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Authors: Perkinson, Matthew T., Faith, Trevor D., Vahey, Grace M., Vena, John E., and Williams, Edith M.

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# Quantifying the Seafood Consumption Patterns of Recreational Anglers in Charleston and Berkeley Counties, South Carolina

Matthew T. Perkinson<sup>1</sup>, Trevor D. Faith<sup>2</sup>, Grace M. Vahey<sup>2</sup>, John E. Vena<sup>2</sup> and Edith M. Williams<sup>2</sup>

<sup>1</sup>Marine Resources Research Institute, South Carolina Department of Natural Resources, Charleston, SC, USA. <sup>2</sup>Department of Public Health Sciences, Medical University of South Carolina, Charleston, SC, USA.

**ABSTRACT:** This study was designed to provide self-reported data on the frequency of fish consumption and shellfish consumption in Charleston and Berkeley (CB) counties, South Carolina. While commercial fishing and recreational fishing have played an important role in the culture and history of the area, information on the specific patterns of consumption by recreational anglers has been previously unavailable. The pilot data presented here will help determine the feasibility of a large-scale survey of seafood consumption in coastal South Carolina. The study's sampling frame consisted of CB county anglers who had purchased a recreational saltwater fishing license for the 2005/2006 year with oversampling in North Charleston. Survey recipients were asked to provide information on fish consumption and shellfish consumption, general angling habits, perception of water and fishing quality, and demographics. Of the 2500 individuals who were sent questionnaires, about one-fourth responded. Respondents were generally white, middle, or upper class and highly educated. The majority fished by boat and most often ate flounder, spotted sea trout, and red drum. Most respondents ate shrimp several times a month and also supplemented their recreational catch with seafood purchased from grocery stores, markets, and restaurants. Almost all respondents had eaten some seafood in the last year, and more than one-fourth ate seafood twice a week or more. Most anglers responded positively about the area's fishing and water qualities, but many referred to areas where they would hesitate to eat their catch. Further research may need to incorporate direct distribution of surveys to underrepresented groups and financial incentives to encompass a more diverse population of anglers.

**KEYWORDS:** seafood, environmental pollutants, creel survey, recreational anglers, diet

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**CORRESPONDENCE:** wiled@musc.edu

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## Introduction

The University of South Carolina (USC) Sportsman Study was a cross-sectional study of licensed saltwater anglers conducted in the summer of 2006. We devised and implemented a self-administered mail survey questionnaire for licensed Charleston area anglers. The primary research aim of the study was to provide the first available data on self-reported seafood consumption patterns of recreational anglers in Charleston and Berkeley (CB) counties. Recreational saltwater fishing and commercial saltwater fishing are an important part of the history and culture of coastal South Carolina, and the region is well-known for its seafood restaurants and markets. Despite this cultural heritage, we are unaware of any data that specifically target seafood consumption in CB counties (hereby referred to as the Charleston area). The study was designed to provide data on the consumption of local seafood, with an emphasis on recreationally caught fish and shellfish, and assess perceptions of local water quality. The vast network of rivers, estuaries, and open ocean in the area created challenges in surveying recreational seafood consumption that may not be present in less hydrologically

complex locales. In order to provide the most relevant data, the study focused heavily on those coastal tidal creeks and rivers with an increased potential for seafood to become contaminated due to a persistent influx of toxic pollutants.<sup>1–3</sup> While freshwater species also are a potential pathway for contaminants such as mercury, polychlorinated biphenols, and dioxins,<sup>4</sup> they are beyond the scope of this study and have been excluded.

Although our study focuses on the risks associated with consuming contaminated seafood, it is important to note that seafood “contain[s] essential nutrients and omega-3 fatty acids, and are low in saturated fat.”<sup>5</sup> A joint report by the World Health Organization and the Food and Agriculture Organization of the United Nations<sup>6</sup> as well as the most recent dietary guidelines from the United States government<sup>7</sup> recommends a moderate seafood consumption (1–2 servings per week), indicating that the benefits outweigh the potential risks of exposure to contaminants in the general population. However, recreational fishermen sometimes eat large quantities of fish from a few local sources, and we were particularly interested in consumption rates to determine the prevalence of high-frequency



seafood consumers. High-frequency consumers eat seafood with greater frequency and volume and could potentially be exposed to greater levels of toxic contaminants than to lower level of consumers.<sup>8</sup> These anglers may be at greater risk from specific polluted areas and species of fish.<sup>9–11</sup> Even where state consumption advisories are in place, anglers are often unaware of these advisories or choose to ignore them.<sup>9,10,12,13</sup> Similarly, we were interested in anglers who eat seafood from areas characterized by degraded water quality and high concentrations of toxic chemicals, as they may also be at greater risk. Site-specific information is necessary to provide risk analysis for local populations of recreational anglers.

While the mail survey targeted a broad segment of the local angling community, we were particularly concerned with the consumption patterns of residents living around the Neck area of North Charleston (NC). The Neck area of NC refers to the portion of the Charleston Peninsula where the Cooper and Ashley Rivers bend toward each other, creating a narrow strip of land. This narrow section of land has been highly industrialized since the 19th century.<sup>14</sup> The area, associated with the 29405 zip code, corresponds with the Charleston waters where elevated levels of organic toxic chemicals such as polycyclic aromatic hydrocarbons<sup>1,2</sup> and perfluoroalkyl substances<sup>15</sup> are present. Polycyclic aromatic hydrocarbons are considered to be a probable carcinogen to humans,<sup>16</sup> and emerging research suggests that perfluoroalkyl substances may be a carcinogen and an immunotoxin as well.<sup>17</sup> All licensed anglers living near those potential areas of concern (the 29405 zip code) received a questionnaire. The rest of the sample population consisted of a random sample of all other CB county licensed anglers. It is important to note that in 2006, recreational saltwater fishing licenses were only required for anglers aged 16 years and older, fishing from private boats.<sup>18</sup> Pier-, bridge-, and shore-based anglers were not required to purchase a fishing license (the regulations have subsequently changed to require all anglers aged 16 years and older to possess a license). As noted in the discussion, utilizing the license holder list may have influenced the demographic makeup of respondents. However, sampling individuals with South Carolina saltwater fishing licenses gave us the best opportunity to reach large numbers of avid anglers and seafood consumers.

Several existing studies either directly or indirectly quantify seafood consumption on a large scale. Studies like the National Marine Fisheries Service's Marine Fisheries Statistics Survey (now the Marine Recreational Information Program) and the United States Department of Agriculture's (USDA) Continuing Survey of Food Intake by Individuals have been analyzed by the Environmental Protection Agency (EPA) and others to make inferences about seafood consumption.<sup>19</sup> Other studies like the Florida statewide consumption study and Burger's 2002 study of South Carolina sportsmen and women aim to directly provide per capita seafood consumption figures.<sup>20,21</sup> Several of the available studies have quantified seafood consumption rates in order to gage the

potential risk of contaminants on human health. The chemicals studied include mercury,<sup>22–24</sup> organochlorides,<sup>25–29</sup> and arsenic.<sup>26</sup> Much of the consumption literature is concerned with the perceptions of anglers and seafood consumers. Beehler et al.<sup>10</sup> and Burger<sup>30</sup> have looked at the social and cultural explanations for why people fish. Other studies have focused on the angler's perception of the environment and the safety of eating recreationally caught seafood,<sup>9,12,21,31</sup> the demographic variability of seafood consumers,<sup>8,10,12,31,32</sup> and the reasons why people eat seafood.<sup>33,34</sup> The available literature provides a wealth of past experience to draw from and also illustrates the need for localized data of consumption patterns in coastal South Carolina. Our study provides more data on those high-frequency consumers who may be at risk from increased exposure to environmental toxins.

## Materials/Data and Methods

**Creating the survey.** Our sampling frame consisted of Berkeley and Charleston county residents who purchased saltwater fishing licenses for the period between July, 1, 2005, and June, 30, 2006. This list was obtained from the South Carolina Department of Natural Resources' (SCDNR) Licensing Division in Columbia, South Carolina. Out of the roughly 53,000 licensed anglers in the two counties, 2500 were chosen for the survey. All 475 licensed anglers with a 29405 zip code received surveys. The other 2025 anglers were randomly selected from the rest of the licensed population in CB counties.

Survey questions were broken loosely into the following five sections: general angling information, fish consumption, shellfish consumption, fish and water quality opinion, and personal and demographic information.

The general angling section was designed to provide information on the respondent's fishing history. Anglers were asked to identify the number of years that they had fished in the survey area and their fishing frequency over the last 12 months. They were also asked to identify how often they had fished from different locations such as the beach, piers, bridges, and by boat. Finally, a map comprising much of the survey area was provided. Respondents were asked to mark the locations that they had fished in the previous 12-month period. The map was divided into 16 specific regions based on the geography of the area.

The fish consumption section included questions about specific species of fish consumed by the respondent and his/her family. The species list was comprised the most commonly eaten estuarine species according to the personal observation and the shrimp baiting survey performed by Laska and Vena.<sup>35</sup> Anglers were also asked about their methods of preparing and cooking recreationally caught fish and their usual serving size for fish meals. Finally, survey recipients were asked to provide general information about their consumption of offshore fish species, purchased seafood meals, and their total frequency of seafood consumption.

The shellfish consumption section included a question about recreationally caught shrimp (*Penaeid* spp.), oyster



(*Crassostrea virginica*), clam (*Mercenaria mercenaria*), and blue crab (*Callinectes sapidus*) consumptions and a question about typical shellfish portion size. The section also included a question about oyster consumption from both recreational and commercial sources. Recipients were asked if they participated in the shrimp baiting season (a method of targeted recreational shrimp harvest for which a separate license is required) and the amount of shrimp that they kept. Finally, anglers were asked about purchased seafood meals and their total frequency of seafood consumption.

The opinion section allowed respondents to give their opinion on the quality and safety of the local resource. This section included questions about fishing quality, water quality, and the safety of eating locally caught seafood. Survey recipients were asked if there were any locations in which they would hesitate or refuse to eat their catch. The question allowed an open-ended response about certain areas of concern within the study region.

The final section included questions about the respondent's race/ethnic group, household income, education, and age. Recipients were also asked to provide an updated address as needed.

This project qualified for exemption from IRB oversight at the University of South Carolina in accordance 45 CFR 46.101(b)2 due to the anonymous nature of the work. The research performed also complied with the principles of the Declaration of Helsinki.

**Implementing the survey.** Most of the methodology utilized in implementing the survey followed the tenets of Dillman's Total Design Method.<sup>36</sup> This method calls for multiple waves of survey mailings intended to increase the total rate of response. For our survey, the selected population initially received both the survey questionnaire and a personalized letter that explained the importance of their response to our research goals. A postage-paid return envelope was provided for ease of response. The survey was sent on August 15, 2006. Two weeks after the initial mailing, the entire surveyed population received a postcard either thanking them for their participation or asking that they please complete and return the questionnaire as soon as possible. During this time period, we began to receive responses and removed respondents' names from the mailing list. Approximately three weeks after the postcard mailing, those remaining on the mailing list (the nonrespondents) were sent an identical questionnaire and

a similar (but slightly different) personalized letter. The second letter reiterated the importance of their response to our success. Nonrespondents received another postage paid return envelope to facilitate better response. No responses were accepted after December 1, 2006. This cutoff date was approximately three and a half months after the initial mailing.

**Data entry and analysis.** The responses were converted to numerical codes that were then manually entered into a Microsoft Access database using a form modeled after the survey itself. Quality assurance/quality control was monitored through independent spot check comparisons of the paper surveys and the Access database. All descriptive and analytical statistics (including  $\chi^2$  test and Student's *t*-test) were completed using the Stata® version 12.1 software. Differences were considered statistically significant if the *P* value was  $<0.05$  for  $\chi^2$  and *t*-tests. All statistics exclude missing data (questions with no response recorded on a returned survey). All original paper surveys were retained for quality assurance and are kept in a secure location for security purposes and future research.

## Results

**General angling information.** We received 581 responses from 2500 surveys, for an overall response rate of 23.2%. The response rate for the NC group (from zip code 29405) was lower than the CB county group at 17.9% (85/475) and 24.5% (496/2025), respectively. The respondents were predominantly (93.0%) White, (4.7%) African American, and (less than 1%) Native American, Hispanic, Asian, or other races. The NC group was more likely to report being non-White ( $P \leq 0.001$ ), with 95.3% of the CB group and 79.5% of the NC group reporting their race as White. Comparison of the survey respondents to the general population of these regions by race are presented in Table 1. The overall average age of respondents was 45.8 years. The youngest respondent was 17 years, and the oldest respondent was 79 years. The mean age of the NC group was three years older than the CB group (48.4 vs. 45.4 years,  $P = 0.016$ ). Almost all (96.7%) of the respondents completed high school. Three-quarters completed some college, and 24.2% attended graduate school or higher. There was a significant difference in the highest level of school completed between the two survey populations ( $P = 0.048$ ), with the NC group having lower percentage of people who completed at least one year of education past high school (76.9% vs. 59.5%). Almost half (45.8%) of all respondents reported earning

**Table 1.** Response by race/ethnic group by percentage.

	TOTAL (n = 575)	CB GROUP (n = 492)	ACTUAL CB POPULATION* (N = 548,054)	NC GROUP (n = 83)	ACTUAL NC POPULATION* (N = 97,635)
White	93	95.3	65	79.5	41.6
Nonwhite	7	4.6	35	20.5	58.4

**Note:** Based on 2010 census data.<sup>37</sup>



more than \$75,000 per year. There was a significant disparity in income between the two groups ( $P \leq 0.001$ ), with only 18.0% of the NC group earning above \$75,000 per year compared to 50.4% of the CB group.

The amount of time that respondents had fished in CB counties varied with 36.7% fishing in the area for 10 years or less, 28.6% for 11–25 years, and 34.7% for greater than 25 years. There was no statistically significant difference ( $P = 0.072$ ) in years fished between the two population groups, but 45.2% of the NC group reported fishing in the study area for over 25 years compared to 32.8% of the CB group. Of the total group of anglers, most (56.9%) had fished between 1 and 20 days in the past year and only 3.8% fished more than 100 days. There was no difference in days fished in the last 12 months between the two groups. Fishing by boat was by far more popular than surf, pier, or bridge fishing, with 97.8% of overall respondents indicating that they fished by boat at least some of the time. This is reflective of the 2006 SC saltwater license requirements, as licenses were only required if the angler was over 16 years old and fishing from a private boat. The CB group fished by boat more often than the NC group with 80.5% of the CB group reporting fishing by boat *often* or *always* compared to 72.9% of the NC group, although differences between the two groups were not statistically significant ( $P = 0.071$ ). Figure 1 shows the map of the area

that was provided in the angler questionnaire. The Middle Harbor was the most popular area with 45.0% of respondents fishing it in the last 12 months. The Open Ocean (42.5%), Lower Wando (34.3%), and the Upper Intracoastal Waterway (32.3%) were also the popular locations. The areas of the greatest concern based on water quality data, such as the Upper Cooper (21.3%), the Lower Cooper (22.1%), the Lower Ashley (15.2%), and the Upper Ashley (9.9%), were also visited frequently by anglers. These areas of particular interest are illustrated in Figure 2. Many anglers (43.4%) only fished one or two locations in the area, and most (72.4%) fished four locations or less. Respondents reported fishing in up to 14 of the areas on the map.

**Fish consumption.** When asked about their consumption of specific species of fish, flounder (*Paralichthys* spp.) was the most commonly consumed inshore food fish. Of all respondents, 64.0% indicated that they had eaten sport-caught flounder in the past year. Among flounder eaters, 21.8% indicated that they eat sport-caught flounder two or more times a month. Sea trout (*Cynoscion* spp.) and red drum (*Sciaenops ocellatus*) were the next most frequently eaten by our respondents. Red drum consumption was followed by, in order: black sea bass, whiting, sheepshead, spot, croaker, sharks, Spanish mackerel, bluefish, and striped mullet. In general, a higher proportion of the NC group reported eating at least one meal



**Figure 1.** Map of the study area in Charleston and Berkeley counties that was included in the questionnaire sent to licensed anglers.



**Figure 2.** Map of the study area in Charleston and Berkeley with common fishing areas marked.

in the past year of each species compared to the CB group. This difference was only statistically significant for sheep-head and croaker ( $P = 0.039$  and  $P = 0.015$ , respectively). The frequency of consumption data for inshore gamefish is found in Table 2.

Most of the total group of anglers surveyed (55.4%) indicated that they usually eat an 8-oz portion of fish at one serving.

There was no significant difference in typical portion sizes between the groups, but 10.98% of respondents from the NC group reported eating 16-oz portions compared to 4.96% of respondents from the CB group. The anglers in this study prepared their fish using a variety of methods. Filing the fish with the skin on or off, as well as cutting steaks, was the most popular preparation method. Very few anglers always used one method.

**Table 2.** Percentage of respondents who consumed at least one meal in last 12 months, by species and group.

FISH SPECIES	OVERALL (%) N = 583	CB GROUP (%) N = 498	NC GROUP (%) N = 85	P-VALUE
Flounder	64.67	64.46	65.88	0.800
Sea trout	53.69	53.41	55.29	0.748
Red drum	52.14	51.00	58.82	0.182
Whiting	30.36	29.12	37.65	0.114
Black sea bass	29.85	28.51	37.65	0.089
Sheepshead	28.3	26.71	37.65	<b>0.039</b>
Spot	23.67	22.89	28.24	0.284
Croaker	18.70	17.07	28.24	<b>0.015</b>
Sharks	16.47	15.66	21.18	0.205
Black drum	13.38	12.25	20.00	0.052
Spanish mackerel	9.61	10.04	7.06	0.389
Bluefish	5.83	5.62	7.06	0.601
Striped mullet	4.46	4.42	4.71	0.905

**Note:**  $P$  values come from  $\chi^2$  analysis.





**Figure 3.** Areas indicated by anglers from which they would hesitate to eat fish.

Similarly, anglers cooked their fish using a variety of methods. Panfrying, deep frying, and grilling were the most common methods of cooking. As with fish preparation, very few of the anglers surveyed used one cooking method all of the time.

**Shellfish consumption.** The data indicate that shrimp is the most commonly consumed shellfish in the region, with 79.4% of all respondents eating some recreationally caught shrimp in the last 12 months. Almost one-quarter of the respondents (24.1%) ate three or more shrimp meals a month. Shrimp consumption was followed by blue crabs and oysters with 59.2% and 57.6% eating at least one meal in the past year, respectively. Clams were the least consumed shellfish with only 29% of respondents eating at least one meal in the past year. There were no significant differences between the shellfish consumption habits of the two survey groups. Almost half (47.0%) of the anglers said that their typical shrimp portion was 8 oz. Eight ounces was the most popular serving size for oysters as well (36.8%), while 4 oz was the more common serving size for clams (61.0%) and blue crabs (37.8%).

Of the recreational anglers that we surveyed, 33.4% indicated that they participate in the annual shrimp baiting season. Of these participants, 37.7% reported keeping more than 25 pounds of shrimp per year. According to the data, most of our anglers supplemented their recreational catch with commercially supplied seafood. Of the total group of respondents, 60.6% had eaten canned or frozen seafood from the grocery store in the last year, and 65.3% had eaten fresh seafood from the grocery store.

Even more anglers (75.8%) had eaten seafood meals purchased from a local seafood market, and the vast majority (96.5%) had eaten a seafood meal from a restaurant in the last year.

In addition to inquiring about frequency of consumption of specific species that were locally caught, the survey included one question about consumption frequency of any species from any source. Table 3 shows the frequency of eating all seafood (recreationally caught and commercially bought) in the last 12 months for the overall, CB, and NC groups. Of all the respondents, only four (0.7%) respondents indicated that they had eaten no seafood in the last year, while 91.9% of the respondents ate two or more seafood meals per month. Almost one-quarter (22.4%) respondents said they ate seafood once a week, and 28.7% respondents ate seafood twice a week or more. When comparing overall seafood consumption by group, there was no significant difference ( $P = 0.382$ ) between the NC and CB groups. However, when comparisons were made by race instead of survey group, the differences in consumption of any seafood become highly significant ( $\chi^2$ ,  $P = 0.001$ ). Non-white respondents were 6.8 times more likely to report eating seafood at least five times a week (95% CI 2.18, 21.268) than white respondents.

**Angler opinion.** This section allowed respondents to voice their perceptions of the state of the area's water and fishery resources. Table 4 refers to the perceptions of area's fishing quality. Of the entire group of respondents, only 3.6% claimed that the fishing quality of area was *poor*, while another 23.1% labeled

**Table 3.** Frequency of seafood consumption from all sources by percentage.

# OF MEALS IN THE PAST 12 MONTHS	CB GROUP (N = 498)	NC GROUP (N = 85)	OVERALL (N = 583)
None	0.61	1.18	0.69
1 time or less per month	7.47	7.06	7.41
2 times per month	16.36	21.18	17.07
3 times per month	23.43	24.71	23.62
1 time per week	23.43	16.47	22.41
2 times per week	20.61	17.65	20.17
3–4 times per week	6.06	5.88	6.03
5 times or more per week	2.02	5.88	2.59

Note:  $\chi^2$  for difference between groups  $P = 0.432$ .

**Table 4.** Opinions on local fishing quality by survey group.

	TOTAL (n = 576)	CB (n = 494)	NC (n = 82)
Poor	3.6	3.6	3.7
Fair	23.1	23.5	20.7
Good	55.6	54.7	61
Excellent	17.7	18.2	14.6

it as *fair*. Most (55.6%) said that area's fishing quality was *good*, while another 17.7% said that it was *excellent*. No significant differences in fishing quality were found between the two groups ( $P = 0.734$ ).

Table 5 refers to opinions about local water quality. Of the 574 respondents, only 3.7% of those surveyed believed that area's water quality was poor and another 38.2% said that it was *fair* compared to *good* (50.9%) and *excellent* (7.3%). Differences between the NC and CB groups were found to be significant ( $\chi^2$ ,  $P = 0.026$ ). More respondents in the NC group reported water quality as being *poor*, and less respondents in the NC group reported water quality as being *good* or *excellent*. The majority (85.66%) of all respondents reported having no or minor concerns about the safety of consuming locally caught seafood. There were significant differences ( $\chi^2$ ,  $P = 0.009$ ) in the perception of local seafood safety between the groups. Most (26.2%) of the NC group had either moderate or major concerns than the CB group (12.3%). When

**Table 5.** Opinions on local water quality by survey group.

	TOTAL (n = 574)	CB (n = 493)	NC (n = 81)
Poor	3.7	2.8	8.6
Fair	38.2	37.7	40.7
Good	50.9	52.5	40.7
Excellent	7.3	6.9	9.9

asked if there were any areas in which they would hesitate or refuse to eat their catch, anglers frequently cited the Cooper River (particularly the Westvaco Paper Plant and Naval Shipyard areas), the Ashley River, and Charleston Harbor. These areas are highlighted on the survey map in Figure 3.

## Discussion

**Key findings.** Questionnaire respondents were generally white, middle, or upper class and well educated. Most fished between 1 and 20 days in the last year and most commonly fished by boat. These anglers commonly kept sport-caught fish to eat, and flounder, sea trout, and red drum were the three most commonly consumed fish species. This is consistent with personal communication with experienced local fishermen, who stated that these species are the most commonly targeted by the area's inshore anglers (Captain John Irwin, personal communication). Future studies on this issue will more purposefully include mixed methods, including focus groups, interviews, and participant observations, with the intent of understanding the differences between fishing experiences among different demographic groups and geographic areas. Detailed proposals have been developed to study the target population of recreational anglers. Our goal is to conduct more ethnographic and qualitative studies before designing another survey or health study to inform the type of questions asked, how they are asked, whether or not there need to be changes made to the survey's language, etc. Such an approach should also identify segments of the population that would be missed by a mailed survey.

Charleston area anglers also commonly ate recreationally caught shellfish, with shrimp and oysters the most popular. Shrimp baiting was very popular among recreational anglers, and many shrimp baiting participants kept over 25 pounds of shrimp per year. This may help account for the high frequency of recreationally caught shrimp consumption found in our surveyed population. Charleston area anglers also supplemented their sport-caught seafood consumption by purchasing fresh or frozen fish and shellfish from grocery stores, seafood markets, and restaurants. Including all commercially and recreationally caught fish and shellfish, the vast majority of respondents ate seafood at least twice a month, with close to one-third eating seafood twice a week or more. A much higher percentage of nonwhite anglers ate seafood five or more times a week than white anglers. Most anglers participating in the survey felt that area's fishing quality and water quality were *good*, and most had little or no concern about the safety of eating locally caught fish. Almost all locally caught fish that make it into seafood markets are offshore species. Red drum and sea trout have gamefish status and cannot be sold. There may be a small amount of flounder and sheepshead that make it into markets, but the majority of inshore species come from North Carolina, where gill netting is still allowed in inshore environments. Shrimp are caught offshore but are estuarine dependent. Crabs and oysters are caught and sold locally.





When comparing the NC and CB groups of anglers, several differences were readily apparent. The NC group had a higher percentage of nonwhite anglers, a less yearly household income, and the lower levels of education. The NC group respondents were older and more likely to have lived and fished in the area long term. NC anglers, while fishing most often by boat, were more likely to fish from shore-based locations than their CB group counterparts. They also ate larger portions of both fish and shellfish but did not eat seafood with greater frequency. NC anglers also had greater concerns about water quality and the safety of eating local seafood than CB anglers.

**Sampling error and biases.** There are many factors at play that can help explain the high levels of income and education of our survey respondents. The most important factor is the nature of our sampling frame. We sampled a percentage of saltwater recreational fisheries license holders, as opposed to the general population. According to the SCDNR, in 2006, recreational saltwater licenses were required for individuals aged 16 years or older to harvest oysters, clams, or fish from private boats.<sup>18</sup> In 2006, the state did not require shore-based or pier fishermen to purchase recreational fishing licenses, unless they engage in oyster and clam harvesting or cast netting. Therefore, a large portion of the license holder list is composed of boat owners or those who often fish from boats. Boat ownership requires both an initial investment and the continuing expenses associated with maintenance, fuel, and registration fees. Even for those license holders who do not own boats, fishing is not always an inexpensive pastime. Even shore fishing requires tackle, accessories, and some form of bait or artificial lures. The \$10 annual license fee may also discourage some low-income households from purchasing the saltwater license. The increased income level of our respondents may be correlated with other socioeconomic factors, like education and race. While sampling only saltwater license holders has its drawbacks, it was the most practical means of targeting a large number of high-frequency seafood consumers, one of the stated goals of the research. In 2011, the SCDNR began requiring all anglers aged over 16 years, whether fishing from shore or boat, to purchase a saltwater recreational fishing license. Therefore, the biases inherent in the initial study may be somewhat ameliorated by utilizing the more inclusive current license list in future sampling efforts. Additionally, surveys could be distributed to fishing clubs and community organizations in order to reach a more demographically representative sample population. For example, involving Gullah/Geechee organizations or female angler clubs would expand the reach of the survey to these previously underrepresented groups.

**Survey results.** The results indicate that a wide variety of anglers participated in the survey. The NC-targeted group had generally fished in the area longer than the CB county respondents. This information could be interesting from an epidemiological standpoint, as anglers fishing from a polluted area for long periods of time may be more likely to accumulate

deleterious levels of environmental toxins.<sup>9</sup> The NC group also contained a larger number of anglers who had fished more than 50 days in the last year. The data suggests as expected, that people who fish very frequently eat more seafood than the average angler. Of our respondents who fished more than 50 days, nearly half ate seafood two or more times per week compared to just over a quarter of those who fished less. Similarly, anglers who fished often ate more sport-caught fish than those who fished less. Of the anglers who fished more than 50 days last year, the vast majority ate at least one flounder meal during the year and almost one-half ate flounder two or more times per month. By comparison, of anglers fishing 50 days or less, just over half ate at least one flounder meal during the year and less than one-fifth ate flounder two or more times per month. The anglers who fished most often were also high-frequency consumers of the other inshore gamefish listed in the survey.

When asked if there were any areas in which anglers would hesitate or refuse to eat their catch, our respondents provided interesting and sometimes detailed information. Many anglers referred to very general places, such as industrial sites and marinas. Others referred to specific river systems, with the Ashley and Cooper Rivers mentioned most often. Some were even more detailed in their response, referring to specific creeks, such as Shipyard and Shem, and industrial sites, such as the Westvaco Paper Mill and the Navy Shipyard. Many of these sites correspond to the areas known to have increased levels of persistent environmental toxic chemicals.<sup>1,2</sup> These data suggest that many anglers are aware of the potential risks that accompany with eating seafood from contaminated areas and choose to harvest seafood from less polluted bodies of water. However, slightly less than one-half of anglers stated that they have no concerns about eating seafood anywhere within the area. There is some concern that many anglers, especially minorities, could be harvesting large amounts of fish and shellfish from polluted sources over long periods of time. Any future research in this area should deal more specifically with local anglers' knowledge on area's water quality and the potential risks associated with consuming seafood from contaminated areas.

When compared with previous angler surveys, our respondents generally reported eating fish less frequently. Lincoln et al.<sup>38</sup> found that 55% of Louisiana anglers surveyed ate fish once per week compared to 22% in our survey. Thirty-eight percent of Louisiana anglers reported eating fish more than once a week compared to 28% of our respondents. Taylor and Williamson<sup>39</sup> found that 78% of anglers in southern New England ate fish greater than once per week compared to 51% of our respondents. There is no much existing literature regarding seafood consumption patterns of recreational anglers in the southeastern United States, and most existing studies implemented in-person, telephone, or online surveys, which may return different results than our mail-in survey. Most surveys asked anglers about consumption of freshwater fish and saltwater fish from all sources. Many previous studies



only reported fish consumption in gram per day, which we are unable to compare with our results.

## Conclusion

When viewed as a pilot survey, the USC Sportsman Study was effective at creating very specific data on the seafood consumption of Charleston area residents. Given that previous data on local seafood consumption were nonexistent, researchers now have some basis for estimating consumption patterns of local anglers. More importantly, future studies attempting to collect consumption data in the area will be well served by evaluating what aspects of this study were successful and what aspects were not.

First, the relatively low overall response rate (23.4%) should be improved by trimming the length of the survey. In order to provide pilot data, the survey was very detailed and included several questions that dealt with a similar theme. By eliminating redundancy and excluding ineffective questions, the questionnaire's length could be easily reduced to a size that would prove less daunting for prospective respondents. Response rate could also be increased through greater use of incentives. Though a large number of incentives were not feasible for our study, evidence suggests that even small incentives have the potential for large increases in response.<sup>36</sup> Finally, response may be increased by timing survey drop dates to coincide with the winter months. This survey was primarily conducted during the busy summer months, and there is a reason to believe that a winter survey period might provide a sampling frame of individuals with more available free time (John Vena, personal communication).

Future survey attempts could increase success by targeting a more diverse group of fishermen. Our mail survey methodology and use of recreational saltwater license holders as a sampling frame led to a very high percentage of boat anglers. These anglers were overwhelmingly white, middle, or upper class and highly educated. Because all saltwater anglers are now required to purchase a recreational fishing license in South Carolina, the current license holder list may more closely reflect the demographics of the general population. In addition, the direct distribution of surveys with the potential for financial incentives to specific fishing clubs and community groups may improve the response of underrepresented segments of the population.

Despite its shortcomings, the USC Sportsman Study provided necessary initial data on the seafood consumption patterns of area anglers. It confirmed the prominence of high-frequency seafood consumers among local recreational anglers. The site-specific information on consumption will help future researchers assess threats to human health posed by persistent environmental contaminants.

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## Author Contributions

Conceived and designed the experiments: MTP. Analyzed the data: MTP, GV. Wrote the first draft of the article: MTP. Contributed to the writing of the article: MTP, TF, GV. Agreed with the article results and conclusions: MTP, TF, GV, EMW, JV. Jointly developed the structure and arguments for the article: MTP, TF, GV. Made the critical revisions and approved the final version: MTP, TF, GV, EMW, JV. All authors reviewed and approved the final article.

## REFERENCES

1. Sanger D, Holland A, Scott G. Tidal creek and salt marsh sediments in South Carolina coastal estuaries: I. Distribution of trace metals. *Arch Environ Contam Toxicol*. 1999;37(4):445–57.
2. Sanger D, Holland A, Scott G. Tidal creek and salt marsh sediments in South Carolina coastal estuaries: II. Distribution of organic contaminants. *Arch Environ Contam Toxicol*. 1999;37(4):458–71.
3. Vikas M, Dwarakish G. Coastal pollution: a review. *Aquatic Procedia*; 2015;4. International Conference on Water Resources, Coastal and Ocean Engineering (ICWRCOE'15):381–8.
4. USEPA. National Lake Fish Tissue Study; 2016. Available at: <https://www.epa.gov/fish-tech/national-lake-fish-tissue-study-results-and-data>.
5. USEPA. Fish and Shellfish Advisories and Safe Eating Guidelines; 2016. Available at: <https://www.epa.gov/choose-fish-and-shellfish-wisely/fish-and-shellfish-advisories-and-safe-eating-guidelines>.
6. FAO/WHO. *Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption*. Rome; Geneva: Food and Agriculture Organization of the United Nations; World Health Organization; 2011:50.
7. U.S. Department of Health and Human Services and U.S. Department of Agriculture. *2015–2020 Dietary Guidelines for Americans*. 8th ed. 2015. Available at: <https://health.gov/dietaryguidelines/2015/guidelines/>.
8. Burger J, Campbell K. Fishing and consumption patterns of anglers adjacent to the Oak Ridge Reservation, Tennessee: higher income anglers ate more fish and are more at risk. *J Risk Res*. 2008;11(3):335–50.
9. May H, Burger J. Fishing in a polluted estuary: fishing behavior, fish consumption, and potential risk. *Risk Anal*. 1996;16(4):459–71.
10. Beehler G, McGuinness B, Vena J. Polluted fish, sources of knowledge, and the perception of risk: contextualizing African American anglers' sport fishing practices. *Hum Organ*. 2001;60(3):288–97.
11. Toppe J. Which fish to eat: enjoying the benefits while minimizing the risks. *Procedia Food Science*; 2016:6. International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015):47–50.
12. Beehler G, McGuinness B, Vena J. Characterizing Latino anglers' environmental risk perceptions, sport fish consumption, and advisory awareness. *Med Anthropol Q*. 2003;17:99–116.
13. Niederdeppe J, Connelly N, Labuer T, Knuth B. Using theory to identify beliefs associated with intentions to follow fish consumption advisories among anglers living in the Great Lakes Region. *Risk Anal*. 2015;35:1996–2008.
14. USEPA. Summary of Environmental Information Collected for the Charleston/North Charleston Community-Based Environmental Protection (C/NC CBEP) Project. A Collaborative Project Conducted by the Environmental Protection Agency, Medical University of South Carolina, SC Department of Health and Environmental Control, And Charleston/North Charleston CBEP CAG; 1999. Available at: <https://www.epa.gov/sites/production/files/2015-09/documents/eval-cbep.pdf>.
15. White N, Balthis L, Fair P, et al. Elevated levels of perfluoroalkyl substances in estuarine sediments of Charleston, SC. *Sci Total Environ*. 2015;521:2:79–89.
16. Agency for Toxic Substances and Disease Registry. Toxic Substances Portal-Polycyclic Aromatic Hydrocarbons (PAHs). Available at: <https://www.atsdr.cdc.gov/phs/phs.asp?id=120&tid=25>. Accessed January 21, 2015.
17. Grandjean P, Clapp R. Perfluorinated alkyl substances: emerging insights into health risks. *New Solut*. 2015;25(2):147.
18. Saltwater Fishing Regulations. South Carolina Department of Natural Resources; 2007. Available at: <http://www.dnr.sc.gov/regs/pdf/saltfishing.pdf>. Accessed September 4, 2006.



19. Jacobs H, Kahn H, Stralka K, Phan D. Estimates of per capita fish consumption in the U.S. based on the continuing survey of food intake by individuals (CSFII). *Risk Anal.* 1998;18(3):283–91.
20. Portier KM, Um Y, Degner RL, Mack SK, Adams CM. Statistical Analysis of Florida Per Capita Fish and Shellfish Consumption Data. National Sea Grant Library: Florida Agricultural Market Research Center Industry report 95–1; 1995:1–11.
21. Burger J, Gochfeld M. Role of wild game in the diet of recreationists in South Carolina. *J Environ Plan Manage.* 2002;45(1):103–28.
22. Williamson D, Choury E, Hilsdon R, Taylor B. Improving data quality in community-based seafood consumption studies by use of two measurement tools. *J Environ Health.* 2004;67(3):9–13.
23. Tran NL, Barraj L, Smith K, Javier A, Burke TA. Combining food frequency and survey data to quantify long-term dietary exposure: a methyl mercury case study. *Risk Anal.* 2004;24(1):19–30.
24. Schaefer A, Jensen E, Bossart G, Reif J. Hair mercury concentrations and fish consumption patterns in Florida residents. *Int J Environ Res Public Health.* 2014;11(7):6709–26.
25. Mendola P, Robinson L, Buck G, et al. Birth defects risk associated with maternal sport fish consumption: potential effect modification by sex of offspring. *Environ Res.* 2005;97(2):134–41.
26. Gagnon F, Tremblay T, Rouette J, Cartier J. Chemical risks associated with consumption of shellfish harvested on the north shore of the St. Lawrence River's lower estuary. *Environ Health Perspect.* 2004;112(8):883–8.
27. Bloom M, Swanson M, Vena J, Moysich K, Olson J. Profiles of ortho-polychlorinated biphenyl congeners, dichlorodiphenyldichloroethylene, hexachlorobenzene, and Mirex among male Lake Ontario sportfish consumers: The New York State Angler Cohort Study. *Environ Res.* 2005;97(2):178–94.
28. Bloom M, Vena J, Olson J, Kostyniak P. Assessment of polychlorinated biphenyl congeners, thyroid stimulating hormone, and free thyroxine among New York state anglers. *Int J Hyg Environ Health.* 2009;212(6):599–611.
29. Karmaus W, Zhu X. Maternal concentration of polychlorinated biphenyls and dichlorodiphenyl dichloroethylene and birth weight in Michigan fish eaters: a cohort study. *Environ Health.* 2004;3(1):1.
30. Burger J. Regular article: consumption patterns and why people fish. *Environ Res.* 2002;90:125–35.
31. Burger J, Gaines K, Gochfeld M. Ethnic differences in risk from mercury among Savannah river fishermen. *Risk Anal.* 2001;21(3):533–44.
32. Allen M, Diehl D, Velez P, McFadden S, Kelsh M. Demographic variability in seafood consumption rates among recreational anglers of Santa Monica Bay, California, in 1991–1992. *Fishery Bull.* 1996;94(4):597–610.
33. Myrland O, Trondsen T, Johnston R, Lund E. Determinants of seafood consumption in Norway: lifestyle, revealed preferences, and barriers to consumption. *Food Qual Preference.* 2000;11(3):169–88.
34. Honkanen P, Olsen S, Verplanken B. Intention to consume seafood – the importance of habit. *Appetite.* 2005;45(2):161.
35. Laska D, Vena J. Seafood Consumption Habits of South Carolina Shrimp Baiters: A Pilot Study. Unpublished 2006 Report. University of South Carolina, School of Public Health, Department of Epidemiology and Biostatistics, Columbia, SC 29208.
36. Dillman D. *Mail And Telephone Surveys: The Total Design Method [e-book]*. New York, NY: Wiley; 1978:c1978.
37. State & County Quickfacts. U.S. Census Bureau; 2010. Available at: <http://quickfacts.census.gov>. Accessed September 8, 2016.
38. Lincoln RA, Shine JP, Chesney EJ, Vorhees DJ, Grandjean P, Senn DB. Fish consumption and mercury exposure among louisiana recreational anglers. *Environ Health Perspect.* 2011;119(2):245–51.
39. Taylor DL, Williamson PR. Mercury contamination in Southern New England coastal fisheries and dietary habits of recreational anglers and their families: implications to human health and issuance of consumption advisories. *Marine Pollut Bull.* 2016;doi: 10.1016/j.marpolbul.2016.08.072.