a range of nutrients information (omega-3, protein) to allow informed risk balancing by the public.

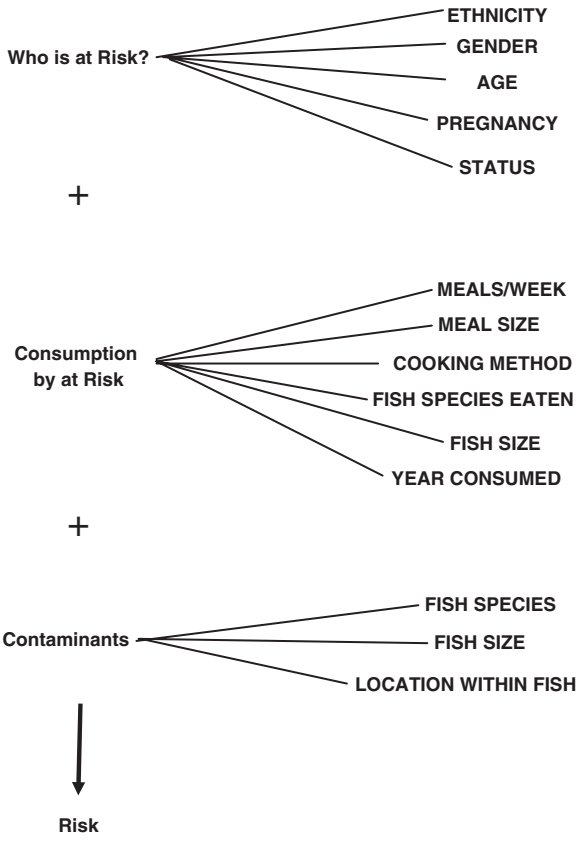

Fig. 4. Schematic showing the factors that affect who is at risk and the consumption parameters that affect risk.

We suggest that public health officials will not change personal behavior unless they take a multi-faceted approach to managing the risk that includes cultural sensitivity and audience-specific positive information. It must be noted that the objective is not necessarily to change behavior but to provide sufficient information on all aspects of fish consumption that individuals can make informed decisions.

Several different factors affect the population at risk, and several different aspects of consumption affect internal dose (Fig. 4). The usual factors considered include meals/week, meal size, and years of exposure. Other factors that should be included both in risk assessments and in the provision of information to the public include contaminant-specific information about cooking and fish characteristics (species, size, age). There are a number of factors that are related to contaminant levels in fish, including fish species, fish size and age, tissue (muscle, fat), location within the fish (where the fillet came from), and location where the fish was caught. Information in brochures and on web sites could include tables or graphs that show how mercury (or other contaminants) vary by location within the fish or cooking methods. It is well established (for some contaminants such as methylmercury) that levels increase with both age and size of the fish (Lange et al., 1994; Bidone et al., 1997; Burger et al., 2001a; Green and Knutzen, 2003). Graphics or tables could be developed for key fish species for local regions; in New Jersey graphics on the levels of mercury in different-sized bluefish would be helpful to fishermen. Fishery management practices which place size limits on fish (keep large/discard small) have a negative impact on health risks and force anglers to ''throw back'' smaller fish which would have lower contaminant levels.

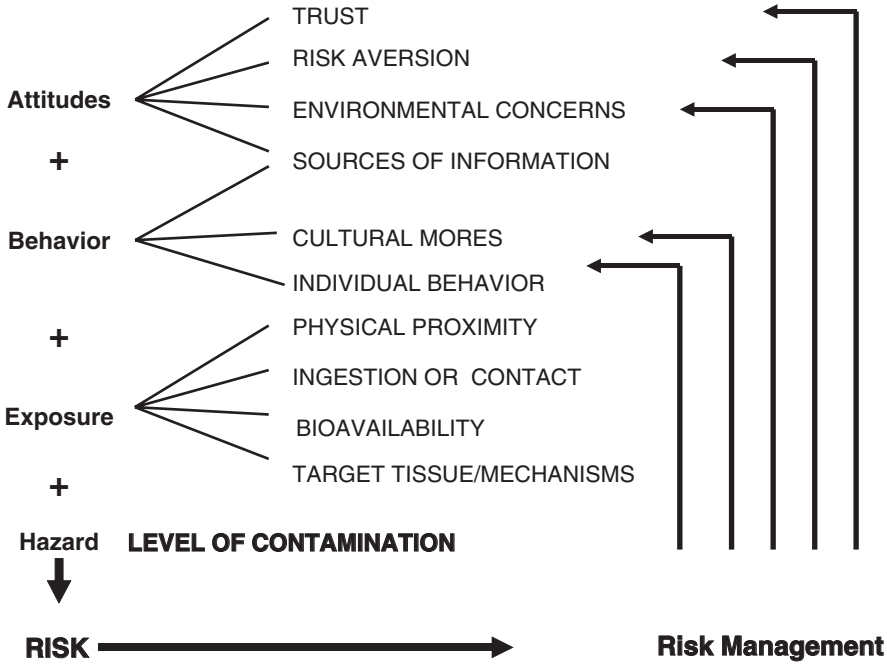

Fig. 5. Framework showing the factors that contribute to risk from consumption of contaminants in fish, including attitude, behavior, exposure, and hazard level. Risk management should be directed at all four categories.

There are also trophic-level relationships independent of overall fish size: fish that are high on the trophic web accumulate higher levels of metals such as mercury (Campbell, 1994; Fairey et al., 1997; Burger et al., 2001a, b). Trophic level relationships could also be illustrated in brochures and on web sites. Further, while the removal of fat and skin can reduce exposure to PCBs (because they are preferentially stored there), removal has no effect on mercury (Morgan et al., 1997; Wilson et al., 1998; Burger et al., 2003c).

We suggest that risk from fish consumption is a combination of attitudes, behavior, exposure, and hazard levels (Fig. 5). Whether and how a person responds to consumption advisories depends upon their level of trust in the conveyor of risk information, whether they are risk aversive, overall environmental concerns, and the sources of information that they encounter or listen to (Slovic, 1987, 1993; Pilisuk and Acredolo, 1988; Mitchell, 1992; Barke and Jenkins-Smith, 1993). Additionally, the reasons that people fish varied in the study populations that we examined, which suggests that state agencies should gather site (or region)-specific information on the reasons for fishing. This would allow for a communication strategy aimed at the local fishing population. Individual behavior

Table 1
Specific suggestions for improving knowledge about the risks from fish consumption aimed at minimizing risks

Target audiences to be considered (may require targeted brochures and educational courses and materials):

1. Fish-consuming public (including specific ethic/cultural groups, and schools)
2. Pregnant women
3. Health professionals
4. Leaders and teachers in health clinics, including pregnancy clinics
5. State (and federal) personnel dealing with fishing (including licenses)
6. Fishing clubs, party boat captains, bait shops

Information needs for site-specific information:

1. On levels of different contaminants (PCBs, mercury, others) in the range of commonly eaten fish (including those with low levels)
2. On levels of different contaminants in fish of interest to different ethnic/social groups
3. On levels of contaminants as a function of part of the fish, size and age of the fish, and trophic levels
4. On effects of different preparation (i.e., skin on or off) and different cooking methods on contaminant exposure
5. On fish consumption preferences, particularly of those that would appeal to children, including health-oriented and convenience-oriented knowledge
6. On the magnitude of the risk from specific contaminants in different kinds of fish as a function of consumption patterns; this includes what is not known about contaminants in locally caught fish; this matrix for risk ideally could include information on contaminants as a function of size and weights of fish
7. On the reasons why people fish and why they fish in particular locations on particular fish
8. On risk-balancing information, such as the relationship of omega-3 fatty acids, various contaminants, and other nutritional information about specific fish
9. On risk-balancing information dealing with nutritional/contaminant benefits/risks in relation to other social benefits of fishing (e.g. being outdoors, family fun, social networks); this involves the wider context of why people fish or eat self-caught fish
10. On the percentage of target audiences that receive and understand the information

Types of risk communication materials needed:

1. Short laminated keys for contaminant levels and nutritional values of specific local and commercial fish, with advice on meals per month
2. Pamphlets and brochures for each of the targeted audiences (in several languages)
3. Courses (of various lengths) and lesson plans for different target audiences (including lesson plans for teachers)
4. Short radio and TV announcements about the risks and benefits of fish consumption, including social benefits of fishing
5. Longer videos and radio programs about the risks and benefits of fish consumption suitable for public TV, schools, fishing clubs, and other venues
6. Methods of evaluating the above risk communication materials for understanding, efficacy, and usefulness by specific target audiences

Institutional needs:

1. Methods of ensuring communication among governmental agencies responsible for fishing and public health
2. Methods of requiring communication among governmental agencies responsible for issuing consumption advisories, health advisories, fishing regulations, and communications about the health risks and benefits of fishing (and fish consumption)
3. Methods of ensuring communication between state and federal agencies about fishing, fishing consumption, and the risks/benefits of fishing and fish consumption
4. Methods for ensuring the appropriate provision of information on the risks (contaminants) and benefits (health, cultural, social) for commercial fish
5. Appropriate governmental oversight of the separation of commercial interests from protection of public health
6. Clear institutional responsibility for ensuring that the different types of interagency communication is carried out
7. Creation of mechanisms (and rewards) to motivate agencies to change current practices of stove-piping

We suggest that this kind of site-specific information is necessary for a holistic approach to managing the risk from consuming self-caught fish.

results from these attitudes, cultural mores and customs, and their own individual actions. Exposure then depends upon physical proximity, ingestion, bioavailability, and mechanisms and fate of the contaminants in individual organs and tissues.

Effective risk management will occur only when several of these factors are addressed and not just when consumption advisory information is provided to the public. Risk managers must address multiple attitudes, behavioral patterns, and exposure pathways. Most risk managers start at the bottom with contaminant levels and work back to behavior. We are suggesting that risk is shaped as much by attitudes and behavior as it is by exposure and contaminants. Further, effective risk communication will have occurred when the target audience has been provided with sufficient site- and fish-specific information about the risks and benefits of consuming a given species of fish (at a given size or weight) to make an informed decision.

Risk communicators then must address all these factors, including defining the target audience(s), filling information gaps or needs on a site-specific basis, and designing risk communication tools (Table 1). Finally, there must be institutional changes that allow for the free flow of information and collaborations between agencies and people responsible for fishing, the risks and benefits from fish consumption, and public health. This is a daunting task but one that must be faced if risk communication and risk management are to be effective. Further, managing the risks (and benefits) from fish consumption requires a multi factorial approach, since the informational needs apply to each of the target audiences.

The cultural, economic, and nutritional benefits of fish consumption and the risks from contaminants must be considered together for the risk communication messages to gain acceptance by the public (Table 1). Many of the data needs listed under target audience and information needs are relatively straight forward and, although time consuming and expensive to collect, it is possible for state agencies to do so. They are expensive and time consuming because, to be done correctly, the information for a wide range of fish must be available and this complexity of information must be available to the public. It will be more difficult to handle the institutional needs. These revolve around ensuring collaboration among and within state agencies, between agencies from bordering states, and between federal and state agencies so that there is coherence between messages given by different agencies. Interagency collaboration can be fostered by institutionalizing one agency as the steward of organizing the interactions. Ideally, nongovernmental organizations will also participate, providing additional trust for the messages and advice given.

Emphasizing the benefits of fish consumption, while providing consumers with information on how to minimize their risks from contaminants, would lead to greater acceptance and provide fishermen with the knowledge that they need to fish (and consume) wisely. To some extent it is the complexity of information, dealing with a range of benefits and risks for different fish, that needs to be made easily accessible to the public. As with many complex environmental problems, it is a matter of balancing risks and balancing the benefits and costs of fishing and fish consumption within a cultural, economic, and social context.

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