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Assessing Stakeholder Needs and Preferences for Coastal Swimming Advisories in Charleston, South Carolina

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ASSESSING STAKEHOLDER NEEDS AND PREFERENCES FOR COASTAL SWIMMING ADVISORIES IN CHARLESTON, SOUTH CAROLINA

by

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DEDICATION

I dedicate this work to my father, who passed away of non-COVID illness on August 1, 2020. He wholeheartedly supported me earning a terminal degree, and I wish that he could have stayed with us long enough to see it happen.

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I would like to acknowledge my wife, who without hesitation supported me in beginning a *commuter* Ph.D. program that would keep me away from home for three days per week when our daughter was only three years old. Without Leslie's unwavering support, this adventure never would have begun. I'd also like to acknowledge my mother and late father, who housed and fed me during my weekly trips to Columbia for two years while I took classes. Although my presence was most certainly a disruption to their routine, they showed nothing other than gratitude and joy that I was there.

ABSTRACT

The Beaches Environmental Assessment and Coastal Health (BEACH) Act was established in 2000 to reduce the risk of illness among recreational users of beaches in the United States. Specifically, the Act provides coastal states and territories with annual grants to conduct routine water quality monitoring at beaches and to notify the public when pathogen levels exceed safe thresholds. Many coastal states use beach signs, agency websites, and press releases to notify the public, but a 2011 evaluation of the public notification component of the BEACH Act found that few states are choosing methods based on target audience characteristics and interests. Additionally, inland coastal waterways such as rivers, creeks, and harbors are outside the purview of the BEACH Act and generally do not experience the same level of rigor with respect to monitoring, reporting, and public notification when health threats exist, yet significant contact recreation may occur in these waterways. In many coastal areas, this represents a growing public health risk, as coastal population growth paired with expanding recreational use of inland coastal waters results in more individuals entering the water across a broader geographical expanse.

This project assessed stakeholder needs and preferences for swimming advisory notifications in Charleston, South Carolina through an online survey of water recreators and telephone interviews with the owners and managers of water-recreation businesses. Study participants indicated high awareness of water quality problems in the area, a strong desire to know when contact with water posed health risks, and a strong preference

for automated notifications about water quality. These findings may inform the responsible state agency's evolving beach communications strategy as well as the communications of local nonprofit organizations who supplement state water quality monitoring and reporting. More broadly, the research suggests the need for similar studies in other coastal locations; it highlights the need for collaboration among water quality data providers, public health officials, and healthcare providers to conceptualize better mechanisms for diagnosing and documenting water recreation-based illnesses; and it suggests that federal funding levels for the BEACH Act, which have been stagnant over the last two decades, should be re-evaluated considering a growing public health risk.

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LIST OF ABBREVIATIONS

AGI ..... acute gastrointestinal illness

BEACH Act ..... Beaches Environmental Assessment and Coastal Health Act

CCL ..... Coastal Conservation League

cfu ..... colony-forming unit

CWA ..... Clean Water Act

EPA ..... Environmental Protection Agency

FIB qPCR ..... fecal indicator bacteria quantitative polymerase chain reaction

HABs ..... harmful algal blooms

MPN ..... most probable number

NGO ..... nongovernmental organization

NOAA ..... National Oceanic and Atmospheric Administration

RWQC ..... Recreational Water Quality Criteria

SCDHEC ..... South Carolina Department of Health and Environmental Control

SCDNR ..... South Carolina Department of Natural Resources

SECOORA ..... Southeast Coastal Ocean Observing Regional Association

SUP ..... stand-up paddleboarding

CHAPTER 1

WATERBORNE PATHOGENS AND PUBLIC HEALTH

Introduction

In United States coastal areas, where population density far exceeds national averages and is expected to become even more dense in the future (National Oceanic and Atmospheric Administration, 2013), beaches and other tidally influenced waterways such as rivers, creeks, and harbors serve as economic engines and provide many opportunities for public recreation and associated water-based commercial activities. In Charleston County, South Carolina, in 2018 alone the coastal tourism and recreation sector, which includes several water-based activities, accounted for 29,623 total jobs and approximately $1.8 billion in gross domestic product, ranking it the 18th most productive out of 402 coastal counties for both metrics (NOAA, 2021). Beachgoing, along with watersports such as surfing, boating, kayaking, and stand-up paddleboarding (SUP) clearly generate significant economic activity while typically bringing waterway users into direct contact with coastal waters—waters which can at times harbor dangerous levels of naturally occurring or environmentally introduced human pathogens (EPA, 2014).

Human pathogens, or microorganisms that can cause disease in humans, can occur naturally in coastal waters from wildlife or can be introduced via contamination with fecal material from humans or domestic animals including livestock and pets. Three groups of human pathogens are most concerning in the context of coastal, recreational

waters: viruses such as hepatitis A and noroviruses, bacteria including *Salmonella* spp. and *Vibrio* spp., and protozoa such as *Giardia lamblia* and *Cryptosporidium* (EPA, 2014). While modern wastewater treatment methods are designed to remove many of these pathogens, they are not entirely effective, and these pathogens can sometimes enter waterways via permitted point source discharges. Other sources of contamination include accidental discharges of untreated sewage, runoff of untreated water from nonpoint sources via stormwater drains, and runoff from a variety of other nonpoint sources such as vessels, marinas, farms, and areas where pet waste is frequently left behind.

Marine (and non-coastal) water quality is typically gauged through the monitoring of specific fecal indicator bacteria (FIB) that are abundant in the intestines of warm-blooded animals and thus serve as effective indicators of the degree of contamination in water, namely *E. coli* and *Enterococcus spp*. (NRC, 2004). *Enterococcus* spp. has become the preferred FIB for marine environments, while *E. coli* remains the standard FIB for freshwater ecosystems. In 1986, The US Environmental Protection Agency (EPA) first issued Recreational Water Quality Criteria (RWQC) to suggest safety thresholds for various water quality indicators and to assist states in establishing their own water quality standards. Federal legislation detailed in the following subsection requires that national-level RWQC are revisited by the EPA every five years to assess whether revisions to the criteria are necessary. Last revised in 2012, the RWQC were again reviewed in 2017, and although this most recent review did not result in revisions to the criteria, the review did call attention to evidence suggesting that most illness in recreational waters results from enteric viruses and that development of viral indicators such as coliphage are a priority (EPA, 2018). The review also recognized the growing

risk to recreators associated with cyanotoxins released during Harmful Algal Blooms (HABs), noting that the agency was working to develop criteria for two common freshwater cyanotoxins—microcystins and cylindrospermopsin. Criteria for these two cyanotoxins were indeed published shortly after the review, in a detailed report summarizing the human health risks surrounding incidental ingestion of freshwater containing these toxins during recreation; the report did not provide criteria for the toxins in marine and estuarine waters (EPA, 2019).

The most documented human illnesses linked to recreating in waters contaminated with high levels of FIB are acute gastrointestinal illness (AGI), and to a lesser degree respiratory illness, skin rashes, and ear, eye, and wound infections (EPA, 2014). The main route of exposure to water contaminated with fecal bacteria is incidental or accidental ingestion of water during recreation (EPA, 2014). As such, the risk of illness from water recreation stems from both the concentration of pathogenic organisms in the water and the degree of contact with those pathogens, so the different types of recreational activities pose differing levels of risk, with swimming and sports-related contact presenting clearly elevated risk (Russo et al., 2020). With respect to age groups, children are more prone to experience contact with surface waters (Deflorio et al., 2018b) and are subject to an increased risk of illness (Arnold et al., 2016), and of course the elderly and those with compromised immune systems are also at elevated risk.

A recent investigation of the economic burden related to waterborne recreational illness in the United States suggests that an estimated 4 billion surface water recreation events occur each year, resulting in approximately 90 million annual illnesses costing between $2.2 and $3.7 billion (DeFlorio-Barker et al., 2018). This annual cost of illness

far exceeds the annual federal funding that supports implementation of the BEACH Act, which has never exceeded $10 million in total grant awards to the 39 eligible grantees (30 states, five territories, and four tribes) for any given year (EPA, 2021).

The BEACH Act and Swimming Advisories

The BEACH Act, which amended the Clean Water Act in 2000, is intended to reduce the risk of public illness among recreational users of beaches in the United States (Beaches Environmental Assessment and Coastal Health Act of 2000). The BEACH Act established a framework and grant program to assist states in monitoring the water quality of coastal beaches to support public health. Another major component of the Beach Act is the requirement that participating states notify the public when waters exceed safe thresholds of pathogen levels. More specifically, the EPA (2014) requires that states meet the following four notification requirements:

- "Public Notification and Risk Communication Plan (performance criterion 6)—States and tribes must develop public notification and risk communication plans."
- "Actions to Notify the Public (performance criterion 7)—States and tribes must give notice to the public that the coastal recreation waters are not meeting or are not expected to meet applicable WQS or the beach notification threshold for pathogens and pathogen indicators."
- "Notification Report Submission (performance criterion 8)—States and tribes must compile their notification actions in timely reports submitted to EPA."

- "Delegation of Notification Responsibilities (performance criterion 9)—States must describe any delegation of notification responsibilities that they have made, or intend to make, to local governments."

Although EPA (2014) notes that specific target audiences are best reached through different routes of communication, and it suggests general guidelines for certain demographic groups, the above "performance criteria" for grants permit significant flexibility in terms of how states implement public notifications.

The flexibility permitted by EPA in how states notify the public of beach conditions, not surprisingly, has resulted in significant variation in how states deliver this information to beachgoers. An assessment of the 30 states (territories and tribes were not included) receiving BEACH Act grants revealed that although all states posted signage at beach access points, all states except for one used websites, and almost three quarters (74%) used press releases to communicate beach water quality, little consistency exists beyond these practices (Barker, 2009). Pratap et al. (2011) affirmed that notification practices vary substantially at the state and local levels, and they added that few of the most popular methods have undergone systematic evaluation to assess their consistency and effectiveness in promoting behavioral changes. Follow-up work to this initial investigation, with Lake Michigan beachgoers in the Chicago, revealed limited awareness of water quality information posted at beaches, and study participants suggested that water quality communication should be current, from a reputable source, and should describe health consequences (Pratap et al., 2013).

A 2011 study commissioned by EPA entitled "Assessing the Effectiveness of the Beaches Environmental Assessment and Coastal Health (BEACH) Act Notification Program" reaffirmed others' findings, showing consensus usage of websites and near-consensus usage of beach signs among the 18 agencies (nine states, one tribe, and eight localities) included in the study, but little consistency beyond that (EPA, 2011). Notably, the evaluation also revealed that few states are choosing communication methods based on a systematic, formative evaluation, or a needs assessment, of the target audiences for the notifications. More specifically, EPA found that of the 18 agencies interviewed for the evaluation, only several interviewees reported choosing notification methods based on target audience characteristics. These were interviewees managing local-level (i.e., county or tribal) beaches where community norms were well understood (e.g., the use of community billboards and newsletters), making the job of choosing risk communication methods more straightforward.

Swimming Advisories in South Carolina

The SCDHEC, as the agency responsible for implementing the BEACH Act in South Carolina, conducts beach water sampling and testing for *Enterococcus* bacteria May 1 through October 1 at approximately 120 sites along the South Carolina coast. Sites at "Tier 1" beaches, which are those with higher levels of use or high to medium historical risk to those who enter the water, are sampled weekly, while those that are less used or have historically lower risk levels are sampled twice monthly. Although the EPA has described significant advancements in methodology using FIB qPCR to detect *Enterococcus*, which can yield results in 2-6 hours (EPA, 2018), SCDHEC continues to use traditional laboratory culture techniques to test for the presence of indicator bacteria.

This is due largely to logistical constraints surrounding the large sampling area and the number of SCDHEC staff (three) available to collect samples throughout the state (B. Rabon, personal communication, October 19, 2021). These traditional culturable indicator methods typically take 24 hours to yield results; samples are usually collected throughout the state on Tuesday mornings and then processed at SCDHEC in-house laboratories at the agency's three main coastal locations: Beaufort, Charleston, and Myrtle Beach.

Swimming advisories are triggered when test results exceed the state's water quality criteria for Enterococcus, which is 104 cfu/100 ml. The agency issues a "temporary advisory" in several different scenarios in which the criteria is exceeded:

- when locations near a known stormwater discharge exceed criteria once;
- when any location exceeds criteria in two consecutive samplings; or
- when any location exceeds 500 cfu/100ml once.

Sites under a temporary advisory are then sampled daily until *Enterococcus* levels no longer exceed water quality criteria and the advisory can be lifted. "Long-term advisories" are issued in South Carolina for sites at which more than 10% of samples over the preceding five years have exceeded criteria, and the list of sites under a long-term advisory is reassessed at the conclusion of each sampling season (i.e., after October 1). Neither temporary nor long-term swimming advisories in South Carolina equate to beach closures; beachgoers are simply advised to limit their water contact to minimal-contact activities such as wading, fishing, or collecting shells, except for individuals with open sores or lesions, who are advised to avoid water contact altogether.

Historically, SCDHEC has used each of the most common methods for communicating beach swimming advisories (signage, websites, and press releases), specifically:

- permanent signage at sampling sites that are under a long-term advisory;
- an interactive, map-based website called the "S.C. Beach Guide" which communicates the status of all sampling sites in the state (during sampling season) and allows users to choose from a list of beaches or input their location to gauge conditions at the nearest beaches (Figure 1.1);
- an SCDHEC agency web page that provides basic education on beach monitoring and swimming advisories in the state, along with FAQs, links to other relevant pages and resources such as the S.C. Beach Guide described above, and a list of active swimming advisories (during sampling season); and
- press releases shared through local broadcast news and newspapers.

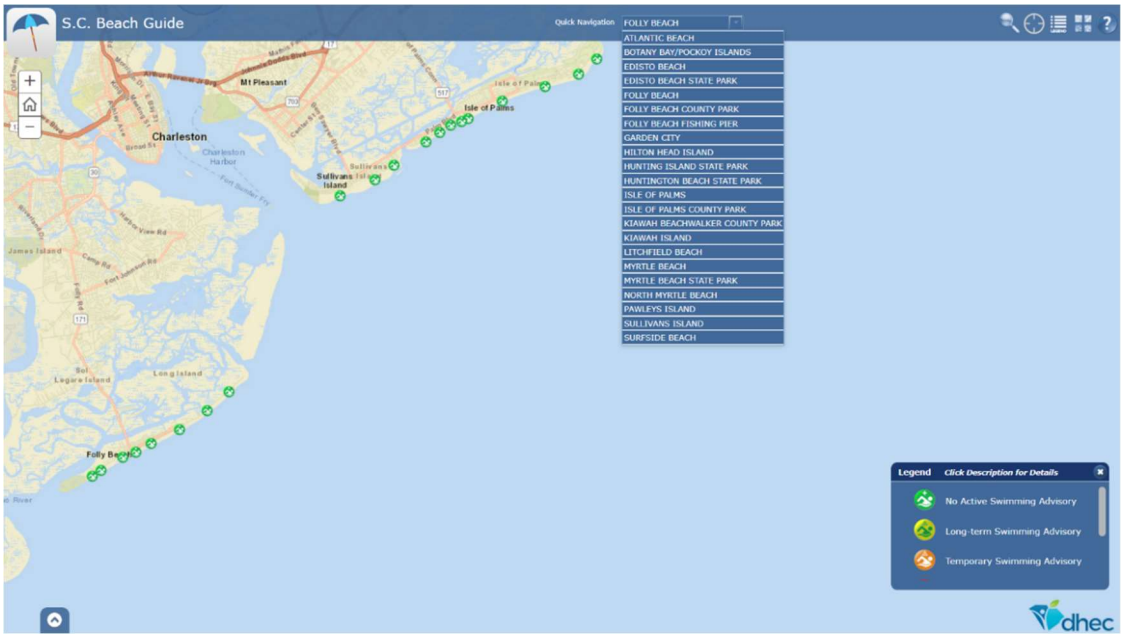

Figure 1.1 S.C. Beach Guide Website Screenshot

The effectiveness of these methods does not appear to have been formally evaluated in the state. Further, recent public misinterpretation and associated negative media attention surrounding monitoring data in the Grand Strand region of SC, where all long-term advisories have been issued, led SCDHEC to develop and pilot an "Updated Beach Communications Strategy" (SCDHEC, 2020). The centerpiece of this updated strategy is a new website called "CheckMyBeach.com," which centralizes various streams of information related to swim and beach safety: beach monitoring data, tides, surf reports, general beach safety information, beach cameras, and weather (Figure 1.2). The website was piloted August-October 2019 in the Grand Strand region, which includes the popular tourist destinations of Myrtle Beach and North Myrtle Beach along with other smaller coastal municipalities. In partnership with these municipalities, QR codes sending beachgoers to the site were added to beach signage, and CheckMyBeach was promoted through various other media including press releases, municipal television channels, digital signage on major roadways, social media, email groups and flyers available at hotels for tourists. Importantly, the launch of CheckMyBeach.com in the Grand Strand replaced the longstanding practice of issuing press releases for short-term advisories there, to direct beachgoers to the most current available information on active beach advisories. This significant change to SCDHEC's risk communication strategy for beach water quality in the Grand Strand garnered generally positive media attention in the area (see Fleming, 2020), and SCDHEC officials reported that during the pilot project, approximately 30% of the visits to the agency's main beach monitoring web page (with the list of active closures) were referred from CheckMyBeach.com (SCDHEC,

2020). The agency plans to expand site coverage to the remainder of the state's beaches in a second phase of implementation.

Figure 1.2 CheckMyBeach.com Website Screenshot

Water Quality and Monitoring in Charleston, South Carolina

A challenging situation in Charleston, SC is that although area beaches rarely exceed water quality criteria and trigger swimming advisories, certain tidal rivers and creeks in the area, and even Charleston Harbor at times, are commonly the focal point of negative media attention for exceeding water quality criteria, especially after rainfall events. The selected local newspaper headlines that follow illustrate the ongoing coverage of this relatively high-profile environmental issue.

- Commentary: Cleaning up James Island Creek isn't cheap. Federal COVID funds should help (Woolsey, 2021);

- "SC reviews cleanliness rules for Charleston Harbor's Shem Creek (Peterson, 2019);
- "Many Charleston creeks, rivers can pose health risks following rain" (Slade, 2017);
- "Septic tank pollution a hidden menace in coastal waterways" (Peterson, 2017);
- "Sullied Shem Creek Waterkeeper says it's too polluted to swim, urges faster cleanup" (Peterson, 2016).

These non-beach coastal waterways are in many cases easily accessible via public boat launches, marinas, and other means, and as such they are extremely popular for water-based recreation such as kayaking, SUP, fishing, and boating. Because they are outside the purview of the BEACH Act, however, monitoring and notification for these waterways is not a responsibility of SCDHEC. SCDHEC staff have confirmed this, explaining that there is a "huge difference between what's done behind the jetties and what's done on the beach" (B. Rabon, personal communication, January 23, 2018). This situation leaves an unfortunate and increasingly dangerous risk communication void related to recreational waterway users' exposure to pathogens in non-beach coastal waterways. This problem has been exacerbated by recent attempts by many local beach municipalities to limit public parking, thus reducing public access to beaches, which results in greater use of inland waters for contact recreation.

In Charleston and other coastal locations, community-based organizations have formed to supplement the monitoring done by state and local agencies and to keep waterway users more informed of water quality conditions in popular non-beach

waterways. Founded in 2009, the Charleston Waterkeeper uses a network of volunteers to conduct weekly *Enterococcus* sampling at 20 of the most popular non-beach recreational waterways in the area during the main season of usage, from May 1 to October 31. Sampling is conducted on Wednesday, results are available online on Thursday, and results are shared on Fridays via email to those who have subscribed to water quality updates from the organization. These weekly water quality updates also commonly include information about relevant legislation, events, and media coverage of local water quality issues. Charleston Waterkeeper also makes its water quality data available on its website in an interactive map, alongside beach data collected and reported by SCDHEC, and it also provides free access to historical testing results from all sampling sites (Figure 1.3).

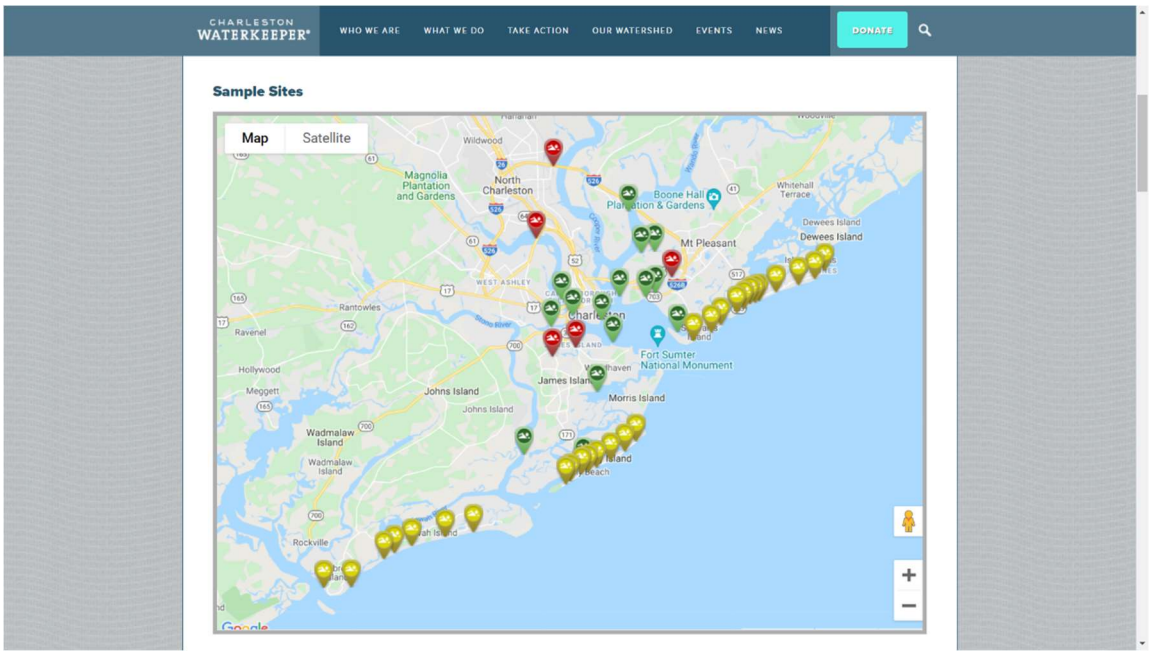

Figure 1.3 Charleston Waterkeeper Water Quality Map Screenshot

While the Waterkeeper's data collection protocol was designed with assistance from SCDHEC and meets widely accepted standards for monitoring water quality, the

Waterkeeper is not an advisory-style program and was not designed with the authority to issue official swimming advisories (B. Rabon, personal communication, January 23, 2018). As such, the organization's data are for informational purposes, to help Charleston recreators to make informed decisions about entering the water.

The unique popularity of Charleston's coastal waterways for recreational purposes, combined with dramatically growing resident populations in the area, call for a focused and informed strategy to communicate high pathogen levels to audiences at risk. Although water quality data for the Charleston area are collected and reported through various media by both SCDHEC and the Charleston Waterkeeper, Charleston waterway users themselves have not yet been systematically engaged to assess if and how they would prefer to access and use this information. Further, engaging resource users on the content and delivery of water quality messages could provide valuable input to the evolving state-level beach communications strategy, namely the buildout of CheckMyBeach.com.

Risk Communication

The discussion of swimming advisories would be incomplete without reference to the broader body of literature on risk communication. Risk communication is an evolving field that adapts as communicators and psychologists gain new understanding of the ways that humans receive, perceive, process, and respond to risk. Originally gaining significant attention in the 1980s, Reynolds and Seeger (2014) assert that the field of environmental health is a major contributor to the elevated prominence of risk communication.

The literature offers various frameworks that delineate different types of risk communication. These frameworks commonly revolve around the context or the "urgency" within which the risk information is being delivered to the target audience. Peter Sandman, one of the earlier authors on the topic, defines risk itself as hazard (the magnitude and likelihood of undesirable outcomes) + outrage (negative public perceptions about the situation) (1989), and he articulates four kinds of risk communication based on this definition: public relations (high hazard; low outrage), stakeholder relations (moderate hazard; moderate outrage), outrage management (low hazard; high outrage), and crisis communication (high hazard; high outrage) (2003). Similarly, Lundgren and McMakin (2013) make functional distinctions among care communication, consensus communication, and crisis communication. Frameworks such as these generally suggest appropriate goals and approaches for each kind of risk communication, and they can serve as helpful starting points once communicators ascertain the levels of hazard and outrage at hand. Interestingly, Sandman considers stakeholder relations (medium hazard; medium outrage) to be the "sweet spot" or optimal scenario for risk communication because the audience is interested, engaged, and not too enraged to listen. Also noteworthy is that Sandman categorizes health education as the public relations (high hazard; low outrage) type of risk communication, with the audience generally apathetic and inattentive about oftentimes nefarious health risks (2003).

A recurring theme in the literature on risk communication is the relevance of trust and credibility with respect to those delivering messages on risk. The COVID-19 pandemic has underscored the importance of trust in risk communication, with recent research asserting that "The COVID-19 pandemic has shone a light on one of the central

aspects of government communication work, namely the ability to ensure that citizens find the public messages, recommendations, and directives given in a time of crisis credible and trustworthy" (Offerdal et al., 2021, p. 247). Even decades ago, Peters et al. (1997) stressed the importance of trust in environmental risk communication specifically and suggested that trust and credibility are dependent on three main factors: perceptions of the communicator's knowledge and expertise; perceptions of the communicator's openness and honesty; and perceptions of the communicator's concern and care. Covello and Sandman (2001) offer a robust list of sources of distrust including insufficient training of experts and spokespeople in risk communication, disagreement among experts, and lack of coordination among agencies managing and communicating about risk, just to name a few. Corroborating Covello and Sandman's (2001) assertion that insufficient training of scientists plays a role is recent research specifically with researchers at the University of South Carolina's Center for Oceans and Human Health and Climate Change Interactions ($OHHC^2I$), finding that 10 of 13 researchers had not received formal training in science communication and that most researchers felt they needed additional training on plain language development (Altman et al., 2020).

Covello and Sandman (2001) have outlined a variety of other obstacles to effective risk communication: complexity, uncertainty, and incompleteness of environmental data; selectivity in the news media about reporting on risk information; and the social and psychological factors that influence how humans process risk. These challenges are inherent to many environmental risks to human health, making environmental risk communication an important yet undervalued aspect of environmental management. Rowan (1991) supplements this list of obstacles in pointing out that many

risk communicators lack an understanding of how communication can be used as a problem-solving process, and the author offers a framework for analyzing situations and developing appropriate risk communications.

EPA has widely acknowledged this body of research on risk communication, naming "establishing public trust" as one of four key steps in risk communication (2011) while noting that in the context of recreation and water pollution, stakeholders are much more likely to take note of water pollution when they can perceive the pollution themselves or have direct experience with the effects of unsafe water, which may add to the challenges surrounding trust. EPA has also provided technical guidance for BEACH Act grantees on risk communication concepts and terms as well as creating a risk communication strategy; this guidance includes content on assessing the information needs of stakeholders (2014)—an important activity that has apparently been neglected by many grantees according to the EPA's own evaluation of the BEACH Act notification program (2011).

The remainder of this document details the assessment of stakeholder needs related to recreational water quality advisories in Charleston, South Carolina. The results of an online survey completed by 143 individuals, and ten interviews with the owners and operators of water-recreation businesses, are used as the basis for recommendations specific to the Charleston area as well as broader suggestions on future collaborations and scientific research.

CHAPTER 2

METHODS

Overview

Project design began with consultation with subject matter experts on local water quality and swimming advisories. Informal telephone interviews were conducted in late 2018 to build understanding of current monitoring and advisory practices, perceived shortcomings of current monitoring and advisory practices, and perceived needs and preferences among stakeholders. Six subject matter experts representing four organizations (Carolina Clear, CCL, Charleston Waterkeeper, and SCDHEC) were involved in this initial information-gathering through informal telephone conversations, and these experts were asked to share their thoughts on the following five general questions:

- How would you summarize the current water quality situation in Charleston, South Carolina?
- What do you believe are the root causes of any problems?
- How is community awareness of these problems?
- How do people get advisories and other information about risks?
- What data do you believe I should collect from stakeholders?

These informal conversations led to the targeting of two discrete categories of stakeholders for data collection. The primary target audience was recreational users of

beaches and non-beach coastal waterways such as tidal rivers, creeks, and Charleston Harbor. The second target audience, which was suggested by subject matter experts, was owners and managers of water- recreation businesses such as those that lead on-water tours and provide instruction in surfing, paddleboarding, kayaking, and other water-based sports. Survey and interview design experts were then consulted to choose data collection methods and design data collection instruments. The primary target audience (water recreators) was engaged through an online survey. The original survey plans also included field-based survey administration, using tablets and paper surveys, with beachgoers at popular beach access sites as well as attendees at annual recreation-oriented festivals in the greater Charleston area. The onset of COVID-19 pandemic restrictions in March 2020, however, necessitated that survey data be collected entirely through the online survey. Members of the second target audience for data collection (owners or managers of water-recreation businesses) were engaged through semi-structured telephone interviews. Data collection was designed to address four primary research questions:

1. To what extent are stakeholders aware of coastal water quality problems in the Charleston, South Carolina area?

2. To what extent do stakeholders want to be made aware of high levels of pathogens in the water?

3. What entities would stakeholders consider credible sources of water quality messages?

4. What are stakeholders' preferences with respect to mode and delivery of water quality messages?

Online Survey

The survey instrument was drafted in early 2019 and was granted approval from the University of South Carolina Institutional Review Board in March 2019. The online survey was later piloted with four individuals involved in water-based recreation, which resulted in minor modifications to the phrasing and choice options of several questions, as well minor changes to the survey functionality (e.g., allowing survey respondents to return to previous questions). The final, deployed survey instrument included 25 questions in six categories. Four categories related to the project research questions (awareness of water quality problems, desire to know about dangerous conditions, preferences on learning about dangerous bacteria levels, and trust); the other two categories focused on important contextual information—recreational uses of Charleston's coastal waters (e.g., types, frequency, and seasonality) and respondent demographics. The majority of the survey questions were quantitative in nature, presenting respondents with multiple choice options, rating scales, or Likert scales. Three survey questions called for open-ended, narrative responses. Four of the 25 survey questions generated probing questions for respondents who selected certain choices, and three of these four probing questions requested open-ended, narrative responses.

Inclusion criteria for survey respondents were self-identification as a recreational user of non-beach coastal waterways, and English-speaking. The survey was deployed using Qualtrics (2021), a professional online surveying platform which adapts surveys to mobile devices to maximize response rates. The link to the online survey was distributed

primarily through informal, locally focused social media groups with interest in water-based recreation. Staff of local nonprofit organizations with a focus on water quality or water-based recreation were also asked to share the survey with their membership via email lists or private social media groups that they administered. The survey was distributed through these channels intermittently from late March of 2019 until early May of 2021. Survey participation was incentivized through the opportunity for respondents to win one of three $100 gift cards to a local outdoor recreation retailer.

Responses to quantitative survey questions were reported through tables and a variety of infographics generated by Qualtrics (2021) including bar charts, pie charts, and breakdown bars. In multiple instances responses to individual questions were downloaded and manually aggregated to provide greater perspective on the data, for example all responses indicating some level of agreement with a statement in a survey question. Qualitative data collected through the several open-ended questions in the survey and the several open-ended probing questions presented to a subset of respondents were downloaded and analyzed using content analysis. Details surrounding the content analysis of open-ended survey responses and interview data are detailed in the following subsection.

Phone Interviews

Interview questions were drafted and approved by the University of South Carolina Institutional Review Board in early 2019, concurrently with development and approval of the survey instrument. The interview schedule was composed of nine open-ended questions, five of which included open-ended probing questions prompted by

certain responses from interviewees. The interview schedule is found in Appendix A. As with the survey instrument, questions on the interview schedule revolved around the four research questions, and interviewees were encouraged to share examples or personal stories informing their opinions. Minor changes to the phrasing of interview questions, to improve their clarity and specificity, occurred following the first and second interview. All phone interviews were recorded and later professionally transcribed using the Rev commercial app and transcription service (2021).

Inclusion criteria for interviewees were a confirmed business owner or manager, and English-speaking. Owners and managers of water-based recreation businesses were initially targeted through convenience sampling, in which local businesses and those with significant name recognition were the first to be approached. Once an initial set of interviewees were engaged, snowball or chain sampling (Patton, 2014), in which interviewees are asked to recommend others with opinions on the subject, was employed to recruit additional interviewees. In the invitation to participate in an interview, which was delivered via email or verbally, each interviewee was promised a modest gift card in the return for their time; these gift cards were delivered via email typically within one day of the interview.

Interview transcriptions and open-ended survey responses were analyzed using qualitative data analysis, commonly called content analysis. Simply defined, content analysis is a way to systematically identify ideas, themes, and findings as they emerge from textual or other qualitative data (Tolley et al., 2016). The general approach employed in this project followed that described by Patton (2014). For the interview data specifically, structural categories aligning with the survey questions were established to

organize the data. Initial reading and re-reading of the interview responses facilitated development of an initial coding frame—a "menu" of possible responses within each of the structural categories. The coding frame was based on specific words, phrases, and concepts communicated by interviewees. For example, the four codes encompassing all responses to the first interview question on interviewees' perceptions of waterway health in Charleston were: generally concerning, unhealthy at certain places only, unknown but assuming healthy, and unknown but assuming not healthy. Application of the initial coding frame to the full interview data set produced minor refinements and additions to the coding frame, and codes were reported using descriptive statistics. This overall process was replicated for the qualitative survey data, supporting the identification and reporting of key themes discussed in the following two chapters.

CHAPTER 3

RESULTS: SURVEY OF RECREATIONAL WATERWAY USERS

Overview

The online survey garnered responses from 163 unique individuals, with 143 respondents completing the questionnaire. As mentioned in the Methods, in addition to survey questions revolving around the project's four research questions, the survey also included demographic questions as well as questions gauging the frequency and seasonality of respondents' water-based recreation. Survey results begin with these data on demographics and recreational uses, followed by data addressing each of the research questions.

Demographics and Recreational Uses

With respect to residency, the vast majority (127; 95%) of respondents reported being full-time residents of the Charleston area. The remaining seven respondents for this question identified as seasonal residents (four) or visitors (three). As summarized in Table 3.1, respondents represented a spectrum of age classes, with individuals in the age class of 25-34 comprising the largest group.

Table 3.1 Distribution of Age Classes Among Survey Respondents

Age Class	# of Respondents	% of Respondents
Under 18	1	0.7%
18-24	14	10.2%
25-34	43	31.4%
35-44	32	23.4%
45-54	27	19.7%
55-64	14	10.2%
65-74	6	4.4%
Total	137	100%

91 (64%) respondents reported being the parent or guardian of a child under 18, and 12 (8%) respondents indicated that they had a medical condition causing immune system suppression or compromise.

When questioned about the frequency of their water-based recreation during the time that they considered their "peak season," respondents indicated remarkably high levels of recreation that brings them into contact with coastal waters. As summarized in Figure 3.1, the most widely represented group was those who engage two to three times per week in water-based recreation, with individuals participating more than three times per week almost as heavily represented.

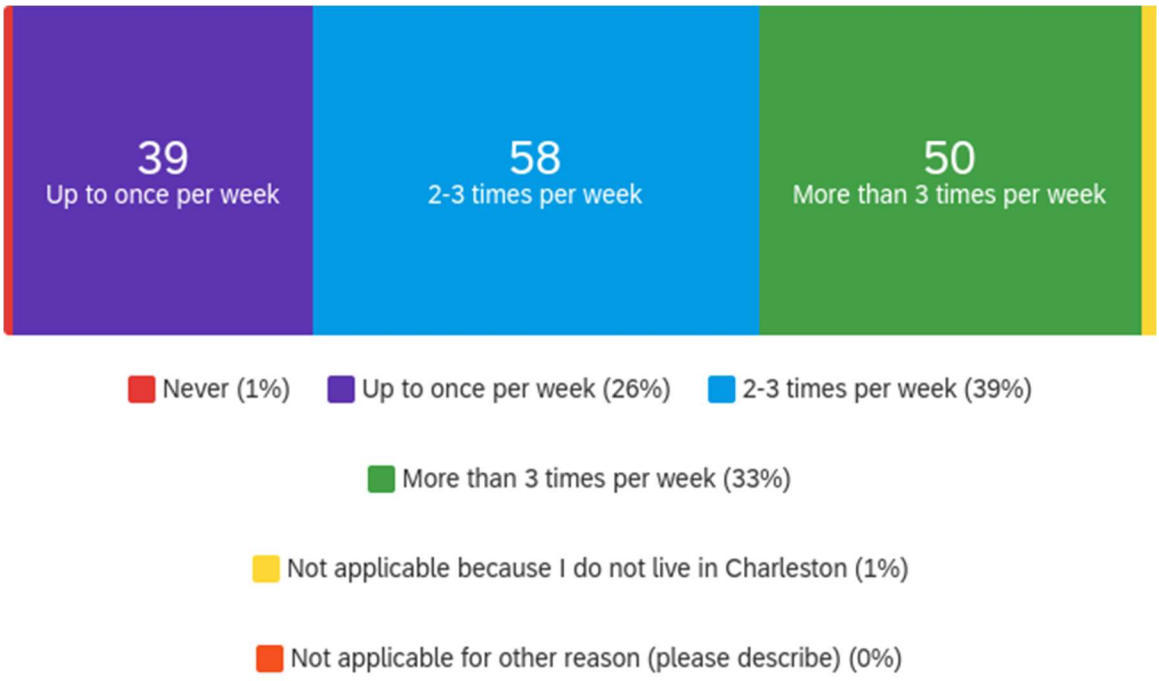

Figure 3.1 Frequency of Water-Based Recreation at Peak Season

Respondents also reported having used Charleston-area waters recreationally for many years; almost half (63 or 43.45%) reported that they had been using Charleston-area waters recreationally for more than fifteen years, with 34 respondents (23.45%) reporting 6-10 years of usage and 32 respondents (22.07%) reporting 1-5 years of usage.

Regarding types of water-based recreation and specific locations for doing so, respondents commonly indicated participating in multiple water-based activities, with swimming, surfing or bodyboarding, and boating or sailing among the most popular as summarized in Figure 3.2.

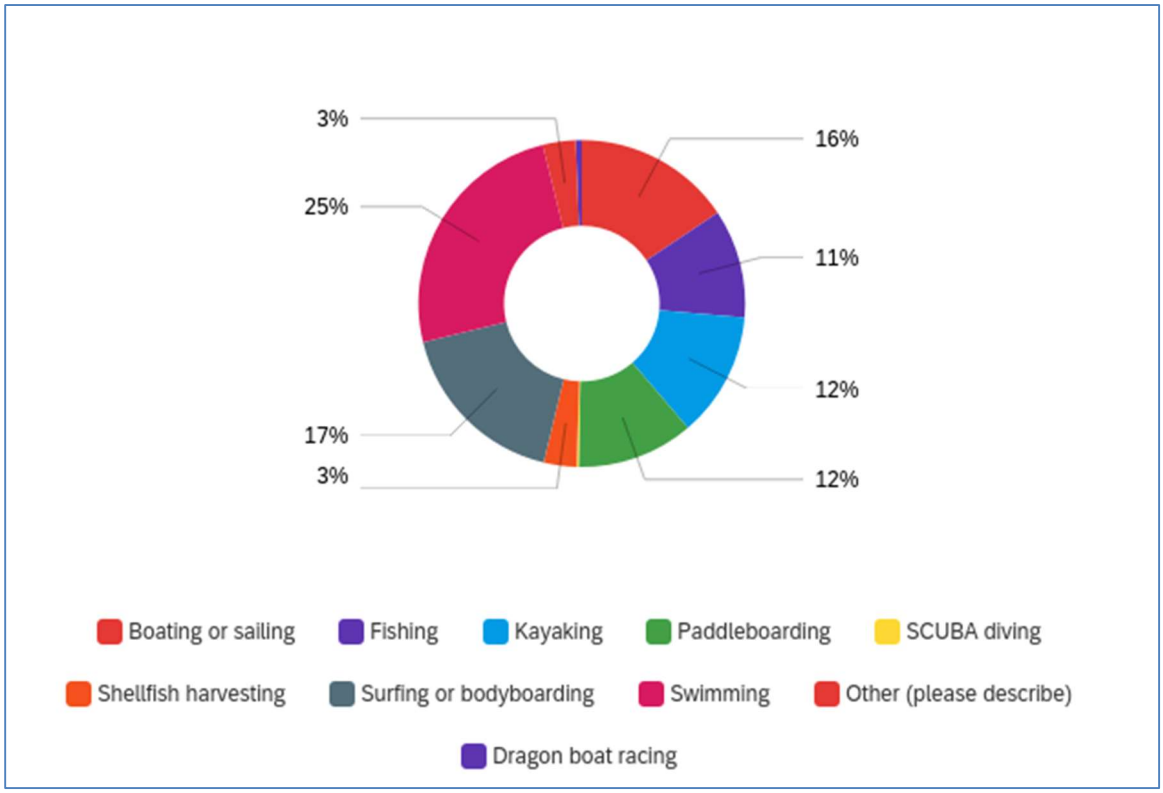

Figure 3.2 Preferred Types of Water-Based Recreation

Preferred sites for water-based recreation were nearly as diverse. The survey question on preferred sites was an open-ended one, with some respondents listing as many as eight specific locations in the Charleston area. Among the most reported sites for recreation were Folly Beach (63 responses), Isle of Palms (44 responses), Sullivan's Island (37 responses), and Charleston Harbor (24 responses). Importantly, 41 respondents indicated recreating in the many popular creeks of Charleston, where local water quality problems are typically at their worst, with 19 respondents specifically mentioning Shem Creek in the town of Mount Pleasant, which has been the topic of much negative media coverage for several years.

Awareness of Water Quality Problems

Overall, survey respondents were highly aware that local, coastal waters "sometimes experience high levels of bacteria that can make you temporarily ill." As summarized in Figure 3.3, 126 (86.3%) of the 146 respondents for the question reported at least slight awareness of this occasional environmental risk, with 50 individuals claiming to be "extremely aware."

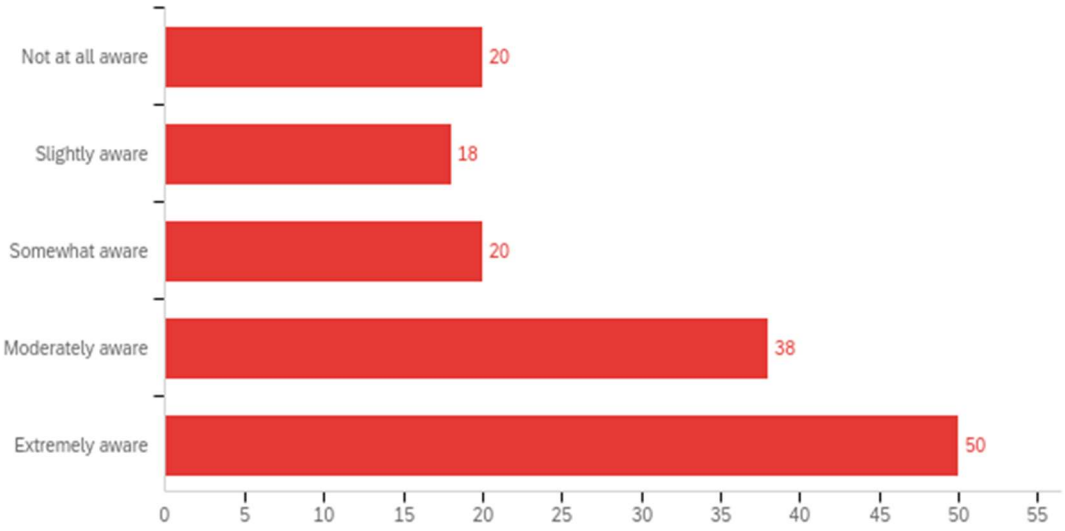

Figure 3.3 Awareness of Water Quality Problems

Survey respondents were also questioned about whether they had ever used available information on bacteria levels to make decisions about entering coastal waters. 90 of 146 (62%) respondents replied "yes," and perhaps not surprisingly, 71 of these 90 individuals where those who identified as "extremely aware" or "moderately aware" of occasionally high bacteria levels. Those who indicated usage of information on bacteria levels to inform personal decisions about water-based recreation were asked about broad categories of information providers that they had used, and they were also asked to cite specific sources of information. As summarized in Figure 3.4, local sources of

information, including local non-profit organizations and local media outlets, were the most widely used resources. Within the non-profit category, the Charleston Waterkeeper was by far the most cited resource, with 30 respondents explicitly naming the organization, and nine additional respondents referenced weekly email and social media updates likely produced by the Waterkeeper.

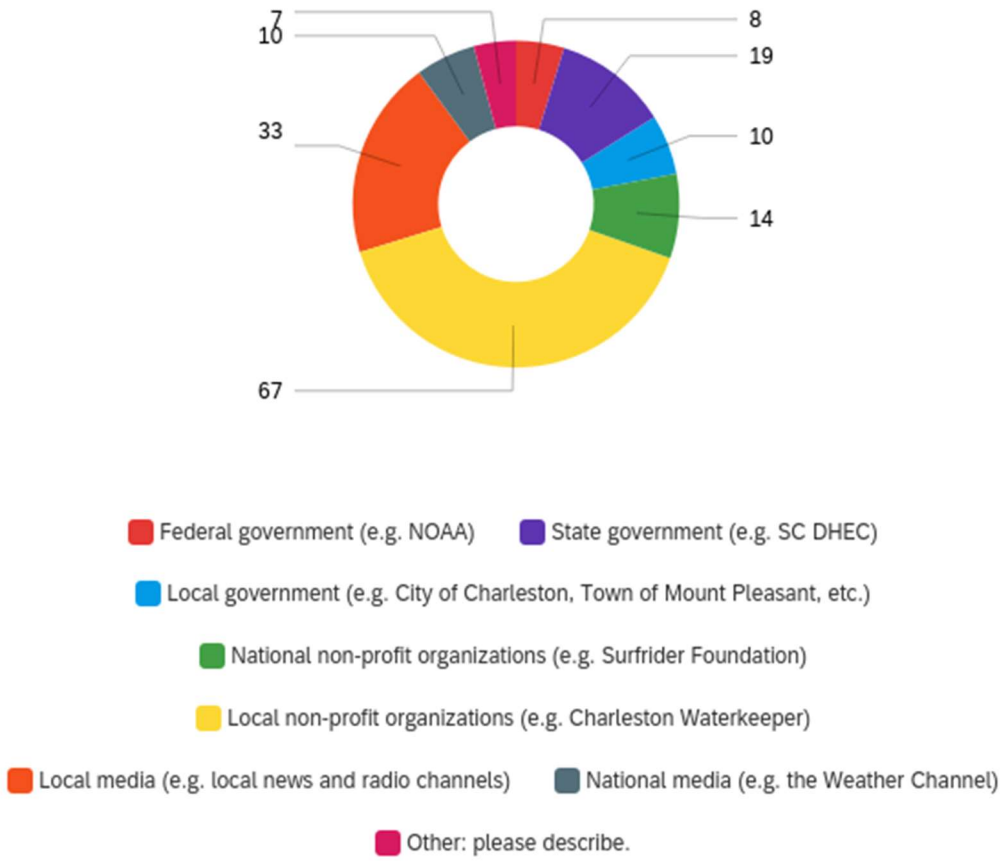

Figure 3.4 Current Sources of Water Quality Information

Fifty-three respondents replied that they had never used available information on bacteria levels, while five respondents were not sure if they had done so. Those who replied “no” were asked why they had not used existing resources, and most indicated that they did not

know water quality was a local problem or that they didn't know how to access water quality data.

Survey respondents were also questioned about perceived (or confirmed) personal health impacts from contact with coastal waters, as well as their likelihood of notifying someone if they believed that water contact had made them ill. As summarized in Figure 3.5, most (103 or 72% of 144) respondents did not believe that they had become ill from contact with contaminated coastal waters in the past. Only five respondents felt certain that they had become ill through contact with coastal waters, as indicated through a "completely agree" response.

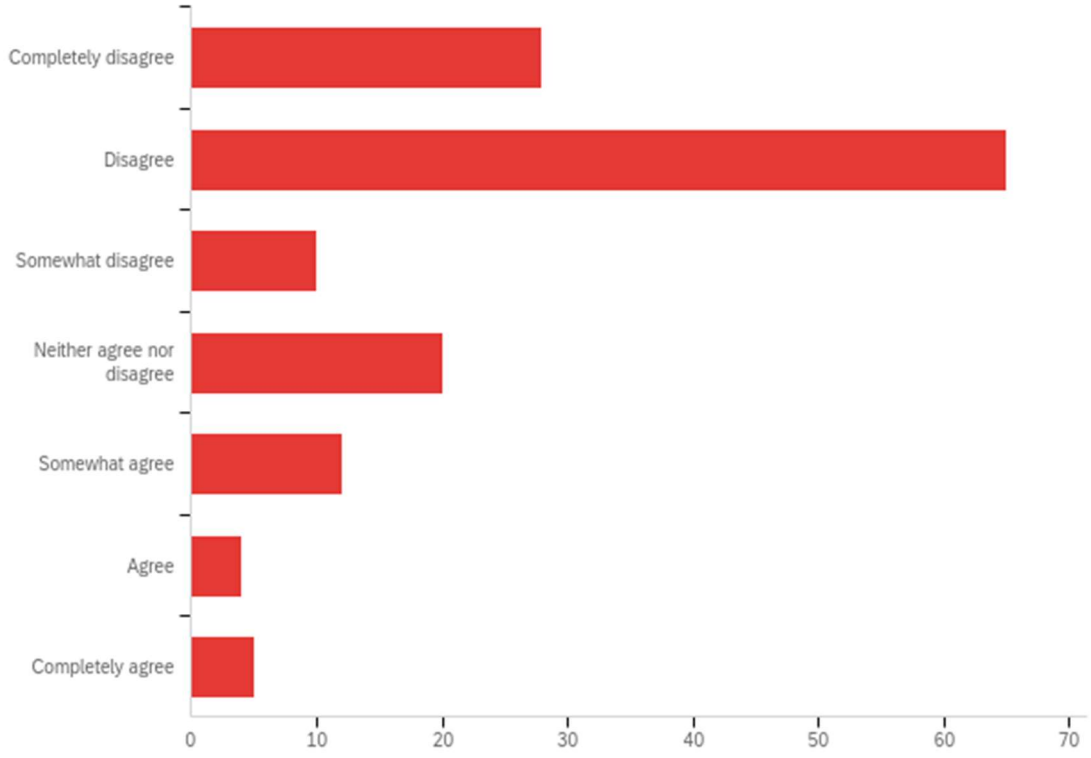

Figure 3.5 Agreement That Contaminated Water Had Caused Personal Illness

When asked whether they would be likely to notify someone if they thought that water contact had made them ill, the majority (99; 69%) of the 144 respondents for the question reported being either "completely likely, "very likely," or "somewhat likely" (Figure 3.6).

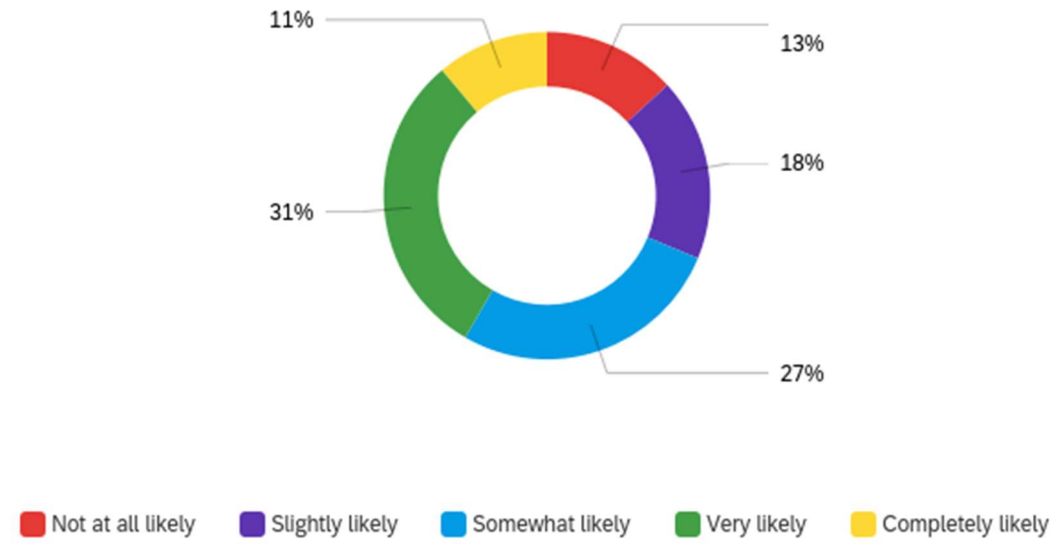

Figure 3.6 Likelihood to Report Suspected Illness from Water Contact

Those who indicated that they would be likely to report illness were prompted with an open-ended, probing question about who they would likely notify. The most common among the 120 responses to the question were SCDHEC (32 responses), a physician (31 responses), and the Charleston Waterkeeper (18 responses). Notably, 20 responses specifically indicated uncertainty about who to contact in this situation, for example:

- "I thought you would tell me because I don't know"
- "Not sure who I am supposed to notify?

- "Honestly, no idea. Charleston Waterkeepers at first to ask about proper channels. No pun intended…"

The 19 individuals who indicated that they would be "not at all likely" to report illness were presented with a different open-ended, probing question about *why* they would not be likely to notify anybody. All 19 of these survey participants responded to the question, with the most common reason being that respondents simply don't know who to notify (11 responses). Other sentiments expressed by multiple respondents include:

- It would be difficult to prove that the illness was caused by contact with water (three responses); and
- Reporting the illness would not spur regulatory action or make a difference (three responses).

Desire to Know about Dangerous Conditions

The section of the survey designed to gauge respondents' desire to know about potentially dangerous conditions in coastal waters began with a general question on individuals' level of concern about becoming ill from contact with contaminated coastal waters. As summarized in Figure 3.7, levels of concern among the 143 respondents were quite evenly distributed, with the most common response being "slightly concerned" (35 responses; 24%).

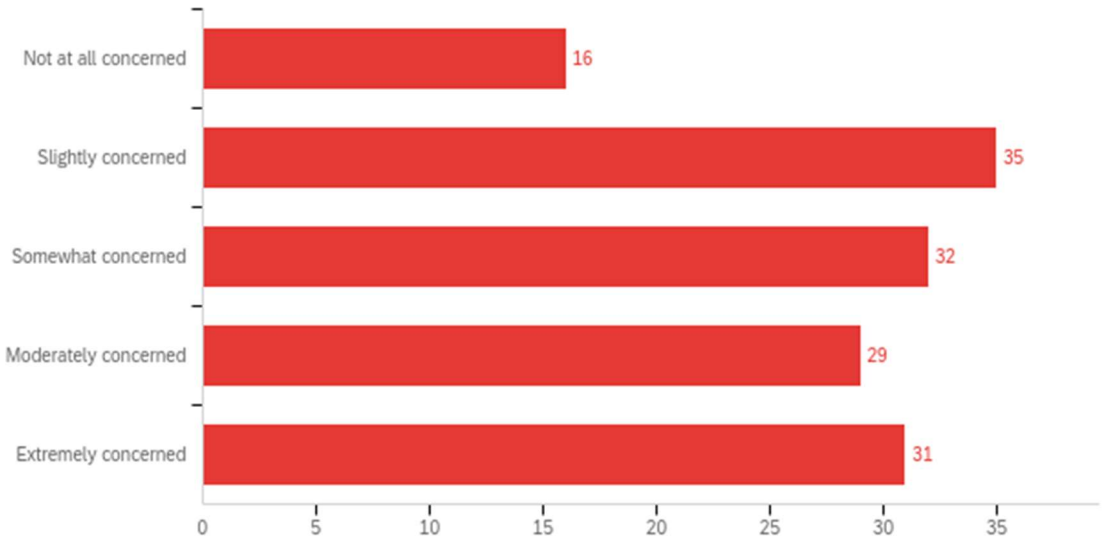

Figure 3.7 Level of Concern about Becoming Ill

In contrast with these varying levels of concern about becoming ill were respondents' feelings on whether they would like to know if their planned recreation in coastal waters could make them ill. Survey participants showed a clear preference for wanting to know about this risk in advance of recreation, with more than half "strongly agreeing" that they'd like to know, as summarized in Figure 3.8 below.

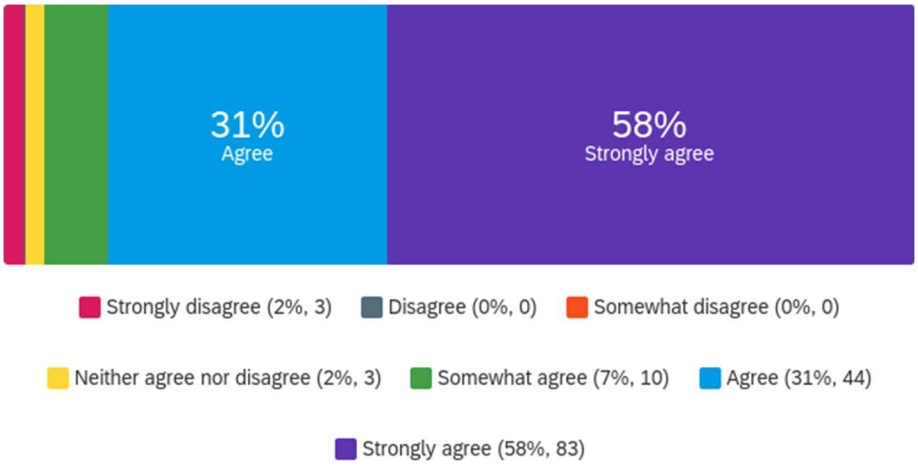

Figure 3.8 Agreement with Wanting to Know about Dangerous Conditions

Respondents were also asked to complete a statement indicating the geographic scale at which they'd like to receive notification about high bacterial levels. Survey respondents were able to select multiple categories—and many did—with 359 total options selected. "All Charleston area waterways" was the most selected option (119 responses), with "waterways that I use recreationally" generating 97 selections. "Waterways in my zip code" and "Waterways in zip codes near mine" were selected by 74 and 64 individuals, respectively, and four respondents provided open-ended answers including all coastal SC waters, SC lakes and rivers, and community assets such as public pools and water parks.

This subsection of the survey included a final question aimed at gauging the likelihood of behavior change among individuals who learned of high pathogen levels in the water. When asked how likely respondents would be "to avoid contact with the water if you learned that it could make you ill," 120 (84%) of 143 total responses were "likely" responses, while only 11 choices were "unlikely" choices, as summarized in Figure 3.9.

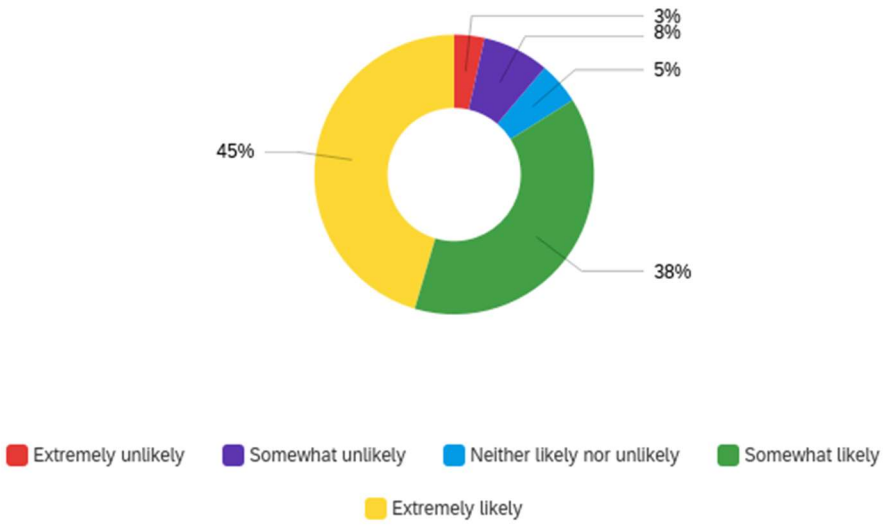

Figure 3.9 Likelihood to Avoid Water Contact if Advised

Preferences on Learning about Dangerous Bacteria Levels

The longest section of the survey focused on understanding stakeholders' preferences for learning when potentially dangerous bacteria levels are present in coastal waters. Questions revolved around both the *content* (e.g., the terminology used) and the *delivery* of water quality notifications. As an important starting point for this line of questioning, survey participants were asked if they would prefer to "be notified automatically" or to "seek out the information myself" if bacterial levels were potentially dangerous in a waterway that they use. As summarized in Figure 3.10, 120 (77%) of 155 respondents indicated that they would prefer to be notified automatically, with 17% (26) of respondents preferring to seek out the information themselves. Five respondents who selected "other" offered supplemental detail, for example:

- "Public service text or phone recording like is used for hurricane evacuations" and "Be notified automatically when extremely serious"
- "See postings at sites I frequent"
- "It could be part of the weather report"

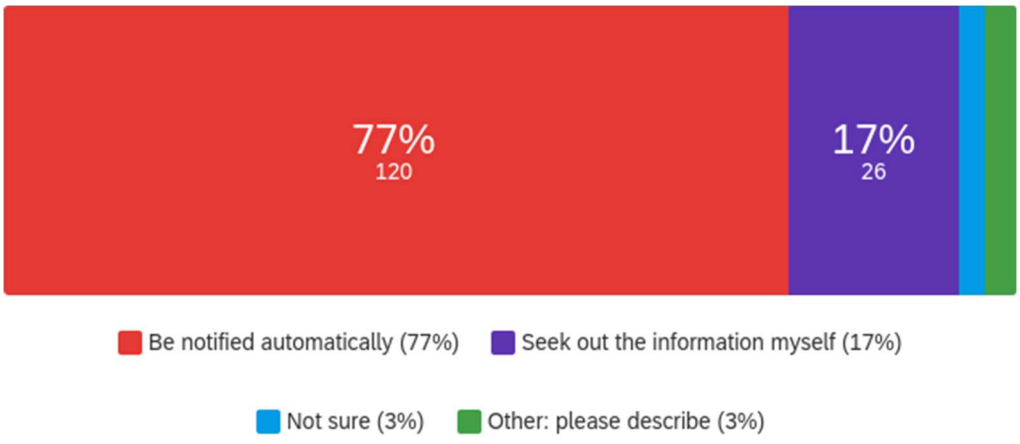

Figure 3.10 Preference for Type of Notification

Survey respondents were next asked about preferred timing for learning of water quality situations and about preferred modes of accessing this information. Specifically, survey participants were provided with choices on when they would be most likely to seek out information on bacteria levels in water that they were planning to enter. Respondents were allowed to make multiple selections, although few did. As summarized in Figure 3.11, the most popular response was "the day of" (104 selections), with a roughly equivalent number of selections for "one day before" (65 selections) and "two or more days before" (35 selections) combined.

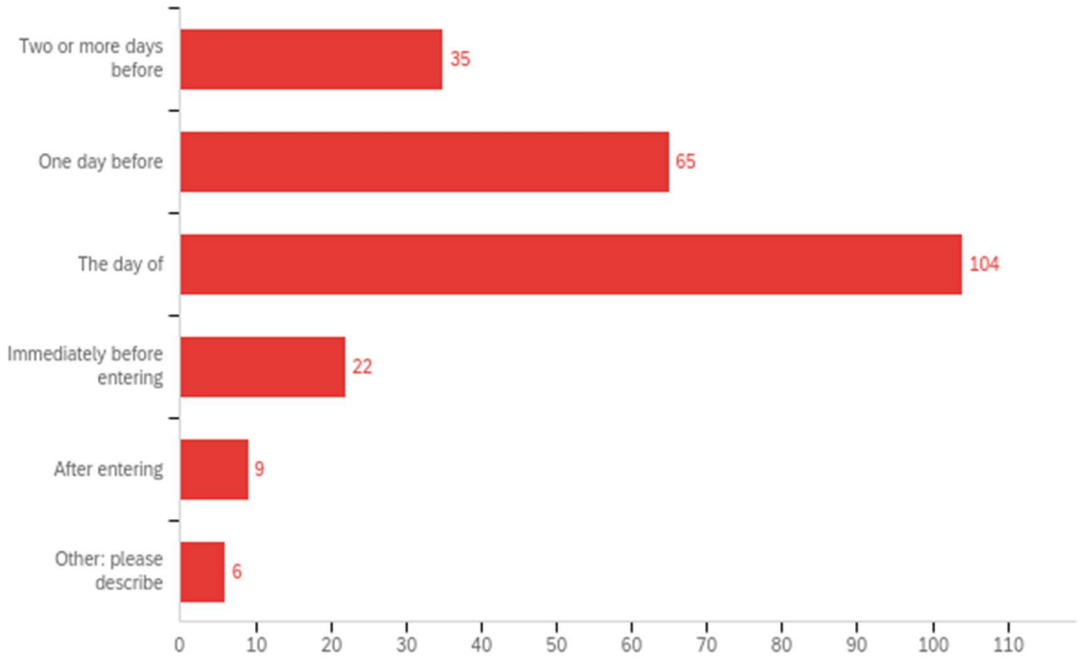

Figure 3.11 Preferences for Timing of Notification

Building on survey participants' preferences for *when* they'd like to access water quality information, respondents were next asked *how* they would prefer to access information on bacteria levels in waters that they were planning to use. Among the channels of communication provided as answer choices for the question, 357 selections

were made, with “mobile app” and “website” comprising more than half of all selections, as summarized in Figure 3.12. 26 individuals offered open-ended responses through an “Other” selection: 12 of these responses specifically mentioned variations of text messaging (i.e., texts, text message, push texts), 6 mentioned social media, and 6 mentioned email notification.

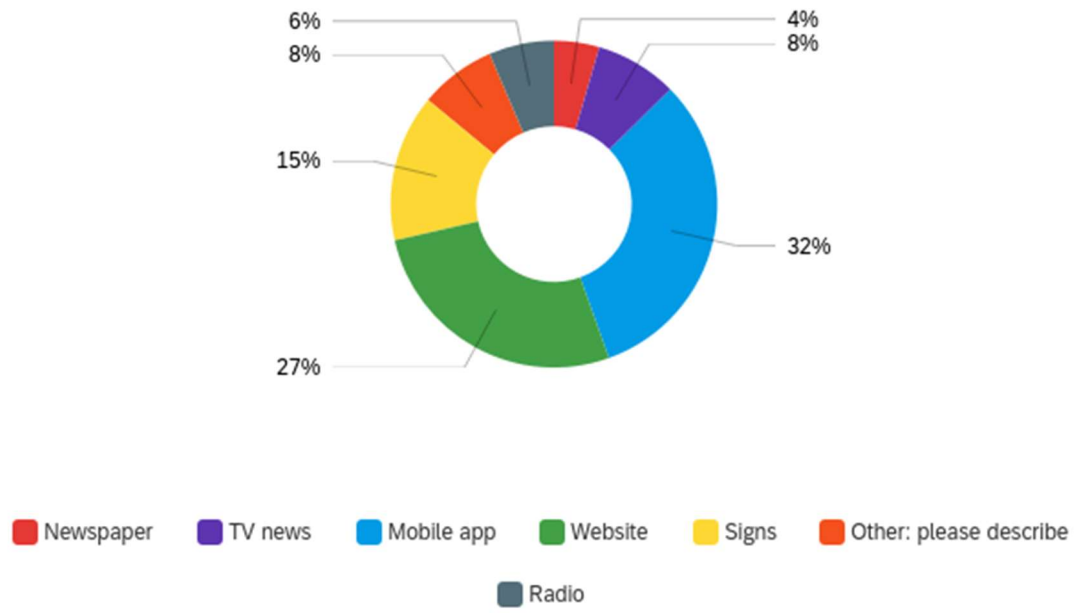

Figure 3.12 Preferred Channels of Accessing Information on Bacteria Levels

Notably, 52 (15%) selections made were for “signs,” which as discussed in the opening sections of this document, are a common point-of-access notification method at recreational sites with recurring water quality problems. The survey included a question about survey respondents’ reactions to these signs. When asked if individuals had ever “noticed signs about bacteria levels at waterways that you use,” 106 (75%) replied “no,” 25 (18%) replied “yes,” and 11 (8%) were “not sure.” Those who replied “yes” were

prompted with a probing question about whether these signs had ever convinced them to avoid contact with the water; of the 24 responses, 15 replied “yes,” 5 replied “no,” and 4 replied that they were not sure.

The final three questions in this subsection of the survey were aimed at identifying potential improvements to the form and delivery of water quality notifications. First, respondents were asked to rate how likely they would be to enroll in “automatic notifications about dangerous bacteria levels in waterways that you use.” Of the 142 respondents for the question, 126 (89%) chose one of the three “likely” responses as summarized in Figure 3.13 below, with nearly half of all respondents choosing the “extremely likely” option.

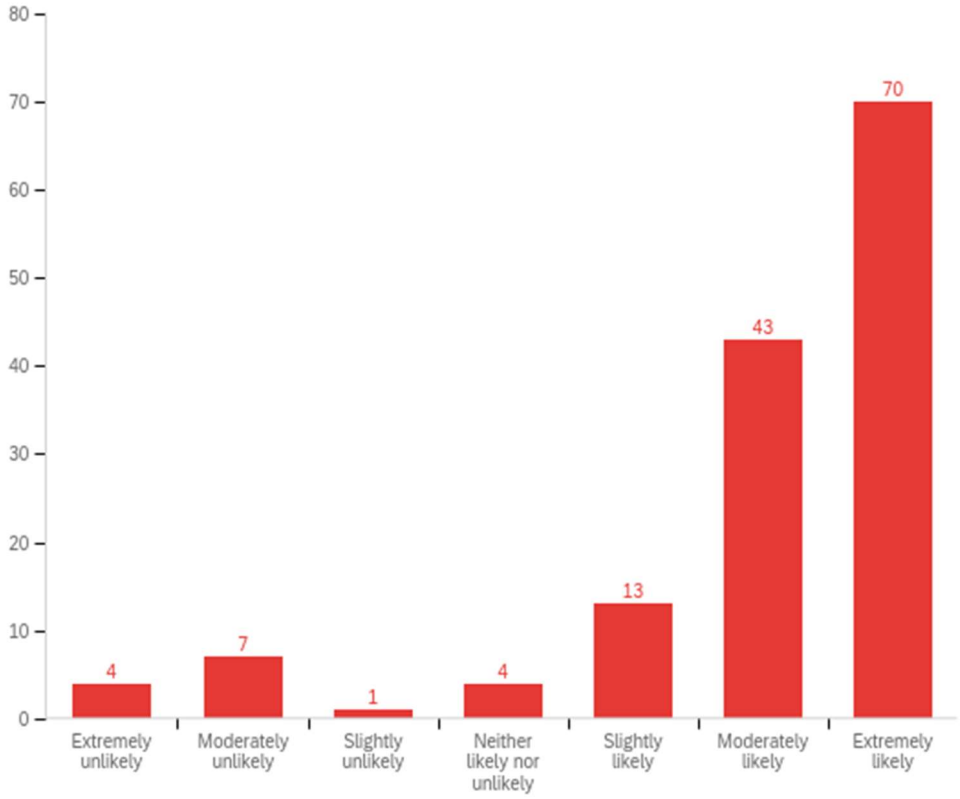

Figure 3.13 Likelihood of Enrolling in Automatic Notifications

Continuing the line of questioning about improving water quality notifications, survey participants were next asked to offer feedback on the term currently used by SCDHEC when contact with water poses health risks—swimming advisory. Specifically, respondents were asked to rate how informative they found the term to be. As summarized in the following figure, opinions on the term were highly variable, although the majority (99 or 69%) of the 143 respondents rated the term using one of the three "informative" (i.e., positive) ratings, with the "slightly informative" rating earning the most selections (39 or 27%) (Figure 3.14).

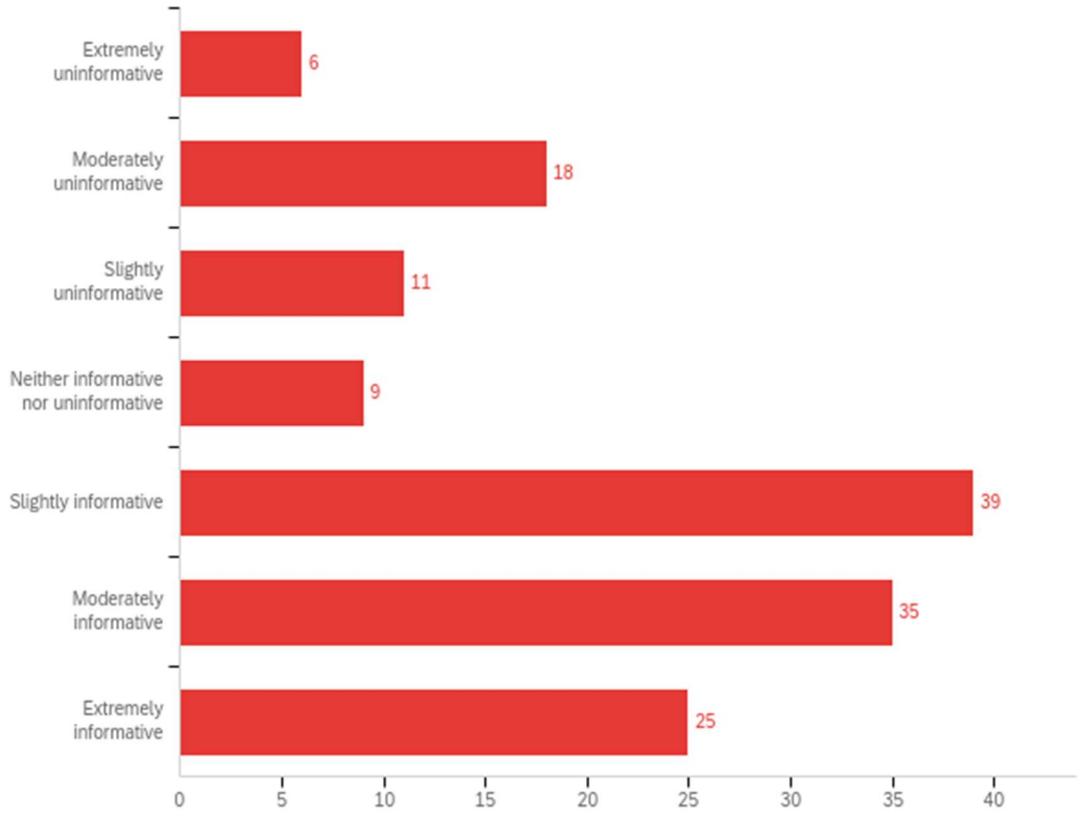

Figure 3.14 Opinions on the Term "Swimming Advisory"

Respondents who indicated that they found the term "swimming advisory" to be anything other than "extremely informative" were prompted with a probing question

asking what they suggest as a more informative, alternative term. Many of the 93 open-ended responses to this probing question suggested including a term that more clearly identified the underlying reason for the advisory: 36 responses included the term "bacteria," while several others used less specific terms such as "toxic," "polluted," "dirty," or "contaminated" to underscore the nature of the advisory. A subset of these responses included the suggestion that the underlying reason be appended to the broader warning language, for example "Swimming Advisory: high bacterial levels" or "Swimming Advisory: rip currents." 19 respondents offered explicit or implicit revisions to the term "advisory," replacing the term with ones that they felt conveyed more urgency and importance: "warning," "alert," "caution," "concern," and "recommendation" were among the most commonly offered replacements. Finally, 7 respondents recommended a tiered or graded advisory system, indicating increasing levels of risk, for example through a color-coding scheme or descriptors of the risk level (i.e., low/moderate/high).

The final question in the survey subsection on preferences for learning about high bacteria levels focused on the *content* of water quality messages, prompting respondents with an open-ended question about what details they feel should be included in water quality advisories to the public. Qualitative feedback from the 123 individuals who responded to the question yielded several clear preferences on the content of advisories:

- Risk level—52 respondents suggested that advisories include the level of risk posed by the situation, with many specifically suggesting reference to safety thresholds or the use of a scaled (e.g., color-coded) system to convey the likelihood of illness.

- Cause of advisory—49 respondents suggested that the underlying cause of the advisory be included in the statement itself. These suggestions ranged from naming the general cause of the advisory (e.g., bacterial or chemical) to naming the specific pathogen(s) present. 9 respondents went so far as to recommend including the source of the pathogen or contaminant, when possible.
- Illness or symptoms to expect—35 individuals suggested listing the most likely symptoms to expect from exposure to the pathogens or contaminants present in the water, and 6 respondents suggested including guidance on what to do (i.e., who to contact, where to go for treatment) if a person becomes ill following contact with water under an advisory.

Trust

The final substantive section of the survey included two questions aimed at understanding which *sources* of information respondents considered "trusted messengers" and which source they would prefer to use as their main source. The categories of information providers available in the trust question mirrored those of the earlier survey question on currently used sources of water quality information. For the survey question on trust, participants were able to make multiple selections; 624 total selections were considered a "trustworthy source for information on bacteria levels." As summarized in Figure 3.15, local non-profit organizations were the most trusted source of information, with national non-profits also earning high trust. Also highly trusted was government at all levels, ranging from local government at the city and town level to state and federal government agencies.

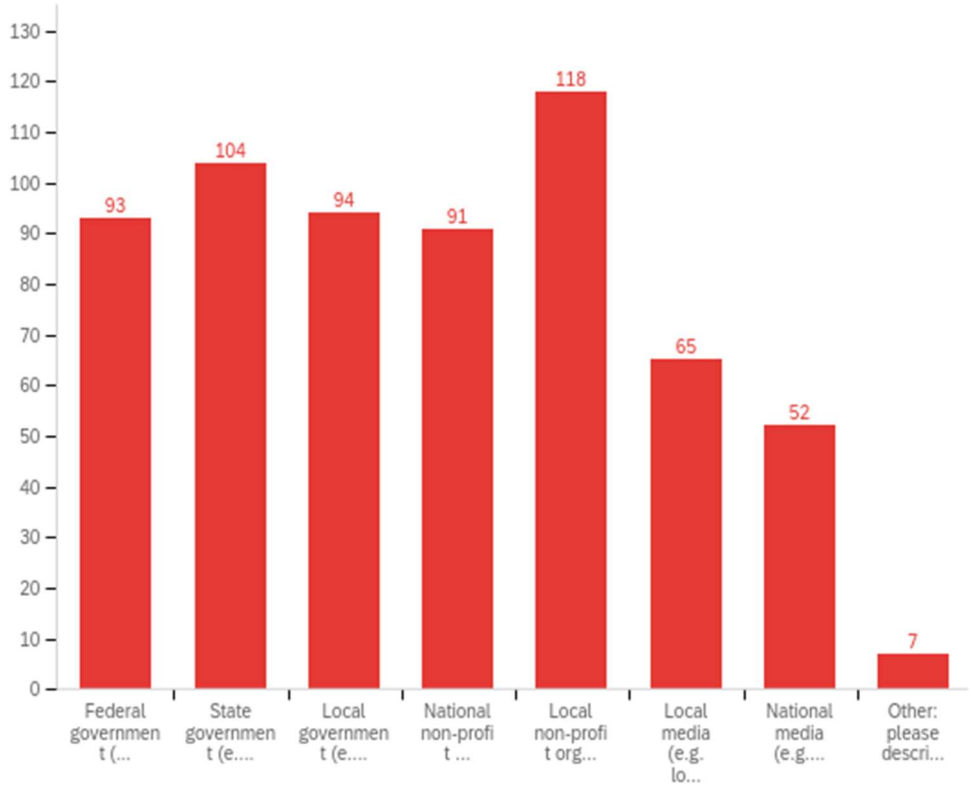

Figure 3.15 Trusted Sources of Information on Bacteria Levels

The survey question asking who respondents would prefer to use as their main source of information on bacteria levels was an open-ended one. Responses ranged from specific organizations and agencies to lengthy comments on the need for "a more constant testing system." Among those who identified specific organizations as preferred sources, the Charleston Waterkeeper (43 responses), SCDHEC (21responses), and the SC DNR (6 responses) were the most widely cited. Notably, the term "local" appeared in 36 responses. The term was in some cases used as a descriptor for the specific organizations mentioned previously, but more often it was used in a general sense, for example local government (14 responses), local news or media outlets (11 responses), or local non-profit organizations (7 responses). In two cases the term was used without reference to specific categories of information providers, for example "who ever [*sic*] is the local

watch dog/tests the local waterways regularly." Additionally, the term "app" appeared in 12 responses. In several cases the term was associated with existing apps, namely the Swim Guide app and the Weather Channel app, but in most cases the term was used in the context of a general preference for accessing information via an app, for example:

- "Any organization that has an app and reports in timely manner."
- "Which ever has the most accessible data or ease of use of the website or app."

CHAPTER 4

RESULTS: INTERVIEWS WITH WATER-BASED RECREATION BUSINESS INTERESTS

Overview

Ten representatives of local businesses, nonprofit organizations, and government agencies with a vested interest in water-based recreation participated in recorded telephone interviews. Saturation was assumed to have been reached when interviewees began suggesting individuals that had already been interviewed, upon being asked for referrals. Most interviewees were the owners of water-recreation businesses offering tours and lessons on kayaking, SUP, and surfing. These businesses ranged from sole proprietor operations to small businesses with multiple employees. The remaining several interviewees were manager-level employees of water-recreation businesses, local government offering water recreation programming, and a nonprofit providing surf programming. Once trimmed of extraneous conversation, interview recordings averaged approximately 15 minutes, with two interviews exceeding 20 minutes. As detailed in the Methods, the nine-question schedule for the semi-standardized interviews revolved around the four core research questions being addressed in the project, of course modified to account for the unique positions of these individuals—as businesspeople and as caretakers for their clientele.

Awareness of Water Quality Problems

Interviewees' awareness and perceptions of waterway health in the Charleston area mirrored those of survey respondents, with eight of ten interviewees expressing concern over waterway health either in a general sense (n=2) or at specific Charleston sites (n=6). The remaining two respondents claimed to have no knowledge on the health of Charleston's waterways, with one assuming good water quality and one assuming poor water quality.

Interviewees were next asked to explore the relationship between healthy waters and the health of their business, specifically about "any relationships between the health of Charleston-area waterways and your business." Five interviewees expressed a direct and positive relationship between healthy waterways and healthy businesses, for example:

> "Well, it's vital, of course. If it's bad water then it makes for unhappy clients and unhappy me. We don't want to be in the water if the bacteria count's very high. Yeah. Extremely important to have good water quality."

By contrast, three interviewees felt that water quality has little bearing on their business. Two felt so because water quality simply is not a priority concern of the business owners, with physical safety of clientele while in the water of utmost concern. Notably, both interviewees who shared this perspective were involved with organizations that lead surf camps and lessons, where more immediate threats to personal safety such as powerful waves, rip currents, and dangerous marine wildlife are the main worries. The other interviewee who reported no relationship between health waters and the health of their

business felt so because the clientele themselves show no awareness or concern for potentially unsafe bacterial levels in the water.

Further exploring this topic, interviewees were asked to discuss any specific impacts on their business stemming from local water quality. Four interviewees felt certain that media coverage of poor water quality conditions had negatively affected their business, and an additional interviewee felt likely of these negative impacts but was not certain of the association. One of the four certain interviewees communicated that:

> "For example, when Shem Creek makes headlines with their toxic level, I see a diminishing in bookings with... People are like, "Oh, we read that Shem Creek has high fecal content," or whatever. And then next, people are canceling their tours or not booking at all. You know what I mean?"

Two interviewees conveyed that although their water-based activities are limited to areas with good water quality, they believe that their business would be negatively impacted if their business occurred in areas with poor water quality. Three interviewees expressed that water quality has had no impacts on their business due to their clients' lack of awareness of the local problems, and one conceded that business likely would be impacted if awareness of these occasional issues was greater.

Desire to Know about Dangerous Conditions

Interviewees were asked to discuss their clients' and their own levels of concern about water quality, and their desire to know when conditions posed health risks. The interview schedule first addressed business owners' perceptions on their clientele's concern about the issue, beginning with interviewees asked to "discuss your

customers/clients' level of concern about the quality of Charleston area waterways." Seven interviewees reported minimal or no concern about water quality among clientele, with two interviewees specifically stating that clientele seem deferential to the judgement of the business operator with respect to safety. Four interviewees articulated distinctions between local clientele and tourists or other visitors with respect to concern about water quality. These interviewees all expressed that local clientele generally show at least some awareness and concern about water quality.

> "Yeah, very much, especially locals who are more aware of it are concerned. People who are more tourist, in which case they're not going to be out in the water as much, they're just in a kayak doing a tour, don't seem as concerned. But if I'm working with any local clientele that are doing any type of safety training or any type of event where we're going to be in the water, most people are, at least they're aware of it all the way to very concerned about it."

When asked to recall their clientele's use of available water quality information, six interviewees reported no recollection or anecdotes of clientele using such data. Four interviewees reported otherwise, noting various of sources of water quality information that had been mentioned by their clientele, with two interviewees specifically referencing that these users of information were local clientele. Additionally, one interviewee noted that the company itself furnishes water quality data at a kiosk where customers purchase tickets or check in for their excursion.

- "I think news and obviously the internet and whatever they see on Facebook or whatever is probably the number one."

- “I know a lot of people in the area keep up with Charleston Waterkeeper, other than that, I'm not quite sure.”
- “So we have, at our booth, we actually have a page, a statement of water quality out there. And so if it's high, we make an indication. We just say, "Hey guys, try to avoid the water." We don't try to avoid it, we take it head on, but the locals either sight the news or Waterkeeper, or just hearing it from a friend.”
- “I think a lot of people hear it from local news, and then I know there's an app called The Swim Guide.”

The final topic on the theme of “desire to know about dangerous conditions” was gauging interviewees’ use of available water quality data to inform their business services or programming. Interviewees were first asked whether they ever use available water quality resources during the course of their business. Eight interviewees reported at least occasionally using such resources, while two reported that they do not. A probing question posed to those who use water quality data explored specific sources of data. Among the eight who did report using water quality data, all eight specifically mentioned using the Charleston Waterkeeper. Four of these interviewees mentioned additional, specific sources of information that they use: the SCDHEC website, local televised news, the local daily newspaper, and the SwimGuide app.

Trust

Interviewees were next asked to discuss who they consider to be trustworthy sources of information on water quality. Reflecting the high use of Charleston Waterkeeper data among interviewees (n=8), seven interviewees cited that organization

as a trustworthy source of water quality information. Four other sources of information each earned two mentions as trusted information providers: NOAA, the SCDNR, SCDHEC, and local news.

Preferences on Learning about Dangerous Bacteria Levels

The final interview theme revolved around interviewees' preferences for learning when contact with coastal waters could present health risk. Interviewees were asked the simple question "What would be the ideal way for you to be made aware when local water quality could cause temporary illness among your customers/clients?" Reflecting the dominant sentiment among survey respondents, seven interviewees indicated a preference for receiving a direct alert or notification, with seven specifically mentioning delivery via a text message and six mentioning delivery via email.

- "So I would say perfect for me is an optional subscription to a text service that texts you, either a daily water report or texts you if quality has decreased to a level that might be deemed unsafe. That would be most ideal. And then second would be any other automatic source, whether it be email or phone call or whatever. And I would say third would be a website that I can check every day on my own accord."
- "It would be nice if I could get text alerts or how some people send out an alert over just your phone and not only just email, but a text alert would be really cool and helpful, at least for my business."
- "I would love for it to be something delivered straight to us and some sort of text or email update, that was not something I had to go find."

- “For me, either being signed up with an email text alert, or an email alert, or a text alert would be great, if you could subscribe to some type of service that would do that would be ideal.”
- “But it'd be cool if there was some app and then a push out notification, not dissimilar from an Amber alert or even like we had some weather apps that will tell me when there's a lightning storm. If there was a feature on that where I could get push out notification on my phone, that would be the most ideal. Because I view that as being as real-time as possible and again, not having to search for it and remind myself of another thing that I need to check, but if it was just pushed out to me, that would be great.”
- “Gosh, I mean, email blasts are pretty easy, pretty much. This time of year, I don't check it that often, but in the summer I'm checking it usually twice a day and so some kind of email blast, I mean, I don't mind getting text messages about that kind of stuff. That seems the most likely or the easiest for me.”

Among the remaining three respondents who did not indicate a preference for direct notification via mobile technology, one suggested that digital, public signage en route to popular sites would be an ideal way to deliver water quality information; one suggested that integrating water quality information into popular weather apps already used by the interviewee would be preferred; and one suggested that local officials visit businesses in person to deliver advisories related to water quality.

The final aspect of the interview was gauging interviewees’ reactions to the current term used when bacteria levels exceed safety thresholds established by the SCDHEC—"swimming advisory.” Only one interviewee felt that the term appropriately

conveyed the message of avoiding contact with the water. Eight interviewees found the term to be vague, ambiguous, or uninformative, with one of these eight individuals offering the caveat that the term was sufficiently meaningful for residents but unintuitive for visitors to the area. One of these eight interviewees also conveyed that the term is not "enthusiastic" or "forceful" enough and should be more specific in terms of the suggested course of action for waterway users. Finally, one interviewee felt that the term was altogether inappropriate in the context of water-based recreation in that is not intended to bring individuals into contact with water, for example kayaking and paddleboarding.

CHAPTER 5

DISCUSSION, RECOMMENDATIONS, AND FUTURE DIRECTIONS

Discussion and Recommendations

Survey and interview results in several categories warrant discussion and suggest potential improvements to water quality communications in the Charleston area. Although the subset of water recreators reached through the survey represents just a sample of a very diverse and much larger population (of unknown size), the variety of age classes and preferred types of water-based recreation represented in the responses provide important insight into a "cross-section" of this recreational community. Additionally, an important caveat to these research results, which is discussed further in the Future Directions subsection, is that the results represent an almost entirely resident pool of respondents. With only three visitors to the Charleston area represented in the data, findings cannot be generalized to tourist and other visitor populations.

Awareness of Water Quality Problems

The Carolina Clear program of Clemson Extension works to educate South Carolina citizens on issues surrounding polluted stormwater runoff and to influence actions and behaviors that ultimately protect the state's water resources. Carolina Clear periodically (2009, 2013, and 2019 thus far) conducts a statewide telephone survey, with sampling conducted in five regions of the state, to gauge public awareness of and attitudes toward stormwater pollution. Survey results are then used to guide educational

programming delivered by the organization. The most recent survey found significant concern about "pollution in your local waterways" among the 400 respondents in the Charleston Area (Charleston, Berkeley, and Dorchester Counties). Specifically, 88% of Charleston Area respondents reported being either "Very concerned" (58%) or "Somewhat concerned" (30%) (Responsive Management, 2019).

Expanding upon this recurring survey work by Carolina Clear, the current study began with questions related to respondent *awareness* of existing water quality issues in the Charleston area as well as their *use of available water quality data and other resources*. 86.3% of the 146 respondents reported at least slight awareness that local, coastal waters "sometimes experience high levels of bacteria that can make you temporarily ill." Respondents' high levels of awareness of these water quality issues should not come as a surprise considering the recent public sentiment uncovered by Carolina Clear, which demonstrated strong concern about local waterway pollution, combined with routine coverage of local water quality problems in various media outlets, as detailed in Chapter 1.

The disparity, however, between respondents' awareness of local water quality problems (86.3%) and their use of available water quality information (62%) suggests a lack of knowledge about such resources. Importantly, 71 of the 90 individuals who reported using water quality information were those who identified as "extremely aware" or "moderately aware" of occasionally high bacteria levels, so the lack of resource use, not surprisingly, is most apparent among those with lower awareness of the water quality problems in the Charleston area. Indeed, as detailed in Chapter 3, among survey respondents who reported no use of existing resources, most indicated that they didn't

know water quality was a local problem or that they did not know how to access water quality data.

Although data from the interviews with water-recreation business owners and managers contrasted survey findings in that rates of interviewee concern about waterway health (80%) were equivalent with at least occasional use of water quality resources (80%), survey findings suggest that outreach on available water quality resources combined with context on the underlying, public health need for these resources could spur additional individuals to begin using water quality resources before entering the water, especially if such efforts were targeted at those who participate in water-based recreation less on a less frequent basis and were thus less likely to be aware of existing water quality problems in the Charleston area.

The final series of questions in this subsection of the survey gauged respondents' perceptions on whether they had ever become ill as a result of water recreation and whether they would be likely to notify someone in that scenario. Although most (72%) respondents did not believe that they had become ill from contact with contaminated coastal waters in the past, most (69%) indicated being likely to report their situation, most commonly to SCDHEC (32 responses), a physician (31 responses), or the Charleston Waterkeeper (18 responses). Importantly, 20 responses specifically indicated uncertainty about who to contact in this situation, and equally important is the lack of consensus on who respondents would contact to report potential water-related illness. Those who acquire an illness from water recreation often don't associate their condition with swimming because of the typical delay in the onset of illness, so disease outbreaks of this kind are often recognized inconsistently, and as a result, their occurrence is likely

underestimated in the literature. (EPA, 2014). As such, providing recreators who would be likely and willing to report their illness with a convenient means to do so (i.e., through water quality reporting apps or websites), or at least providing them with guidance on who to contact, could be an efficient route to gaining a better understanding of the incidence of recreation illness.

Desire to Know about Dangerous Conditions

Although survey respondents' level of concern about becoming ill from contact with contaminated coastal waters was highly variable, with the greatest number of respondents (n=35) claiming to be only "slightly concerned" about becoming ill, respondents showed a strong preference for wanting to know about this risk in advance of recreation, with a combined 89% indicating that they either "agree" or "strongly agree" with wanting to know if their planned recreation in coastal waters could make them ill. Additionally, with respect to respondents' intent to change their behavior based on swimming advisories, 84% of total responses were "likely" (to avoid contact with the water) responses, suggesting that swimming advisories could indeed be effective at promoting public health behaviors (i.e., not entering the water when pathogen levels are unsafe).

Although interviewees' *perceptions* of their clientele's desire to know about dangerous conditions differed from survey responses in that most interviewees reported minimal or no concern about water quality among clientele, an important distinction to note is that representatives of multiple interviewed businesses cater primarily to tourists. As discussed in Chapter Four, four interviewees themselves suggested that visitors to the

area generally show less concern about water quality and health issues resulting from it, while local clientele generally show at least some awareness and concern about water quality. This apparent distinction between tourist and local water recreators suggests differing risk communication strategies for the two target audiences, because as the EPA (2011) notes, awareness of advisory messages seems to be a predecessor to understand the advisories and changing behavior. In other words, risk communication to non-resident populations should begin with more fundamental messaging on what swimming advisories are and why they are necessary.

Trust

Both survey results and interview data suggest that locally trust is not a limiting factor with respect to use of water quality information and resources; rather, lack of awareness of water quality problems themselves and lack of awareness of available water quality resources are the limiting factors. Recreators (n=138) selected 624 total information providers in various categories as "trustworthy sources for information on bacteria levels," clearly demonstrating that trust is not limited to a single category of information provider. Local non-profit organizations were the most trusted source of information, with the Charleston Waterkeeper explicitly named by 43 individuals (29.1%) as their "preferred" source of information and earlier in the survey cited by 30 individuals (21.7%) as a currently used source of water quality information. National non-profits also earned high levels of trust, as did government at all levels, ranging from local government at the city and town level to state and federal government agencies. Interestingly, local and national media fared worst on the question related to trustworthiness, yet local media was the second most widely cited source of information

on water quality. This could be attributable to the fact that those who watch televised news do so for updates on a variety of issues, and although they may not fully trust the media outlet delivering the information, they do occasionally glean information on local water quality.

Among interviewees, trust was less broadly distributed and was more concentrated in the nonprofit category, with seven interviewees (70%) specifically citing the Charleston Waterkeeper as a trustworthy source of water quality information. These interview results on trust were corroborated by interviewees' high use of Charleston Waterkeeper data, with eight interviewees reporting that they use the resource. NOAA, the SCDNR, SCDHEC, and local news were also mentioned as trusted sources of water quality information by some interviewees.

As discussed in Chapter 1, the Charleston Waterkeeper was not originally established as an advisory-style program (B. Rabon, personal communication, January 23, 2018), meaning that these data furnished by the organization to its stakeholders are for informational purposes only and does not carry the officiality of a swimming advisory issued by SCDHEC. Importantly, the Waterkeeper has completed initial steps required to become an advisory program in that it has an SCDHEC-approved "Quality Assurance Project Plan" in place, which allows SCDHEC to use Waterkeeper data for certain other regulatory purposes. This high levels of trust for the Charleston Waterkeeper among both Charleston recreators and water-recreation business owners/managers in the area begs the question of whether the organization, and more broadly recreators in Charleston, would benefit from the Waterkeeper being able to issue official swimming advisories.

Charleston Waterkeeper would not be the first such nongovernmental organization (NGO) in the state with advisory capacity. The Midlands Rivers Coalition, which is headquartered in Columbia, SC and monitors bacteria levels at various sites within several popular freshwater rivers in the "Midlands" region of the state, issues official advisories for recreators in that area via a web-based map. An important consideration surrounding this discussion is the additional workload and presumably costs that would be incurred if the Waterkeeper were granted advisory authority. In addition, the legal liability incurred would have to be addressed. Specifically, organizations with advisory capacity must revisit those sites that are under a temporary swimming advisory, to re-test for unsafe bacteria levels. Although SCDHEC makes daily visits to sites under a temporary advisory until safety thresholds are no longer exceeded, the Midlands Rivers Coalition takes a less labor-intensive approach, re-testing advisory sites just once and continuing advisories through the weekend if warranted (B. Rabon, personal communication, November 10, 2021). As noted earlier, the Waterkeeper is a small organization relying largely on a network of volunteers to collect water samples at its 20 testing sites, so re-testing requirements could be problematic. With newly granted advisory authority, however, the Waterkeeper may become eligible for additional sources of funding that were previously unavailable.

Preferences on Learning about Dangerous Bacteria Levels

This subsection of the survey contained the most questions because it explored two discrete aspects of water quality communications, beginning with questions about the *delivery* of messages and transitioning into questions on the *content* of the messages. One of the early questions in the subsection asked respondents when they would be most

likely to seek out information on bacteria levels in water that they were planning to enter. By far the most common responses to the question were "the day of" (n=104) and "one day before" (n=65). As discussed in Chapter 1, laboratory culturing techniques used by SCDHEC and the Charleston Waterkeeper take one to two days to yield results from the time a water sample is cultured in the laboratory. The one- or two-day lag means that water quality data generated in this manner never represent real-time conditions and are somewhat outdated from the moment they are available. This scenario introduces health risk to water recreators, particularly those making decisions based on older information. For example, as detailed in Chapter 1, both SCDHEC and the Waterkeeper collect water samples mid-week and share results on Thursday or Friday, in time for the weekend when water-based recreation peaks. While an individual in Charleston who uses water quality data released on a Thursday or Friday to inform Friday plans is using recent measurements that are more likely to reflect current conditions, water quality can change dramatically and quickly (e.g., following a heavy rainfall), so those who use the same data early the following week may be basing their decisions on data not at all reflective of current conditions. As discussed in Chapter 1, the qPCR methods used by some states and municipalities to test for indicator bacteria typically yield results in 2-3 hours, but this method is more costly and still does not produce real-time data.

Recognizing these limitations of both culture methods and qPCR methods, the EPA encourages the use of predictive (i.e., modeling) tools to supplement, but not replace, water quality monitoring when there is a lag between sampling and results, or on non-sampling days (EPA, 2014). In fact, EPA recently issued guidance entitled "Six Key Steps for Developing and Using Predictive Tools at Your Beach," to facilitate the

development and use of these public health-promoting statistical methodologies that use historical data and currently available water quality parameters to predict FIB levels at beaches (EPA, 2016). As the title suggests, the guidance document proposes a step-by-step process to develop a predictive tool, and it includes five case studies of tool development including a case study from the Grand Strand region of South Carolina.

Water quality predictions are available for various locations in the southeastern region. “How’s the Beach,” for example, is a collaborative project funded by the Southeast Coastal Ocean Observing Regional Association (SECOORA) and managed by the University of South Carolina. The mobile-enable website furnishes water quality predictions for six popular beach areas in three southeastern states: North Carolina, South Carolina, and Florida (Figure 5.1).

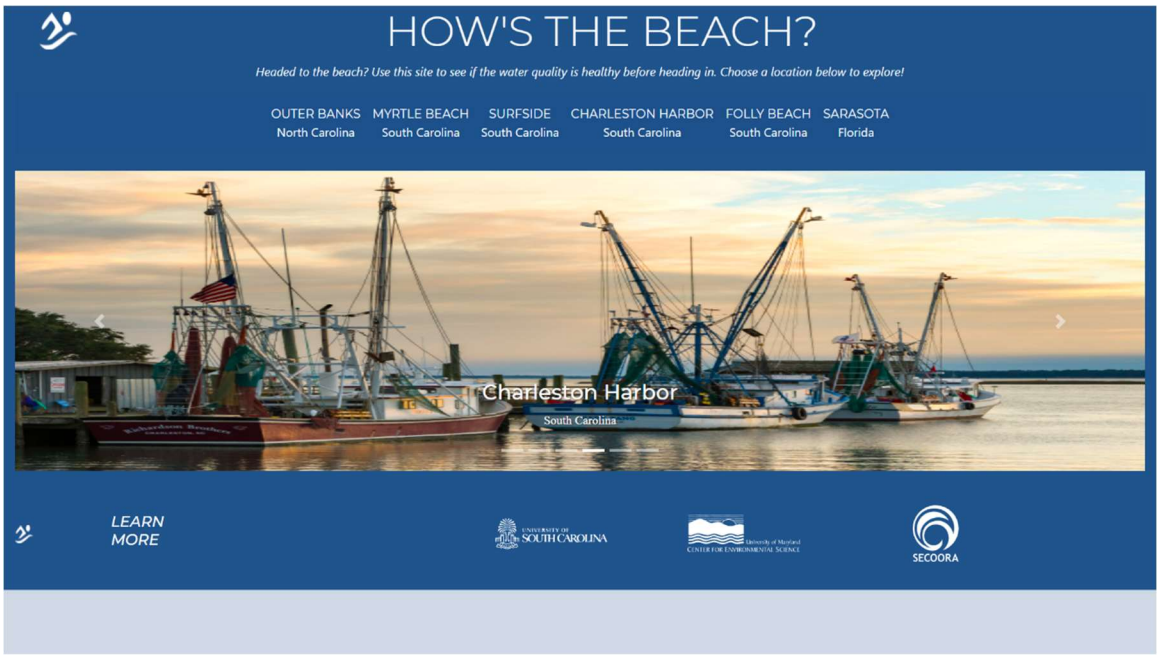

Figure 5.1 How’s the Beach Website Screenshot

Another predictive tool being used in North Carolina is ShellCast, a forecast tool that helps shellfish growers in the state to anticipate poor water quality conditions and resulting closure of shellfish harvesting areas.

The anticipated statewide expansion of the CheckMyBeach website piloted in the Grand Strand region, as detailed in Chapter 1, could provide an ideal opportunity to integrate the results of water quality monitoring with water quality modeling, to provide a more complete and more continuous stream of data surrounding recreational water quality. A recommendation for future survey work or other data collection from coastal water recreators in South Carolina is to include questions gauging stakeholder understanding of, perceptions towards, and openness to water quality modeling results as the basis for decision-making on recreation. Ideally, this relatively small set of questions could be incorporated into an existing, ongoing data collection effort such as the Carolina Clear survey periodically deployed by Clemson Extension.

Another important finding on the delivery of water quality information is related to whether recreators wish to seek out the information themselves or whether they prefer to have advisories and other important communications "pushed" to them in an automated manner. 77% of respondents indicated that they would prefer to be notified automatically, while 17% indicated preferring to seek out the information themselves. Expanding upon the idea of automatic water quality notifications was the question gauging survey respondents' likelihood to enroll in "automatic notifications about dangerous bacteria levels in waterways that you use," with 89% choosing one of the three "likely" responses, and nearly half of all respondents choosing the "extremely likely" option. Interview findings corroborated these survey preferences for automated

notifications, with seven interviewees (70%) indicating a preference for receiving a direct alert or notification, seven (70%) specifically mentioning delivery via a text message, and six (60%) mentioning email delivery.

These findings suggest a more proactive, technology-oriented approach to swimming advisory notifications, like those used by various weather apps to alert subscribers to dangerous weather phenomena. Current providers of both water quality monitoring results and water quality predictions could explore the feasibility of adding such functionality to their communications, to provide more timely and proactive information for recreators. Beach communication programs in multiple locations have incorporated text messages to reach recreators. EPA's most recent guidance for BEACH Act grantees (EPA, 2014) includes two case studies involving the use of text messaging to relay swimming advisories—one in New York (administered by the New York City Department of Health and Mental Hygiene) and one in Chicago (administered by the Chicago Park District). While the New York service, which boasts the tagline "Know Before You Go," provides subscribers with beach status messages *on demand* (i.e., the user must send a text message to receive a text message summarizing the status of a beach), the service in Chicago appears to proactively send users beach notification messages about the user's selected beaches of interest. Evaluations and lessons learned from these programs, as well a more general inventory of state and municipal governments using this approach do not appear to be available, so a panel session or other organized discussion involving public health officials who have experimented with this approach would be very beneficial.

The final aspect of stakeholders' preferences on learning about dangerous bacteria levels addressed in the survey and interviews was the *content* of the swimming advisories. Survey respondents' opinions on the term "swimming advisory" differed from those of interviewed business stakeholders in that 69% of survey respondents rated the term using one of the three positive (i.e., "informative") ratings, whereas most interviewees (n=8) found the term to be vague or uninformative. Despite survey respondents' generally positive reactions to the term, open-ended survey feedback from 123 individuals (88.9% of survey completers) underscores that certain details are important to stakeholders and should be included in the advisory communications: risk level, the cause of the advisory, and the range of illness or symptoms to expect. These details are generally consistent with implications of risk communication literature for beach advisories discussed by EPA (2014), so providers of water quality monitoring results and predictions should include these details in tandem with their advisory status information.

The key findings in each of the thematic areas discussed above, along with the recommendations proposed to address them, are summarized in Table 5.1 on the following page.

Table 5.1 Research Findings and Associated Recommendations

Theme	Research Finding	Recommendation
Awareness (use of resources)	Recreators who don't use water quality resources to inform their decisions cite the following reasons for not doing so: 1) they didn't know that water quality was a problem locally; or 2) they don't know how to access water quality resources.	Conduct a coordinated outreach effort to bring awareness of occasional water recreation risks and the availability of resources to avoid these risks to water recreators.
Awareness	Interview findings suggest differing levels of awareness and concern about water quality issues between tourist and resident populations.	Assess visitors' baseline understanding of water quality issues and swimming advisories, as well as their needs and preferences for water quality notifications.
Awareness (reporting illness)	Many recreators would be likely to report illness that they suspect is a result of water contact, but their perceptions of who they should contact with this information are mixed.	Provide a convenient mechanism for recreators to report illness suspected to be a result of water contact, or at least provide them with guidance on who to contact to report the illness.
Trust	Water recreators trust many different sources of water quality information, with nonprofit organizations and specifically the Charleston Waterkeeper earning the highest trust.	Explore the costs and benefits of the Charleston Waterkeeper being granted the authority to issue official swimming advisories.
Notification preferences	Recreators would prefer to access water quality information the day of, or the day before, their planned recreation, yet the monitoring data available to them may be outdated.	Survey recreators on their understanding of, perceptions towards, and openness to water quality modeling results as the basis for decision-making on recreation.
Notification preferences	Recreators and business owners prefer automated notifications of swimming advisories delivered via text or email.	Explore the feasibility of adding automatic notifications to existing water quality monitoring and predictive resources.
Notification preferences	Recreators feel that key details such as risk level, the cause of the advisory, and illness or symptoms to expect should be included with swimming advisory notifications.	Ensure that proper context supports swimming advisory communications, so that recreators can make informed personal decisions.

Conclusion and Future Directions

The main goal of this research was to identify ways to improve current water quality communication methods and content used by state agencies and local community-based organizations in Charleston, SC, to maximize the impact of these organizations and to illuminate more effective avenues to achieving public health outcomes articulated in the BEACH Act. In addition to directly serving the Charleston area, the results of the assessment may help other coastal locales in South Carolina or even other states with similar recreator populations to improve or streamline their communications.

A secondary goal of the project was to add to the methodological literature on environmental risk communication, specifically demonstrating the utility of needs assessment and other types of formative evaluation in the design of communications on environmental threats to public health. While the typical illness (gastrointestinal illness) that results from exposure to FIB is generally not life-threatening, the results of this research become even more pertinent in the context of advisories related to more pernicious environmental health risks, for example the toxins from harmful algal blooms (HABs), the accidental release of pollutants into marine surface waters, and more virulent human pathogens such as *Vibrio* spp., including *Vibrio vulnificus,* which accounts for half of all seafood consumption-deaths in the USA (Deeb et al., 2018) and is highly associated with wound infections as well. Additionally, the IPCC (2014) suggests that oceans will continue to warm during the 21st century, potentially providing ideal conditions for range expansion and greater exposure risk for a variety of marine pathogens.

In addition to the preceding recommendations stemming from specific research findings, discussed earlier in this chapter, the research has suggested several directions for future inquiry and collaboration:

- **Replicate the study in other coastal locations or at a broader scale**. The results of this localized study cannot be generalized to other coastal locations, or even to non-resident populations who visit Charleston. As such, replicating certain aspects of the study at a broader scale, or at least in multiple other coastal locations, could yield better perspective on whether the preferences detailed in this report are widely held ones. As noted earlier in this chapter, future studies in this line of research should include both resident and non-resident populations, and they should include an assessment of recreators' willingness to accept water quality predictions as a basis for decision-making.
- **Forge new relationships with the public health and healthcare communities to improve reporting of water recreation-related illnesses**. Underreporting and misdiagnosis of illness resulting from contact with contaminated water contributes to a poor grasp of how common and widespread this public issue is. As marine waters continue to warm through the current century, resulting in a greater range for marine pathogens, mechanisms for tracking these illnesses will become an increasingly important public health priority. One promising avenue for improved tracking of water recreation illnesses'—an avenue which is already being used by the SCDHEC in certain scenarios, is syndromic surveillance which refers generally to detecting and reporting individual and population health indicators that are discernable before diagnoses are confirmed (Mandl et al., 2004). Syndromic surveillance in areas with

high levels of water recreation, with symptoms being reported by healthcare providers or potentially by recreators themselves, could present an important avenue to preparing for greater cases of water recreation illness. Facilitating collaboration among those providing water quality testing results and predictions, the public health community, and healthcare providers, to conceptualize syndromic surveillance or other mechanisms for better tracking these illnesses, could provide state agencies and other water quality monitoring organizations with the needed guidance to build illness reporting capability into their water quality reporting resources.

- **Establish long-term comparisons between federal funding for the BEACH Act and cases of recreation illness over time**. Federal funding provided to eligible grantees for implementing the BEACH Act has remained stagnant since 2002, when the first round of full funding for the program was distributed. In fact, the 2002 total funding for the program of $9,999,990 has not been reached again since then. These stagnant funding levels come as a surprise considering multiple factors: growing population and associated levels of water recreation in coastal areas; increasing recognition of the cost of illness from surface water recreation; and global consensus that ocean temperatures are likely to continue increasing in the 21st century. While some states and larger municipalities supplement federal BEACH Act funding with state or local funds, many rely wholly on federal funds for the monitoring and notification components of the program. The Accommodation Tax levied at hotels in South Carolina and other coastal states would seem to be an appropriate way to supplement BEACH Act funding. Initiating a long-term comparison of federal BEACH Act funding to cases of recreation illness, or an appropriate proxy (e.g.,

coastal population or beach visits) in light of the aforementioned underreporting of recreation illness, could bring attention to the need for greater federal support of this increasingly important public health law.

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APPENDIX A

ONLINE SURVEY INSTRUMENT

Introduction (delivered at the outset of the online survey):

This survey is being conducted by Zac Hart, a doctoral student in environmental health sciences at the University of South Carolina. You're invited to participate in this research, which is funded by the National Institutes of Health (NIH) and is focused on discovering how people who use Charleston area waters recreationally would like to be informed when high levels of bacteria could cause temporary illness such as stomach upset, skin rashes, and ear/eye/wound infections. The survey should take approximately 10 minutes to complete. Your responses will remain anonymous, and you will be entered into a drawing for one of several $50 Amazon gift cards for completing the survey. You may contact Zac at zhart@email.sc.edu with any questions.

A. **Recreational uses**—This set of questions looks at the ways you use Charleston area waters recreationally.

    1. On average, during your peak season how many times per week do you participate in recreation that brings you into contact with the water? (Never/Up to once per week/2-3 times per week/more than 3 times per week/not applicable because I do not live in Charleston/not applicable for other reason: describe)

2. Which types of water-based recreation do you participate in? (Choose all that apply: Fishing/kayaking/paddleboarding/sailing/SCUBA diving/surfing or bodyboarding/swimming/shellfish harvesting/other: describe)
3. Which Charleston area waters do you use for recreation? (Open-ended)
4. For how many years have you been using Charleston area waters recreationally? (Less than 1, 1-5, 6-10, 11-15, more than 15)

B. **Awareness of water quality problems**—This set of questions asks about your awareness of Charleston area water quality conditions.

1. How aware are you that coastal waters here sometimes experience high levels of bacteria that can make you temporarily ill? (Not at all aware, Slightly aware, Moderately aware, Very aware, Extremely aware)
2. Have you ever used available information on bacteria levels to make decisions about entering coastal waters?
    - (If yes) Which sources of information? (Choose all that apply) (federal government (e.g., NOAA), state government (e.g., SCDHEC), local government (e.g., City of Charleston, Town of Mount Pleasant, etc.), national non-profit organizations (e.g., Surfrider Foundation), local non-profit organizations (e.g., Charleston Waterkeeper), local media (e.g., local news and radio channels), national media (e.g., the Weather Channel), other:

please describe. *For each source of information that is selected, a probing question will appear asking "What specific resource(s) (e.g., specific TV channels, radio stations, websites, apps, etc.) do you use?"*

- (If no) Why not? (open-ended)
- Not sure

3. Indicate your agreement with the following: I believe I have become ill from contact with contaminated coastal waters in the past. (Completely disagree, Disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Agree, Completely agree)
4. How likely would you be to notify someone if you felt that contact with coastal waters had made you ill? (Not at all likely, Slightly likely, Moderately likely, Very likely, Completely likely)
    - (If likely) Who would you likely notify? (Open-ended)
    - (If unlikely) Why not?

C. **Desire to know about dangerous conditions**—This set of questions asks about your desire to know when bacteria levels in the water could make you ill.

1. Indicate your level of concern about becoming ill from contact with contaminated coastal waters. (Not at all concerned, Slightly concerned, Moderately concerned, Very concerned, Extremely concerned)

2. Rate your agreement with the following: If I were planning activities that would cause contact with coastal waters, I would want to know if the water could make me ill. (Completely disagree, Disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Agree, Completely agree)
3. How likely would you be to avoid contact with the water if you learned that it could make you ill? (Not at all likely, Slightly likely, Moderately likely, Very likely, Completely likely)
4. Please complete the following statement by choosing all that apply. I would like to know of high bacteria levels in: (waterways that I use recreationally/waterways in my zip code/waterways in zip codes near me/all Charleston area waterways/other: describe)

D. **Preferences on learning about dangerous bacteria levels**—This set of questions asks how you would like to learn about dangerous bacteria levels.

1. Please complete the following sentence. If bacteria levels are potentially dangerous in a waterway that I use, I would prefer to: (be notified automatically/seek out the information myself/not sure/other: describe)
2. If you decided to seek out information on bacteria levels in waters that you were planning to enter, when would you be most likely to do so? (Two or more days before/One day before/The day of/Immediately before entering/After entering/Other: describe)

3. How would you prefer to access information on bacteria levels in waters that you were planning to use? Choose all that apply. (Newspaper/TV news/Mobile app/Website/Signs/Other: describe)
4. Have you ever noticed signs about bacteria levels at waterways that you use? (Yes/not sure/no)
    - (If yes) Have those signs ever convinced you to avoid contact with the water? (Yes/not sure/no)
5. How likely would you be to enroll in automatic notifications about dangerous bacteria levels in waterways that you use? (Not at all likely, Slightly likely, Moderately likely, Very likely, Completely likely)
6. How appropriate do you find the term "swimming advisory" for situations when contact with water could make you ill? (Absolutely inappropriate, Inappropriate, Slightly inappropriate, Neutral, Slightly appropriate, Appropriate, Absolutely appropriate)
    - (If anything other than "absolutely appropriate) What do you suggest as a more appropriate alternative term(s) to "swimming advisory"? (open-ended)
7. What details do you feel should be included in warnings to the public when contact with water could make you ill? (open-ended)

E. **Trust**—This short set of questions explores who you would trust for information on bacteria levels.

1. Who would you consider a trustworthy source for information on bacteria levels? (Choose all that apply) (federal government (e.g., NOAA), state government (e.g., SCDHEC), local government (e.g., City of Charleston, Town of Mount Pleasant, etc.), national non-profit organizations (e.g., Surfrider Foundation), local non-profit organizations (e.g., Charleston Waterkeeper), local media (e.g., local news and radio channels), national media (e.g., the Weather Channel), other: please describe.
2. Who would you prefer to use as your main source of information on bacteria levels in Charleston waterways? (open-ended)

F. **Demographics**—This final set of questions asks for statistical information about you.

1. What is the zip code of your primary address? (open-ended, but a 5-digit response will be forced)
2. What is your age? (under 18/18-24/25-44/45-64/65 or over)
3. Are you the parent or guardian of a child under 18? (yes/no)
4. Do you have a medical condition that causes your immune system to be suppressed or compromised? (yes/no)

APPENDIX B

INTERVIEW SCHEDULE

Introduction (delivered over the phone or via email):

Dear sir/madam,

My name is Zac Hart. I'm a doctoral student in environmental health sciences at the University of South Carolina, and I'm working on a research project funded by the National Institutes of Health (NIH). I invite you to participate in a research project focused on discovering how people who use Charleston area waters recreationally would like to be informed when high levels of bacteria could cause temporary illness such as stomach upset, skin rashes, and ear/eye/wound infections. As an individual with business interests in Charleston area waterways, your opinions could be especially helpful. The interview will take no longer 30 minutes. Although the conversation will be recorded to ensure that I capture your thoughts accurately, your identity will be confidential. You'll be given a small token of appreciation for your participation, and you can contact Zac at (843) 532-5244 or at zhart@email.sc.edu with questions at any time.

1. What are your opinions on the health of Charleston area waterways?
2. Please tell me about any relationships between the health of Charleston area waterways and your business.
3. Please talk about any possible impacts on your business stemming from local water quality.

4. Please discuss your customers'/clients' level of concern about the quality of Charleston area waterways.
    a. What are some examples?
5. Please talk about how your clients use available information to make decisions about entering the water.
    a. What sources of information do they use?
6. How do you currently use available sources of information on local water quality?
    a. What sources of information do you use?
    b. Discuss your satisfaction with these sources of information.
7. Who do you consider to be a trustworthy source(s) of information on local water quality?
    a. What makes them a trustworthy source of information?
8. Describe the ideal way for you to be made aware when local water quality could cause temporary illness among your customers/clients?
9. What are your reactions to use of the term "swimming advisory" for when water quality could cause temporary illness?
    a. (If applicable) Please propose more appropriate terms for when water quality could cause temporary illness.