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Original Contribution

Stakeholder Participation in Research Design and Decisions: Scientists, Fishers, and Mercury in Saltwater Fish

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Abstract: Individuals who fish and eat self-caught fish make decisions about where to fish, the type to eat, and the quantity to eat. Federal and state agencies often issue consumption advisories for some fish with high mercury (Hg) concentrations, but seldom provide either the actual metal levels to the general public, or identify the fish that have low contaminant levels. Community participatory research is of growing importance in defining, studying, and resolving complex exposure and risk issues, and this paper is at the intersection of traditional stakeholder approaches and community-based participatory research. The objective of this paper is to describe the process whereby stakeholders (fishers), were involved in directing and refining research questions to address their particular informational needs about mercury levels in fish, potential risks, and methods to maintain health, by balancing the risks and benefits of fish consumption. A range of stakeholders, mainly individual fishers, fishing organizations, and other scientists, were involved at nearly every stage. Community participants influenced many aspects of the design and implementation of the research, in the determination of which fish species to sample, in the collection of the samples, and in the final analyses and synthesis, as well as the communication of results and implications of the research through their fishing club publications, talks and gatherings. By involving the most interested and affected communities, the data and conclusions are relevant to their needs because the fish examined were those they ate and wanted information about, and directly address concerns about the risk from consuming self-caught fish. Although mercury levels in fish presumed to be high in mercury are known, little information was available to the fishermen on mercury levels in fish that were low and thus provided little risk to their families. While community participatory research is more time-consuming and expensive than traditional scientific research, both the process and results are better scientifically in terms of community relevance.

Keywords: Anglers, Community-based participatory research, Fishing, Recreational, Stakeholders, Stakeholder involvement

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Introduction

An important component of successful environmental policy and management is meaningful stakeholder involvement in environmental issues that are important to them. "Stakeholder" refers to everyone involved or interested in a particular site, problem, or potential risk (or benefit), including governmental agencies (local, state, federal), regulators, scientists, companies, health professionals, social scientists, citizen's groups, and the public, among others (Burger 2011). Many risk assessors, managers, and public policy officials recognize the importance of including this full range of stakeholders in dealing with environmental problems in a manner that is informative, iterative, and interactive, and that solutions are sometimes dynamic, include feedback loops, and often involve on-going management, now termed "adaptive management"(Walters and Hilborn 1978; Lee 1999). Adaptive management recognizes that there are few final solutions, and that adjustments must be made iteratively as new information and data appear. Although initially, decision-makers and managers were reluctant to include stakeholders in their deliberations (Boiko et al. 1996), they gradually embraced them (President's Commission (PCCRAM) 1997), particularly in soliciting public comments and in public meetings (Mitchell et al. 1997; Environmental Protection Agency (EPA) 2003; National Research Council (NRC) 2008).

Stakeholder involvement has often been limited to the examination of public perceptions and attitudes about environmental problems (Slovic 1987, 1993; Kunreuther et al. 1990; Burger et al. 2007a; Bohnee et al. 2011), risks and benefits of facilities (Barke and Jenkins-Smith 1993), habitat value (Chase et al. 2004; Harper et al. 2008; Burger et al. 2008), and land use (Greenberg et al. 1995; Nielsen et al. 2007), among others. More recently, stakeholder involvement has included dealing with remediation and future land use (Bohnee et al. 2011). The value of community participatory research that addresses exposure assessment, among other topics (National Institute of Environmental Health Research (NIEHS) 2011), is now receiving considerable attention (Allen et al. 2010; Ramsden et al. 2010; Ahmed and Palermo 2010; Dulin et al. 2010; Munoz and Fox 2011).

Another environmental issue that concerns stakeholders involves the use of food or water, medicines, fibers, and other materials that are self-collected. Fishing is a popular recreational activity, as well as providing food (Toth and Brown 1997). Fish are an excellent, low-fat source of protein that contributes to low blood cholesterol, to positive pregnancy outcomes, and to better child cognitive test performances (Oken et al. 2008). Fish contain omega-3 (n-3) fatty acids that in many studies reduce cholesterol levels and the incidence of heart disease, stroke, and pre-term delivery (Daviglus et al. 2002; Patterson 2002; Institute of Medicine (IOM) 2006; Virtanen et al. 2008).

However, levels of methylmercury (MeHg) and other contaminants in some fish are high enough to potentially cause effects on the fish themselves, on top-level predators, and on people (World Health Organization (WHO) 1989; Institute of Medicine (IOM) 1991, 2006; Environmental Protection Agency (EPA) 1997, 2002; National Research Council (NRC) 2000; Consumer Reports 2003; Hightower and Moore 2003; Hites et al. 2004; Oken et al. 2008). Fish consumption is the only significant source of methylmercury exposure for the public today (Rice et al. 2000). Hughner et al. (2008) estimated that 250,000 U.S. women may be exposing their fetuses to levels of methylmercury above federal health guidelines because of fish consumption. To make informed decisions, consumers of fish must understand both the risks and benefits of fish consumption (Burger and Gochfeld 2005; Gochfeld and Burger 2005; Institute of Medicine (IOM) 2006; Hughner et al. 2008).

The risks to humans from consuming fish with high levels of chemicals (primarily mercury and PCBs) can be reduced either by source reduction (removing contaminants from the environment), by selectively closing contaminated fisheries, by embargoing contaminated fish or by influencing human consumption patterns. In the case of consumption, state agencies issue consumption advisories or fishing bans for particular species or regions. In the past, state agency scientists have tested chemicals, developed risk assessments, and issued advisories, although more recently some state agencies have convened focus groups to discuss both the content and form of advisories. Additional stakeholder involvement has usually included assessing consumption patterns and public perceptions of risk (Toth and Brown 1997; Silver et al. 2007; Burger and Gochfeld 2009a). Yet, stakeholders could also participate meaningfully in other aspects of assessment of the risks from consuming fish, such as problem formulation, research design and implementation of studies to examine contaminant levels in fish. While toxicologists and environmental health scientists often deal primarily with science issues, designing their own research and implementing it, involvement of stakeholders can improve the research design, implementation,

and conclusions, making them more relevant and usable by the public and public policy makers (Burger et al. 2007b). Directly involving stakeholders can result in collecting data and conducting analysis about both contaminants and potential risk that provide desired information to stakeholders to help them make informed decisions (Burger et al. 2001, 2007b; Burger and Gochfeld 2009b). Evaluation of stakeholder-driven research, however, is in its infancy, although Ahmed and Palermo (2010) have provided a framework for evaluating such projects.

The objective of this paper is to describe collaboration between stakeholders and scientists in designing and implementing research on mercury levels in New Jersey saltwater fish. The overall aim was to conduct research that addressed the particular information needs of stakeholders, which turned out to be more complex than the information normally provided by state agencies. That is, fishers and fishing associations wanted more information on species, geographical, seasonal, and size-related differences in mercury levels that could affect their risk, and they wanted this information for fish species that had low as well as high levels of mercury. In this study, stakeholder involvement was most effective when it was interactive and iterative, rather than merely having each group describe their position or impart information at the beginning of the process. Data on mercury levels in fish are provided elsewhere (Burger 2009, Burger et al. 2009, Burger and Gochfeld 2011).

Overall Design and Methods

The overall research aim involved the scientists: (1) examining species generally consumed by fishers in New Jersey, (2) identifying the relevant stakeholders, (3) meeting with fishing associations, individual fishers, and NJ Division of Fish and Wildlife fishers to hear their information needs and questions, (4) designing a study to examine levels of mercury in a range of saltwater fish, (5) collaborating with the stakeholders to refine the research, particularly the species to be targeted to address stakeholder concerns, (6) developing a multi-stakeholder dialogue about these issues, and (7) writing pieces for newsletters that reported results and addressed stakeholder concerns. The work reported herein is part of a general study to understand fishing behavior, consumption patterns, habitat use, recreational use, contaminant levels, and risk to humans and eco-receptors in the marine biota in coastal New Jersey. The project began in 1985, and is on-going.

Interviews and meetings with stakeholders were conducted under approved Rutgers University Protocols for examining fishing behavior and contaminants in fish (E96-108, 92-036, 97-019). Stakeholder groups were identified with the initial aid of the New Jersey Department of Environmental Protection, from established fishing clubs and organizations, and from listings of marinas along the New Jersey coast. Three main types of interactions were conducted: scheduled listening sessions and formal presentations (with questions), informal meeting (by phone, email, or in-person) with individuals or groups, and publications (in web-sites, brochures, newsletters, and scientific publications). Because the work was collaborative, meetings, interviews, and interactions were frequent, sometimes planned, sometimes fortuitous, and sometimes scheduled well in advance with notices sent or emailed to fishing association members. Methods and results for the levels of mercury and other contaminants in fish and other seafood are published elsewhere (Burger 2009; Burger and Gochfeld 2004, 2011; Burger et al. 2004, 2005, 2009). Most samples were collected by researchers, who accompanied fishermen or met them at docks. Samples collected by fishers (a small percentage) were collected using a protocol distributed to them. All samples were collected from the same muscle location, placed in plastic bags and immediately frozen for later analysis. Interview information on fishing behavior, consumption patterns, and why people fish or use the Jersey shore can be found in Burger (2000, 2002, 2004, 2009) and Burger et al. (1999). The objective of this paper is to report on the process of stakeholder collaboration in problem formulation, and research design and implementation. Information on the goals and secondary goals of different stakeholders (see Table 1) were derived from discussions with each of the stakeholder groups in formal and informal meetings. Information on how stakeholders influenced the research (Table 2) was derived from the discussions with each group, and whether they influenced these aspects, which led directly to the information in Table 3.

Results: Collaborations and Involvement

Stakeholders and Their Interests

One key aspect of community participatory research is identification of all interested and involved stakeholders. The main stakeholders involved with decisions about fishing and fish consumption patterns are people who fish

Table 1. Stakeholders Interested in Scientific Data Necessary to Understand Potential Risk from Contaminants in Fish.

Player	Primary goal	Secondary goals
Fishers (individual)	How to reduce risk while continuing to enjoy fishing and fish consumption	Maintaining their lifestyle of fishing; knowing which fish species have low and high levels of mercury
Jersey Coast Anglers Association	How to reduce risk of mercury for all saltwater fish while continuing to foster fishing	Reducing risk to members from mercury; providing information to their members; knowing which fish species have low and high levels of mercury to advise their members
Jersey Coast Shark Anglers	How to reduce risk from mercury levels in sharks while continuing to fish	Reducing risk to members from mercury; providing information on mercury in sharks to their members; identifying which species have low and high mercury levels
Marina owners	What advice should they give their clients about mercury in fish	Continuing to encourage fishing (and their business) while providing people with the best information on mercury levels in different fish and potential risk
New Jersey DEP	Understanding mercury levels in fish that are below the legal size limit; Understanding mercury levels to set any fish consumption guidelines	Knowing how mercury varies seasonally and by size. Considerations for issuing advisories for saltwater fish
Scientists	Understanding how mercury varies as a function of species of fish, size of fish, location and season of collection	Using the data to provide information to fishers and consumers that can help them make informed decisions about their own risk, and that of other family members; Understanding potential risk from mercury to the fish themselves, and to higher level eco-receptors (e.g., birds, predatory fish)

(=fishers), fishing membership associations, people who eat fish (consumers), agencies that regulate fish takes or issue health advisories, and health professionals. The present paper focuses on stakeholder participation in design and implementation of the study of mercury in fish, and potential risk. It represents collaborations among research scientists, fishers and their organizations, and state agencies, although the overall project has previously included risk assessors and health professionals (Pflugh et al. 1999; Stern et al. 2001; Chess et al. 2005).

The main concerns of each of the stakeholders groups differed somewhat, although the overall goal of all was to reduce potential risk and harm from fish consumption (Table 1). Individual fishers were primarily interested in the risk from eating different kinds of fish, for themselves and their families. Some people were interested only in how mercury levels varied among species, while others were concerned about the places they fished, whether fishing elsewhere would reduce their risk, whether fishing at some seasons would result in fish that were lower in mercury, and what species of fish they should freeze for later consumption (from what location and season).

The Jersey Coast Anglers Association (JCAA), formed in 1981, represents 75 recreational angler or fishing clubs in New Jersey, and works to foster marine recreational angling. Its mission is to champion the causes of its member clubs, and to protect rights pertaining to fishing, fisheries, and environmental quality. JCAA's main concern with respect to this research was how to reduce risk while continuing to foster fish consumption and environmental quality. Basically, members wanted to know which fish species were high, and which had low mercury levels so they could make informed decisions.

The Jersey Coast Shark Anglers (JCSA) was loosely formed in 1977, and conducts a number of activities, including holding shark tournaments. It has similar goals, focusing on the species of sharks that could be caught in New Jersey's marine waters.

Table 2. Involvement of Fishers and Others on Research Design and Implementation.f

Phase	Jersey coast anglers association	Jersey coast shark anglers	Fishers (individuals)	NJ division of fish and wildlife
Define problem and develop initial research plan	X		X	
Refine target species	X	X	X	
Add species	X	X	X	
Refine sampling methods				
Sample different locations	X	X	X	X
Sample different seasons	X		X	X
Sample different sized-fish	X		X	X
Sample smaller fish[a]	X			X
Add fisher collected samples		X	X	
Refine sampling locations				
Select sites of tournaments	X		X	
Select sites in N, middle and S	X	X	X	
Stakeholder meetings during research (and at conclusion of research)	X	X	X[b]	X[c]
Chemical analysis				
Include small sample sizes	X	X	X	
Include selenium	X	X		
Data analysis and reports[d]	X	X		

Marina owners mainly made suggestions about species selected (those their clients fished), location (near their marina), and informational meetings.
[a]Collection of fish below legal size limit.
[b]Mainly individual meetings with fishers.
[c]Mainly during trawls.
[d]Presentations at fishing associations and scientific papers.

Marina owners were not initially contacted, but since many belonged to either JCAA or JCSA, they learned about the project. Subsequently many contacted us, offering to distribute information, and to collect samples. They were primarily interested in being able to provide advice to their clientele about mercury levels in fish, particularly the species that had low levels.

New Jersey Department of Environmental Protection personnel were interested in understanding how mercury levels varied in fish as a function of species and seasonality. They encouraged the collection of small fish that could not be collected by fishers, and provided logistical support to do so on their regular trawls. Ultimately, they are responsible for examining the health of fish populations, issuing fish consumption advisories, and determining risk from contaminants in fish and shellfish. Although not discussed directly, state regulators for mercury emissions and deposition also play a role in addressing potential health risks from mercury in fish.

The research goal for the scientists was to understand how mercury varies as a function of species of fish, size of fish, and location and season of collection, and the risk these levels pose to eco-receptors and to humans. These data could then be used to provide information to consumers that will allow them to make informed decisions about what fish to eat.

Finally, other stakeholders of note are those that contribute to mercury pollution in the environment. The main source of mercury in the environment in New Jersey, including in fish tissue, is from coal-fired power plants to the west of New Jersey (New Jersey Mercury Task Force 2001). While information about contaminants in fish is of interest to these companies, they are not New Jersey based and were not included in the research design or implementation.

The Research Process

The overall research process was one of collaboration whereby the research design and implementation were initially designed by the scientists after considerable discussion with and among the stakeholders (Figure 1). While the initial

Table 3. Relationship Between Research Protocol of Scientists and Final Implementation Because of Stakeholder Collaboration.

Initial scientist's plan	Modified plan
Refine target species	*Fishers and fisher's associations added species that they enjoyed eating or catching
	*Fishing associations suggested collecting striped bass even though data on mercury levels are available
	*Marina owners suggested species their clientele preferred
Refine sampling methods	*Stakeholders suggested a range of locations for sampling, including the main regions they fished specifically for shark and tuna, as well as the locations of major tournaments
	*Marina owners suggested sampling near their marina, and also provided some samples
	*NJDEP and others suggested also collecting fish below the legal catch limit to examine influence of size on mercury levels; NJDEP allowed sampling on their trawls
	*Fishers and fishing associations suggested we solicit samples from fishers themselves and asked to be provided protocols and contact numbers
Stakeholder meetings	*Fishing associations suggested meetings with their groups during the research (as well as at the end), and asked that we write articles for their newsletters
	*Individual fishers contacted us during the research
Chemical analysis	*Fishers and associations suggested the analysis of small samples to provide an indication of mercury levels for fish species caught by specific groups or in specific locations (e.g. ling, porgy)
Data analysis and reports	*Fishing associations requested meetings to discuss results, and articles for newsletters

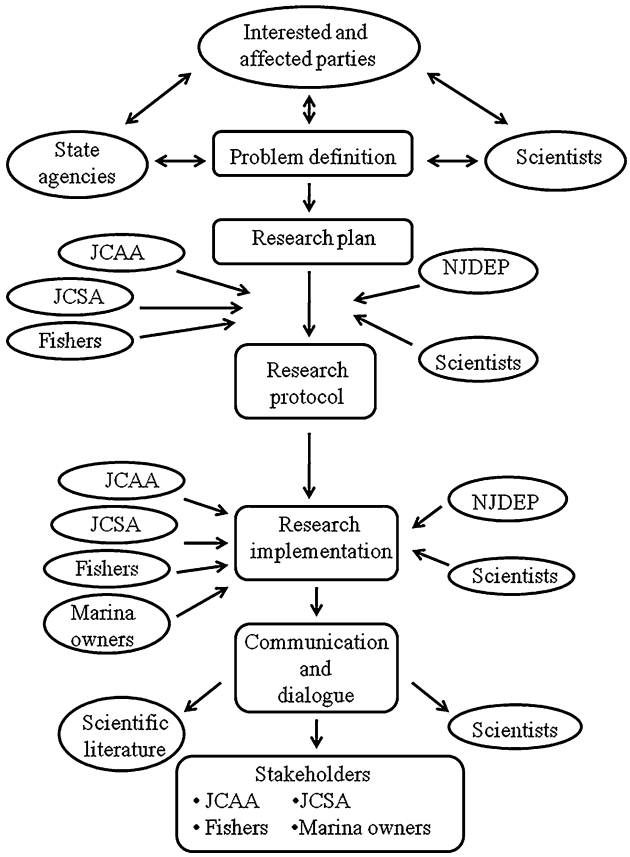

Figure 1. Inclusion of a range of stakeholders and community members in different research phases (shown as *boxes*). *JCAA* Jersey Coast Anglers Association, *JSSA* Jersey Shore Shark Anglers, *NJDEP* New Jersey Department of Environmental Protection.

design was developed mainly with the JCAA and individual fishers, subsequently a number of other stakeholders became involved. Different stakeholders were interested in different aspects of the research design and implementation (Table 2). For example, fishers and fishing associations were interested in adding additional species, and in analyzing mercury levels in species with small sample sizes, while everyone was interested in sampling different locations and in being informed about results and meetings.

The reasons that stakeholders made refinements in the research process varied (Table 3). While the scientists had originally selected species based on their overall popularity in the state, fishers and fishing associations wanted fish species added that they enjoyed catching or eating (albacore, *Thunnus alalunga*), that were rare but appreciated (cunner, *Tautogolabrus adspersus*), or that were present only along one part of the coast. The scientists were initially not going to include Striped Bass (*Morone saxatilis*) because there are sufficient data on mercury in this species. However, the fishers and JCAA thought that it would be useful to have information by size and location, and from the same time period as other fish were being sampled (and so Striped Bass were added).

Stakeholders provided the most suggestions about sampling methods, including where to collect fish, how to collect fish, where on the fish to sample (i.e., tuna fisherman were quite particular about where samples were taken from on the fish), and who should collect fish (individual fishers wanted to take samples, even though the researchers mainly collected the samples from fish caught by fishers) (Table 3). NJDEP personnel suggested taking samples from fish below the legal size limits to provide information on how mercury accumulates with size and age, and provided the logistical support to do so.

Stakeholders generally had access to the scientists through the telephone and email, through the field personnel collecting samples, and in public meetings. Some of the public meetings were initiated by the scientists, and others were initiated by the fishing associations. Articles for newsletters, aimed at reaching people who did not come to meetings, served to inform a larger audience, were widely distributed, and could be passed on to friends and family.

Tracking Community Value

Community members saw value in the research, and thus participated for the following reasons: (1) they could directly influence which fish species were sampled, and from where, (2) they could obtain information on mercury levels in fish they themselves had caught (and later ate), (3) they could see how mercury levels varied within species of fish, as well as among fish species, (4) they could see how mercury levels varied as a function of the size of the fish they caught, (5) information was provided to them in a timely manner, and (6) information was provided on their favorite fish, even if they were not commonly caught by others. That information was provided at all was remarkable to most of the stakeholders, as often in the past, people were ''studied'', but they never found out the results (Burger et al. 2007b). All of the above reasons for participating were given by each of the organizations, although some were expressed more frequently than others. Further, the fishermen and angler associations continued to be involved during the 5 years of the study, and organizational officers remarked that they would continue to use the information in their newsletters and events. Examining and evaluating community participation in research projects is an important aspect of participatory research (Ahmed and Palermo 2010), and one that will contribute markedly to improving research.

Discussion

The continued involvement of a range of stakeholders in the refinement of research plans, protocols, selection of fish species, and selection of collection sites, clearly adds time, resources, and money to the overall project. Had the scientists addressed their initial objectives only (see Table 2), the project could have been accomplished in less time, with fewer personnel, and with less money. The addition of species, sampling sites, different seasons, and fisher-collected samples added considerably to the schedule and cost of the project. However, participation of the fishing community, including providing samples, offset some costs.

Stakeholder input also resulted in the following: (1) sample size varied by species (Burger et al. 2009), (2) sample size varied by location and season (Burger 2009), and (3) samples sizes of some species were very low, but reported because of public interest (Burger and Gochfeld 2011). In the end, however, the mercury results can serve both the interests of science, and those of the public. Those wishing to see large sample sizes, and relatively equal sample sizes, need only consider the species for which these conditions apply. Others, however, can see the levels of mercury

present in species where sample sizes were very low (for species, locations, or seasons, Burger and Gochfeld 2011). The additional cost of analyzing the mercury levels in species with small samples sizes is out-weighed by the data that can be provided to stakeholders who are particularly concerned about those species or conditions.

In the present study of 19 species of fish, three species had small sample sizes (e.g., below 20), and an additional three (e.g. porgy, southern kingfish, and ling) were generally popular only in some NJ regions and for some ethnic groups. They would not normally have been part of a mercury study because of these conditions. Thus, including them, at the request of stakeholders, added the collection and mercury analysis of 120 samples (10 % of the total of 1,258). However, the additional time and cost was far greater, as they were more difficult to collect from fishermen because they were rarer, limited to only a small section of the NJ coast, or limited to a particular ethnic group. Additional costs related to meeting with stakeholders in formal and informal settings, writing pieces for their newsletters and websites, and meeting with the wide range of interests. Thus, we estimated that at least 25 % of our research costs were directly attributable to involving the full range of stakeholders in the project.

Further, the additional time required to complete the sampling with the changes suggested by stakeholders only resulted in delayed publication in the scientific literature, but did not slow down reporting results to stakeholders. Preliminary results were presented to individuals and clubs, and in newsletters on a regular basis. In these settings, additional feedback was provided, and specific additional samples were suggested or provided, which allowed additional analyses of interest to them.

The advantages of increased stakeholder involvement during the research program were enormous. In the end, the inclusion of stakeholders throughout the project improved the science itself, as well as the social science aspects (after Ahmed and Palermo 2010). The major advantages can be summarized as follows.

1. Open meetings and other forms of communication provided transparency and openness about goals and protocols.
2. Emails, phone, one-on-one meetings allowed individuals to express a range of views that might not be expressed in open meetings.
3. Continued dialogue allowed the scientists to add species or locations when they were warranted.
4. Participating in fishing association tournaments allowed the scientists to collect fish of different sizes.
5. Inclusion allowed stakeholders (e.g., fishers) to collect samples themselves, once provided with the protocols), which built trust in the results, and increased the relevance to individuals.
6. Including fishers and the fishing associations allowed scientists to become aware of less commonly fished species that were of particular interest.
7. Dialogue with NJDEP personnel allowed scientists to collect smaller fish than the legal limit, providing additional information for managers of fish populations and risk assessors.
8. The participation by stakeholders in all phases of the design and implementation of the research insured that they felt an ''ownership'' in the project and its outcome, and made the research more relevant to the needs of the marine recreational fishers, and marine fish consumers.
9. Research effectiveness was enhanced because the stakeholders had participated, understood the research, and did not later criticize the design.
10. Results could be used to guide the information provided to the fishing public by agencies and fishing organizations.

The policy implications are that inclusion of a range of stakeholders, particularly the user group, results in scientific research that is responsive to a range of needs involving recreational marine fishing. Information on mercury levels (and of risk from those levels) was provided (1) for a range of fish species not usually examined because they are local or eaten by a small segment of the population (often ethnically diverse), (2) for fish species believed by regulators and scientists to be low in mercury (e.g., flatfish, among others), and (3) for species that are sufficiently low that they pose very little risk. Thus, stakeholders had information on both the species of fish to avoid, and the species of fish that could be eaten frequently with little or no risk (because mercury levels were low). Since regulators (and those writing fish consumption advisories) are concerned only with fish that pose a risk (those with high mercury levels), information on fish with low mercury levels is seldom available or provided to the public. Unlike many other projects that are considered to involve the public, this project did not merely involve stakeholders at the beginning of the project, but included them in all phases. Our research suggests that the inclusion of stakeholders in

the refinement and execution of the research itself greatly improved both its quality and its relevance to the stakeholders themselves. Thus, it has the potential to change behavior because the public knows not only which fish species to avoid eating, but which species of fish provide little risk to their families.

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