ABSTRACT

GRAY, KATHLEEN MARIE. Characterizing Environmental Health Literacy Related to Fish Consumption Advisories: Knowledge and Beliefs of Informal Educators in a Southeastern State. (Under the direction of Dr. Margaret R. Blanchard and Dr. Catherine E. LePrevost).

Informal science education occurs in many settings, often without an explicit goal of teaching or learning science. Sometimes scientific content and practices are opportunistically encountered through daily activities. Such is the case with fish consumption advisories, which inform people who eat fish about their potential exposure to harmful chemicals. These advisories are issued by all 50 states, some tribes, and United States territories. Research has shown that awareness of advisories is generally low, particularly among the populations most likely to consume locally-caught fish. Limited research has been conducted in the informal science learning contexts in which such communications occur and about the role of informal educators in these contexts. The purpose of this study was to understand the environmental health knowledge, teaching efficacy beliefs, and educational practices of informal educators who share advisory information with fishermen. Semi-structured interviews were conducted with 24 educators and other environmental and public health professionals from institutions spanning environmental nonprofits, local governments, universities, and state environmental, health, and wildlife agencies. Participants also completed a knowledge questionnaire, a teaching efficacy survey, and a demographic survey. The theoretical frameworks of the Health Belief Model, social cognitive theory, and environmental health literacy informed this study.

This research provided insight into the environmental health literacy of these informal educators and included a cross-case analysis of three educators who exemplified specific dimensions of environmental health literacy. Educators’ knowledge of relevant environmental health concepts varied, and the potential adverse health impacts of consuming contaminated fish
were not well understood. Educators in the study held health beliefs and teaching beliefs that were consistent with placing less emphasis on fish consumption advisory education. Specifically, many believed that the severity of harm from eating contaminated fish was moderate, even for susceptible populations. Their self-efficacy associated with teaching about FCAs could be characterized as low to moderate and showed that they were more confident in their ability to communicate about advisories than they were in their expectations that people would follow their recommendations related to FCA guidance. In the cross-case analysis, all three educators expressed dimensions of environmental health literacy, with variations based on the extent of their interactions with fishermen, connections to waterways under advisory, and organizational contexts.

Overall, opportunities were limited for fishermen and their families to learn about FCAs from informal educators. Participants described a range of educational activities, only a subset of which were focused on FCAs. Notably, none of the participants were solely tasked with FCA education, and for some, it was incidental to their positions. Educators who had most direct contact with fishermen through planned programming were housed in the state wildlife agency, and these educators tended to be least conversant with environment health topics. Those who regularly addressed FCAs were housed in local governments and environmental nonprofits focused on water quality; and they tended to reach smaller numbers of fishermen, primarily through unplanned interactions along waterways.

These results underscore potential challenges to communicating advisory information and opportunities for more effectively deploying informal science education resources to do so. Specifically, wildlife agencies are an important conduit to fishermen, and as such, could play a more active role in effective FCA communication. Local governments with direct connections to
waterways under advisory also have opportunities to interact with large numbers of fishermen and develop planned programming. Targeted professional development on environmental health concepts relevant to advisories may better position these educators to educate fishermen about FCAs. Similarly, skills-based professional development, focused on preparing educators to take advantage of fishermen’s intrinsic interest in learning about fishing, could improve educators’ teaching efficacy beliefs and increase the likelihood that they share FCA information with fishermen.
Characterizing Environmental Health Literacy Related to Fish Consumption Advisories:
Knowledge and Beliefs of Informal Educators in a Southeastern State

by
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DEDICATION

To my mom, Mary Rita Trovato Gray, a tireless advocate for vulnerable populations in our local community, and to subsistence fishermen and the informal educators who share information with them about the potential harms of eating contaminated fish.
BIOGRAPHY

Kathleen M. Gray is associate director for outreach and public service and a clinical assistant professor in the UNC Institute for the Environment. Her work focuses on sharing UNC’s environmental science research in informal learning contexts across the state, responding to environmental health needs in North Carolina communities, and science communication. In 2015, she was awarded one of UNC-Chapel Hill’s highest honors for engaged scholarship, the Office of the Provost Engaged Scholarship Award for Partnership, recognizing a longstanding collaboration with a regional environmental nonprofit and a county park to inform vulnerable populations about the risks of consuming contaminated fish. She holds a B.S. in mathematics from Vanderbilt University and a M.S.P.H. in environmental sciences and engineering from UNC-Chapel Hill. She lives with her husband and two children in Chapel Hill, NC.
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CHAPTER 1: INTRODUCTION

Annually, millions of Americans learn about science in informal contexts that range from designed settings (e.g., museums and nature centers) to everyday settings (e.g., recreational activities like fishing and hiking, participation in clubs and family activities) (NRC, 2009). In everyday contexts, there may not be explicit goals related to teaching and learning science. Instead learning may occur spontaneously, at opportune moments. Such is the case with fish consumption advisories. Although fish can be a source of lean protein in the diets of Americans, certain fish in lakes and rivers in the United States contain high levels of pollutants that can harm human health. For this reason, all 50 states and some tribes and United States territories issue fish consumption advisories to inform people who eat fish about potential exposures to harmful chemicals. These advisories were first issued in the Great Lakes in the 1970s, and at present, they most commonly address exposure to methylmercury and polychlorinated biphenyls (PCBs) (USEPA, 2013). Sources of these chemicals include coal combustion, energy production, and mining and industrial operations. When consumed, these contaminants may impair neurodevelopment in children and cause birth defects, liver damage, cancer, and other serious health problems (ATSDR, 2014; ATSDR, 2015). Recently, low-level prenatal methylmercury exposure has been associated with delayed language and communication skills in children (Vejrup et al., 2016) and adverse effects on fetal growth and neurologic, immune, and cardiovascular systems function (Karagas et al., 2012).

The populations most vulnerable to the harmful effects of contaminated fish include children and pregnant/breastfeeding women (Ha et al., 2017; Karagas et al., 2012; NRC, 2000). Children are at greater risk because their bodies are still developing and they tend to have more limited diets, which can amplify the effects of any unhealthy foods they eat (WHO, 2017).
Additionally, they consume more calories per unit of body weight as compared to adults, magnifying the effects of toxicants in foods. For pregnant women, chemicals to which a mother is exposed could potentially affect her baby’s development, even after birth, as some chemicals may be passed to children through the placenta and breast milk (ACOG, 2013). In addition, subsistence fishermen and Native American populations also are at risk, because they eat substantially more fish than others (Moya, 2010).

A typical fish consumption advisory (FCA) identifies fish species for which measured contaminant levels in fish tissue exceed health-based standards. Although most FCAs are location-specific (i.e., apply to specific bodies of water), some are more widespread. For instance, in North Carolina, the methylmercury advisory for largemouth bass applies in all state waters. For several other fish species in which high concentrations of methylmercury or other contaminants have been measured, regional and local advisories also have been established (North Carolina Department of Health and Human Services (NCDHHS), 2017a). In many areas, FCAs issued by NCDHHS have varying recommendations based on whether individual consumers are more or less sensitive to the effects of the contaminants in the fish. For example, a local advisory for Badin Lake (in Montgomery and Stanly Counties, North Carolina) states: “Pregnant women, women who may become pregnant, and children under 15 should avoid eating catfish and largemouth bass from this lake due to high levels of mercury as well as PCBs. Other people should eat no more than one meal per week of catfish and largemouth bass from this lake” (NCDHHS, 2017b). These targeted recommendations underscore that some populations are at greater risk from exposure to the contaminants found in fish and indicate that the total amount of fish consumed matters for all populations.
Fish Consumption Advisory Communications

The potential for negative health impacts among these vulnerable populations raises the question of why FCAs are preferred over fishing bans or catch-and-release policies, in which fish could be caught but not kept. According to the US Food and Drug Administration (USFDA, 2017), fish contain high quality protein, omega-3 fatty acids, vitamins and minerals, and are low in saturated fat. Further, the nutritional value of fish is important for developing babies in the womb, in early infancy for breastfed babies, and in childhood due to the role of omega-3 fatty acids in neurological development (Mahaffey et al., 2011; Nesheim & Yaktine, 2007). National organizations of physicians and nutritionists support the USFDA’s recommendations that fish are part of a healthy diet (Oken et al., 2012). At the same time, eating fish is the primary mechanism for human exposure to methylmercury (Engelberth et al., 2013), and fish also may contain other contaminants. This interplay between health and harm from fish consumption has challenged public health professionals and health care providers to communicate that, although contaminated fish should be avoided, fish is an essential part of a healthful diet.

This challenge has spurred a body of research on FCA communication, in which multiple educational approaches (including classroom lessons, brochures, and other educational materials) have been used with varying degrees of success (Burger et al., 2003; Burger & Waishwell, 2001; Engelberth et al. 2013). Research has identified a range of factors that influence whether fishermen\(^1\) attend to FCA information presented in varying locations and formats (Burger et al.,

\(^1\)Research has shown that men and women who fish prefer and use the term “fishermen” to describe themselves, rather than a gender-neutral alternative such as “anglers” (Tan, Ujihara, Kent, & Hendrickson, 2010). In this paper, the term fishermen applies to both men and women who fish.
2003; Connelly & Knuth, 1998; Velicer & Knuth, 1994); however, only a few studies have applied theoretical frameworks or explicitly addressed the informal science learning context in which such communications typically occur (Cooke, Suski, Arlinghaus & Danylchuk, 2013; Niederdeppe, Connelly, Lauber, & Knuth, 2015; Tan, Ujihara, Kent, & Hendrickson, 2010). Cooke et al. (2013) called for a greater emphasis on voluntary educational approaches and involvement of informal institutions and educators in all aspects of fisheries management, including communication of FCAs. Even earlier, Furgal, Powell and Myers (2005) underscored the importance of informal educators, noting their ability to understand the “informal paths of information flow in communities” and their use “spoken word and quality relationships” to effectively share information about contaminants in locally-harvested food in ways that account for the beliefs and cultural practices of diverse populations.

**Theoretical Frameworks**

Application of theoretical frameworks that address influences on human behavior have the potential to enhance understanding of the ways that FCA communication could be improved. Three frameworks underpin the research described in this paper: the Health Belief Model, social cognitive theory, and environmental health literacy. The **Health Belief Model** (Rosenstock, 1974) is a widely used health education and promotion theory. The underlying concept is that individuals will perform a health behavior if they perceive they are susceptible to a negative health condition or disease, if they expect that taking action will help them avoid the negative condition or disease, and if they believe they can successfully perform the action. The core constructs of the theory include the following: *perceived susceptibility, perceived severity, perceived benefit, and perceived barriers*. Rosenstock, Strecher, and Becker (1988) later added
self-efficacy and cues to action to the model to advance its predictive capability. (See Figure 1.1.)

![Health Belief Model](image)

*Figure 1.1. Health Belief Model, based on Rosenstock, 1988*

The resulting model has been applied to a variety of public health issues, including voluntary cancer screening, smoking cessation, and healthy eating (Orji, Vassileva, & Mandryk, 2012). Despite being used to understand healthy eating decisions, this model has not been applied to decisions of whether to consume fish. The Health Belief Model could be used to gain an understanding of the extent to which educators perceive fishermen to be susceptible to harm from eating contaminated fish, the severity associated with any potential harms, and any benefits or barriers they perceive to taking protective actions. This information could provide insights into the beliefs that influence whether educators prioritize these communications and inform next steps on how to work with educators who address FCAs.

The Health Belief Model is grounded in another influential behavioral theory, **social cognitive theory** (Bandura, 1998), which asserts that human behavior is affected by cognitive processes and personal and environmental factors; stated more simply, we use existing knowledge and beliefs to interpret external situations and develop expectations that influence
future behavior (Figure 1.2). Bandura (1977) asserted that individuals chose a specific behavior when they believed in their ability to perform that behavior (self-efficacy) and expected it to produce desired outcomes (outcome expectancy). Gibson and Dembo (1984) applied Bandura’s constructs to teaching, defining personal teaching efficacy as a teacher’s judgment of her/his ability to positively influence student learning and teaching outcome expectancy as a teacher’s belief that teaching can generally result in positive learning outcomes. Riggs and Enochs (1990) extended this approach to science teaching and developed and validated an instrument to assess elementary teachers’ beliefs about science teaching and learning.

Limited research on the self-efficacy of informal educators has shown that informal educators’ teaching self-efficacy was lower than that of experienced classroom teachers and that institutional affiliation may shape their teaching practices (LePrevost, Blanchard, & Cope, 2013). Application of social cognitive theory could improve our understanding of informal educators’ ability to effectively communicate with their target audiences about fish consumption advisories, based on their teaching self-efficacy and outcome expectancy, potentially identifying opportunities to improve both outcomes.

![Diagram](image)

*Figure 1.2. Social cognitive theory, based on Bandura, 2004*
**Environmental health literacy** (EHL) is an emerging conceptual framework that defines the range of knowledge and skills that prepare people to make health-protective decisions using available environmental data (Finn & O’Fallon, 2017). Preliminary research has focused on how people understand connections between environmental exposures and health and, to a more limited extent, how improving literacy can lead to policies and infrastructure development that reduce environmental exposures (Gray, 2018). Gray recently included socio-cultural dimensions in the EHL framework (Figure 1.3). Application of this framework to education about fish consumption advisories enables exploration of how environmental health knowledge interacts with health beliefs and teaching beliefs to influence individual and community action to reduce exposures to harmful contaminants in fish.

*Figure 1.3. Three dimensions of environmental health literacy, Gray (2018)*
Fishing Populations in North Carolina

In North Carolina, the population potentially exposed to contaminants in fish is large. Annually, over 479,000 fishing licenses are issued by the State of North Carolina, with more male than female license holders (K. Linehan, personal communication, September 23, 2015). Additionally, over 70,200 fishing license subsistence waivers2 were issued by local social service agencies in the State from October 1, 2015 through September 30, 2016. Based on demographic data collected by issuing agencies, Black fishermen were about as likely to be subsistence fishermen as Whites (46% versus 48%, respectively; K. Linehan, personal communication, August 10, 2017). Latinos represented only 1% of the population of fishermen with fishing license subsistence waivers in this period, yet environmental advocates and county park managers have reported that Latinos are among the most common subsistence fishermen encountered along waterways in central North Carolina (M. Starr, personal communication, June 20, 2017; D. Cade, personal communication, March 4, 2014). Although insufficient information is available to determine the reasons for this discrepancy, it is possible that factors include language barriers or the immigration status of the fishermen resulting in them not seeking or acquiring waivers. Subsistence fishermen represent a population for whom fish may be a significant part of their diets, and if they are unaware of consumption advisories, they may be eating more fish than is recommended to protect health.

2 In North Carolina, county social services agencies issue a free license waiver upon request to any individual who receives benefits from Medicaid, the Food Stamp Program or Work First.
Research Questions

Limited research has been conducted in informal science learning contexts in which fish consumption advisory communications occur. Thus, little is known about the role of educators in these contexts and the environmental health knowledge and teaching beliefs of these educators. Drawing on the theoretical frameworks described above, this study was designed to enhance understanding of the educational practices of informal educators who share information about fishing and fish consumption advisories (FCAs) with fishermen, their families, and other public audiences in a southeastern state in the United States. A goal of this study was to inform the development of educational interventions that disseminate information about FCAs, to ensure that those most vulnerable to the harmful effects of contaminated fish are aware of advisories and empowered to follow them. An understanding of informal educators’ knowledge of the potential harms of eating contaminated fish as well as information about their self-efficacy for communicating that knowledge to others seems essential to develop meaningful interventions.

To address existing gaps in the literature, this study employed a mixed methods design to answer the following research questions:

1. How do the informal educators who share information with fishermen describe their knowledge and beliefs related to fish consumption advisories?

2. How do they describe their communication about advisories with fishermen, their families, and other public audiences?

3. How are the different dimensions of environmental health literacy exemplified by informal educators who share information about fish consumption advisories?

4. What do any differences imply about the relative importance of the three environmental health literacy dimensions?
Summary

In this chapter, the public health challenge of simultaneously communicating the potential harms and benefits of fish consumption was introduced, alongside the associated challenges of sharing such messages with the populations most vulnerable to potential harm. The study context of a southeastern state with a large fishing population and a sizable population of subsistence fishermen was described; and three theoretical frameworks that inform this mixed methods study—the Health Belief Model, social cognitive theory and environmental health literacy—were introduced, followed by four research questions. Chapters Two and Three are each compiled as draft manuscripts, each including an abstract, introduction, literature review, theoretical frameworks, research questions, methods, findings, discussion and conclusions and implications. Chapter Two examines the educational practices, environmental health knowledge, and health and teaching beliefs of informal educators and other environmental and public health professionals who share information about fishing and fish consumption advisories with fishermen, their families, and other public audience. Chapter Three is an exploratory case study of environmental health literacy in the context of fish consumption advisory communication, highlighting three participants who exemplified aspects of environmental health literacy in their communications with fishermen and other public audiences. Finally, Chapter Four synthesizes the conclusions of the two draft manuscripts and presents recommendations, limitations, and implications for future research.
CHAPTER 2: Informal Educators’ Environmental Health Knowledge and Teaching Beliefs: Implications for Communicating Fish Consumption Advisories

Abstract

Informal science learning occurs in many settings, and scientific content and practices may be opportunistically encountered through daily activities. Such is the case with fish consumption advisories, which inform people who eat fish about their potential exposure to harmful chemicals. These advisories are issued by all 50 states, some tribes, and United States territories. Research has shown that awareness of advisories is generally low, particularly among the populations most likely to consume locally-caught fish. Limited research has been conducted in the informal science learning contexts in which such communications occur and about the role of informal educators in these contexts. The purpose of this exploratory case study was to understand the knowledge, beliefs, and teaching efficacy of informal educators who share advisory information with fishermen. Semi-structured interviews were conducted with 24 educators from institutions spanning environmental nonprofits, local governments, universities and state environmental, health, and wildlife agencies. Participants also completed a knowledge questionnaire, a self-efficacy survey, and a demographic survey. The theoretical frameworks of the Health Belief Model, social-cognitive theory, and environmental health literacy informed this study. Many participants were able to describe relevant environmental health concepts, yet the potential health impacts of consuming contaminated fish were not well understood. Additionally, many participants believed that the severity of harm from eating contaminated fish was moderate, even for susceptible populations. Participants’ self-efficacy associated with teaching about FCAs could be characterized as low to moderate, which may have influenced their decisions to teach about FCAs. Science teaching efficacy data also suggested that educators were more confident in their ability to communicate about FCAs than they were in
their expectations that people would follow their recommendations related to FCA guidance. These results underscore potential challenges to communicating advisory information and opportunities for more effectively deploying informal science education resources to do so. Specifically, wildlife agencies are an important conduit to fishermen, and as such, could play a more active role in effective FCA communication. Local governments with direct connections to waterways under advisory also have opportunities to interact with large numbers of fishermen and develop planned programming. Targeted professional development on environmental health concepts relevant to FCA education may better position these educators to address FCAs in their practice. Similarly, skills-based professional development, focused on opportunities to take advantage of fishermen’s intrinsic interest in learning about fishing, could improve the teaching efficacy beliefs of educators who share FCA information with fishermen along waterways.

**Introduction**

Fish consumption advisories (FCAs) inform people who eat fish about their potential exposure to harmful chemicals. Although such advisories are widespread in the United States, awareness of them is generally low, particularly among the populations most likely to consume locally-caught fish. For this reason, the impact of FCAs has been extensively studied, including the extent to which fishermen\(^3\) are aware of and understand these advisories. In contrast, limited research has been conducted on the informal science learning contexts in which such advisory communications occur and the role of educators in these contexts. This is a mixed methods study.

\(^3\) Research has shown that men and women who fish prefer and use the term “fishermen” to describe themselves, rather than a gender-neutral alternative such as “anglers” (Tan, Ujihara, Kent, & Hendrickson, 2010). In this paper, the term fishermen applies to both men and women who fish.
study of 24 informal educators in a southeastern state who share information with fishermen. This research was designed to enhance understanding of their educational practices, environmental health knowledge, and health and teaching beliefs. The following sections present an overview of the relevant literature, describe participants and methods, and present findings, discussion, conclusions, and implications.

**Literature Review**

A large body of research on fish consumption advisory (FCA) communication has examined multiple educational approaches and identified a range of factors that influence whether fishermen attend to advisory information. Yet limited research has considered the role of informal educators in these communications.

**Awareness of FCAs**

Fishermen have reported general awareness of FCAs across 10 studies spanning multiple regions of the United States (Niederdeppe, Connelly, Lauber, & Knuth, 2015). Most participants could not recall the details of specific advisories (e.g., how to limit exposure or which populations were at greatest risk), and few fishermen reported using FCAs when deciding whether to eat locally-caught fish. Along these lines, in a study of 254 fishermen in a northeastern state, Burger (2004) found that awareness levels did not necessarily translate into altered consumption patterns, for reasons that included distrust in government, fishermen’s belief in their ability to visually identify contaminated fish, and lack of experience with people becoming sick from consuming fish. Overall, approximately 50% of participants in this study knew about advisories. There were differing levels of awareness across racial/ethnic groups, with Whites reporting the highest awareness and Latinos reporting the lowest awareness. The authors
noted that many participants who knew about advisories still reported consuming their catch although no quantitative data were provided in the article.

Similarly, Tan, Ujihara, Kent, and Hendrickson (2010) reported that advisories were ineffective at reaching some vulnerable populations, including non-White racial and ethnic groups and anglers of low-income or low educational attainment. Johnson, Hoffman, Wing, and Lowman (2016) surveyed 50 fishermen along river banks in a southeastern state and found that only about one-third were aware of a local methylmercury advisory, with Spanish-speakers having the lowest levels of awareness. About 16% of the sample had exceeded the recommended number of fish servings indicated as safe in a local advisory, and only 8% reported that advisories influenced their fishing practices. Similarly, in a pilot study in a large urban center in the northeast, researchers demonstrated limited awareness of advisories and high levels of consumption of fresh-caught fish among a sample of 34 Asian fishermen (Perez, Sullivan, Michael, & Harris, 2012). In a northeastern state, Ratnapradipa et al. (2010) surveyed Southeast Asian fishermen (N=95) about their fishing behaviors and found that only 34% had heard about local fishing bans.

Research also has shown that women are less aware of advisories than men, and risk reduction messages are not reaching women of childbearing age (LePrevost et al., 2013b; Tan et al., 2010). Further, LePrevost et al. (2013b) found that fishermen in the western Piedmont region of North Carolina who shared their catch with women and children were less aware of FCA information than their counterparts who were not sharing fish.

**Understanding of FCAs**

Several factors related to the content and format of advisory communication have been shown to influence attention to and comprehension of FCAs. Early research identified
fishermen’s desire for detailed information on chemicals in fish and potential risk-reduction behaviors that they could implement (Velicer & Knuth, 1994). Another study suggested that a mix of qualitative and quantitative information and diagrams and text facilitated greater understanding of advisories (Connelly & Knuth, 1998). More recently, Tan et al. (2010) found that understanding of FCA information was enhanced when simplified categories (e.g., high, medium, low) were used to communicate the amount of contaminant present in a fish. The authors also found that use of specific age ranges was best understood, and they identified a set of commonly used but often misunderstood terms (such as “angler,” “uncooked,” and “omega-3 fatty acids”).

Lauber, Niederdeppe, Connelly, and Knuth (2013) also identified confusing terms used in advisories as well as the common misconception that fishermen could visually detect the presence of contaminants. Additionally, the authors reported that participants were confused by the inclusion of different consumption recommendations for different populations, a standard feature of many site-specific FCAs. More recently, Lauber, Connelly, Niederdeppe, and Knuth (2017) found that efforts to use plain language might still confuse some fishermen. Specifically, phrases like “fish that eat other fish” led to confusion about whether all fish were under advisory, and “smaller younger fish versus larger older fish” led some to believe that the guidance applied across species rather than within species. In a separate content analysis of online FCA information, a key barrier to lay public understanding was the readability level of educational materials, which was just above grade 9 reading level (i.e., above the average reading level of adults in the United States) (Henderson et al., 2016).

Burger and Gochfeld (2008) showed that consumers can process and weigh the benefit and risk information conveyed in FCAs, provided that the advisories indicate which fish should
be avoided and which can be consumed. However, they also found that fishermen do not have access to full information, such as which contaminants are of concern, which fish have the highest levels of contaminants, which locations are the most contaminated, and which populations are most at risk (Burger & Gochfeld, 2009).

More recently, Engelberth et al. (2013) demonstrated increased knowledge of the risks and benefits of consuming fish while pregnant, following use of a written guide that included both types of information ($N = 808$ pregnant women). Similarly, in a review of online FCA information issued by state and federal agencies in the United States, the authors noted a need to more effectively balance information about the potential harms from specific fish with a message about the health benefits of eating uncontaminated fish (Scherer, Tsuchiya, Younglove, Burbacher, & Faustman, 2008).

In an effort to target women as key decision makers about their health and the health of their children, Teisl, Fromberg, Smith, Boyle, and Engelberth (2011) surveyed 769 new mothers via a mail survey sent to women who had given birth in the prior three months. They found that carefully including positive information alongside negative information about fish consumption shortened the length of time that pregnant women reduced fish consumption during pregnancy. The mail survey included questions about participants’ fish consumption before and after reading educational materials that accompanied the survey. The women who read the advisory reported decreasing their consumption of high-risk fish and increasing their consumption of low-risk fish.

**Role of Beliefs**

Several studies evaluated the role of beliefs in decision-making associated with following FCA guidance. Using a grounded theory approach, Tan et al. (2010) highlighted the influence of personal beliefs on acceptance of FCA messages. Through 46 interviews, the research team
identified beliefs that influenced advisory acceptance, including inaccurate beliefs about fish biology and behavior (e.g., fish that swim near the surface are cleaner), environmental factors (e.g., fast-flowing water is cleaner), and methods for cleaning and cooking that could reduce levels of contaminants (e.g., high heat “gets germs out,” p. 1099). The authors discovered that participants typically considered FCAs in the context of their existing beliefs and discounted them when they contradicted these beliefs. Notably, these beliefs came from experience and trusted sources (such as friends); and government-issued information was not a significant information source.

In a study of 1,712 Great Lakes fishermen, Niederdeppe et al. (2015) examined the key beliefs that were associated with intention to follow FCAs, focusing on fishermen’s behavioral, normative, and control beliefs. The authors noted that those who believed health effects were short-term were less likely to follow advisories, so they suggested that advisories emphasize that chemical contaminants in fish can accumulate in the body over time and cause long-term impacts. They also noted that fishermen who questioned government agency data on chemical contaminants were not likely to follow FCAs. In addition, normative beliefs about whether family and friends were likely to follow FCA guidance predicted the behavioral intentions of a subset of respondents (i.e., participant choices regarding whether to follow FCA guidance were influenced by the choices of family and friends). This finding led the researchers to recommend using language such as “most licensed anglers like you say they try to follow the advisories” or “your friends and family want you to be healthy—and the advisories can help you make the best choices” (p. 2005).

Two behavioral theories that have been used in health education contexts provide insight into how beliefs may influence actions: the Health Belief Model (Rosenstock, 1974) and social
cognitive theory (Bandura, 1998). The Health Belief Model has been applied to a variety of public health issues, including voluntary cancer screening, smoking cessation, and healthy eating (Orji, Vassileva, & Mandryk, 2012). In a meta-analysis, Carpenter (2010) showed that the Health Belief Model has been validated across various domains and a wide range of populations. Among four core constructs in the original model, perceived barriers (i.e., beliefs about the costs or barriers to taking action) and perceived susceptibility (i.e., the extent to which individuals believe they are at risk of developing a negative health condition or illness) were shown to be the strongest predictors of behavior; however, there are no strict guidelines on how the different variables combine (Orji et al., 2012).

Specific to healthy eating behaviors, Deshpande, Basil, and Basil (2009) applied the model to college students’ dietary choices and found important differences in eating behavior by gender, leading the authors to recommend distinct educational interventions for males and females. For females, they recommended interventions that would influence the extent to which the female students believed the potential health consequences of not eating a healthy diet were serious (i.e., emphasizing impacts of obesity on cardiovascular health), to increase their perceived severity. For males, the authors recommended interventions that would increase the extent to which male students believed they were at risk of developing a negative health condition as a result of not eating a healthy diet (i.e., highlighting obesity prevalence among men), to increase their perceived susceptibility. These findings underscore the importance of understanding a target audience’s beliefs about severity and susceptibility in scoping interventions.

Despite broad use of the Health Belief Model, recent research has suggested that the four core constructs in the original model accounted for only about 20% of the variance in health
behavior. In an expanded model, Orji et al. (2012) found that *self-efficacy, or the individual belief that a person can perform a desired behavior*, was the strongest and the most significant determinant of healthy behavior. Further, they found that *perceived barriers*, such as the belief that healthy foods would not taste good, were the only variables that negatively influenced health behavior (i.e., corresponded with decisions not to adopt a desired behavior).

In the context of environmental exposures to harmful chemicals, Chen et al. (2014) applied the Health Belief Model to understand how women perceive and respond to risks of exposure to endocrine disrupting chemicals during pregnancy. Using semi-structured interviews and a survey (*N* = 124), the researchers identified participants’ health outcomes of concern as well as which ones they were motivated to achieve or avoid. Results suggested that the traditional approach to prenatal education, which focused on risks, was not effective. Nor did this approach address participants’ perceptions of the severity of the risks and the benefits of taking action. Although all women wanted healthy babies, they did not connect chemical exposures during pregnancy to impacts on future health outcomes for their children, leading most women to dismiss some risks or avoid protective actions. Additionally, the women valued personal experience and anecdotal evidence over probability of risk. For these reasons, the authors underscored the need to help women understand how exposure to these contaminants could cause long-term harm to developing fetuses.

In another study using the Health Belief Model, Quandt et al. (2013) prepared lay health advisors (or “promotoras” in Spanish) to educate Spanish-speaking families about pesticide exposure. The promotoras delivered a six-lesson, in-home, culturally appropriate curriculum to 610 members of farmworker families. Significant improvements in knowledge were reported related to the content in all six lessons as well as practices related to residential pest control and
para-occupational exposure (i.e., pesticides brought home from occupational exposure). Quandt et al. attributed these results, in part, to a heightened sense of susceptibility among participants as a result of the training.

LePrevost, Blanchard, and Cope (2013) evaluated the beliefs of a sample of 19 farmworker educators in a southeastern state. Using data from surveys and interviews, they characterized the educators’ beliefs about teaching, pesticide risk, and self-efficacy. They found that these educators’ beliefs aligned with their institutional affiliations and were influenced by the number of lessons an educator taught annually, speaking the same language as the farmworkers, and the extent of their hands-on experience with pesticides.

With respect to fish consumption advisories, Driscoll, Sorenson, and Deerhake (2012) applied concepts from the Health Belief Model to understand the knowledge, attitudes, and practices related to subsistence fish consumption in a diverse, rural, low-income county in a southeastern state. Their goal was to inform the development of culturally competent educational materials. They interviewed 194 residents in three communities and then developed and tested educational materials, tailoring them based on the cultural beliefs and practices identified in the interviews. Next they assessed whether the information influenced participants’ perceptions of susceptibility, severity of risk, and self-efficacy. The authors found that economic and social constraints reduced perceived self-efficacy among Latinos, and skepticism of messages from government agencies reduced African Americans’ belief in the messages.

Constructs from socio-cultural theory were harnessed for an intervention by Derrick, Miller, and Andrews (2008). The authors developed, implemented, and evaluated a risk communication intervention related to a fish consumption advisory in a low-income, predominantly African American public housing community in a southeastern state. Their study
used social cognitive theory as the basis for design of key aspects of the intervention, including use of race-specific role models as educators and participatory input in the content, which referenced cultural beliefs about fishing behaviors. In-person surveys were conducted with 23 community residents as baseline data and 3 months post-intervention to assess changes in knowledge and behaviors. Findings showed knowledge gains for the participants, who also reported behavior changes related to preparation of fish fillets and reduced consumption of larger fish, internal organs, and fish eggs as well as reduced consumption of fish by pregnant women and children.

Recently, Burger, Gochfeld, and Fote (2013) demonstrated the potential of community-engaged research for improving understanding of the risks associated with fish consumption, which Burger had proposed in earlier work (Burger, 2000). The authors actively engaged fishermen in a research project that involved sampling fish along the coast of a northeastern state. Individual fishermen, fishing clubs, and businesses participated in all stages of the research, helping to identify sampling locations and target species as well as disseminating findings. Specifically, the fish sampled were those actually consumed by fishermen (including some species that were presumed to be lower in mercury along with high mercury fish) to better inform risk reduction decisions. The Burger, Gochfeld, and Fote study provides an example of how to structure engagement with the fishing community and how it could impact fishermen’s understanding of the risks of consuming contaminated fish.

**Educators who are Positioned to Address FCAs**

Limited research has been conducted on the informal science learning contexts in which advisory communications occur and the role of educators in these contexts. Burger et al. (2003) evaluated the effectiveness of a classroom lesson versus a brochure and found that women who
participated in classroom lessons through a Women, Infants and Children program had a better understanding of the FCA than those who had access to a brochure, though both approaches measurably increased understanding. Based on these findings, the authors argued for health care and nutrition education agencies as a conduit for increasing understanding of FCAs and buy-in among pregnant and breastfeeding women.

Jardine (2003) analyzed awareness of and compliance with FCAs in a western province of Canada, focusing on an area with existing methylmercury and dioxin/furan advisories. She identified community information needs, ranging from information on health effects and acceptable exposure levels to actions taken to remedy contamination and ongoing monitoring and testing of fish. Participants found information to be more credible when communicated by multiple agencies and recommended that it come from people whom they frequently consulted for information (specifically conservation officers and health professionals). Additionally, Jardine suggested that locally relevant advisories should be brought to fishermen’s attention when licenses were issued, not just in the regulatory brochures, and that FCAs should be promoted through local conservation organizations.

**Theoretical Frameworks**

Three theoretical frameworks guided this study: the Health Belief Model, social cognitive theory, and environmental health literacy. Taken together, these theories identify aspects of environmental health knowledge (e.g., health beliefs) that interact with self-efficacy and outcome expectations to influence adoption of (or education about the adoption of) health protective behaviors. The framework of environmental health literacy then provides a context within which
health-protective behaviors may move beyond the individual level, to community-wide or community-focused actions to protect health.

The Health Belief Model

The Health Belief Model (Rosenstock, 1974) was originally developed to explain why medical screening programs were underutilized. Now one of the most widely used health education and promotion theories, its core constructs include the following:

- **Perceived susceptibility**: the extent to which individuals believe they are at risk of developing a negative health condition or illness;
- **Perceived severity**: the extent to which individuals believe the negative health condition or disease has serious consequences;
- **Perceived benefits**: beliefs about the effectiveness or benefits of taking action to avoid the condition or disease; and
- **Perceived barriers**: beliefs about the costs or barriers to taking action.

These four variables combine to form two categories that are believed to influence decision making about health behaviors: *perceived threat* (a combination of perceived susceptibility and perceived severity) and *behavioral evaluation* (an assessment of whether perceived benefits outweigh perceived barriers). The underlying concept is that individuals will perform a health behavior if three conditions are met: (1) they perceive they are susceptible to a negative health condition or disease, (2) they expect that taking action will help them avoid the negative condition or disease, and (3) they believe they can successfully perform the action. Rosenstock, Strecher, and Becker (1988) later added self-efficacy to the model in an effort to advance its predictive capability. Within this expanded theoretical framework, education and public health interventions can be viewed as *cues to action*, which influence behavior by influencing perceived
threats, which is a combination of perceived susceptibility and perceived severity. (See Figure 2.1.)

Social Cognitive Theory

Another theory that has been influential in the fields of health promotion and disease prevention is social cognitive theory (Bandura, 1998). Core determinants include knowledge of health risks and benefits, perceived self-efficacy, outcome expectations, health goals and strategies for realizing goals, and perceived facilitators and social and structural impediments (See Figure 2.2.). In earlier work, Bandura (1977) asserted that individuals would choose a specific behavior when they believed in their ability to perform that behavior (self-efficacy) and expected it to produce desired outcomes (outcome expectancy). He argued that self-efficacy beliefs influenced which actions individuals would choose to pursue, the amount of effort they would expend, and how long they would persist in the face of obstacles. In making connections between efficacy beliefs and health behavior choices, Bandura (2004) noted that enabling people...
with “self-management skills and self-beliefs needed to take charge of their health habits” (p. 148) was a superior approach to the scare tactics often used to depict poor health.

Gibson and Dembo (1984) applied Bandura’s constructs to teaching, defining personal teaching efficacy as a teacher’s judgment of her/his ability positively influence student learning and teaching outcome expectancy as a teacher’s belief that teaching can generally result in positive learning outcomes. Riggs and Enoch (1990) developed and validated the Science Teaching Efficacy Belief Instrument (STEBI), to assess elementary teachers’ beliefs about science teaching and learning. This instrument measured beliefs about teaching effectiveness (personal science teaching efficacy) and whether teaching would produce desired outcomes (science teaching outcome expectancy). According to Tschannen-Moran and Hoy (2001), changes in teaching efficacy can be important, because teachers’ sense of self-efficacy has been associated with teacher motivation. Teachers with higher self-efficacy tend to be more open to new ideas and more willing to experiment with new methods to meet students’ needs. Additionally, efficacy beliefs influence teachers’ persistence in the face of challenges.

**Environmental Health Literacy**

Environmental health literacy (EHL) is a relatively new framework that describes a range of knowledge and skills that enable people to make health-protective decisions using available
environmental data. At its most basic, EHL has been described as an ability to make connections between environmental exposures and human health (Finn and O’Fallon, 2017). Representations of EHL tend to start with individual understanding of specific risks and then lead to broader understanding, including strategies that empower people to reduce or eliminate environmental exposures that can harm health. In a recent review of literature (Gray, 2018), studies representing different forms of EHL were grouped into three categories:

- **Individual-level EHL** was described as: (a) understanding the connection between environmental exposures and health; (b) representations of content knowledge, such as a score on a survey of environmental health knowledge or gains in content knowledge demonstrated with pre/post-assessments; and (c) individual behavior changes reported in response to environmental exposures.

- **EHL that spanned individual and community levels** appeared in studies that emphasized “report-back” of individual and community-wide results to participants, most often biomonitoring studies.

- **Community-level EHL** was represented as community change or collective action reported in response to environmental exposures.

In these studies, awareness and knowledge were an important starting point for EHL. When combined with information-seeking and decision-making skills and self-efficacy for specific behaviors, knowledge informed collective action and community change. Thus, EHL can be conceived of as having three dimensions, each of which builds upon the next: (a) awareness and understanding, (b) skills that enable health protective decision-making and self-efficacy associated with those skills, and (c) community change or collective action to reduce or eliminate harmful environmental exposures (Figure 2.3). The interdisciplinary nature of EHL
has the potential to lead to greater understanding of specific environmental health risks and, ultimately, to actions that result in improved health outcomes (Finn & O’Fallon, 2017). For this reason, EHL provides a useful context for exploring the factors that influence how informal educators share FCA information with fishermen.

![Diagram showing three dimensions of environmental health literacy](image)

*Figure 2.3. Three dimensions of environmental health literacy, Gray (2018)*

**Research Questions**

Guided by the theoretical constructs underlying the Health Belief Model, social cognitive theory, and environmental health literacy, this exploratory case study investigated the knowledge, beliefs and practices of informal educators who communicate fish consumption advisory information to fishermen. This research addresses the following research questions about these informal educators:
1. How do they describe their knowledge and beliefs related to fish consumption advisories?
2. How do they describe their communication about advisories with fishermen, their families, and other public audiences?

Methods

The study was conducted in a southeastern state in the United States that has a large population of licensed fishermen, including subsistence fishermen, and fishing locations distributed across the state. A statewide methylmercury advisory was in place as well as site-specific fish consumption advisories (FCAs) for PCBs and dioxins.

Participants

The intention was to locate as many professionals in the state as possible who communicated with the public about fish consumption advisories to gain an understanding of their knowledge of, beliefs about, and communication of this information to fishermen. The population of these educators in this southeastern state is unknown but estimated to be less than 100 people. To recruit participants, a list of educators was developed, starting with organizations that are required to communicate FCA information and then using a snowball sampling method. Participants were recruited using email, listservs, and in-person gatherings of relevant organizations. In total, 101 individuals were contacted. Of these, 24 informal educators and other environment and public health professionals agreed to participate. All study protocols were approved by the North Carolina State University Institutional Review Board (#6263).

Participants were primarily Caucasian (21). One indicated “other” for race, two did not indicate a race, and two participants identified as Latino. Their ages ranged from 27 to 64, with the average age being 43. Thirteen participants were male, 10 were female, and one indicated
“other” for gender. All participants had some form of education beyond high school, including an associate degree (1), bachelor’s degrees (6), master’s degrees (16), and a professional degree (1). The organizations represented by participants included: environmental nonprofits, local governments, universities, and state environmental, health, and wildlife agencies.

Research Design

This exploratory case study employed a triangulation design (Figure 2.4), which enabled comparison and contrast of qualitative findings with quantitative results. Qualitative sources included the following: (a) transcripts from interviews, used to explore environmental health knowledge and teaching practices and beliefs, (b) brief researcher summaries (or reflections) of each interview highlighting key perspectives and ideas, and (c) a subset of questions on a survey of FCA-related knowledge. Quantitative data sources included the following: (a) responses to the Science Teaching Efficacy Belief Instrument (STEBI; Riggs & Enochs, 1990), modified for use with informal educators to assess science teaching efficacy beliefs, (b) a subset of questions on a survey of FCA-related knowledge, and (c) a demographic survey. The data sources are summarized below (Table 2.1), and data collection instruments are included in Appendices A-D.

Table 2.1. Data Sources

<table>
<thead>
<tr>
<th>Qualitative</th>
<th>Quantitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interview transcripts</td>
<td>• Modified STEBI questionnaire</td>
</tr>
<tr>
<td>• Interview reflections</td>
<td>• FCA knowledge survey, quantitative questions</td>
</tr>
<tr>
<td>• FCA knowledge survey, qualitative questions</td>
<td>• Demographic survey</td>
</tr>
</tbody>
</table>

Data Collection and Analysis

Interview guide. The interview guide (Appendix A) was designed to capture information related to participants’ educational practices, environmental health knowledge, and teaching beliefs. Original questions, including several that related to core constructs of the
Health Belief Model, were combined with questions excerpted and adapted from the Teacher Belief Interview (TBI; Luft & Roehrig, 2007). Two TBI questions were adapted for this informal science learning context and incorporated into the interviews. One focused on how participants decided what information to share, and the other focused on how they knew when these audiences understood what they were trying to communicate.

**Science Teaching Efficacy Belief Instrument (STEBI).** To assess participants’ science teaching efficacy beliefs—a combination of personal science teaching efficacy and science teaching outcome expectancy associated with teaching about fish consumption—the STEBI was modified and administered as a 10-item quantitative questionnaire. (See Appendix B.) The wording of items was modified for informal science education contexts in which educators share information with fishermen, and the 1 to 5 scoring scale (for strongly disagree to strongly agree, respectively) was reversed for some items.

**Surveys.** An 8-item, selected- and constructed-response survey was used to assess participants’ knowledge of FCA-related issues, such as the agencies that create FCAs, common contaminants, health effects of these contaminants, and advisories in their local area and the state (Appendix C). Several of the questions related to core constructs of the Health Belief Model.
(e.g., susceptibility and severity). Participants also completed a demographic survey (Appendix D).

**Interviews.** Interviews, which lasted between 45 and 90 minutes, were conducted in-person or via telephone and were audiotaped. After each interview, participants were asked to complete the modified STEBI, an FCA knowledge survey, and a demographic survey, which were all available online. STEBI scores and correct responses to the FCA knowledge survey were calculated and compared to qualitative findings.

Audiotapes were transcribed verbatim. The resulting transcripts were coded using a priori codes and emergent codes. (The codebook is included in Appendix E.) Four interviews were co-coded by another person, with 80% inter-rater reliability before coding differences were reconciled through discussion.

All coded text was reviewed for comments related to a set of core environmental health concepts: hazard, dose, health effects, and vulnerable populations. Comments about ecosystem dynamics relevant to environmental exposure also were coded.

**Findings**

Results are presented below in three sections: (1) environmental health knowledge, (2) teaching efficacy beliefs, and (3) communications about FCAs.

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4 Although route of exposure also is a core environmental health concept, it was not included because ingestion of fish was the focus of these interviews. As a result, the interviewer posed questions that addressed this route of exposure in all interviews, making it difficult to determine how participants would have introduced this concept on their own.
Research Question 1: Environmental Health Knowledge

Both quantitative and qualitative methods were used to understand participants’ environmental health knowledge. In response to the 8-item FCA knowledge survey (n=22), participants showed varying degrees of familiarity with relevant environmental health concepts and FCAs (Table 2.2). Most participants (86%) identified mercury as a common contaminant in fish, and a majority (64%) also identified polychlorinated biphenyls (PCBs); but just five participants (23%) knew a statewide mercury advisory for largemouth bass existed. Half of the participants (n=12) identified children as a vulnerable population, and a similar percentage (46%; 10) knew that the state health agency created FCAs.

Table 2.2. Responses to FCA Knowledge Survey (n=22)

<table>
<thead>
<tr>
<th>Contaminants Included in FCAs</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>19</td>
<td>86%</td>
</tr>
<tr>
<td>PCBs</td>
<td>14</td>
<td>64%</td>
</tr>
<tr>
<td>Dioxins</td>
<td>5</td>
<td>23%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Health Effects</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurological effects</td>
<td>10</td>
<td>46%</td>
</tr>
<tr>
<td>Cancer</td>
<td>7</td>
<td>32%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vulnerable Populations</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>11</td>
<td>50%</td>
</tr>
<tr>
<td>Subsistence fishermen</td>
<td>8</td>
<td>36%</td>
</tr>
<tr>
<td>Pregnant/breastfeeding women</td>
<td>7</td>
<td>32%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Agency that Creates FCAs</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCDHHS</td>
<td>10</td>
<td>46%</td>
</tr>
</tbody>
</table>

Participant comments during interviews provided further insight into their environmental health knowledge in the context of fish consumption issues, and these findings are organized below by the four environmental health concepts mentioned in methods: hazards, dose / duration, health effects, and vulnerable populations.
**Hazards.** Most participants (n=20; 83%) spoke about the contaminants included in state-issued FCAs (i.e., dioxin, mercury, PCBs) without prompting from the interviewer. About one-third of participants (n=8) focused their comments about hazards on safe handling procedures and spoilage and said they relied on sensory cues in assessing whether fish were safe to eat. Several other participants (n=4; 17%) noted the limits of using sensory cues for contaminants commonly included in FCAs, because these contaminants have no visible manifestations. An extension educator (Caucasian female, 14 years of experience) noted:

> How do you communicate things you can’t see? Like organic compounds, like PAH and PCBs, or mercury. There’s no way. You put two slices of tuna down here, I don't know which one has high mercury and which one doesn’t.

When addressing FCAs, many participants (17; 70%) talked about ecosystem concepts that related to environmental exposures, such as bioaccumulation, food chain or food web, bottom feeders, and top predators. Four participants reported using these concepts to make their messages more understandable. A state agency educator (Caucasian male, 13 years of experience) said that he advises fishermen that if “you’re catching largemouth bass…or any top predator over a certain size…if you take it home and eat it, you’re pretty likely to be having something that’s over the state’s limit [for mercury].”

**Dose.** About half of participants (13; 54%) discussed the frequency of consumption or other concepts associated with dose and duration of exposure. Some comments were general, such as the nonprofit program manager (Caucasian female, 14 years of experience) who said, “I guess my point in talking to people is…just to make sure they understand that there should be a limit.” Another participant (Caucasian male, health agency educator, 3 years of experience) noted that frequency of consumption affected health risks, saying, “for a lot of non-science folks
that level is a line in the sand; and once you cross it, you’re in a danger zone, which is not the case. On a one-off exposure, you’re just marginally increasing your risk.”

**Health effects.** Far fewer participants (n=7; 29%) discussed the potential health effects of consuming contaminants in fish, and some of the comments referred generally to health risks. Nevertheless, health was identified as an important context for communicating FCAs and environmental messages more generally. A Caucasian, female nonprofit program manager (14 year of experience) said:

> We’ve started to really recognize that connecting personal health to environment is a way for us to really make meaningful connection...when people start to think about their own health or the health of their children, they tend to perk up and pay more attention.

Another strategy suggested was to include more concrete data about health effects in the local area to make a more compelling case for following FCAs:

> To know that...whatever number of people had mercury toxicity...this isn’t some New York Times report; this happens here...it’s happened to your neighbors. This isn’t just a somewhere-else problem. Without being alarmist...this happens, so take it seriously. (Caucasian female, extension educator, 14 years of experience)

In response to questions about whether fish were safe to eat, some participants (7; 29%) reported using qualifiers to reflect the limited data available. They made statements such as “to the best of our knowledge, this is what we know you shouldn’t eat...we’re not sure about the rest” (wildlife agency educator, Caucasian male, 3 years of experience). Nonprofit educators tended to err on the side of caution in the face of data gaps, making recommendations like this one from a Caucasian, male educator (with 3 years of experience), “I personally wouldn’t eat fish out of [name of river].”

**Vulnerable populations.** Seventeen participants (70%) talked about at least one of the populations most vulnerable to potential adverse health effects from consumption of contaminated fish (i.e., women of childbearing age, pregnant or nursing women, children and
subsistence fishermen). A few participants (n=3) highlighted the challenge of convincing male fishermen to attend to FCAs, given their greater relevance to women and children. One nonprofit educator said he tells male fishermen to “pay more attention if you’re feeding this to your children or your wife is pregnant.” Similarly, in describing how he would talk with an older male about FCAs, a Caucasian, male wildlife agency educator (3 years of experience) said:

*I joke with older males...there's not much it can do to you. It's pretty much the women of childbearing age and kids that are the main issue. It may make you [i.e., older males] a little slower thinking, but that's gonna happen anyway.*

**Health Beliefs.** Both quantitative and qualitative data provided evidence of participants’ health beliefs. Using constructed-response items, the FCA survey provided information on the health risks participants associated with consumption of contaminated fish; selected-response items provided information on their perceptions of the severity of those risks and information on the susceptibility of various populations to harmful effects. The interviews provided insight into participants’ understanding of the barriers and benefits of following FCA guidance.

Participants (n=22) indicated the **severity** of the potential health effects they had identified for fishermen (or vulnerable populations) who consumed contaminated fish, in the context of all health issues they may deal with. They also indicated the **susceptibility** of the vulnerable populations to the health effects they had identified. (See Table 2.3.)

Table 2.3. Perceived Severity and Susceptibility Rankings (n=22)

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity of health effects for fishermen</td>
<td>(3, 10)</td>
<td>6</td>
</tr>
<tr>
<td>Severity of health effects for vulnerable populations</td>
<td>(1, 10)</td>
<td>6</td>
</tr>
<tr>
<td>Susceptibility of vulnerable populations to health effects</td>
<td>(1, 10)</td>
<td>7</td>
</tr>
</tbody>
</table>

Comments from several interviews align with these data and suggest that participants assumed that most fishermen (including vulnerable populations) were not eating sufficient
amounts of contaminated fish to pose a serious hazard. For instance, one educator said, “To really have an effect on somebody health-wise, they would have to really be eating it on a regular basis, which very few [do].”

**Barriers.** Every participant identified at least one barrier that fishermen might experience related to following guidance provided in FCAs; and on average, they identified five distinct barriers. (Figure 2.5 presents the most commonly cited barriers.)

One barrier, related to the complexity of FCA information, focused on the amount of information, the level of detail in FCAs, and the difficulty in finding all of the information. A Caucasian, male nonprofit educator (7 years of experience) said:

> You could go to an obscure web site and make about four clicks and finally find it buried at the back end...if you were fairly computer literate, had a computer, could read English, and had the patience.

A second barrier focused on economics as a driver in decisions about whether to consume fish that were under advisory. One nonprofit educator noted that people with less wealth were

![Figure 2.5. Common barriers to following FCA guidance (N=24)](image)
less able to move around and get to locations without site-specific advisories. Another nonprofit educator (Caucasian male, 3 years of experience) highlighted the effects of job insecurity saying, “If I'm hungry, I'm gonna eat; and I'll worry about tomorrow tomorrow.”

A third barrier was the belief that the advisory information did not apply to them due to never seeing negative effects from consuming fish. A nonprofit educator said he was told, “I been fishing here for a long time…nobody’s gotten sick yet.” Similarly, a wildlife educator (Caucasian male, 8 years of experience) reported hearing comments like, “What difference does it make? My granddaddy [fished and] lived ‘til he was 97.” He noted that another fishermen said, “I never eat more than two meals a week.”

The next set of barriers involved language and culture. Participants reported a lack of multi-lingual educational materials for speakers of Spanish and Asian languages (particularly but not limited to Chinese). They also described two cultural barriers to FCA communication: (a) populations that came from regions or ethnic backgrounds where fish and mollusks were dietary staples, and (b) families who passed down fishing practices through generations. In both cases, participants noted that these cultural experiences might limit receptivity to FCA information.

Additional barriers included negative attitudes towards government and perceptions of government overreach, which may have been related to the educators not being from the communities they were trying to reach, and perceptions of FCA information as “fake news.”

**Benefits.** Participants were less likely to focus on the benefits of educating individuals about FCAs, with only 13 participants (54%) identifying specific benefits. Health benefits were mentioned by 77% (10) of these participants, such as “somebody’s health is better protected that day.” (See Figure 2.6.) One local government educator (Caucasian female, 6 years of experience) said, “[PCBs are] a carcinogen and health wise you don't want to consume that.”
She followed that comment by saying, “[it’s the] long-term effects. I know that’s negative but in a positive way.” Focusing on mercury, a wildlife agency educator (Caucasian male, 3 years of experience) said, “That would be neurological effects, especially for those children and fetuses…you want your children to be as developmentally healthy as possible and here’s a way you can do that.”

Participants expressed the hope that increased knowledge of health risks among fishermen could enhance their decision making. A health agency educator (Caucasian male, 3 years of experience) said:

*I think it’s prudent to at least have people have information... that’s better than just going along and not knowing what you're exposing yourself to and then later finding out that you didn’t have a choice or you were involuntarily exposed to something.*

Participants also viewed as benefits the potential for broader dissemination of information, by fishermen, and responsive community action to reduce contamination and work towards “systemic change.”

**Research Question 1: Teaching Efficacy Beliefs**

**Instructional choices.** When educators were asked how they decided what information to share, approximately one-third (8; 33%) indicated that they relied on curriculum guides, such
as Project WET, Project WILD, and Eat Smart-Move More. A nonprofit educator said she also referred to the state Standard Course of Study for middle grades science, because some of her outreach occurred in classroom settings. Five participants, including local government, nonprofit, and wildlife educators, reported using requirements for scouting badges and patches as guides in designing activities. Two local health department educators emphasized adhering to established protocols with clients.

Fewer participants (7; 29%) indicated that they had freedom to develop new educational activities. These participants described developing materials based on their interests and expertise, participants’ interests, their instructional needs, or timely topics. Examples included using their organizational research portfolios as a guide in choosing topics and focusing on important or emerging issues in their geographic regions, such as industrial spills in local waterways.

**Agency roles.** Almost half of participants (n=11; 46%) identified institutional constraints in FCA education. These participants primarily were housed in state agencies (n=7). Participants described the varied contributions of three different state agencies (environment, health, and wildlife) and local governments in FCA development and communication. The involvement of multiple agencies seemed to contribute to a bounded sense of how participants from the agencies could engage on FCA issues and concerns about what they were officially approved to communicate. For instance, a state agency educator (Caucasian male, 13 years of experience) said, “It’s not my job to communicate whether or not something is safe…I am not allowed to tell you if something is safe or not.” Similarly, a health agency educator (Caucasian female, 3 years of experience) said, “We want to make sure people are protecting their health, and it’s in [another agency’s] jurisdiction to worry about source attribution and pollution.”
Participants believed that having three state agencies and local governments sharing information about FCAs contributed to public confusion about whom to contact with questions or concerns. As a health agency educator (Caucasian male, 2 years of experience) noted, “Environmental health is structured differently in every county, so it just kind of depends on that particular day…who [the county] decides would be the best person for you to talk to.” Participants also recognized that agency roles did not necessarily align with public perceptions. One health agency educator (Caucasian male, 3 years of experience) noted that the Wildlife Resource Commission was perceived as the “authority on fish consumption,” saying “people think they’re the ones who do this work and that we give them information…but Wildlife Resources is not really involved in the process of doing the [fish consumption] advisory.”

**Assessing understanding.** A range of answers were provided in response to a question about how participants knew whether the people they interacted with understood the ideas or science they communicated (Figure 2.7). The most common reply, given by 16 (68%) of the participants (N=24), related to questions they were asked by the people they interacted with. A health agency educator (Caucasian male, 3 years of experience) said, “Normally it reaches a point where they’re [fishermen] stopping asking questions…or they’ve gone into the territory of just asking questions for interest rather than understanding the situation.” Similarly, another participant who used questions to gauge understanding indicated that he knew people understood when they “moved on from the science to other issues.” Almost 40% of participants (n=9) acknowledged that they had no way to know whether the people they were interacting with understood the information they had communicated. One said, “I’m never 100 percent sure 'cause I know people can just say okay, and they're just overwhelmed at this point, and they just want to move on.”
An equal number of participants (n=6; 25%) said they relied on (a) positive and negative visual cues, such as head nodding and “eyes glazing over” and (b) pre-/post-assessment, including the use of i-clicker quizzes, to determine whether people understood. Several participants that reported using pre-/post-assessment said it was required by their organization or their funders, yet two participants who regularly used this method questioned its value. A Caucasian, male wildlife educator (3 years of experience) who combined pre-/post-assessment questions with satisfaction surveys said:

*I tried a couple of different kinds [of assessments], like a pre-workshop and post-workshop, and generally I don't know how much faith I put in them right now...I think if you're nice to folks, they're nice on the evaluation.*

For skills-based workshops, this educator asked participants whether their confidence in a specific skill had increased because of the workshop, but he questioned whether a positive response was an indicator of understanding. The only educators who reported using skills attainment to determine whether people understood the concepts being conveyed (n=4, 17%) did not address FCAs in their fishing clinics.
**Likelihood of expected outcomes.** Responses to questions about the likelihood ranged from highly likely (n=5) (“probably 90–95 percent of the people act upon the information I give them”) to unlikely (n=5) (“[this information] wouldn’t stop me from eating fish”). Two-thirds of participants (16; 67%) indicated that they believed at least some of the fishermen they interacted with acted on the FCA information they provided. A few participants responded with hopeful comments (n=3), such as “I would like to think everybody understood [FCA information]…and did something about it,” while others acknowledged that they didn’t know (n=3), saying “I have no good way of answering that.” Participants believed that parents and populations with higher education or higher income levels were more likely to act on FCA information than people for whom fish represented their only source of protein. Several educators (n=4) also thought that a fisherman’s ability to relate (or not) to them as messengers might influence whether they followed the FCA. A nonprofit program manager (Caucasian female, 14 years of experience) noted that a physician might be a more effective messenger for health issues than an environmental activist or educator.

**Science teaching efficacy beliefs.** Participant science teaching efficacy belief scores ranged from 2.5 to 4.1 out of 5 possible points. (See Figure 2.8.) Only one participant, who worked for the state health agency, had a score above 4 (4.1; 80%). Six additional participants had scores of 3.5 (70%) or higher. These participants represented environmental nonprofits, local government, and state environmental, health, and wildlife agencies. Extension educators had lower scores than these groups.
Looking at the two components of science teaching efficacy beliefs separately and starting with personal science teaching efficacy (PSTE), scores ranged from 2.4 to 4.6 out of 5 (or 48% to 92%). Seven participants had PSTE scores of 4 or higher, and five additional participants had PSTE scores of 3.5 or higher. For science teaching outcome expectancy (STOE), scores ranged from 2.2 to 3.8 out of 5 (or 44% to 76%). Six participants had STOE scores of 3.5 or higher.

Overall, participants’ PSTE scores were slightly higher than STOE scores (mean of 3.6 versus 3.0, respectively), and this difference was statistically significant (p<0.00003). Neither trends in aggregated scores nor STOE scores were evident when the sample was sorted by gender; however, females were over-represented, as compared to the sample, among those with the lowest PSTE scores (PSTE ≤3.4). Similarly, no trends in aggregated scores were evident when the sample was sorted by whether participants actively shared FCA information or by years of experience.

![Figure 2.8 Science teaching efficacy belief scores (n=22)](image-url)
Research Question 2: Communication about FCAs

Participants described a variety of ways they shared information with fishermen, their families, and the public. These comments were coded under two code families, “education” and “education about FCAs,” and 13 sub-codes were applied related to format, content, audience, and aspects of their educational activities. The activities ranged from public presentations on timely topics and skills-based instruction to informal conversations along waterways and at large festivals. (See Figure 2.9 for the most commonly reported activities).

All participants shared general information with fishermen and their families, but only 17 participants (71%) addressed FCAs. Of those who shared FCA information, 10 participants (42%) did so regularly or deliberately. Several participants noted that they incorporated fishing and FCA information into their ongoing activities as appropriate. Examples included adding FCA information to class lectures (university-based educators), summer camp or environmental education programming (nonprofit and local government educators), and ongoing training for

![Figure 2.9. Common educational activities (N=24)]
commercial fishermen (university-based educators). A nonprofit educator (Caucasian male, 4 years of experience) said, “the fishing line collection devices took on a whole new outcome when I found out about the PCB contamination…[we] partnered to put [FCA] brochures in those fishing line canisters.”

Local government educators and staff were most likely to regularly address FCAs (3; 75%), followed by nonprofit educators (5; 63%), and state agencies (2; 25%). Others from state agencies and extension educators addressed FCAs infrequently, by responding to public inquiries or questions asked by students in classes. Many participants reported that they interacted with vulnerable populations in their educational activities. Twelve (50%) identified children among their target audiences, and seven (29%) mentioned subsistence fishermen. One health department educator (Latina, 11 years of experience) identified pregnant/breastfeeding women, but said she only talked about FCAs when clients asked questions about the safety of consuming fish. A community college lecturer (Caucasian male, 7 years of experience) said, “a lot of those folks [my students], I would probably categorize as quasi-subsistence fishermen because…they don't have the means to feed themselves.”

Discussion

Environmental Health Knowledge

Many participants understood that exposure to toxic metals and other contaminants in fish could impact health, which some researchers have asserted constitutes a form of environmental health literacy (Finn & O’Fallon, 2017; White & Hall, 2015). However, few participants identified specific health outcomes resulting from this exposure, which may suggest that their environmental health knowledge base was incomplete. Perhaps not surprisingly, those who reported that they did not address FCAs regularly discussed fewer environmental health and
ecosystem concepts during their interviews. Further, those who referred to ecosystem concepts tended to use them to explain the science behind fish consumption advisories in what they believed were more accessible or relatable terms, although it is not clear whether fishermen would view those terms in the same way (Lauber et al., 2017) Some participants also lacked awareness of the populations most at-risk of harm from exposure to contaminants, a finding consistent with prior research on awareness of vulnerable populations among fishermen (LePrevost et al., 2013b; Tan et al., 2010) that suggests challenges to communicating with at-risk individuals. While 70% of participants were able to identify at least one of the vulnerable populations, just under half identified children as a vulnerable population, and about one-third identified pregnant and breastfeeding women as susceptible.

Participant health belief data provide additional insight into why educators may not frequently communicate FCAs to fishermen and why their communications may not be maximally effective. These data indicated a low perceived threat associated with consumption of contaminated fish (i.e., low perceived susceptibility of fishermen, including vulnerable populations, to health risks from eating contaminated fish and low perceived severity of associated health risks). They also identified many barriers and few benefits, a combination referred to as low behavioral evaluation, which occurs when people perceive that the barriers to taking protective action outweigh the benefits of taking action.

All participants were able to identify barriers to fishermen following their advice or FCA guidance, with participants identifying five distinct barriers, on average. Some of these barriers could be significant to overcome, such as income limitations and cultural barriers. At the same time, few were able to identify benefits of doing so. Those that identified benefits tended to use vague language associated with potential health impacts or mention larger scale outcomes that
would be difficult to measure. Educators who are more aware of barriers than benefits may be less likely to encourage fishermen to adopt behaviors that align with FCAs and may be unable to strategize ways to implement healthier behaviors with their audiences.

Because most educators in this study did not perceive the associated threat to be particularly high, they would not be expected to engage in FCA education. Although research using the Health Belief Model primarily has focused on individuals making health decisions, studies of educators have shown that their educational activities are influenced by three model constructs: perceived susceptibility, barriers, and self-efficacy (Quaranta & Spencer, 2015). Prior research has shown that this combination of beliefs would be unlikely to prompt an individual to take protective action (Orji et al., 2012).

Teaching Efficacy Beliefs

Quantitative data suggested that many participants had moderate science teaching efficacy beliefs, specific to FCA education, which may influence the likelihood that they seek out opportunities to share information with fishermen. The average science teaching efficacy belief score, which is a combination of a personal science teaching efficacy (PSTE) score and science teaching outcome expectancy score (STOE), was 3.3 (out of 5, 67%). These scores generally were in the same range as have been reported for other informal educators (LePrevost et al., 2013a). Across the board, PSTE scores (average 3.6, 72%) were higher than STOE scores (average 3.0, 60%); and the difference was statistically significant. This difference could be related to the limited evaluation occurring in most of the FCA-related education described by participants. Specifically, a lack of information about effectiveness collected through evaluation may contribute to low outcome expectancy. Research has shown that educators with higher self-
efficacy for teaching specific health behaviors are more likely to teach about and encourage those preventive health behaviors (Quaranta & Spencer, 2015).

Qualitative data on teaching efficacy beliefs were mixed, in that some participants expressed confidence that fishermen would follow their advice regarding advisories, while others did not. About one-third of participants stated that they believed fishermen would act on the advice they gave regarding fish consumption, and another third believed that only some would (e.g., parents and higher income fishermen).

Participants’ teaching beliefs also provided insight into the challenges of communicating FCA information. For instance, only about one-third of participants reported that they had the freedom to develop their own educational activities and outreach. Several, including those who had most contact with fishermen and subsistence fishermen through wildlife agencies, attributed the inability to develop their own activities to specific institutional constraints, a finding that is consistent with prior research among informal educators (LePrevost et al., 2013a).

Participants also identified challenges to effectively assessing whether fishermen or other audiences understood the information they shared, with about 40% indicating that they did not know whether these audiences understood what they were communicating. For those who believed that fishermen and other audiences understood, they tended to rely on casual interactions, such as questions they were asked by fishermen. Few participants used pre-/post-assessment and skills acquisition to gauge understanding, and these methods tended to be used for activities that did not address FCAs (such as fishing clinics).

**Communication about Fish Consumption Advisories**

Education about fish consumption advisories appears to fall into the category of everyday science learning, in which scientific content is encountered spontaneously and at opportune
moments rather than through more deliberate and focused pursuits (NRC, 2009). An important finding of this research is that none of the participants identified education about fish consumption advisories (FCAs) as a primary function of their jobs. Participants in local governments and environmental nonprofits were most likely to actively address FCAs. All participants who addressed FCAs tended to have short interactions with fishermen (through brief, waterside conversations or responses to public inquiries) or only addressed FCAs briefly in longer interactions, such as environmental education workshops and public talks. The subset of educators that engaged the highest numbers of fishermen annually (those housed in the state wildlife agency) rarely addressed FCAs in their educational activities and were least conversant in environmental health topics. Thus, opportunities were limited for fishermen, their families, and the public to learn about FCAs from informal educators in North Carolina.

Prior research has suggested health care and nutrition professionals could be a conduit for advisory information (Burger, 2003), yet the study participants who reported the least freedom in deciding what to teach or share were based in local health departments. In fact, these educators were required to use established curricula that did not include FCA information, similar to informal educators who teach farmworkers about pesticide use (LePrevost et al., 2013a). Several participants, including educators with the state health and wildlife agencies, recommended that the wildlife agency play a greater role in FCA education, resonating with prior research that conservation officers are among the most credible resources on advisories (Jardine, 2003).

**Limitations**

Several limitations apply to these findings. First, the choice of outcomes and how they were measured shaped the findings about educators’ knowledge and beliefs, meaning that findings may have differed if different outcomes had been measured. Second, the small,
homogenous sample (with respect to education level and race/ethnicity) and the use of a convenience sample limit the ability to generalize from these data. Third, all measures were based on one point in time, so it impossible to know how participant responses would change over time. Finally, although this study addressed educator perceptions about their interactions with fishermen, it did not include evidence from fishermen, which could lead to inaccurate or biased interpretations of these interactions.

Conclusions and Implications

Many participants provided evidence of environmental health knowledge relevant to FCA education, and not surprisingly, participants who most often addressed FCAs with fishermen and other public audiences showed greater familiarity with environmental health concepts. In contrast, participants who had contact with the largest numbers of fishermen tended to be least conversant in environmental health topics. Even those with more robust content knowledge had limited knowledge of potential health effects and the full range of vulnerable populations, meaning they were not well-positioned to develop tailored educational messages for those audiences.

Many participants also described health beliefs and teaching efficacy beliefs that were consistent with limited FCA education. Specifically, their beliefs indicated a low perceived threat associated with consumption of contaminated fish (i.e., low perceived susceptibility of fishermen, including vulnerable populations, to health risks from eating contaminated fish and low perceived severity of associated health risks). They also identified many barriers and few benefits.

This study provided insights into informal educators’ current practices and constraints in communicating about fish consumption advisories (FCAs). Although a subset of participants
regularly interacted with fishermen through planned educational programming, few of these educators addressed FCAs. In contrast, the subset of participants that regularly addressed FCAs primarily engaged with fishermen in unplanned interactions along waterways, reaching small numbers. Local government participants with connections to waterways under advisory proved the exception to this finding, in that they interacted with substantial numbers of fishermen and addressed FCAs in planned programming or in other deliberate ways.

This research suggests that two groups are well positioned to incorporate FCA education into their programming: local government staff with specific connections to waterways that are under advisory, such as county parks and water quality monitoring programs, and wildlife agency educators. Findings suggest that some of the local government and wildlife agency educators may not be well versed in environmental health concepts and, thus, may benefit from professional development on the core environmental health concepts relevant to FCA education. Similarly, interventions that improve educator science teaching efficacy beliefs may also contribute to an increase in FCA education, as has been shown with informal educators teaching asthma management behaviors (Quaranta & Spencer, 2015).

Further research with a larger sample of informal educators, including those outside of the southeastern United States, and a more racially and ethnically diverse sample may identify additional opportunities and constraints regarding FCA communication. Additionally, further research could provide insight into the health beliefs of fishermen and whether educators’ health beliefs align with those of fishermen, which could inform development of messaging tailored to address relevant health beliefs.
CHAPTER 3: Factors that Influence Informal Educators’ Communication of Fish Consumption Advisories: An Exploratory Case Study of Environmental Health Literacy

Abstract

Environmental health literacy is an outgrowth of several other efforts to develop a science-literate populace that can participate in decision making and inform public policy. It has been defined as progressive in nature, suggesting that as literacy develops, individuals move along a continuum of associated knowledge, skills, and individual and community outcomes. The goal of this exploratory case study was to better understand what it means to be environmental health literate in the context of fish consumption advisory communication. Towards that end, this study investigated the environmental health knowledge, teaching efficacy beliefs, and educational practices of three informal educators who share information about fish consumption advisories with fishermen. Participants took part in semi-structured interviews and completed a fish consumption advisory knowledge questionnaire, a science teaching efficacy survey and a demographic survey. Relevant theoretical frameworks included environmental health literacy (EHL), the Health Belief Model and social cognitive theory. Findings suggested that all three cases exhibited at least basic EHL, with each of three EHL dimensions (environmental health knowledge, self-efficacy beliefs and community-wide outcomes) evident in qualitative or quantitative data. Further, two of the cases, representing a local government and an environmental nonprofit, appeared to be farther along the continuum of EHL, based on evidence of community-wide outcomes related to fish consumption advisories. Factors that may have influenced these outcomes included organizational contexts, such as whether organizations prioritized and resourced fish consumption advisory education, and informal learning contexts, such as the extent of direct interaction with fishermen and connections to waterways under
advisory. This analysis also showed that partnerships between formal learning institutions and local communities can help to structure informal learning across settings. Given the importance of organizational priorities and resources for fish consumption advisory education, this analysis raised questions about whether lower-resource organizations are at a disadvantage in achieving community-level EHL.

Introduction

The Society for Public Health Education (SOPHE) has defined environmental health literacy as “the wide range of skills and competencies that people need in order to seek out, comprehend, evaluate, and use environmental health information to make informed choices, reduce health risks, improve quality of life and protect the environment” (SOPHE, 2016). Some have argued that environmental health literacy is progressive in nature, suggesting that individuals move along a spectrum of associated knowledge, skills, and individual and community outcomes (Finn & O’Fallon, 2017; Gray, 2018). Because this framework is new, important questions have yet to be answered, such as: what kinds of knowledge, beliefs, and behaviors can be considered to represent environmental health literacy? In what ways are knowledge, beliefs, and behaviors context dependent (for instance, dependent on geographic setting, socio-demographics of impacted communities, etc.)? How do these dimensions interact with one another?

To begin to address these questions, this exploratory case study presents examples of three educators and environmental professionals who share information about fish consumption
advisories with fishermen\textsuperscript{5}, their families, and the public. Using the environmental health literacy framework (Gray, 2018), this study considers the educators’ environmental health knowledge, teaching self-efficacy beliefs, and associated community-wide educational activities to understand what it means to be environmental health literate in the context of fish consumption advisory communication. The following sections present an overview of relevant literature and theoretical frameworks, describe participants and methods, and present findings, discussion, and conclusions of this case study.

**Literature Review**

Environmental health literacy is an outgrowth of several other literacies: science literacy, health and public health literacy, and environmental literacy. Science literacy, which is now a mainstay of discussions of public understanding of science, has been a goal of primary and secondary science education since the 1980s (Snow & Dibner, 2016). Miller (1998) conceptualized science literacy as a two-dimensional measure, including vocabulary associated with basic scientific constructs and understanding of scientific process or inquiry. Researchers have used large-scale samples, standardized questions, and survey techniques to analyze trends in science literacy, and a majority of this research has focused on individual literacy (Snow & Dibner, 2016). Similarly, health literacy has been defined as individual capacity to “obtain, process, and understand” information needed to make health decisions (Ratzan & Parker, 2000, as cited in Institute of Medicine (IOM), 2004, Executive Summary, p. 2). It was initially focused

\textsuperscript{5} Research has shown that men and women who fish prefer and use the term “fishermen” to describe themselves, rather than a gender-neutral alternative such as “anglers” (Tan, Ujihara, Kent, & Hendrickson, 2010). In this paper, the term fishermen applies to both men and women who fish.
on strengthening patient-provider interactions, because research has shown that people with low health literacy have difficulty understanding health information, receive less preventive care and pay more for their care (IOM, 2004; Nutbeam, 2008). At least 112 health literacy instruments measuring a range of skills have been developed, though none have been rigorously validated (Snow & Dibner, 2016).

Freedman et al. (2009) criticized the framing of health literacy at the level of the individual, because it resulted in low levels of health literacy being associated with individual deficiencies rather than socio-cultural dynamics. This critique led to the conceptualization of public health literacy, which emphasized an individual’s ability to evaluate information quality and work in groups to organize activities and accomplish public health goals through civic engagement (Freedman et al., 2009). Additionally, public health literacy recognized that individuals are a part of environmental and social contexts and not just part of a patient-provider dyad.

Aspects of science literacy and public health literacy are also found in environmental literacy, which identified core content knowledge and skills and presupposed that knowledge led to action at the individual and collective level (North American Association of Environmental Education (NAAEE), 2011). There are cognitive, affective, and behavioral components of environmental literacy, which NAAEE defined as developing along a continuum over time.

Both environmental literacy and health literacy have individual and community levels and dimensions related to understanding information, making decisions, and taking action (Freedman et al., 2009; NAAEE, 2011). For this reason, environmental health literacy (EHL) has been represented both as the intersection of environmental literacy and health literacy (Hoover, 2014) and as a necessary outgrowth of health literacy (Finn & O’Fallon, 2017).
Literature on EHL is just beginning to include socio-cultural dimensions, recognizing that individuals acting alone may not be able to influence community-scale and policy issues (Gray, 2018; Ramirez-Andreotta, et al., 2016a).

Early research on EHL has focused primarily on how people understand connections between environmental exposures and health (Chen et al., 2014; Barrett et al., 2014; White & Hall, 2015). Along these lines, Valdez, Velez, Chen, Jenkins, and Lindsey (2014) explored the core knowledge and skills needed to be considered environmental health literate, using semi-structured interviews of 28 environmental health professionals in the United States. They identified a set of essential knowledge items and skills, which included the following: (a) understanding that environmental exposures influence health; (b) ability to identify well-known or established hazards in one’s environment; (c) understanding that environmental agents can enter the body through three primary routes (ingestion, inhalation and dermal absorption); (d) understanding the harmful health impacts of specific environmental agents; (e) understanding that environmental agents can be reduced but not always avoided; and (f) the ability to find information about how to reduce environmental health risks in one’s life.

Other studies have attempted to demonstrate how students, patient populations, and community residents connect environmental exposures and their health. In one study, college women’s use of personal care products and their views on potential health effects from exposures was evaluated. Participants reported high daily use of multiple personal care products and lack of awareness of the potential health effects of the environmental toxicants (i.e., endocrine disrupters) in these products (Chan, Chalupka, and Barrett, 2015). Another study found that educated women were more likely to believe that environmental chemicals were dangerous, and these beliefs were associated with healthy behavior choices (Barrett et al., 2014). In contrast,
younger women in the study were more likely to believe that it was impossible to limit their exposure to environmental chemicals. In other studies, the ability to identify health risks from environmental exposure is presented as a form of EHL. For example, White, Hall, and Johnson (2014) found that when residents of a public housing complex defined environmental health risk factors, they included risks from pollutants as well as physical safety concerns from crime and law enforcement interactions.

Researchers also have developed instruments to measure EHL. Recent testing of one such instrument indicated that participant perceptions of environmental health were based on misinformation or lack of information, which could lead to poor environmental health decision making (Ratnapradipa, Wodika, Brown, & Preihs, 2015). Results from earlier versions of this instrument indicated a general lack of knowledge of environmental health concepts across a sample of 395 college students from a Midwestern university (52% female), with significant differences among sub-groups. Specifically, White participants had higher knowledge scores than Black participants (Ratnapradipa, Brown, Middleton, & Wodika, 2011). Further, lack of environmental health knowledge corresponded to a lack of protective behaviors when faced with environmental risks, leading the authors to call for increased environmental health education. Researchers developed another instrument to assess how people experienced environmental health hazards and their associated risks as well as individual and collective responses to those risks (Dixon, Hendrickson, Ercolano, Quackenbush, & Dickson, 2009). Findings from Dixon et al. (2009) suggested that personal actions were more likely than community-level actions in response to environmental health concerns.

Ramos, He, and Ramos (2012) reported statistically significant improvements in residents’ knowledge related to pesticide exposures, water exposures, and smoking-related
diseases following a long-duration intervention led by community health workers. They interpreted these gains in environmental health knowledge following educational interventions as a form of EHL.

Some studies have spanned individual and community-level EHL. Ramirez-Andreotta et al. (2016b) interviewed parents of children who had participated in a toxic metals exposure study and found that they understood their children’s data and used it to ask new questions. Participants also acted to reduce their family’s health risks, using the personal exposure data to inform their choices, which led the authors to assert that the study advanced participants’ EHL. These findings provided evidence of improved EHL when extensive report-back protocols were coupled with biomonitoring studies, in which biological samples are collected in response to an environmental exposure, demonstrating how study participants used new knowledge to inform action.

Madrigal et al. (2016) reported increased EHL among youth participants in a study of young Latinas’ exposure to endocrine disrupting compounds in personal care products. Participants’ EHL, along with leadership skills, career orientation, and self-esteem, were assessed using written reflections, end-of-event questionnaires, interviews, and observation. One metric highlighted by Madrigal et al. as evidence of EHL was participants’ ability to discuss relevant content fluently and with professionalism with audiences that ranged from families and friends to legislators. Other metrics included participants’ broader definitions of environmental health at the end of the study and their ability to contribute to the development of research protocols and hypotheses. Skills development was a focus of the intervention, and the authors attributed some of these outcomes to deliberate efforts to prepare participants to apply new knowledge in meaningful ways.
Another approach to documenting EHL has been to show how motivated residents influence community decisions to reduce harmful environmental exposures. In a study with members of the Apsaalooke Tribe, Eggers et al. (2015) tested wells for uranium and other contaminants and conducted household water use surveys. Results were disseminated through in-person follow-up visits and varied community channels, including community meetings, maps and displays at health departments, news articles, and school presentations, among others. As a result of active community engagement that ensured the community had access to findings that wells were contaminated, the tribal water and wastewater authority installed an automated water dispensing system, which enabled rural residents to purchase municipal water at low cost. In another well water study, following contamination of public water supply wells with perfluorooctanoic acid (PFOA) from a local industry, residents requested that researchers test the levels of PFOA in residents’ blood (Emmett et al., 2009). When residents’ blood PFOA levels were found to be significantly higher than in the general population, they worked with researchers to develop response strategies. Outcomes included securing free bottled water from a polluting industry until the local water utility could upgrade its system filtration.

Citizen science also is an emerging framework for EHL efforts, as demonstrated by Ramirez-Andreotta, Brusseau, Artiola, Maier, and Gandolfi (2015). In this study, residents of a southwestern community with arsenic contamination assessed uptake of arsenic in garden vegetables and characterized potential risk from gardening and consuming vegetables from home gardens. Researchers evaluated individual learning, programmatic outcomes, and community-level outcomes. As with the biomonitoring studies described above, participants understood the scientific results and implemented behavioral changes to reduce their arsenic exposure. In terms
of community-level outcomes, participants became more involved in resource-related issues, including addressing contamination in the local public water supply.

**Fish Consumption Advisories and Application of the EHL Framework**

To date, few studies of fish consumption advisories (FCAs) have explicitly focused on EHL, though several have addressed one or more of the key dimensions of EHL. Specifically, awareness of the connection between consuming contaminated fish and potential health effects has been well studied, as has risk perception. To a more limited extent, changes to individual behavior and community practices also have been assessed. This section includes brief summaries of several FCA studies with outcomes that represent examples of individual and community level EHL.

Among studies that assessed FCA awareness, some participants knew that consuming contaminated fish could potentially harm health, but few participants were able to cite FCA-specific details (Burger, 2004; Johnson et al., 2016; Niederdeppe et al., 2015; Ratnapradipa et al., 2010). Awareness of FCAs typically was gauged using qualitative methods at fishing locations (Burger & Gochfeld, 2008; Burger & Gochfeld, 2009; Perez et al., 2012; Ratnapradipa et al., 2010). Often the most vulnerable populations were least likely to know about potential environmental health risks (LePrevost et al., 2013b; Tan et al., 2010). Further, these studies found that the content and format of FCAs influenced attention to and comprehension of the key messages (Connelly & Knuth, 1998; Niederdeppe et al., 2015; Tan et al., 2010; Velicer & Knuth, 1994). Several interventions resulted in fishermen reducing their consumption of fish and sea mammals under advisory and adopting methods of preparing food for cooking that reduced exposure to contaminants (Derrick, Miller, & Andrews, 2008; DeWeese, Kmiecik, Chiriboga, & Foran, 2009; McOliver et al, 2015).
Derrick et al. (2008) developed, implemented, and evaluated a risk communication intervention related to a fish consumption advisory in a low-income, predominantly African American public housing community in a southeastern state. This study explicitly included use of race-specific role models as educators and participatory input in the content, which referenced cultural beliefs about fishing behaviors. In-person surveys were conducted with 23 community residents as baseline data and again three months post-intervention to assess changes in knowledge and behaviors. Participants increased their knowledge of FCAs, reduced consumption of fish by pregnant women and children, and also changed behaviors when preparing fish by reducing their consumption of larger fish, internal organs, and fish eggs.

DeWeese et al. (2009) developed and assessed the efficacy of an educational intervention designed to increase awareness of FCAs on tribal lands in three midwestern states. Using formative research, they developed maps that enabled community members to make decisions about reducing methylmercury exposure while preserving tribal “lifeways” (i.e., continuing their harvest and consumption of Ogaa, or walleye) (p. 732). Educators shared maps during oral presentations to tribal leaders, fish harvesters, women of childbearing age, children, elders, and broad tribal populations. Printed maps also were disseminated widely, including through offices that issued harvest permits. Comparison of pre- and post-intervention surveys conducted with fish harvesters and women of childbearing age showed significant increases in their awareness and concern about mercury contamination and changes to harvesting behaviors to reduce mercury exposure. Specifically, following the advice to harvest smaller fish, tribal fishermen reported harvesting smaller Ogaa. As a result, the authors asserted that community participation
in FCA development improved advisory acceptance by incorporating critical cultural attitudes and beliefs.

In a similar vein, McOliver et al. (2015) described a tribally-designed maternal biomonitoring program for organohalogens and heavy metals that was implemented alongside sampling of marine fish and sea mammals for the same compounds. When biomonitoring results showed an association between methylmercury in mothers’ blood and coastal residence, educators designed an intervention to make subsistence fishermen aware that younger, smaller sea mammals had lower levels of contaminants and land mammals had very low levels. As fishermen’s awareness of contaminants in food sources increased, maternal blood levels of contaminants decreased.

A study by Burger (2000) found that fishermen could contribute relevant social and cultural information to risk management decisions and called for governmental health and wildlife agencies to deliberately engage the fishing public in developing educational messaging and behavior modification strategies. Informed by this research, Burger, Gochfeld and Fote (2013) actively engaged fishermen in a research project that involved sampling fish along the coast of a northeastern state. Individual fishermen, fishing clubs and businesses participated in all stages of the research, helping to identify sampling locations and target species as well as disseminating findings. The fish sampled were those actually consumed by fishermen (including some species that were presumed to be lower in mercury along with high mercury fish) to better inform risk reduction decisions.

The findings from these FCA studies involving fishermen and impacted communities have the potential to inform FCA communication by elucidating ways to increase compliance with advisories and, ultimately, reduce exposure to hazards.
Theoretical Frameworks

Three theoretical frameworks guided this study: environmental health literacy, the Health Belief Model, and social cognitive theory.

Environmental Health Literacy

Environmental health literacy (EHL) has been conceived of as having three dimensions, described below, each of which builds upon the next (Figure 3.1).

**Awareness and understanding.** This dimension incorporates the recognition that environmental exposures and socio-cultural dynamics influence health. Such awareness may reflect a general understanding that environmental exposures interact with biological processes to cause negative health outcomes. Or it may occur in the context of a specific environmental

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*Figure 3.1. Three dimensions of environmental health literacy, Gray (2018)*
exposure (such as toxic metals in fish); and, an individual may have varying levels of awareness across different exposures, as represented by Finn and O’Fallon (2017).

Skills that enable health protective decision-making and self-efficacy associated with those skills. This dimension focuses on an individual’s self-efficacy for reducing harmful environmental exposures as well as beliefs about her/his potential to influence a specific outcome. Mastery of relevant skills is an important component of this dimension; and such skills may be general in nature (e.g., the ability to find and understand scientific information) or exposure-specific (e.g., the ability to take steps to avoid or reduce consumption of toxic metals in fish).

Community change or collective action to reduce or remove harmful environmental exposures. In this dimension, both individuals and groups apply their knowledge and skills, in the context of self-efficacy for the desired behavior change, to reduce harmful environmental exposures and improve health.

Health Belief Model

The Health Belief Model (Rosenstock, 1974) is another important framework for this study. The underlying concept is that individuals will perform a health behavior if they perceive they are susceptible to a negative health condition or disease, if they expect that taking action will help them avoid the negative condition or disease, and if they believe they can successfully perform the action. The core constructs of the theory include the following: perceived susceptibility, perceived severity, perceived benefit, and perceived barriers. Rosenstock, Strecher and Becker (1988) later added self-efficacy and cues to action to the model to advance its predictive capability. (See Figure 3.2.)
Social Cognitive Theory

The Health Belief Model is grounded in another influential behavioral theory, social cognitive theory (Bandura, 1998), which asserts that human behavior is affected by cognitive processes and personal and environmental factors; stated more simply, we use existing knowledge and beliefs to interpret external situations and develop expectations that influence future behavior (Figure 3.3). Bandura (1977) asserted that individuals chose a specific behavior when they believed in their ability to perform that behavior (self-efficacy) and expected it to produce desired outcomes (outcome expectancy). Gibson and Dembo (1984) applied Bandura’s constructs to teaching, defining personal teaching efficacy as a teacher’s judgment of her/his ability to positively influence student learning and teaching outcome expectancy as a teacher’s belief that teaching can generally result in positive learning outcomes. Riggs and Enochs (1990) extended this approach to science teaching and developed and validated an instrument to assess elementary teachers’ beliefs about science teaching and learning.
Research Questions

Although several studies have provided insight into efficacy and normative beliefs of fishermen (Niederdeppe et al, 2015; Tan et al, 2010; Teisl et al, 2011), gaps exist in our understanding of the beliefs of informal educators who share information on fish consumption advisories (FCAs). Similarly, limited information is available about the kind of information they share, how they do it, and their teaching efficacy beliefs. Previous studies of FCA communication have not employed the EHL framework, thus, an opportunity exists to focus on informal educators’ efforts to communicate about fish consumption advisories as a means to explore how environmental health knowledge interacts with teaching self-efficacy beliefs to influence individual and community action to reduce harmful environmental exposures. To address these gaps in the literature, this exploratory case study employed a mixed methods design to answer the following research questions:

1. How are the different dimensions of EHL exemplified by informal educators who share information about fish consumption advisories?

2. What do any differences imply about the relative importance of the three EHL dimensions?

Figure 3.3. Social cognitive theory, based on Bandura, 2004
Methods

The cases described here were drawn from a larger study with 24 informal educators who shared information about fishing and/or health and nutrition with fishermen and varied public audiences. In the mixed methods study, triangulation was used to facilitate understanding of the research questions using different sets of complementary data. Qualitative data sources included interview transcripts, interview reflections (i.e., brief researcher summaries of key perspectives and ideas reported in interviews), and responses to a subset of constructed-response items on an FCA-related knowledge survey. Quantitative data sources included a science teaching self-efficacy survey, responses to selected-response items on an FCA-related knowledge survey, and demographics.

Semi-structured interviews, which lasted between 45 and 90 minutes, were conducted in-person or via telephone and were audiotaped. The interview guide included original questions, some of which addressed core constructs of the Health Belief Model (Rosenstock, 1974), combined with questions adapted from the Teacher Beliefs Interview (TBI, Luft & Roehrig, 2007). Audiotapes of interviews were transcribed verbatim and coded using a priori and emergent codes. A subset of interviews was co-coded to establish validity, with 80% inter-rater reliability and coding differences reconciled through discussion.

After participating in interviews, participants were invited to complete online surveys. To assess participants’ science teaching efficacy beliefs—a combination of personal science teaching efficacy and science teaching outcome expectancy associated with teaching about fish consumption—the Science Teaching Efficacy Belief Instrument (STEBI; Riggs & Enochs, 1990) was modified and administered as a 10-item quantitative questionnaire. The wording of items was modified for informal science education contexts in which educators share information with
fishermen, and the 1 to 5 scoring scale (for strongly disagree to strongly agree, respectively) was reversed for some items. Additionally, an 8-item FCA knowledge survey was created to assess participants’ FCA-associated knowledge and health beliefs; the survey included four selected- and four constructed-response items. Participants also completed a demographic survey.

Case Selection

Three cases were identified, one highlighting each dimension of environmental health literacy (i.e., environmental health awareness and knowledge, self-efficacy beliefs and skills, and community change, which in this context was considered to be community-wide education), using the approaches described below. Additionally, educators were selected to represent diverse organizations and with varied levels of education and experience. Participants’ names have been replaced with pseudonyms to ensure confidentiality.

Environmental health knowledge. Information on participants’ environmental health knowledge and health beliefs was gleaned through interviews and an FCA-knowledge survey (see Appendices A and C). For each interview, coded text was analyzed for comments that indicated understanding of a set of core environmental health concepts that aligned with the concepts identified by Valdez et al. (2014). References to ecosystem dynamics were also coded, with a maximum of five distinct concepts referenced: hazard, dose / duration, health effects, vulnerable populations, and ecosystem dynamics. Interview text also was assessed for comments about barriers to and benefits of fishermen following FCA guidance. Additionally,

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6 Although “route of exposure” was a core environmental health concept, conversation related to ingestion/consumption was not counted, because fish consumption was discussed in every interview and introduced by the interviewer.
participant responses to a subset of questions (both qualitative and quantitative) in the FCA knowledge survey provided insight into perceived threat of eating contaminated fish, including perceived severity and perceived susceptibility (as outlined in the Health Belief Model). Four participants referenced all five concepts, and of those, one participant (Sean) discussed these concepts using more scientific and technical terms than the others.

**Teaching efficacy beliefs.** Teaching efficacy beliefs were assessed using two measures: responses to an interview question about participants’ perception of the likelihood of people following their advice regarding fish consumption and scores on the Science Teaching Efficacy Belief Instrument (STEBI), modified for the informal learning context of FCA education. STEBI scores were calculated for each participant, ordered from highest to lowest, and compared to likelihood comments. The participant with the highest STEBI score among those who implemented planned FCA programming (Shelby) also expressed a strong belief that people would act on her advice.

**Community-wide education.** Participant interactions with fishermen were categorized, based on whether they were planned or incidental. Among participants who engaged in planned programs/outreach with recreational fishermen, interview transcripts were reviewed for evidence of community-wide education/outreach or other outcomes. These included partnerships with local organizations to develop and broadly disseminate FCA-related educational materials and securing funding to conduct outreach to subsistence fishermen, among others. Of the participants who identified such outcomes, one was eliminated from consideration for having incomplete data, and the selected case (Tyler), reached the most fishermen through planned programming.
Findings

The three cases are presented below (Table 3.1). Each was chosen to highlight/exemplify one dimension of EHL. Information that relates to the other two dimensions of the framework is also included for each person.

Table 3.1. Characteristics of Cases

<table>
<thead>
<tr>
<th>Name</th>
<th>Org. Type</th>
<th>Degree</th>
<th>Years Exper.</th>
<th>Gender</th>
<th>Race</th>
<th>EHL Dimension Exemplified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sean</td>
<td>State govt.</td>
<td>Master’s</td>
<td>13</td>
<td>Male</td>
<td>Caucasian</td>
<td>Environmental health awareness and knowledge</td>
</tr>
<tr>
<td>Shelby</td>
<td>Local govt.</td>
<td>Associate</td>
<td>6</td>
<td>Female</td>
<td>Caucasian</td>
<td>Self-efficacy and skills</td>
</tr>
<tr>
<td>Tyler</td>
<td>Nonprofit</td>
<td>Master’s</td>
<td>9</td>
<td>Male</td>
<td>Caucasian</td>
<td>Community change</td>
</tr>
</tbody>
</table>

Case 1—Environmental Health Knowledge: Sean

Sean is an environmental specialist within a state agency, with a master’s degree in environmental sciences and more than a decade of experience with the agency. His work includes analyzing fish tissue samples, and his program maintains a database of sampling results for the state. He regularly interacts with other agencies involved in fishing issues, but his primary interaction with fishermen is responding to public inquiries, by phone and in the field. He estimated that he received several calls per month but encountered more fishermen when he was in the field.

When discussing how he decided what information to share with fishermen, Sean described his ability to develop and disseminate materials that he thought were needed. He reported having developed a fact sheet on bioaccumulation because he found that people were not familiar with the concept and needed a graphical representation of it. At the same time, Sean emphasized that he was careful not to overstep the boundaries of his position, saying:

*I’ve always made sure that people understand that it's not my job to do risk assessment or to communicate...whether or not something is safe. I can tell you what I would do...I can*
tell you what I know about whatever species you're talking about and what is the likelihood that you're going to see an issue with that particular species.

Sean acknowledged that he did not know whether people understood the information he was communicating, but he emphasized that he tried to respond to inquiries to the best of his ability. He also commented on his motivation to serve the public, saying:

*I do consider myself to be a public servant, and I do make an effort to make sure when I'm done with someone...they're satisfied. And if I can't satisfy them, then I try to get them to the next level, to another person that can answer their question.*

**Environmental health knowledge.** During the interview, Sean addressed all four environmental health concepts (hazards, dose / duration, health effects, and vulnerable populations) as well as relevant ecosystem concepts. (See Table 3.2 for key environmental health concepts addressed in interviews.) In discussing hazards, Sean was one of a few participants who talked about the sources of the contaminants in fish and how to reduce or eliminate them. For instance, referring to mercury, he said, “You can't really remove it. You can remove the point source, but you're not going to remove the atmospheric deposition until everybody stops converting coal.” In discussing dose, Sean referred to the use of “subsistence ingestion rates” in developing advisories, as a way to be more protective of people who consume fish regularly. Sean connected health effects with vulnerable populations, reflecting his understanding of how risks may differ for different populations. For instance, he said, “[mercury FCAs are] pretty important…to protect the higher risk populations, specifically kids between 0-15…[but] in the case of certain contaminants, say PCBs, it's important to everybody because it's a carcinogen.”
Table 3.2. Environmental Health Concepts Referenced by Cases

<table>
<thead>
<tr>
<th>Participant</th>
<th>Hazards</th>
<th>Dose &amp; Duration</th>
<th>Health Effects</th>
<th>Vulnerable Pops.*</th>
<th>Ecosystem Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sean</td>
<td>Mercury, PCBs**</td>
<td>Subsistence</td>
<td>Neurological effects</td>
<td>C, S, W</td>
<td>Bioaccumulation, trophic levels, bottom feeders, top predators, deposition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ingestion rates, meals/week</td>
<td>cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shelby</td>
<td>PCBs, heavy metals</td>
<td></td>
<td>Cancer</td>
<td>W</td>
<td>Bioaccumulation, food chain, bottom feeders</td>
</tr>
<tr>
<td>Tyler</td>
<td>Mercury, PCBs</td>
<td>Frequency</td>
<td>C, S, W</td>
<td></td>
<td>Top of food chain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>meals/week</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*C=children, S=subsistence fishermen, W=women of childbearing age/pregnant and nursing women

**PCBs=polychlorinated biphenyls, class of compounds used for cooling/lubrication, no longer made in the US

Sean demonstrated knowledge of ecosystem concepts and reported using several of these concepts when responding to questions about whether fish were safe to eat. He reported that he would ask fishermen for their location, so he could determine what “eco-region” they were in and whether mercury levels in fish were higher in that area (as they were in the eastern part of the state because, according to Sean, “you’re more prone to mercury methylation” in that region). He also said that he usually explained that “if you’re there [in the east], you’re catching any top predator…over a certain size, you’re pretty likely to be eating a fish…having something that’s over the state’s limit [for mercury].” For public communications, he explained the value of using more accessible terms, such as “top predator” and “bottom feeder” rather than naming individual species. Sean also said that sometimes he would introduce atmospheric deposition (“how it's all over the planet”) when talking about why mercury is widespread and how it biomagnifies. After describing the more detailed responses he sometimes gave to the question of whether fish were safe to eat in a specific area, Sean summarized his typical response, which combined knowledge of hazards, dose and vulnerable populations:

*I always tell them you'd probably be fine eating it because you're a 55-year-old man. Don't feed it to your grandkid if it's this species and it's over this size, because it's likely that it's going to be high in mercury...ultimately that's what people have to have is some kind of a general guideline, like a cut-off. They're either not going to consume that fish,
or if they are, they got to know at what size to say no, or only grandpa gets to eat that one.

In the FCA survey, Sean indicated a low perceived threat for fishermen, based on his rankings of the severity of health effects from eating contaminated fish (3 out of a maximum of 10). For vulnerable populations, he indicated a slightly higher, but still moderate, severity of health effects (5 out of a maximum of 10). He assessed the susceptibility of these vulnerable populations as moderate to high (7 out of a maximum of 10).

During the interview, he identified several barriers to following FCA guidance, including the following: (a) fishermen’s belief that the advice did not apply to them, (b) complexity of the advice, particularly the recommended servings per week, and (c) fishermen having limited time to read materials that were often detailed. He noted that when he took the time to explain how FCAs were developed, people often discounted the advisories, making comments like, “I’m not worried about it because that's meant for someone who eats that [fish] every single day. That's not me.” Sean did not describe benefits to following FCA guidance.

**Teaching efficacy beliefs.** Table 3.3 combines qualitative and quantitative data related to teaching efficacy beliefs. Related to outcome expectancy, Sean noted that some audiences would be more likely to act on his recommendations or guidance contained in FCAs than others. Specifically, he asserted that parents would follow the advice, but experienced fishermen might not, as their experience likely ran counter to the advisory. To demonstrate this point, he reported hearing comments from fishermen such as the following, “I've eaten this fish my whole life and I've never gotten sick. Ever. I feel fine.” Sean’s personal science teaching efficacy score (4.2 out of a maximum of 5) was higher than his outcome expectancy score (2.8 out of a maximum of 5).
Community-wide education. Because Sean did not work in or serve a single community or region, community-specific outcomes were not discussed during his interview. Yet he did describe outcomes related to his community of practice, which included scientists and technicians working for state environmental and wildlife agencies. He acknowledged that resources for fish consumption advisory work were limited, saying “it's really kind of relying on a volunteer type situation.” Then he described forging a partnership with another state agency, which resulted in greater capacity for both agencies to collect and analyze fish samples. As a result, the state had access to more fish data than it otherwise would, and these data were used to make decisions about FCAs. Although this outcome is significant in terms of leveraging resources, it did not appear to result in greater awareness or knowledge of FCAs among target audiences. Sean’s role and expertise were recognized by three other interviewees, who not only recommended speaking with Sean, but referred to him as a key person who they consulted with about FCA-related questions (“the fish guy”).

Table 3.3. Science Teaching Efficacy Beliefs, Qualitative and Quantitative Data

<table>
<thead>
<tr>
<th>Participant</th>
<th>Self-Reported Likelihood of Outcomes</th>
<th>Personal Science Teaching Efficacy out of 5 points (%)</th>
<th>Science Teaching Outcome Expectancy out of 5 points (%)</th>
<th>Science Teaching Efficacy Beliefs out of 5 points (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sean</td>
<td>Likely for Some</td>
<td>4.2 (84%)</td>
<td>2.8 (56%)</td>
<td>3.5 (70%)</td>
</tr>
<tr>
<td>Shelby</td>
<td>Likely</td>
<td>4.4 (88%)</td>
<td>3.2 (64%)</td>
<td>3.8 (76%)</td>
</tr>
<tr>
<td>Tyler</td>
<td>Don’t know</td>
<td>3.6 (72%)</td>
<td>2.8 (56%)</td>
<td>3.2 (64%)</td>
</tr>
</tbody>
</table>

Case 2—Science Teaching Self-Efficacy: Shelby

Shelby is an environmental educator at a county park that includes a flood-control lake. She has worked with the county park for six years, including several years as a volunteer before being hired by the park. This park has a catch-and-release policy, which is more restrictive than the site-specific FCA for the lake. Shelby is responsible for developing and implementing many...
of park’s educational activities, which include an introductory fishing program for all ages, family fishing days, and youth programming for scouts and homeschool students, summer camps, and Take a Child Outside week. Shelby also regularly talks to fishermen around the lake, whether on park patrol or while closing the park, and actively educates them about the park’s catch-and-release policy. Shelby described a high degree of freedom in deciding what information to share with fishermen and their families. She said, “We’re kind of known for coming up with new and different programs all the time.” She also described the importance of making learning enjoyable, saying “there’s a lot of good lessons in there [the programs], that we sneak into the fun.”

Shelby primarily relied on personal interactions to determine whether fishermen understood what she was communicating, and she mentioned using the questions people asked as an indicator of understanding, including inquiries about how widespread FCAs were.

**Environmental health knowledge.** Shelby addressed three out of four key environmental health concepts in her interview: hazards, health effects, and vulnerable populations. She associated specific health effects with a hazard (e.g., cancer and PCBs), and she differentiated among possible exposure routes, noting that it was “safe to do recreational things here, like fishing and boating…but if you ingest the fish that’s when you can become exposed.” She also mentioned pregnant women as a high risk population. In answering questions about whether fish were safe to eat, Shelby focused on ecosystem concepts (i.e., “these are bottom feeders…they’re actually ingesting these PCBs” and “it’s bioaccumulating in the food chain…if we’re eating the fish, we’re actually consuming the PCBs or heavy metals that might be in the fish”). When she referred people to other local lakes, she shared information on
why some species were more likely to have high levels of contaminants in their tissues (e.g., because they were bottom feeders or older fish).

Shelby’s health beliefs indicated a higher perceived severity of health effects for all fishermen (9 out of a maximum of 10), as compared to Sean, and for vulnerable populations (also 9 out of 10). She also viewed vulnerable populations as highly susceptible to negative health effects (9 out of a maximum of 10). These ratings suggest that Shelby perceived a higher threat associated with eating contaminated fish than did Sean. She also identified fewer barriers to following FCA guidance, though several were more significant in scale, and one specific benefit (i.e., avoiding consumption of carcinogens). The barriers she mentioned included the following: (a) language barriers, (b) cultural barriers, specifically related to fish and mollusks as dietary staples for some populations, and (c) difficulty in changing habits for fishermen who have previously eaten fish under advisory. Shelby also mentioned that once people understood that the park was not trying to “keep them from enjoying fishing” they were more receptive to the FCA information.

**Teaching efficacy beliefs.** Shelby believed it was likely that the fishermen she interacted with would follow FCAs, because she thought they would be influenced by the realization that “it is a health hazard.” At the same time, she noted that she suspected that people might be taking fish home from a seldom-used area of the lake where she sometimes found trash. Shelby’s own fishing experience increased her confidence in the educational outcomes, and she asserted that people who enjoyed fishing, as she did, might be more likely to influence other fishermen than educators who did not fish. Like Sean, Shelby’s personal science teaching efficacy score (4.4 out of a maximum of 5) was higher than her outcome expectancy score (3.2 out of a maximum of 5).
Community-wide education. While the park’s catch-and-release policy represented an important community-wide action, Shelby was not involved in establishing the policy. Instead she was responsible for developing and leading interactive educational activities, most of which addressed the FCA in some way, within the context created by the policy. For instance, Shelby and her colleagues incorporated information about FCA contaminants into a game that they used with youth groups. They also developed an FCA brochure that was distributed within the park and by a local nonprofit organization that collected used fishing line throughout the county. Shelby worked with a local university to develop educational materials that identified nearby waterways that were not affected by the industrial site responsible for the park advisory, to enable park staff to recommend alternate fishing locations. Together, they also created teacher professional development sessions to prepare middle and high school teachers in the region to incorporate the local contamination and cleanup into their teaching.

Case 3—Community-Wide Education: Tyler

Tyler is an educator with an environmental nonprofit organization focused on water quality, and he regularly interacts with fishermen in planned programming and along waterways. He has been with the organization for nine years and has held multiple positions within it. Tyler and his colleagues lead many different water quality and fishing-related educational activities with people of all ages. The organization sponsors several community-wide educational events each year, drawing on a large volunteer base, local universities, and state agencies with overlapping missions. This organization also recognized a lack of diversity among attendees at its events and created companion events in a more diverse area of the city and summer camps with scholarships for lower-income families.
Tyler relied on personal interactions (such as asking questions and nodding) to determine whether fishermen understood what he was communicating and noted that people generally “get it.” Similar to the other participants, he said, “the way you know people are listening is they ask a lot of questions.” Tyler was the only one of the three cases to formally assess learning outcomes, and he reported gains in knowledge among youth in summer camps. Although he mentioned that they “talk some in there about subsistence fishing” during the summer camps, it was not a primary focus. Like Shelby, Tyler had a high degree of freedom in deciding what information to share. He mentioned the organizational mission, regional working groups, and current issues as important influences on those decisions.

**Environmental health knowledge.** Tyler addressed three out of four key environmental health concepts during his interview: hazards, dose / duration, and vulnerable populations. In discussing hazards, Tyler mentioned mercury and PCBs and said that he typically recommended against eating fish from waterways with significant urban runoff. He also said that he usually emphasized that some populations were more at risk than others, particularly women of childbearing age and children. He also mentioned that the frequency of consumption was an important consideration, especially for pregnant women. He said, “If a pregnant woman eats half a pound of largemouth bass once during her pregnancy, probably no big deal; but if she eats that meal twice a week, that is a big deal.” He also referenced ecosystem concepts, such as fish that were at the “top of the food chain,” saying, “I usually say, ‘you know, almost all fish in North Carolina, top of the food chain fish like largemouth bass, have too much mercury in 'em.’” Tyler referenced this concept in the context of vulnerable populations, describing that he told people, “I say you wanna avoid feeding those top of the food chain fish to children and women of childbearing age, nursing or pregnant.”
Like Shelby, Tyler’s health beliefs indicated that he had a higher perceived threat associated with eating contaminated fish, with high perceived severity for all fishermen (8 out of a maximum of 10) and a similar perceived severity for vulnerable populations (7 out of a maximum of 10). Tyler indicated that he viewed vulnerable populations as highly susceptible to negative health effects (8 out of a maximum of 10). However, Tyler identified more barriers than Sean and Shelby, including the following: (a) advisory information is hard to find online or in the wrong locations for fishermen to see it when they are fishing, (b) language barriers, (c) income limitations, (d) the “does not apply to me” mentality, and (e) poor communication between county health departments and state agencies. Several barriers would be significant to overcome, such as income limitations and cultural barriers. Tyler did not describe benefits to following FCA guidance.

Teaching efficacy beliefs. Although Tyler said he hoped the fishermen he interacted with would follow his recommendations regarding FCAs, he acknowledged that he did not know whether they did. As with the other cases, Tyler’s personal science teaching efficacy score (3.6 out of a maximum of 5) was higher than his outcome expectancy score (2.8 out of a maximum of 5).

Community-wide education. Tyler most often addressed FCAs with fishermen along waterways in connection with timely environmental issues, such as the siting of industrial facilities that might contaminate local waterways. In that context, he created signs to draw attention to FCAs when he realized existing signs were lacking and limited information had been provided by the agencies responsible for publicizing FCAs. Through these efforts, he identified a need to improve FCA communication with subsistence fishermen specifically and solicited a federal grant to support a local outreach campaign. With this funding, he and a team that
included university researchers sought to locate subsistence fishermen, interview them about their habits and beliefs, and develop responsive educational materials. This work currently is underway and is the only example of community-level action initiated by an educator in this study that specifically targeted subsistence fishermen.

**Cross-Case Analysis**

Each of these cases represent the three dimensions of environmental health literacy (EHL) outlined by Gray (2018), albeit to differing extents. Based on these data, it could be argued that all three cases represent some level of environmental health literacy, with the greatest strengths in knowledge (Sean) and community-wide outcomes (Shelby and Tyler). (See Figure 3.4.)

**Environmental Health Knowledge**

Related to environmental health knowledge, all three participants described core environmental health and ecosystem concepts, and Sean and Shelby identified specific health effects of the individual contaminants under advisory. Although Shelby did not address dose,
that is likely because she worked at a park with a catch-and-release policy, therefore no consumption would be allowed. All three demonstrated an understanding of the risks to vulnerable populations, and each focused on reaching vulnerable populations with messages about reducing their exposures (such as by avoiding certain species or reducing the frequency of consumption). Sean also addressed scientific uncertainty, focusing on the limits of testing and data gaps related to knowledge of which species were safe to eat. Further, coded text from Sean’s interview suggested that he may have had the most robust content knowledge, which could be a reflection of his degrees in biology and environmental sciences. For example, when responding to questions about FCAs, Sean described being comfortable explaining scientific concepts, such as biomagnification and bioaccumulation, in detail to fishermen. Further, he described explaining scientific protocols, such as risk assessment and fish tissue sampling.

Health beliefs also differed among the three cases, with Shelby and Tyler reporting higher levels of *perceived threat* (the combination of *perceived susceptibility* and *perceived severity*) than Sean. All three identified multiple barriers to action, yet Shelby and Tyler identified more barriers than Sean, with several of them being difficult to overcome (such as income limitations and cultural barriers). It is possible that the scope of these barriers resulted in a low enough *behavioral evaluation* to offset the higher perceived threat they expressed. Prior research has shown that sufficiently high *perceived threat* or low *behavioral evaluation* influence adoption of protective behaviors (Orji et al., 2012).

Despite these knowledge differences, all three cases appeared to have sufficient environmental health knowledge to be considered environmental health literate. Prior research has found that such knowledge corresponds with decisions to adopt protective behaviors when faced with environmental exposures (Ratnapradipa et al., 2011).
Teaching Efficacy Beliefs

All three participants described teaching self-efficacy beliefs that positioned them to operationalize their environmental health knowledge. They had similar science teaching efficacy belief scores, which were on the high end for the sample from which they were drawn (see Chapter 2) and similar to levels reported for other informal educators (LePrevost et al., 2013a). Higher self-efficacy has been found to be associated with educators’ performance of health behaviors, specifically teaching asthma management behaviors to student populations (Quaranta & Spencer, 2015), suggesting that educators with higher self-efficacy might be more likely to educate about FCAs. As with the larger sample, the cases’ personal science teaching efficacy scores were higher than their science teaching outcome expectancy scores, suggesting they lacked confidence that their education or outreach would lead to desired outcomes. Shelby’s beliefs were somewhat stronger than the others when qualitative data were also considered, as she was the only one to unequivocally say that she believed that fishermen took the recommended actions based on the information she shared.

Community-Wide Education

All three participants interacted directly with fishermen on waterways, and two (Shelby and Tyler) implemented planned programming with fishermen. In terms of community outcomes, Shelby had the most diverse portfolio of outcomes (including partnerships with local universities and nonprofit organizations to develop and disseminate educational materials and provide interactive educational activities, such as teacher professional development workshops), while Tyler led targeted outreach to subsistence fishermen over a wide geographic area. Shelby worked for a local government that had been involved in implementation of local advisories or other fish consumption policies and, as such, had extensive organizational support for her
community-wide educational activities. Although Tyler’s organization was not involved in setting advisories, he also had the support of organizational leaders to pursue new programming related to FCA education. Both of their organizations made funding available or secured external funds to develop materials and programming; and both organizations implemented multi-faceted initiatives (e.g., combination of waterside, print/electronic materials, presentations).

Relative Importance of EHL Dimensions

In terms of defining EHL in the context of FCA education, it appears that baseline knowledge includes an understanding of common hazards (i.e., methylmercury and PCBs), the health effects associated with those hazards (i.e., neurodevelopmental effects and cancer), the dose and duration of exposure that would cause health effects (i.e., specific consumption guidelines), and the most vulnerable populations (i.e., children, pregnant/breastfeeding women, subsistence fishermen). Further, a familiarity with relevant ecosystem concepts appeared to position these educators to communicate the environmental health concepts in terms that were more familiar to fishermen. It is unclear whether greater depth of knowledge is a prerequisite for increased literacy levels, but prior research suggests that, for educators, certain aspects of content knowledge may be especially important in developing effective interventions. Specifically, DeWeese et al. (2009) and McOliver et al. (2015) found that culturally tailored interventions resulted in behavior changes related to fishermen following advisory recommendations. Thus, knowledge of vulnerable populations and their communication needs and preferences as well as skills in developing culturally appropriate interventions could enhance educators’ ability to move along the EHL continuum.
It is unclear what levels of teaching self-efficacy constitute EHL in the context of educating about FCAs. Although these educators were on the high end for this sample, especially in terms of personal science teaching efficacy (ranging from 3.6 to 4.4, or between 72-88%), their overall scores represented neutral or moderate beliefs (with values close to 3 on a 5-point scale). Prior research has shown that content- and skills-focused professional development for asthma educators resulted in increased self-efficacy, which led to increased asthma management behaviors. Thus, opportunities exist to bolster FCA educators’ self-efficacy through content- and skills-focused professional development.

These cases also suggest a range of community-wide outcomes that could represent an educator’s EHL, including deliberate integration of FCA information into ongoing, planned educational programs, dedicated outreach to at-risk populations, and partnerships with other local organizations (such as universities and environmental nonprofits) that enable more effective materials development or reach broader audiences.

It is possible that community-wide FCA education may reflect organizational contexts that enable environmental health literacy rather than resulting from higher literacy levels. In other words, Shelby and Tyler’s organizational contexts may have enabled their community-wide outcomes. It appears that the leaders of these organizations prioritized FCA education, had resources on-hand or sought additional resources to educate fishermen, invested in that education, and gave educators relative freedom to decide what information to share and how to do it. Taken together, these factors created a context within which Shelby and Tyler could successfully advance community-level impacts and their own and their communities’ environmental health literacy.
These findings raise important questions related to how infrastructure and access to resources may influence an educator’s development of environmental health literacy. If organizational context is a driving factor, then organizational leaders must prioritize and support this work. Otherwise educators in lower-resource organizations or communities may have more difficulty achieving environmental health literacy, especially at the community level. In that case, additional inputs may be needed to prepare communities to implement actions that reduce or eliminate exposures.

**Limitations**

Several limitations apply to these findings. First, the choice of outcomes and how they were measured shaped the findings about educators’ environmental health literacy, meaning that findings may have differed if different outcomes had been measured. Second, the small sample size and selection bias limit the generalizability of these findings. Finally, all measures were based on one point in time, so it impossible to know how participant responses would change over time.

**Conclusions and Implications**

This study is one of the first to assess educators’ environmental health literacy (EHL) in the context of fish consumption advisory communication. Three cases drawn from a larger sample of 24 informal educators who share information with fishermen each exhibited some degree of environmental health literacy in the context of educating about fish consumption advisories. Participant expression of the three EHL dimensions differed, and differences in knowledge (particularly health beliefs) and community-wide outcomes were most pronounced. A range of factors may have influenced these outcomes, including organizational contexts (e.g., working for organizations that prioritized FCA education) and informal learning contexts.
(specifically, the amount of direct interaction participants had with fishermen and their connection to waterways under advisory). Additionally, this analysis shows that partnerships between formal learning institutions (such as universities) and local communities can help to structure informal learning across settings.

The EHL dimension with the least robust expression was science teaching efficacy beliefs, which is consistent with other research. This finding suggests a need for skills-focused professional development to help educators understand how to support the interest-driven and personally relevant exploration that typically occurs in informal learning contexts. Such training could include information on developing culturally appropriate educational materials for diverse audiences. This analysis also underscores the role of organizational context in facilitating community-wide outcomes, specifically the contributions of leadership that is committed to FCA education and makes resources available to support it.

Along those lines, this analysis identified important questions about how infrastructure and access to resources influence EHL. Specifically, for lower resource organizations, what additional inputs may be needed to prepare communities to implement actions that reduce or eliminate exposures? These results do not untangle the interactions between and among the EHL dimensions, nor do they identify confounders (such as how education level or subject matter expertise might influence environmental health knowledge or self-efficacy). Future research could shed light on these questions, and further study with larger and more diverse samples is warranted.
CHAPTER 4: CONCLUSION

Informal science education occurs in many settings, often without an explicit goal of teaching or learning science. Instead individuals opportunistically encounter scientific content and practices through daily activities (NRC, 2009). Such is the case with fish consumption advisories, which inform people who eat fish about their potential exposure to harmful chemicals. These advisories are issued by all 50 states, some tribes, and United States territories, and they most commonly address exposure to methylmercury and polychlorinated biphenyls (PCBs) (USEPA, 2013). When consumed, these contaminants may impair neurodevelopment in children and cause birth defects, liver damage, cancer, and other serious health problems (ATSDR, 2014 ATSDR, 2015). At the same time, fish are nutritionally important (USFDA, 2017), especially for developing babies in the womb, in early infancy, and in childhood (Mahaffey et al., 2011; Nesheim & Yaktine, 2007). This interplay between health and harm from fish consumption has challenged public health professionals and health care providers to communicate that, although contaminated fish should be avoided, fish is an essential part of a healthful diet.

This challenge has spurred a body of research on fish consumption advisory communication. Findings indicate that there is generally low awareness of advisories, and several factors influence whether fishermen understand and follow guidance included in these advisories. For example, research has shown that the following factors make advisories difficult to understand: inclusion of different consumption recommendations for different populations (Niederdeppe, Connelly & Knuth, 2013), the use of confusing terms (Tan et al., 2010), and readability levels above grade 9 reading level (Henderson et al., 2016). Research also has shown that beliefs influence whether people follow advisory guidance, ranging from normative beliefs 

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(i.e., beliefs about the choices family and friends would make) to beliefs about environmental conditions (e.g., fast-flowing water is cleaner) and fish biology (e.g., fish that swim near the surface are cleaner) (Niederdeppe et al., 2015; Tan et al., 2010). A small number of studies have addressed the informal science learning contexts in which such communications typically occur (Cooke, Suski, Arlinghaus & Danylchuk, 2013; Furgal, Powell, & Myers, 2005; Niederdeppe et al., 2015; Tan et al., 2010). Several have identified a need for greater involvement of informal education institutions and educators in fisheries management, including fish consumption advisory communications (Cooke et al., 2013; Furgal et al., 2005).

The purpose of this study was to understand more about the informal educators who share fish consumption advisory information with fishermen. This study investigated the environmental health knowledge, teaching efficacy beliefs, and practices of 24 informal educators and environmental and public health professionals who share information with fishermen in a southeastern US state. These informal educators were employed by environmental nonprofits, local governments, universities, and state environmental, health, and wildlife agencies. Participants took part in a semi-structured interview and also completed a fish consumption advisory knowledge questionnaire, a science teaching efficacy survey, and a demographic survey.

This research provided insight into the environmental health literacy of these informal educators and suggested opportunities to improve advisory communications. Ultimately, the goal of this research was to inform the development of informal educational interventions that protect the populations most vulnerable to the harmful effects of contaminated fish. Key conclusions, limitations, and implications are presented below.
Environmental Health Knowledge

Many study participants understood that exposure to toxic metals and other contaminants in fish could impact health, which can be considered a form of environmental health literacy (Finn & O’Fallon, 2017; White & Hall, 2015). The participants who regularly addressed advisories with fishermen and other public audiences (approximately 40% of participants) also discussed environmental health concepts most often during their interviews. Among these educators, few described specific health outcomes resulting from this exposure, and some lacked awareness of the populations most at-risk of harm from exposure to contaminants. This finding is consistent with prior research on awareness of vulnerable populations among fishermen (LePrevost et al., 2013b; Tan et al., 2010) but suggests challenges to communicating with at-risk individuals. Further, those educators who had contact with the largest numbers of fishermen tended to be least conversant in environmental health topics.

Informal educators described health beliefs that may inhibit their communication about advisories. Overall, they believed that the severity of harm from eating contaminated fish was moderate, within the context of all other potential health issues fishermen might experience. Many educators identified populations that they believed were particularly susceptible to harm from eating contaminated fish (e.g., children and pregnant/breastfeeding women); however, even for these groups, educators still believed the severity of harm was moderate. Several educators noted that their perceptions were influenced by the assumption that few people ate sufficient quantities of fish to be harmed by the contaminants. Additionally, across all participants, many specific barriers to following advisories were identified (e.g., advisory materials difficult to find and not in multiple languages, subsistence fishermen not having access to other food sources, fishermen not believing the guidance applied to them) and only a few, poorly defined health
benefits (e.g., improved health). Together, these findings indicate that most of these educators had the perception that the harm posed by consuming fish was low (i.e., low perceived threat), and the barriers outweighed the benefits of taking protective action (i.e., low behavioral evaluation). This combination of beliefs tends to lead to inaction (Orji, Vassileva, & Mandryk., 2012).

**Teaching Efficacy Beliefs**

Participant self-efficacy for sharing fish consumption advisory (FCA) information could be characterized as low to moderate, based on scores from a modified version of the Science Teaching Efficacy Belief Instrument, a finding that was similar to what has been reported for other informal educators (LePrevost et al., 2013a). Participants’ personal science teaching efficacy scores were higher than their science teaching outcome expectancy scores, which means that educators were more confident in their ability to communicate about FCAs than they were in their expectations that people would follow their recommendations related to FCA guidance. These low to moderate efficacy beliefs may be another factor that explains why many participants in the study were only addressing FCAs to a limited degree in their communications with fishermen. Research has shown that educators with higher self-efficacy for educating about specific health behaviors are more likely to address those behaviors in their teaching (Quaranta & Spencer, 2015).

In interviews, which were used to triangulate the survey findings, some educators expressed confidence that fishermen would follow their advice regarding advisories, while others did not. About one-third of participants stated that they believed at least some individuals acted on the advice they gave regarding fish consumption, and another third thought only some people would act on their advice (such as parents and higher income fishermen). When asked whether
fishermen understood the FCA information participants shared, about 40% of the educators reported that they did not know whether fishermen understood. Limited evaluation of their interactions with fishermen resulted in a lack of information available to educators about their effectiveness, which likely contributed to low outcome expectancy regarding whether fishermen would follow their advice on FCAs.

**Communication about Fish Consumption Advisories**

As noted above, much informal science learning is opportunistic and may occur without explicit teaching and learning goals (NRC, 2009). This approach was common within the sample of informal educators. Across all participants, findings indicated limited yet varied approaches to FCA education. A subset of participants, most housed in the state wildlife agency, regularly interacted with fishermen through planned educational programming, but few of these educators addressed FCAs, except for responding to periodic questions from fishermen. In contrast, the subset of participants who regularly addressed FCAs primarily engaged with fishermen in unplanned interactions along waterways, reaching small numbers. The exception was local government participants who had specific connections to waterways under advisory. These educators interacted with substantial numbers of fishermen and addressed FCAs in planned programming or in other deliberate ways. Notably, these participants were not located in health departments but instead were employed by county parks and local water quality programs. Although prior research has suggested health care and nutrition professionals could be a conduit for advisory information (Burger, 2003), study participants who reported the least freedom in deciding what to teach or share were based in local health departments. These educators also reported the most contact with subsistence fishermen and their families.

Only about one-third of participants reported that they had the freedom to develop their
own educational activities and outreach. Several, including those based in wildlife agencies, identified specific institutional constraints as the reason that they could not develop their own activities, a finding that is consistent with prior research among informal educators (LePrevost et al., 2013a).

Thus, opportunities were limited for fishermen, their families, and the public to learn about FCAs from informal educators in this southeastern state, despite calls for greater involvement of informal education institutions and educators in FCA communication (Cooke et al., 2013; Furgal et al., 2005). Several participants, including educators with the state health and wildlife agencies, recommended that the wildlife agency play a greater role in FCA education, resonating with prior research that conservation officers are among the most credible resources on advisories (Jardine, 2003).

**Educator Profiles: Environmental Health Literacy**

Data on environmental health knowledge, teaching efficacy beliefs, and educational practices were analyzed for three participants, each of whom provided strong evidence of at least one of the environmental health literacy dimensions, as outlined by Gray (2018). The aim of this analysis was to gain insight into what kind of evidence represents environmental health literacy in the context of FCA education, to better understand how to cultivate environmental health literacy going forward. These cases included educators from a state agency (Case 1; Sean), a local government (Case 2; Shelby), and an environmental nonprofit (Case 3; Tyler).

**Environmental Health Knowledge.** All three cases described core environmental health concepts that were deemed essential knowledge by a group of environmental health professionals (Valdez et al., 2014). Based on this analysis, it appears that baseline knowledge for FCA communication would include an understanding of specific hazards (i.e.,
methylmercury and PCBs), the health effects associated with those hazards (i.e., neurodevelopmental effects and cancer), the dose and duration of exposure that would cause health effects (i.e., specific consumption guidelines), and which populations are most vulnerable (i.e., children, pregnant/breastfeeding women, subsistence fishermen). The state agency educator discussed these concepts in greater detail, indicated an understanding of scientific processes and scientific uncertainty, and described discussing core concepts and scientific uncertainty with fishermen. All these educators also referenced ecosystem concepts and described using them to communicate FCA information in more understandable terms, although recent research suggests such terms may not be well understood (Lauber et al., 2017).

Health beliefs differed among the three cases, with the local government and nonprofit educators reporting higher levels of perceived threat, which is typically associated with health-protective behaviors, such as following FCA guidance (Orji et al., 2012). However, all three identified multiple barriers to action, which can lead to inaction despite higher perceived threat (Orji et al., 2012).

Teaching Efficacy Beliefs. All three participants described teaching efficacy beliefs that positioned them to operationalize their environmental health knowledge. They had similar personal science teaching efficacy scores, which were on the high end for the sample from which they were drawn and which may have influenced their likelihood of educating about FCAs. Prior research has found that higher self-efficacy for teaching about a health behavior is associated with greater likelihood of health educators teaching that behavior (e.g., health educators teaching asthma management behaviors to students were more likely to do so when they had higher self-efficacy) (Quaranta & Spencer, 2015). As with the larger sample from which the cases were drawn, their personal science teaching efficacy scores were higher than
their science teaching outcome expectancy scores, suggesting they lacked confidence that their education or outreach would lead to desired outcomes. The local government educator’s efficacy beliefs were somewhat stronger than the others when qualitative data were considered, as she was the only one of the three cases to unequivocally say that she believed that fishermen followed advisory guidance based on the information she shared. The strength of her beliefs may reflect her regular and, in some cases, repeated interactions with fishermen and her personal fishing experience.

**Community Change.** These cases presented a range of community-wide outcomes that could represent an educator’s environmental health literacy, including deliberate integration of advisory information into ongoing, planned educational programs, dedicated outreach to at-risk populations, and partnerships with other local organizations that enabled more effective materials development or reached broader audiences. All three participants interacted directly with fishermen on waterways, and the local government and environmental nonprofit educators implemented planned programming with fishermen. In terms of community outcomes, the local government educator had the most diverse portfolio of outcomes related to FCA education (including partnerships with other organizations to develop and disseminate educational materials and provide interactive educational activities, such as teacher professional development workshops), while the environmental nonprofit educator led targeted outreach to subsistence fishermen over a wide geographic area. Both of their organizations made funding available or secured external funds to develop materials and programming, and both organizations implemented multi-faceted initiatives (e.g., combination of waterside, print/electronic materials, presentations) rather than singularly focused efforts.
This analysis suggested that the individuals featured in all three cases could be characterized as environmental health literate, representing various ways environmental health literacy could be understood and acted on in informal science contexts. In these cases, the individual who worked for the state agency (Case 1; Sean) had the deepest knowledge of environmental health concepts relevant to FCAs, and the individuals who worked for the local government (Case 2; Shelby) and the environmental nonprofit (Case 3; Tyler) reported stronger community-wide outcomes.

Based on the findings of these case studies, it seems likely that community-wide FCA education may reflect organizational contexts. In other words, it appears that the leaders of these organizations prioritized FCA education, had resources on-hand or sought additional resources to educate fishermen, invested in that education, and gave educators relative freedom to decide what information to share and how to do it. Taken together, these factors created a context within which the local government and nonprofit educators could successfully advance community-level impacts and their own and their communities’ environmental health literacy.

**Relative Importance of EHL Dimensions.** Participant expression of the three environmental health literacy (EHL) dimensions differed, and differences in knowledge (particularly health beliefs) and community-wide outcomes were most pronounced. A range of factors may have influenced these community-wide outcomes, including organizational contexts and informal science learning contexts (specifically, the amount of direct interaction participants had with fishermen and their connection to waterways under advisory). The results of this study do not untangle the interactions between the EHL dimensions, nor do they identify confounding factors (such as how education level or subject matter expertise might influence environmental health knowledge or self-efficacy).
It is unclear whether greater depth of knowledge is a prerequisite for increased EHL and what levels of teaching efficacy constitute EHL in the context of educating about FCAs. Prior research suggests that culturally tailored interventions can result in behavior changes related to fishermen following advisory recommendations (DeWeese et al., 2009; McOliver et al., 2015). Thus, knowledge of vulnerable populations and their communication needs and preferences as well as skills in developing culturally appropriate interventions could enhance educators’ ability to move along the EHL continuum to influence community-wide outcomes. Further, opportunities exist to bolster FCA educators’ efficacy through content- and skills-focused professional development, based on prior research that found content- and skills-focused professional development for informal educators resulted in increased efficacy (Quaranta & Spencer, 2015).

Limitations

Several limitations apply to these findings. First, the choice of outcomes and how they were measured shaped the findings about educators’ environmental health literacy, meaning that findings may have differed if different outcomes had been measured. Second, the small, homogenous sample (with respect to educational attainment and race/ethnicity), and the use of a convenience sample limit the ability to generalize from these data. Third, all measures were based on one point in time, so it impossible to know how participant responses would change over time. Finally, this study addressed perceptions and perspectives of educators about their interactions with fishermen but did not include direct evidence from fishermen about those interactions. As a result, although factors that influence educators’ behaviors may be better understood, their influence on fishermen opting to follow FCA guidance cannot be inferred from these data. For this reason, additional research is needed to be understand fishermen’s decision
making in response to FCA communication, including information on their environmental health knowledge, health beliefs, and efficacy in the context of following FCA guidance.

Conclusions and Implications

This study is one of the first to assess informal educators’ environmental health literacy (EHL) in the context of fish consumption advisory (FCA) communication and provided insights into informal educators’ current practices and constraints in communicating about advisories. A number of conclusions can be drawn from the findings reported here. First, the environmental health knowledge of these informal educators varied greatly, and those who had the most direct interaction with fishermen tended to be least conversant with environmental health issues. Even those with deeper content knowledge had limited knowledge of potential adverse health outcomes and the range of vulnerable populations, meaning that they were not well-positioned to develop tailored messages for the most at-risk individuals. Second, informal educators in the study held health beliefs and teaching efficacy beliefs that were consistent with placing less emphasis on FCA education. Specifically, their health beliefs reflected low perceived threat and low behavioral evaluation, and their teaching efficacy beliefs were low to moderate. Third, the organizations that were most supportive of FCA education also were most likely to have a direct connection to waterways under advisory and implement planned programming with fishermen (versus incidental interactions along waterways). Those organizations with most contact with subsistence fishermen and their families (e.g., health departments) were among the most restricted in their ability to incorporate FCA education. Fourth, in a cross-case analysis of three educators, all three expressed dimensions of environmental health literacy, with variation among the dimensions. This variation seemed to be based on the extent of educators’ direct interactions with fishermen, their connections to waterways that were under advisory, and their
organizational contexts (i.e., how their organizations prioritized and supported FCA education). 

Fifth, not all EHL dimensions seemed to be equally important to these educators. Environmental health knowledge and community-wide interactions were more strongly expressed than teaching efficacy.

**Implications and Recommendations**

These conclusions lead to a number of implications. Two types of organizations are particularly well suited to incorporate FCA education into their programming: local government staff with specific connections to waterways that are under advisory, such as county parks and water quality monitoring programs, and wildlife agency educators. Both types of organizations have direct interaction with substantial numbers of fishermen and are viewed as site-specific fishing resources. Targeted professional development on environmental health concepts relevant to advisories may better position these educators to share information on FCAs, because in the current study, many educators in these organizations were not well versed in relevant environmental health concepts.

For all educators in a position to address FCAs, professional development activities could increase the likelihood that they would incorporate advisory information into their educational activities if the professional development were designed to emphasize the health risks of eating contaminated fish (i.e., enhance *perceived threat*) and helped educators understand how to reduce barriers to following FCA guidance (i.e., increased *behavioral evaluation*). Similarly, skills-based professional development, focused on teaching and evaluation skills that are effective in informal learning contexts, could improve the teaching efficacy beliefs of informal educators who share information with fishermen, especially those who do so along waterways.
Further, the incorporation of fishermen into the development of FCA messaging could lead to more resonant and meaningful communication.

Educators in wildlife agencies and local health departments were among those who identified institutional constraints to sharing FCA information, yet both are important resources, because they reach large numbers of fishermen and directly engage subsistence fishing populations, respectively. For these reasons, more information is needed about the constraints and opportunities for these agencies to participate in FCA education.

The results of this study raise important questions related to how infrastructure and access to resources may influence educators’ development of environmental health literacy. If organizational context is a driving factor, then organizational leaders must prioritize and support this work. Otherwise educators in lower-resource organizations or communities may have more difficulty achieving environmental health literacy, especially at the community level. Additional inputs may be needed to prepare communities to implement actions that reduce or eliminate exposures.

**Future Research**

Further research is needed to understand the health beliefs of fishermen and determine whether educators’ health beliefs align with those of fishermen. This information could inform the design of educational interventions, particularly decisions about whether to emphasize perceived threat or behavioral evaluation dimensions in those interventions. Additionally, future research could provide insights into the baseline environmental health literacy of fishermen, in the context of FCAs, and whether planned FCA programming influences their literacy levels.

Finally, application of the environmental health literacy framework to other environmental health issues and impacted populations is needed to understand how the three
dimensions of EHL interact and what factors ultimately influence lower versus higher levels of literacy. Additionally, such research could assist in developing educational interventions to improve environmental health literacy and could elucidate individual and societal implications of a range of literacy levels.
REFERENCES


Appendix A
Interview Guide

1. What is your job title, and how long have you been in this position?

2. How do you educate fishermen about fishing [or for health department staff, diet and nutrition]? What do you teach?
   a. How often? In what settings? With which age groups? How many people do you reach?
   b. How do you decide what information to share?
   c. How do you know when fishermen understand?

3. What experience or training, if any, prepared you to share information with fishermen?

5. What, if anything, do you tell people regarding how they can tell if fish are safe to eat?

6. Do you educate fishermen about fish consumption advisories (FCAs)? If you don’t, why not?
   a. If so, how often? In what settings? With which age groups? How many people do you reach?
   b. How do you decide what information to share?
   c. How do you know when fishermen understand?

7. How important is it that fishermen know about FCAs?

8. What are the two most important ideas or concepts for fishermen to understand related to FCAs?

9. How likely is it that people would take action based on the information you might share about FCAs?
a. What are the barriers to taking action?

b. What are the benefits?

10. Where do you get information about fish safety or FCAs?

11. Is there anything else you’d like to tell me about how you educate or share information with fishermen?

12. Are there others that you would suggest that I interview?
Appendix B

Modified STEBI

“Educator” refers to a person who shares information with fishermen outside of K-12 classrooms, such as in a park, environmental education center, health department, etc. Please indicate the degree to which you agree or disagree with each statement below by checking the appropriate box.

*SA=strongly agree, A=agree, U=uncertain, D=disagree, SD=strongly disagree*

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<td>is usually due to extra attention given by an educator.</td>
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<td>I don’t know what to do to interest fishermen in learning about</td>
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<td>the potential harms of eating contaminated fish.</td>
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<td>Even educators with good teaching abilities cannot help some</td>
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<td>fishermen learn about the potential harms of eating contaminated</td>
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<tr>
<td>harms of eating contaminated fish well enough to be effective</td>
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<tr>
<td>in educating fishermen.</td>
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<tr>
<td>A fishermen’s understanding of the potential harms of eating</td>
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<tr>
<td>contaminated fish is directly related to an educator’s</td>
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<tr>
<td>effectiveness in teaching.</td>
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<tr>
<td>I find it difficult to explain to fishermen why they shouldn’t</td>
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<tr>
<td>eat contaminated fish.</td>
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</tbody>
</table>
Appendix C

Fish Consumption Advisory Knowledge Survey

1. Which organization(s) create fish consumption advisories in NC? Check all that apply.

- Local health departments
- NC Dept. of Environmental Quality
- NC Dept. of Health and Human Services
- NC Wildlife Resources Commission
- US Environmental Protection Agency
- US Fish and Wildlife Service
- US Food and Drug Administration
- Other: _________________________
- Not sure/don’t know

2. Which contaminants are most commonly included in fish consumption advisories in NC?

- Not sure/don’t know

3. What human health effects, if any, are associated with the contaminants named above?

- Not sure/don’t know

4. How severe are the health effects of eating contaminated fish, in the context of other potential health issues fishermen might deal with? Choose the number that best represents your opinion.

Not at all severe  Very severe
1  2  3  4  5  6  7  8  9  10

5. Which human populations, if any, are vulnerable to these health effects?

- Not sure/don’t know

6. For these vulnerable populations, how vulnerable are they to the health effects of eating contaminated fish?

Not at all vulnerable  Very vulnerable
1  2  3  4  5  6  7  8  9  10
7. For these vulnerable populations, how severe are the health effects of eating contaminated fish, in the context of other potential health issues they might deal with? Choose the number that best represents your opinion.

<table>
<thead>
<tr>
<th>Not at all severe</th>
<th>Very severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
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<td>4</td>
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<td>8</td>
<td>3</td>
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<tr>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

8. Are you aware of any active fish consumption advisories in your local area? If so, please list them. Feel free to use more space if needed.

- [ ] There are no fish consumption advisories in my local area.
- [ ] Location (water body) and species: ____________________________________________________
- [ ] Location (water body) and species: ____________________________________________________
- [ ] Location (water body) and species: ____________________________________________________
- [ ] Not sure/don’t know
Appendix D

Demographic Survey

For the following questions, please check the appropriate box or write your answer in the space provided.

1. What is your gender?
   □ Female
   □ Male
   □ Other ___________________

2. In what year were you born?
   __________________________

3. What is the highest level of education you have completed?
   □ Some High School, No Degree
   □ High School Graduate
   □ Some College, No Degree
   □ Associate’s Degree
   □ Bachelor’s Degree
   □ Master’s Degree
   □ Doctorate Degree
   □ Professional Degree

4. What is your annual household income?
   □ Under $19,999
   □ $20,000-39,999
   □ $40,000-59,999
   □ $60,000-79,999
   □ $80,000-99,999
   □ $100,000 or more

5. What is your race?
   □ White
   □ Black or African American
   □ American Indian or Alaska Native
   □ Asian
   □ Native Hawaiian or Other Pacific Islander
   □ Two or more races
   □ Other ___________________

6. What is your ethnicity?
Hispanic, Latino or Spanish Origin
Not Hispanic, Latino or Spanish Origin

7. How would you describe the area where you live?
   - Urban
   - Suburban
   - Rural
Appendix D

Codebook (with code counts in parentheses)

<table>
<thead>
<tr>
<th>Code name</th>
<th>Sub-code</th>
<th>Definition</th>
<th>Examples of coded text</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Education</strong></td>
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<td></td>
</tr>
</tbody>
</table>
| Ed-content              | Ed-content-decide (+51)   | Description of the content of educational activities/communications. Comments on what determines or how much influence a participant has on the content s/he provides. | *A lot of it is mainly just trying to educate the public about the unique wildlife species we have in the state.*  
*If it's a scout clinic then that's easy 'cause we just use our badges or patches.* |
| Ed-format               | Ed-format-decide (+22)    | Description of format of educational activities about fishing or related environmental issues (but not FCAs). Comments on what determines or how much influence a participant has on the format s/he uses. | *We also have a fishery science forum that happens a little bit before the main education day starts. It's aimed more at adults, and we bring in usually two to three expert speakers.* |
| Ed-audience             |                           | Age groups or other descriptions of people that participate in fishing education. | *I usually just have mine that are age 18 or older. Some of them will specify 16 or older. It'll kind of vary I guess.* |
| Ed-understand           |                           | Beliefs. Description of how participant knows whether a person understands what s/he is trying to communicate about fishing or environmental issues (but not FCAs). | *Sometimes I think they do and then they don’t…we try to do pre or post evaluations. We try to do a lot of that.* |
| Ed-safe to eat          |                           | Knowledge & beliefs. Comments about what participants say to fishermen about whether fish are safe to eat. | *I would say [name of] Lake gets a lotta storm water runoff, a lotta urban storm water runoff, and it's polluted and you shouldn't eat the fish out of there. It's a nice place to go take a paddleboat around, but it's not the kinda place where you wanna feed your family fish out of.* |
| **Education about FCAs**|                           |                                                                             |                                                                                                                                                         |
| Ed-content-FCA          | Ed-content-decide-FCA (+11)| Description of the content of educational activities or communications related to FCAs. Comments on what determines or how much influence a participant has on the content s/he provides. | *The one place that I really emphasize the consumption piece is down at [name of lake with an advisory], because of the PCB issues down there.* |
| Ed-format-FCA           | Ed-format-decide-FCA (+6)  | Description of format of educational activities related to FCAs.             | *And then with the fish game, we actually give them the resources, like they get the PCB brochure.*                                                   |
### Ed-audience-FCA (15)

Age groups or other descriptions of people that participate in FCA education.

*I'm an adjunct instructor at [name of] Community College, and I have contact with...a wide range of individuals that I do have an opportunity to talk about fish consumption with.*

### Ed-understand-FCA (51)

Beliefs. Description of how participants know whether a person understands what s/he is trying to communicate about FCAs.

*I guess from my experience, one of the ways that you know is just the questions that they ask, you know, how they respond to what you're telling 'em. Sometimes if they're quiet and they don't say anything then you're kinda searching for some clarification. You know, do you understand what I'm saying?*

## Knowledge of FCAs

<table>
<thead>
<tr>
<th>Know-FCA important (182)</th>
<th>Knowledge. Knowledge statements by participants related to FCAs. Beliefs. Comments about how important it is for fishermen to know about FCAs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Know-FCA concepts (+187)</td>
<td>Knowledge &amp; beliefs. Description of most important concepts for fishermen to understand to understand FCAs.</td>
</tr>
</tbody>
</table>

*I guess it depends on the area. I mean, I would say that yeah, our freshwater fisherman, our lake fisherman, our upper river fisherman definitely need to know.*

### FCA-roles (108)

Knowledge. Comments about which agencies are responsible for various aspects of FCAs, especially related to education/outreach.

*That's not our role, to issue the advisories but we felt it was our role to maybe nudge the state a little bit and say, ’hey, you know, we need to do a better job of answering these questions’.*

### FCA-questions (40)

Knowledge. Common questions that arise when interacting with fishermen.

*A common question we would get would be were the fish safe to eat.*

## Actions in Response to FCAs

<table>
<thead>
<tr>
<th>Act-likely-FCA (72)</th>
<th>Beliefs. Comments about how likely participants think it is that people follow FCA advice.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>I don't know that I've been met with folks that knew that they shouldn't feed walleye to their kids and do it. I think a lot of it is just getting the word out.</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Act-barrier-FCA (194)</th>
<th>Knowledge &amp; beliefs. Description of perceived barriers to following FCA advice.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>They can say, ’well, it won't hurt me, or one won't hurt’. And one won’t...just like if you smoke one cigarette, you're not gonna get lung cancer from that. If you eat one fish, you're not gonna have contamination, you know, issues with it. It's long-term.</em></td>
</tr>
<tr>
<td>Act-benefit-</td>
<td>Knowledge &amp; beliefs. Description of perceived benefits to following FCA advice.</td>
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<tr>
<td>FCA (30)</td>
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</table>

| Information | | |
| Info sources (132) | Organizations or other sources of fishing/FCA information named by participant. | And I was asking our fisheries biologist...so I was asking him about the western part of the state and he said "oh yeah, there's the mercury advisories and the predator fish, you know, that sort of thing." |

| Communication ideas (58) | Strategies for more effectively communicating FCAs or reaching fishermen and their families. | It's almost like it needs, in my opinion, to be its own little program with us – the safe fish – and we've got to tell them the pros and the cons of eating fish and where we've tested and it's safe, where we haven't tested and we're just not sure, and then where we've tested and they shouldn't. |

| Preparation | | |
| Prep-pos (33) | Prep-pos-yrs (+26) | Demographics. Position title and years in position. | I'm an education specialist. I've been with the [name of organization] for 13 years, and in this position about ten of those years. |
| Prep-exper | Prep-exper-prof (58) | Demographics. Professional experience that prepared participant for position. | I used to work for the [division of state environmental agency], and I did permit reviews, development permits. |
| Prep-exper-personal (33) | Demographics. Volunteer or other personal experience that prepared participant for position. | I fish...I get out and hike and paddle on the river a lot. And I have friends – I paddle with friends who fish a lot. |