

Role of Wild Game in the Diet of Recreationists in South Carolina

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ABSTRACT Risk assessors have devoted considerable attention to the consumption of fish in the diet of recreational and subsistence anglers, but little attention has been directed toward the percentage that wild game contributes to total protein intake for people who engage in hunting and fishing. While recall studies have limitations, the relative errors should be similar for different types of fish and game. We interviewed 454 people attending the Palmetto Sportsmen's Classic in South Carolina to determine their consumption patterns of domesticated animals, fish (both wild-caught and commercial) and wild game. The percentage of people who consumed each type of meat was: chicken (98%); beef (95%); wild-caught fish (79%); deer (79%); restaurant fish (73%); pork (71%); dove (47%); commercial fish (41%); wild turkey (40%), duck, squirrel and self-caught quail (about 25% each); restaurant quail (10%); and raccoon (11%). Although a similar proportion of white respondents and black respondents consumed wild game overall (90%), there were ethnic differences in the number of meals of wild-caught fish and game. Black respondents ate more wild-caught fish, rabbit, raccoon and squirrel, and less deer, than did white respondents. Wild-caught fish and game made up 50% of the meat and fish diet of black sportsmen, but only 32% for whites. Wild-caught fish and game were being eaten disproportionately more by low-income black respondents, while more deer was consumed by higher-income black respondents. The data suggest that managers and planners should take into account age, ethnicity and income when (1) conducting exposure assessments, (2) considering consumption patterns for wild-caught fish and game and (3) managing risk from wild-caught fish and game. The data will be especially useful to policy makers and risk managers who are designing consumption advisories, for risk communicators in identifying the target audience and for managers designing long-term stewardship for sites with contamination.

Introduction

In their daily lives, people are faced with a variety of hazards, and must recognize the hazards, evaluate the risks and act accordingly. The decisions that

are faced daily include what foods to eat, what mode of transportation and route to follow and what medicines to take, among many others. The choices that people make are influenced by their risk perceptions, which are often a result of subjective or non-formal judgements and intuition, as well as objective, more scientific knowledge (Slovic, 1987, 1993; Kasperson *et al.*, 1988; Keeney & von Winterfeldt, 1991; Kamrin & Fischer, 1999). In the following paper we equate risk with the probability of an adverse effect. As a rule, people overestimate negligible risks and underestimate significant ones (Slovic *et al.*, 1979), and their judgements often differ from those of the experts. People often underestimate risks that they consider voluntary or that are familiar (Lowrance, 1976), and overestimate the risks that are foisted upon them, such as proximity to hazardous waste management facilities (Kraus & Slovic, 1988; Schwing & Kamerud, 1988; Trimble, 1988). Risk judgements are often optimistically biased (Weinstein, 1984, 1989); people believe their own risk is less than that of the general public. These principles apply to diets, for people make food choices that are familiar and eat foods that are perceived as safe, as well as desirable.

However, in many instances, the choices people face are not just between doing or not doing a particular thing, but are between many alternatives that involve both costs and benefits. Thus people must balance the risks and benefits of several alternatives, and arrive at a course of action. Such balancing is particularly important in the choice of what foods to eat, because each person must consider not only health costs and benefits of each type of meat or fish, but also other considerations, such as personal likes and dislikes, accessibility, convenience and cost.

Assessing the health risks and benefits of foods such as fish can be difficult. While fish provide many benefits, such as reducing cholesterol levels and reducing cardiovascular disease (Horn, 1992; Daviglus *et al.*, 1997), and providing social interactions (Toth & Brown, 1997), contaminants in some fish can pose a threat, particularly to foetuses and developing newborns (Ratcliffe *et al.*, 1996; Weiss & Elsner, 1996). A positive relationship exists between mercury levels in fish, fish consumption by pregnant women and deficits in neurobehavioural development in children (Weihe *et al.*, 1996), and mercury accounts for most of the consumption advisories in US waters. Other contaminants of concern are polychlorinated biphenyls, chlordane, dioxins and dichloro-diphenyl-trichloro-ethane (Environmental Protection Agency (EPA), 1996, 2000).

Understanding the risks from consuming wild-caught fish and game has gained attention recently because of the increase in the number of water bodies with consumption advisories (EPA, 1996, 2000), and because of increases in our understanding of the role of wild fish and game in the diets of Native Americans (Fitzgerald *et al.*, 1995; Harris & Harper, 1998) and various recreational and subsistence hunters and fishers (Burger *et al.*, 1992, 1998a, 1999a, b; Velicer & Knuth, 1994; Fleming *et al.*, 1995; Toth & Brown, 1997). In most cases, studies of consumption patterns and risk perception deal with self-caught fish, yet the decisions people face include not only whether to eat wild fish and game, what species to eat and how much to eat, but also what other sources of protein to eat. Studies of fish consumption normally examine only fish consumption, and not other game or other protein sources.

In this paper we examine the meat and fish consumption patterns of people interviewed at the Palmetto Sportsmen's Classic in Columbia, South Carolina, in

1998 to determine the total amount of wild fish and game eaten. We tested whether ethnicity, gender, age or income (or a combination of these factors) affected consumption patterns. These factors are normally associated with fish consumption patterns (Fleming *et al.*, 1995; Burger *et al.*, 1999a, b), and might be associated with the consumption of wild game as well. We use multiple regression analysis to determine which of these factors affect consumption patterns, and then examine the factors which contribute significantly to provide information which could be used by risk managers to reduce risk where wild fish or game are contaminated. Such information is also useful to regulators and planners who must design consumption advisories and public information brochures.

Most studies examine only the risk from self-caught fish (i.e. Fleming *et al.*, 1995; Burger *et al.*, 1999a, b), and other sources of game are usually not included in risk assessments. Partly this is because there is no information on the rate of consumption of other species of fish and game. This question is of interest where sites with low-level contamination, such as the Department of Energy's (DOE's) Savannah River Site (SRS), may be opened for additional hunting and fishing. It is particularly critical to obtain site-specific information, since consumption patterns may vary dramatically in different parts of the country and in different groups. The relative role of hunting versus fishing may differ geographically; in some places game may play a more important dietary role, in others fishing may be more important. While we did not expect a large percentage of our sample to live close enough to the SRS to hunt or fish there, the Sportsmen's Classic provided a venue for obtaining a more general picture of overall consumption patterns that might be typical of people in South Carolina.

In the case of the SRS, hunting is already allowed on-site for a limited period each year (Sanchez & Burger, 1998), and fishing is allowed on the Savannah River (Burger, 1998), which borders the site and receives water from several creeks on site (Figure 1). While the potential risk from consumption of fish from the Savannah River has been examined by state agencies and researchers (Burger, 1998; Burger *et al.*, 1999b), less attention has been paid to other wild game, except for mourning doves (*Zenaid macroura*) (Burger *et al.*, 1998a). The state of South Carolina has issued fish consumption advisories for the Savannah River based on levels of mercury and radionuclides, although mercury is the primary contaminant of concern (South Carolina Department of Health and Environmental Control (SCDHEC), 1996, 1999, 2000). Both mercury and caesium (^{137}Cs) are sufficiently elevated to pose some health risk to people consuming fish from the Savannah River (Burger *et al.*, 2001a, b), but advisories for other game are seldom given. Understanding the patterns of consumption of additional game is important for assessing potential risks from the SRS, since fishermen could be consuming wild game as well as contaminated fish from the Savannah River (Burger *et al.*, 1999b), as well as other lakes and waterways (SCDHEC, 2000). The EPA expressed a particular interest in understanding local exposure to a wide variety of wild fish and game, which could serve as a model for other sites regionally. It is clear that designing a long-term stewardship plan for DOE sites, and other Superfund sites, requires an understanding of the possible routes of exposure.

Increasingly, risk assessors are interested in the factors that place some groups of people at more risk than others, and in defining such groups. On the basis of the 1987 National Health Interview Survey, whites eat a more varied diet than

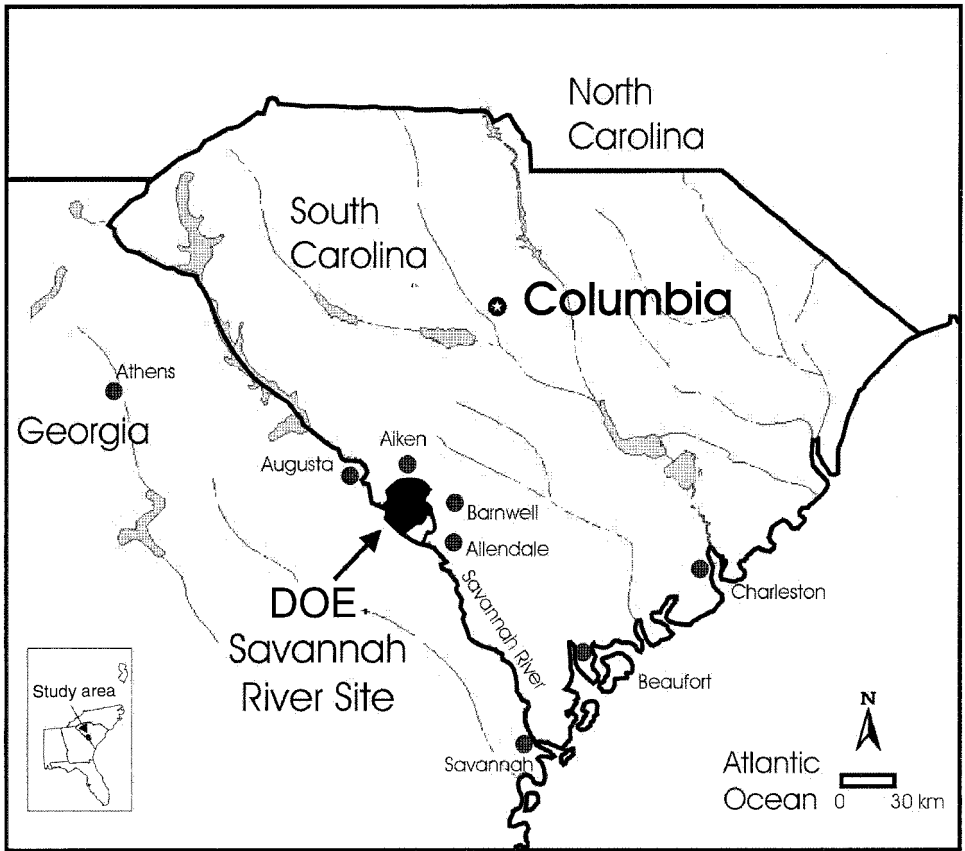


Figure 1. Map of South Carolina and Georgia showing the location of the Palmetto Sportsmen's Classic in Columbia, and the SRS.

blacks (Patterson *et al.*, 1995); this study, however, did not examine any wild-caught foods. While there are both risks and benefits from the consumption of many different types of meats and fish, the consumption of wild-caught foods is potentially riskier because these foods are not subject to regulation and inspection by the federal government, and some fish and game contain contaminants that exceed the allowable limits, as is clear from the number of water bodies in the USA with consumption advisories (EPA, 2000).

Methods

Subjects

We interviewed 454 people attending the Palmetto Sportsmen's Classic in Columbia, South Carolina (27–29 March 1998). This is an event housed in several buildings that has demonstrations, booths and educational talks that relate to outdoor activities and sports, cars and equipment and the history of the region. A small number of people were interviewed along the Savannah River, but their responses did not differ from the larger sample, and are not considered further. This event was attended by about 60 000 people, who visited the display and educational booths, food courts and vendors. Columbia is the capital of South

Carolina and is the population centre for the region (Figure 1). It is located about 80 km from the SRS.

We chose the Palmetto Sportsmen's Classic because (1) it attracted people who hunt and fish, (2) it also attracted people interested in the recreational boating and other outdoor activities, (3) it was sufficiently near the SRS that people could hunt and fish there (Burger *et al.*, 1997), yet it was far enough away that few people interviewed worked at the SRS, which might have biased their actions or responses, (4) hunting and fishing rates might be sufficiently high in this part of the country (US Fish & Wildlife Service, 1996), (5) there is already limited hunting and fishing on or adjacent to the SRS, making it a realistic regulatory concern (Sanchez & Burger, 1998) and (6) the SRS is sufficiently large, with buffer zones around the industrial activities, for recreation to be a potential future land use for larger areas of this site, and has been so recognized in the future use report (DOE, 1996).

Interview Procedures

Subjects were interviewed individually while they waited in lines, were eating or were standing about. The interviews were conducted by eight interviewers who had conducted similar interviews in the past, and were specifically trained for this project.

We walked transects through the exhibit halls and grounds, interviewing a person, and then walking 2 m before interviewing the next person. Upon completing that interview, we interviewed the next person 2 m away along our transect (or the first person thereafter). This ensured that people were interviewed at all areas of the show. Nearly everyone (96%) we approached agreed to answer our interview, and those who declined were in a hurry, attending small, impatient children or about to leave the show. Most people were interested in sports or outdoor recreation, and came with their families or friends to spend the day. We identified ourselves as researchers from Rutgers University who were interested in how much they ate of different types of meat and fish. At the end of the interview we explained more fully what we were doing to those interested. Most people were interested in the survey, and inquired about how they could find out our results.

The questionnaire was divided into three parts dealing with demographics, number of meals consumed of several different types of meat by month for the past year, and information concerning serving size. Information about the number of meals for each meat or fish type was placed in a table, and people were prompted for each type and for each month. We also asked them whether they ate each item during particular hunting or fishing seasons. Species of interest included wild-caught fish, store-bought fish, restaurant fish, deer, wild-caught quail, restaurant quail, dove, duck, rabbit, squirrel, raccoon, wild turkey, beef, chicken and pork. This list was derived from interviews at a prior Sportsmen's Classic, and from interviews with hunters and fisherman along the Savannah River (Burger *et al.*, 1997; Sanchez & Burger, 1998). We specifically asked about wild-caught, restaurant and store-bought fish, and about wild-caught and restaurant quail, because on previous surveys people had indicated that they consumed these categories. Respondents were asked if they ate any other wild game. We did not ask them how many days they hunted and fished because previous studies here and elsewhere indicated that a greater proportion of

people ate wild-caught game than actually hunted or fished for themselves (Burger, 1999a, b).

Subjects were then asked about serving size, and whether they fed each meat type to their children or pets. Cues to portion size were given by providing subjects with a three-dimensional model of an 8 ounce (225 g) fish fillet for comparison with their typical meals, and interviewers mentioned tuna cans as an additional prompt. Further, subjects have an idea of how much beef they eat because, in many restaurants and fast food establishments, menus list how many ounces are in portions of steak or hamburgers. The estimate, in ounces consumed, was converted to grams for this paper.

Demographic information included ethnicity, gender, age, location of residence, occupation and income. Because of the potentially delicate nature of the demographic information, such as income, these questions were asked last. Subjects self-identified ethnicity. We also asked whether and where they had heard warnings about fish consumption, whether they worked at the SRS and whether they (or their wives for men) changed fish consumption patterns when they were pregnant.

The entire survey took about 20 minutes to complete, although some people lingered longer to ask questions about our research. The length of the survey is within the guidelines suggested for dietary surveys (Block *et al.*, 1986). In general, people were interested, and volunteered information about how and why they ate each type of food, including providing recipes for raccoon, squirrel and other wild game.

We computed consumption by determining, for each of the 12 months for each person, the average number of meals eaten as meat, and the average number of meals eaten as stew. Each of these was then multiplied by the average serving size for each meat or fish type. These were summed across months to obtain the total yearly consumption rate.

Statistical Analysis

We used regression procedures (SAS Institute, Inc., 1994, 1996) to determine if age, ethnic group, gender, income or county of residence contributed to differences in the number of meals for all meat and fish meals and wild fish and game meals, as well as for differences in consumption. The procedure adds the variable that contributes the most to the R^2 , then adds the next variable that increases the R^2 the most, continuing until all significant variables are added. Thus independent variables are entered only if they add significantly to explaining the variation. The procedure also allows for interaction variables (income \times ethnicity). The independent variables with the highest F values generally contributed the most to explaining the variation in the dependent variable (amount consumed).

We used Kruskal–Wallis χ^2 tests to determine whether there were differences as a function of race, age and income (SAS Institute, Inc., 1994, 1996). A more detailed examination of gender differences can be found in Burger (2000). Means and standard errors are given in the text. For analysis, the data were divided by age classes: 32 years and under; 33–45 years; and 46 years and over; and income was divided as: up to \$20 000; \$21 000–30 000; and over \$30 000. These categories were selected because of their use in previous, similar studies (Burger *et al.*, 1999a, b).

Table 1. Ethnic difference for various demographic characteristics and consumption patterns for people interviewed

Characteristic	Black		White		Kruskal-Wallis $\chi^2(p)$
	Range	Mean	Range	Mean	
Sample		39		415	
Age	26-73	41.9 ± 1.86 ^a	11-74	39.9 ± 0.63	0.54 (NS)
Self-health rating	2-5	3.70 ± 0.15	1-5	4.13 ± 0.04	9.43 (0.002)
Income	0-60 000	20 900 ± 2620	0-300 000	32 800 ± 1560	11.8 (0.0006)
Yearly consumption (kg)					
All game (no fish)	0-57.4	14 ± 3	0-184	16.2 ± 1.21	0.09 (NS)
All wild-caught fish and game	0-265	63 ± 11	0-232	26.4 ± 1.76	7.55 (0.006)
All meat and fish	0-268	125 ± 10	0-403	83.3 ± 2.85	17.8 (0.0001)

NS, not significant.

^aMean plus or minus standard error.

Results

Demographics

The mean age of subjects was 40 years (range of 15-74, Table 1). Most of the subjects were men (70%), reflecting attendance at the exhibits. Only 9% of those interviewed were black, reflecting attendance (about 6% black according to local officials), and only 6% worked, or had ever worked, at the SRS. There were significant differences in mean income, with white respondents earning 50% more than blacks (Table 1). Of those sampled, 19% lived in Richland, 19% lived in Lexington and 8% lived in Aiken counties; we interviewed people from 38 of the 46 counties in South Carolina. Occupations included technical (21%), sales and service (18%), administrative and clerical (14%), professional (13%), retired (8%), government service (8%) and a variety of other occupations.

Species Consumed

The species of meat and fish consumed by the population overall included chicken (98% of respondents), beef (95%), wild-caught fish (79%), deer (79%), restaurant fish (72%), pork (71%), dove (47%), store-bought fish (41%), wild turkey (40%), duck, squirrel and quail (25% each), restaurant quail (13%) and raccoon (10%). There were significant ethnic differences in the percentage of people who ate several species of wild game, with a higher percentage of whites eating deer, restaurant fish and quail, and a higher percentage of blacks eating rabbit, raccoon and squirrel (Table 2).

Seasonal Patterns

There were seasonal patterns in the consumption of wild fish and game, self-caught fish and deer (Figure 2). In general, people ate more fish in the summer months and more deer in the winter months. However, nearly everyone reported freezing both self-caught fish and deer for later consumption. Although there was also a seasonal pattern in the consumption of ducks, so few people ate them that they were insignificant in the overall consumption patterns.

Table 2. Ethnic differences as percentage of people eating different types of fish and meat

	Percentage who ate some wild fish/game			Contingency ^b $\chi^2(p)$
	All respondents ^a	Black	White	
Sample	458	39	415	
Beef	94.6	92.3	94.8	0.45 (NS)
Chicken	98.0	100.0	97.8	0.89 (NS)
Deer	78.8	64.1	80.2	5.48 (0.02)
Dove	46.8	35.9	47.8	2.03 (NS)
Duck	25.7	15.4	26.7	2.39 (NS)
Fish, restaurant	74.1	33.3	78.0	37.0 (0.001)
Fish, store	41.0	33.3	41.8	1.04 (NS)
Fish, wild-caught	78.9	79.5	78.8	0.01 (NS)
Pork	71.3	63.3	73.5	1.19 (NS)
Quail, restaurant	13.4	0.00	14.7	6.62 (0.01)
Quail, wild-caught	24.2	10.3	25.5	4.53 (0.03)
Rabbit	28.6	53.9	26.2	13.3 (0.001)
Raccoon	10.6	51.3	6.75	74.8 (0.001)
Squirrel	26.4	51.3	24.0	13.6 (0.001)
Turkey, wild	40.1	28.2	41.3	2.52 (NS)

NS, Not significant.

^aA small number of people did not identify their ethnicity.

^bThis test compares black and white respondents.

Factors Affecting Number of Meals and Serving Sizes

The number of meals per year varied by the type of fish or game (Figure 3). There were significant models explaining variations in total wild-caught meals, self-caught fish meals and raccoon meals (Table 3), although the amount of variation explained is low, largely because much of the variation is due to seasonality (see Figure 2). We did not include seasonality in the models presented because we wanted to examine the other independent variables in detail. There was no significant model for total number of meat and fish meals consumed. For deer, only ethnicity entered ($F = 2.9$, $p < 0.08$). In general, income, ethnicity and sometimes age (and interactions among these variables, such as income \times ethnicity) explained the variation. We did not construct models for the other wild game types because they were so rarely consumed. Since gender did not enter as a significant variable, it is not included further in this paper. We use the models to indicate what factors affect consumption patterns, and then examine each one separately so that the information can be used in risk management and risk communication.

There were significant ethnic differences in the mean number of meals per month for different types of meat and fish (Table 4). Black respondents ate significantly more meals of chicken, wild-caught fish, rabbit, raccoon and squirrel, while white respondents ate significantly more meals of deer, restaurant fish, pork and quail. There were fewer ethnic differences in mean serving size, although blacks ate larger portions of self-caught fish and smaller portions of restaurant fish than whites (Table 4). Blacks also ate larger portions of wild-caught game, including rabbit, raccoon and squirrel.

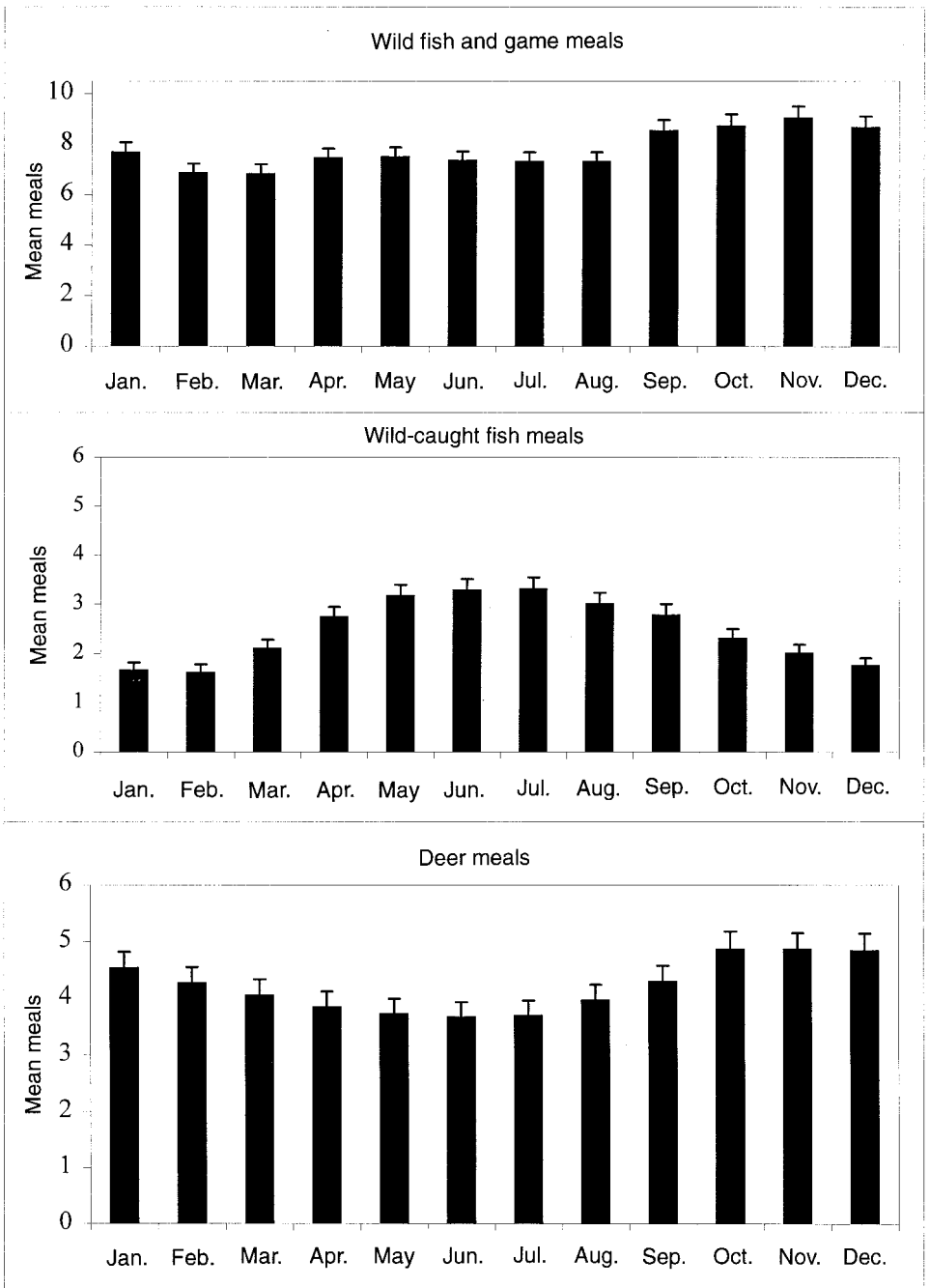


Figure 2. Seasonal differences in mean number (plus or minus standard error) of monthly meals of wild fish and game, wild-caught fish and deer for people interviewed.

The distribution pattern for total fish and meat meals, and wild fish and game meals, indicates that blacks are eating more total fish and meat meals, and more wild fish and game meals, than whites (Figure 4).

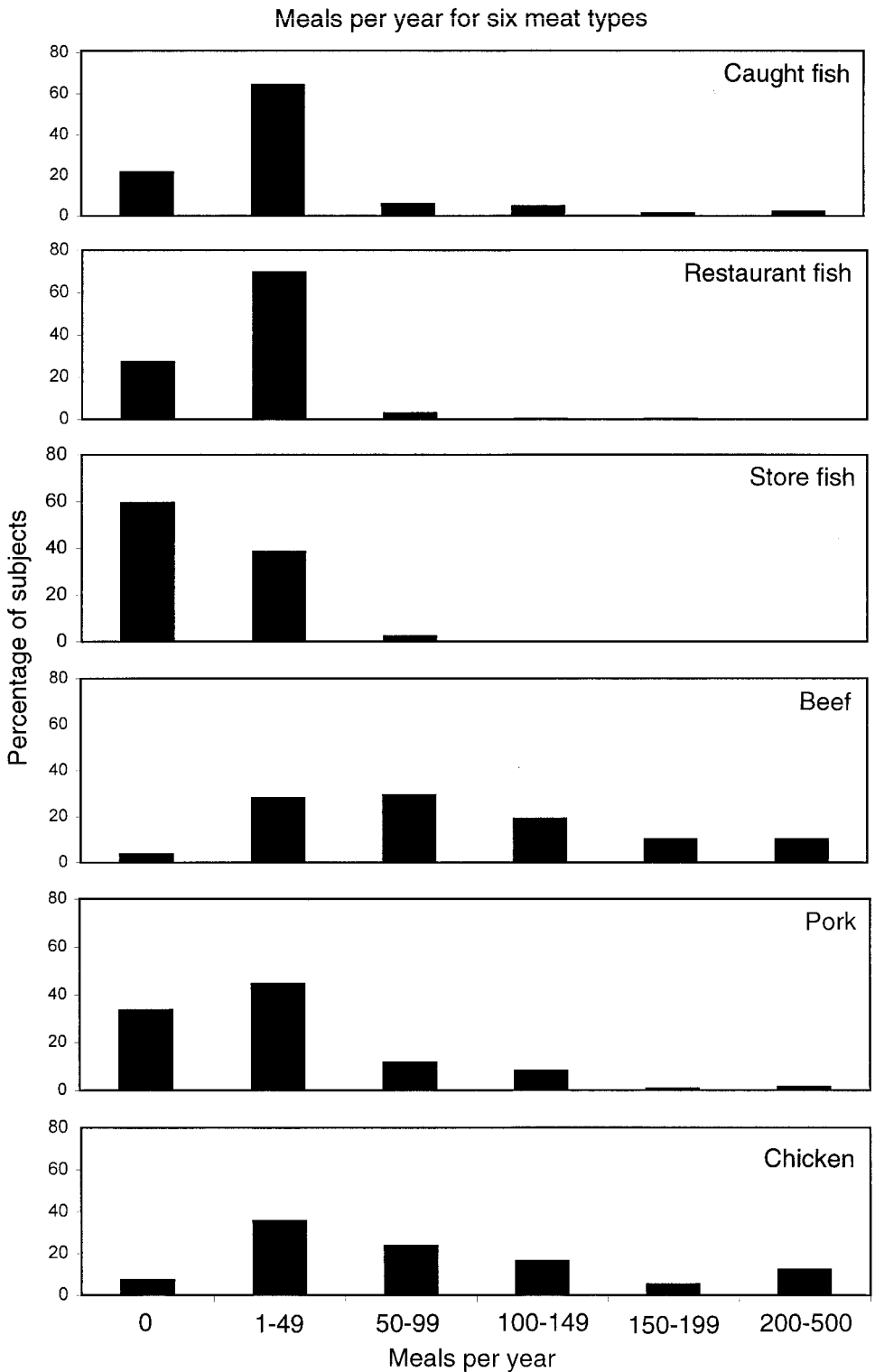


Figure 3. Percentage of people eating different numbers of meals per year of several types of fish and meats, for subjects interviewed.

Table 3. Models explaining variations in total annual meals; the model for deer was not significant ($p < 0.08$)

	Total meat and fish meals	Total wild fish and game meals	Self-caught fish meals	Raccoon meals
Model				
<i>F</i>	0.62	4.68	22.0	48.9
Degrees of freedom	6105	6342	6357	6357
r^2	0.04	0.08	0.27	0.46
<i>p</i>	0.71	0.0001	0.0001	0.0001
Independent variables (<i>F</i> , <i>p</i>) ^a				
Ethnicity	NS	7.88 (0.005)	28.2 (0.0001)	7.96 (0.005)
Gender	NS	NS	NS	NS
Income	NS	11.7 (0.0007)	37.2 (0.0001)	36.1 (0.0001)
Age	NS	NS	NS	11.3 (0.0009)
Income × ethnic	NS	9.44 (0.002)	32.6 (0.0001)	34.0 (0.0001)
Age × income	NS	NS	NS	9.31 (0.003)

NS, Not significant.

^aEthnicity and gender were categorical variables; income and age were continuous variables.

Consumption Patterns

Consumption patterns are a function of the number of meals consumed and the serving size. There were significant models explaining variations in consumption patterns for total meat and fish, wild-caught fish and game, wild-caught fish, deer and raccoon meals (squirrel, quail and rabbit were not examined separately). Income, ethnicity and age entered all models (either separately or as an interaction), while gender entered all models except raccoon (Table 5). In general, dependent variables with the highest *F* values are the most significant contributors to explaining the variation.

For wild-caught fish and game, income was generally the strongest contributing factor (Table 5). Consumption of beef and chicken increased significantly with income, while wild-caught fish and game (dove, rabbit, raccoon and squirrel) consumption decreased with increasing income (Table 6).

There were significant ethnic differences in consumption for several species, including chicken, pork, deer, fish, rabbit and raccoon (Table 7). Whites consumed significantly more beef, deer and restaurant fish, and significantly less of the other meats and fish than blacks.

The interaction between income and ethnicity is similar for most wild-caught fish and game (Figure 5). For blacks, those with lower incomes ate significantly more wild-caught fish and game than those with higher incomes. For deer, middle-income whites and higher-income blacks ate significantly more than other groups (Figure 5).

There were fewer clear patterns with age (Table 8). Middle-aged people ate more doves, raccoon, squirrel and wild-caught fish, and less deer meat, than the other age groups. When ethnicity and age are considered together, however, the patterns are clearer (Figure 6). Middle-aged blacks are consuming higher quantities of wild-caught fish and squirrel than others, while older blacks are consuming more rabbit, and younger blacks are consuming more raccoon, than others.

Table 4. Comparison of mean monthly meals and mean serving size between blacks and whites interviewed; serving size was determined after subjects viewed models of known size

Meal type	Mean monthly meals		Kruskal-Wallis $\chi^2(p)$	Mean serving size (g)		Kruskal-Wallis $\chi^2(p)$
	White	Black		White	Black	
Sample	415	39		415	39	
Beef	8.68 ± 0.41 ^a	7.48 ± 1.10	0.62 (NS)	245 ± 6.34	255 ± 28.3	0.12 (NS)
Chicken	9.20 ± 0.36	9.90 ± 0.78	3.18 (0.07)	226 ± 5.46	230 ± 17.0	0.01 (NS)
Deer	4.50 ± 0.31	2.42 ± 0.63	6.11 (0.01)	238 ± 9.35	185 ± 35.1	2.07 (NS)
Dove	0.30 ± 0.03	0.27 ± 0.09	1.28 (NS)	103 ± 8.97	60.6 ± 17.4	2.90 (NS)
Duck	0.12 ± 0.02	0.11 ± 0.06	2.05 (NS)	74.9 ± 8.28	24.1 ± 10.7	2.72 (NS)
Fish, restaurant	1.21 ± 0.08	0.57 ± 1.31	18.9 (0.0001)	217 ± 9.37	66.9 ± 19.5	30.1 (0.0001)
Fish, store	0.74 ± 0.07	0.73 ± 0.21	0.41 (NS)	125 ± 9.73	89.7 ± 28.4	1.64 (NS)
Fish, wild-caught	2.00 ± 0.15	7.75 ± 1.31	15.3 (0.0001)	322 ± 14.2	366 ± 43.3	2.61 (0.02)
Pork	3.45 ± 0.43	3.10 ± 0.71	0.29 (NS)	156 ± 15.4	147 ± 27.7	0.02 (NS)
Quail, restaurant	0.08 ± 0.02	0.00 ± 0.00	6.57 (0.01)	41.1 ± 6.45	— ^b	
Quail, wild-caught	0.14 ± 0.15	0.06 ± 0.03	4.19 (0.04)	79.6 ± 8.93	37.5 ± 19.8	2.53 (NS)
Rabbit	0.12 ± 0.02	0.56 ± 0.13	20.7 (0.0001)	65.0 ± 7.47	119 ± 23.8	10.2 (0.001)
Raccoon	0.02 ± 0.00	0.58 ± 0.12	83.8 (0.0001)	18.0 ± 3.83	147 ± 32.4	54.2 (0.0001)
Squirrel	0.11 ± 0.02	0.57 ± 0.13	20.8 (0.0001)	64.0 ± 9.58	112 ± 236	10.2 (0.001)
Turkey, wild	0.18 ± 0.03	0.16 ± 0.06	1.77 (NS)	127 ± 18.5	72.6 ± 24.6	1.75 (0.009)

NS, Not significant.

^aMean plus or minus standard error.

^bNo one ate in this category.

Table 5. Models explaining variations in total annual consumption patterns for people interviewed

Model	Total meat and fish	Total wild-caught fish and game	Wild-caught fish only	Raccoon meat only	Deer meat only
<i>F</i>	11.9	10.3	21.4	47.2	2.42
Degrees of freedom	6357	6357	6357	6357	6357
<i>r</i> ²	0.17	0.15	0.27	0.45	0.04
<i>p</i>	0.0001	0.0001	0.0001	0.0001	0.03
Independent variables (<i>F, p</i>) ^a					
Ethnicity	NS	14.6 (0.0002)	31.6 (0.0001)	NS	NS
Gender	35.6 (0.0001)	13.0 (0.0004)	4.62 (0.03)	NS	10.7 (0.001)
Income	8.07 (0.005)	18.7 (0.0001)	32.0 (0.0001)	40.0 (0.0001)	NS
Age	NS	NS	NS	33.4 (0.0001)	NS
Income × ethnicity	10.3 (0.001)	13.8 (0.0002)	26.0 (0.0001)	38.6 (0.0001)	NS
Age × ethnicity	NS	NS	4.41 (0.04)	30.9 (0.0001)	NS

NS, Not significant.

^aEthnicity and gender were categorical variables; income and age were continuous.

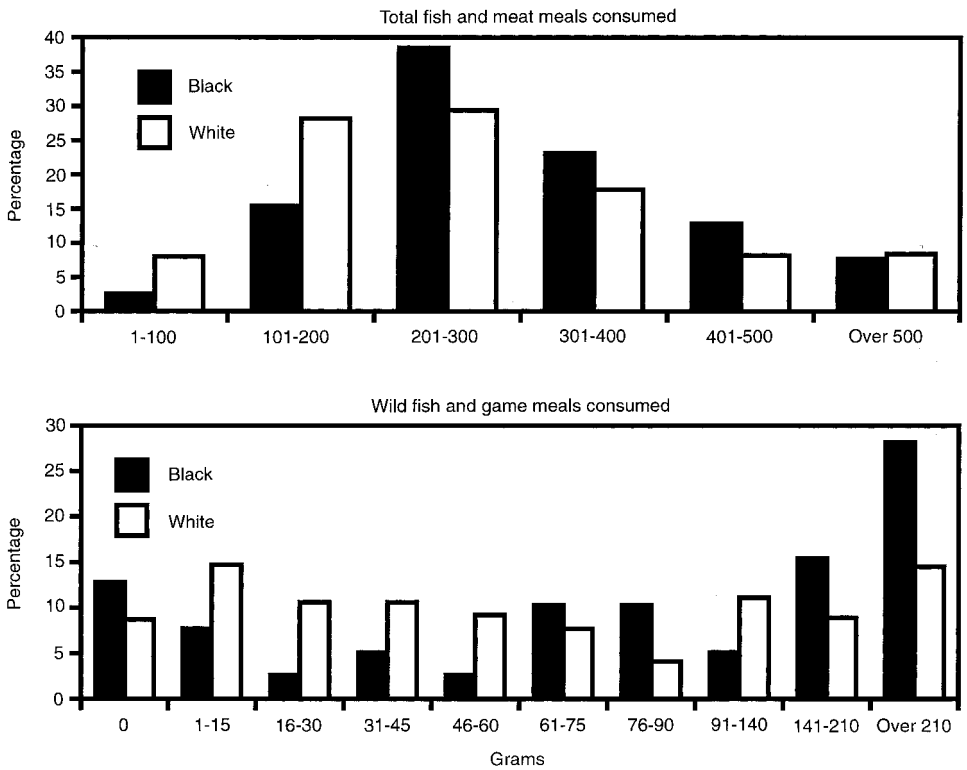


Figure 4. Ethnic differences in the total number of fish and meat meals per year (both commercial and wild-caught, top) and total number of wild-caught fish and game meals per year (bottom) for people interviewed.

Discussion

Methodological Considerations

Methodological problems with this paper involve both our sampling method and concerns with recall of dietary intake (see below). While our sample was a convenience sample at an event, there is no reason to assume that it does not represent the people who attended the event since we deliberately moved through the area in transects, and interviewed people at regular intervals. Many convenience samples do not have a predetermined systematic sampling plan that involves a grid pattern. Such a design ensures more adequate sampling, removing interviewer bias in selection (Buckland *et al.*, 1993). The sample contained both men and women in the same proportion as were present. The only potential bias is that people who attended the event were interested in outdoor activities, and they would have represented the high end of wild game consumption.

Further, the survey represents those who attended the event, and not necessarily the population of South Carolina generally. This is particularly true, given our relatively small sample of blacks. Although they were not under-represented in our sample (compared with the event), they were for South Carolina as a whole. Further work should particularly target this population. Few other ethnic

Table 6. Income differences in total yearly consumption (g) for people interviewed

	< US\$20 000	US\$20 000–30 000	> US\$30 000	Wilcoxon χ^2 (p)
Sample	98	95	172	
Beef	21 700 ± 3140 ^a	25 400 ± 2880	28 500 ± 2250	8.69 (0.01)
Chicken	22 600 ± 2500	25 400 ± 2690	28 900 ± 2300	5.86 (0.05)
Deer	17 000 ± 3100	13 300 ± 2480	13 400 ± 1480	1.18 (NS)
Dove	1 180 ± 276	519 ± 105	690 ± 103	0.97 (NS)
Duck	244 ± 91.8	303 ± 92.0	286 ± 59.5	1.71 (NS)
Fish, restaurant	1 980 ± 390	2 870 ± 474	3 710 ± 463	11.5 (0.003)
Fish, store	1 930 ± 441	3 080 ± 717	2 220 ± 329	0.29 (NS)
Fish, wild-caught	30 900 ± 4920	9 800 ± 2020	9 360 ± 1070	10.6 (0.005)
Pork	1 600 ± 740	2 690 ± 721	1 190 ± 302	5.16 (0.08)
Quail, restaurant	67.9 ± 31.4	84.3 ± 41.4	356 ± 115	6.48 (0.04)
Quail, wild-caught	496 ± 114	249 ± 90.6	736 ± 216	0.13 (NS)
Rabbit	598 ± 154	363 ± 94.9	269 ± 71.7	5.47 (0.06)
Raccoon	972 ± 245	54.5 ± 31.3	72.4 ± 36.4	46.0 (0.0001)
Squirrel	727 ± 156	491 ± 153	193 ± 62.4	11.9 (0.003)
Turkey, wild	1 080 ± 521	436 ± 104	591 ± 109	0.45 (NS)

NS, Not significant.

^a Mean plus or minus standard error.

groups are represented either in our sample or in South Carolina generally (US Census data).

Two possible concerns with recall dietary studies are reliability over time, and recall errors. Studies of short-term reproducibility of dietary history indicate that there is a fairly high and significant correlation in recall (repeated measures averaged correlations of 0.7–0.8 for fish and meat) (Jarvinen *et al.*, 1993). Foods which are never eaten are easy to remember (Krall *et al.*, 1988), and foods which are eaten regularly are recalled reliably (Nomura *et al.*, 1976). Further, food recall

Table 7. Ethnic differences in total yearly consumption (g) for people interviewed

	Black	White	Wilcoxon χ^2 (p)
Sample	39	415	
Beef	23 900 ± 3710 ^a	25 400 ± 1450	0.01 (NS)
Chicken	29 000 ± 3350	24 300 ± 1290	4.39 (0.04)
Deer	7 510 ± 2090	13 500 ± 1120	5.13 (0.02)
Dove	776 ± 320	679 ± 79.3	0.50 (NS)
Duck	229 ± 119	331 ± 61.0	0.93 (NS)
Fish, restaurant	1 290 ± 601	3 130 ± 252	15.3 (0.0001)
Fish, store	2 100 ± 888	2 580 ± 255	1.91 (NS)
Fish, wild-caught	49 500 ± 9880	10 200 ± 928	16.1 (0.0001)
Pork	5 560 ± 1650	1 330 ± 241	35.1 (0.0001)
Quail, restaurant	— ^b	232 ± 54.8	—
Quail, wild-caught	214 ± 121	507 ± 98.3	1.89 (NS)
Rabbit	756 ± 221	293 ± 49.2	11.9 (0.0006)
Raccoon	2250 ± 558	62.4 ± 17.5	86.7 (0.0001)
Squirrel	1080 ± 289	285 ± 51.2	20.5 (0.0001)
Turkey, wild	697 ± 291	585 ± 136	0.55 (NS)

NS, Not significant.

^a Mean plus or minus standard error.

^b No one ate in this category.

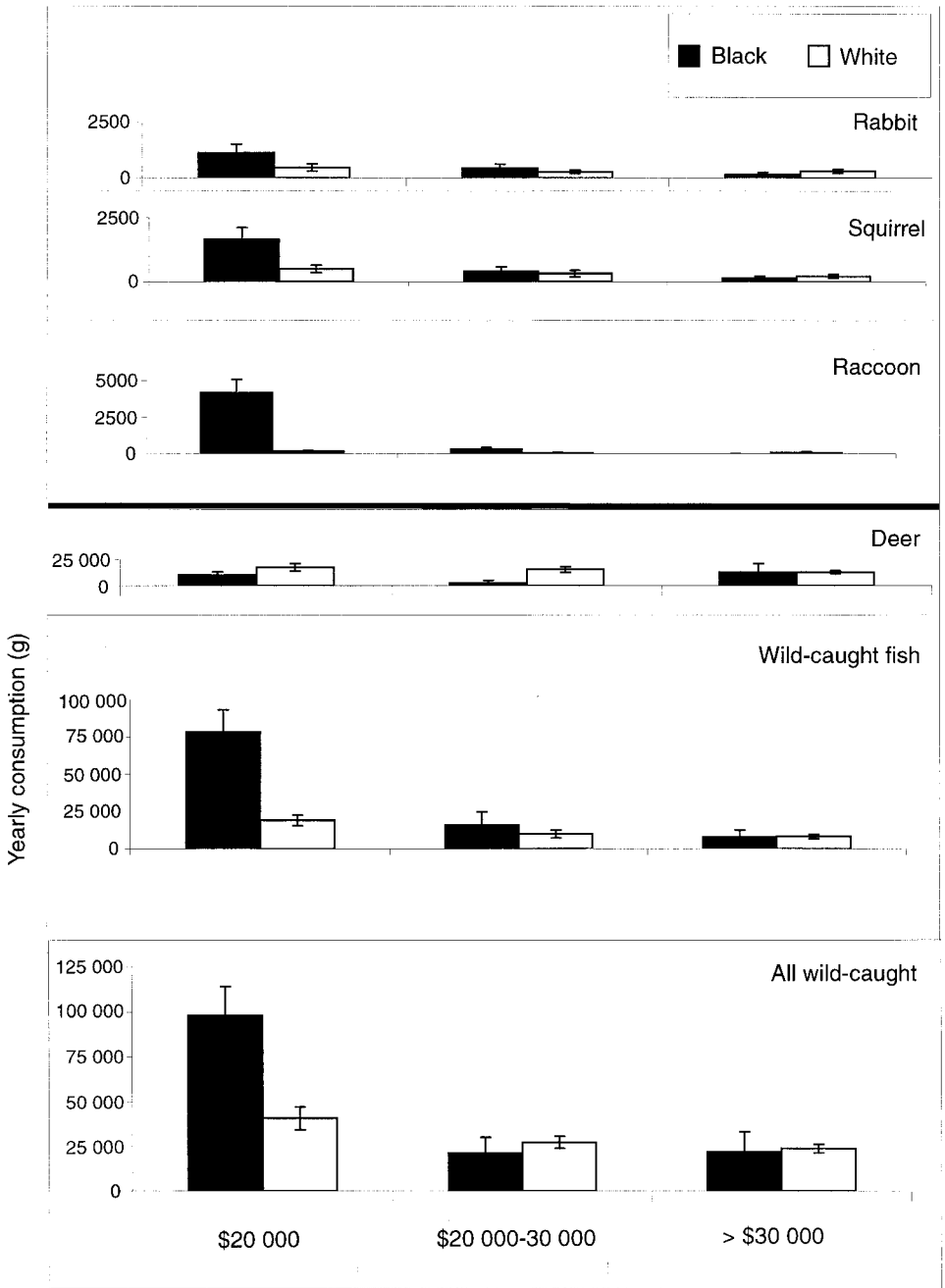


Figure 5. Relationship of income and ethnicity for yearly consumption (g) of different types of wild-caught fish and game for people interviewed. Shown is mean (bar) plus or minus standard error.

studies are generally both robust and reproducible, and often highly correlated with disease outcome measures (Willett, 1998). The recall problem is greatest with infrequently eaten foods (Jarvinen *et al.*, 1993). Smith (1993) identified provision of content cues as one of the important factors in improving accurate recall of foods eaten, and suggested that the length of the reference period was

Table 8. Age differences in total yearly consumption (g) for people interviewed

	≤ 32 years	33–45 years	> 45 years	Wilcoxon χ^2 (p)
Sample	145	159	150	
Beef	31 900 ± 3080 ^a	25 700 ± 2100	19 500 ± 1680	5.47 (0.06)
Chicken	30 500 ± 2680	22 500 ± 1830	21 900 ± 1720	6.98 (0.03)
Deer	14 400 ± 1820	12 300 ± 1790	12 800 ± 1900	2.53 (NS)
Dove	618 ± 161	776 ± 119	603 ± 117	2.88 (NS)
Duck	402 ± 95.2	261 ± 76.9	313 ± 120	2.66 (NS)
Fish, restaurant	2 740 ± 396	2 970 ± 397	3 180 ± 442	0.85 (NS)
Fish, store	1 980 ± 397	2 460 ± 402	3 140 ± 467	4.51 (NS)
Fish, wild-caught	9 120 ± 1450	18 100 ± 2900	12 500 ± 1940	1.92 (NS)
Pork	1 650 ± 416	1 930 ± 460	1 500 ± 506	0.36 (NS)
Quail, wild-caught	477 ± 228	571 ± 126	423 ± 98.3	1.58 (NS)
Quail, restaurant	264 ± 120	293 ± 85.8	80.9 ± 35.2	5.22 (0.07)
Rabbit	291 ± 71.2	421 ± 803	278 ± 101	6.51 (0.04)
Raccoon	87.7 ± 52.5	386 ± 108.0	265 ± 121	7.60 (0.02)
Squirrel	318 ± 104	419 ± 91.8	315 ± 83.7	1.39 (NS)
Turkey, wild	827 ± 350	528 ± 104	432 ± 146	8.28 (0.02)

NS, Not significant.

^aMean plus or minus standard error.

not the issue. In this study we provided respondents with specific verbal cues for each type of meat and game that they might have consumed. Further, they were prompted with questions about whether they ate each item during particular hunting or fishing seasons, or froze the items for later consumption. Since we showed subjects models of 8 ounces (225 g) of fish, it was easy for them to estimate how much they ate of different food items. People in South Carolina reported eating more fish during the summer months, when they fished more often. In any case, it seems critical for people reporting consumption studies to describe in detail their survey methods and time period of recall (Cavan *et al.*, 1996).

Another difficulty is the small sample of blacks in this study, which reflected the attendance at the Sportsmen's Classic. However, we felt it was important to separate the data by ethnicity because of the differences and implications for risk assessment and risk management. In retrospect, it might have been better to deliberately oversample blacks to obtain a larger sample. However, our protocol involved a sampling design where we interviewed people systematically. Further, low-income people might have been under-represented at the show because there was an entrance fee, and much of the equipment was expensive. This is an important point, because low-income people often have relatively high rates of consumption of wild-caught fish and game (Burger *et al.*, 1999a, b).

Consumption Patterns Overall

Determining overall consumption rates for wild-caught fish and game is critical to understanding exposure in the US population. While there is little information for most wild-caught foods, there are many studies on fish consumption. Overall fish consumption has increased in the USA, from 13 g per day per capita in 1960 to 21 g per day in 1986 (Anderson & Rice, 1993), and this has presumably continued to increase. Price *et al.* (1994) suggested that the federal guidance of 30 g per day for fish consumption, used in risk assessments, may overestimate

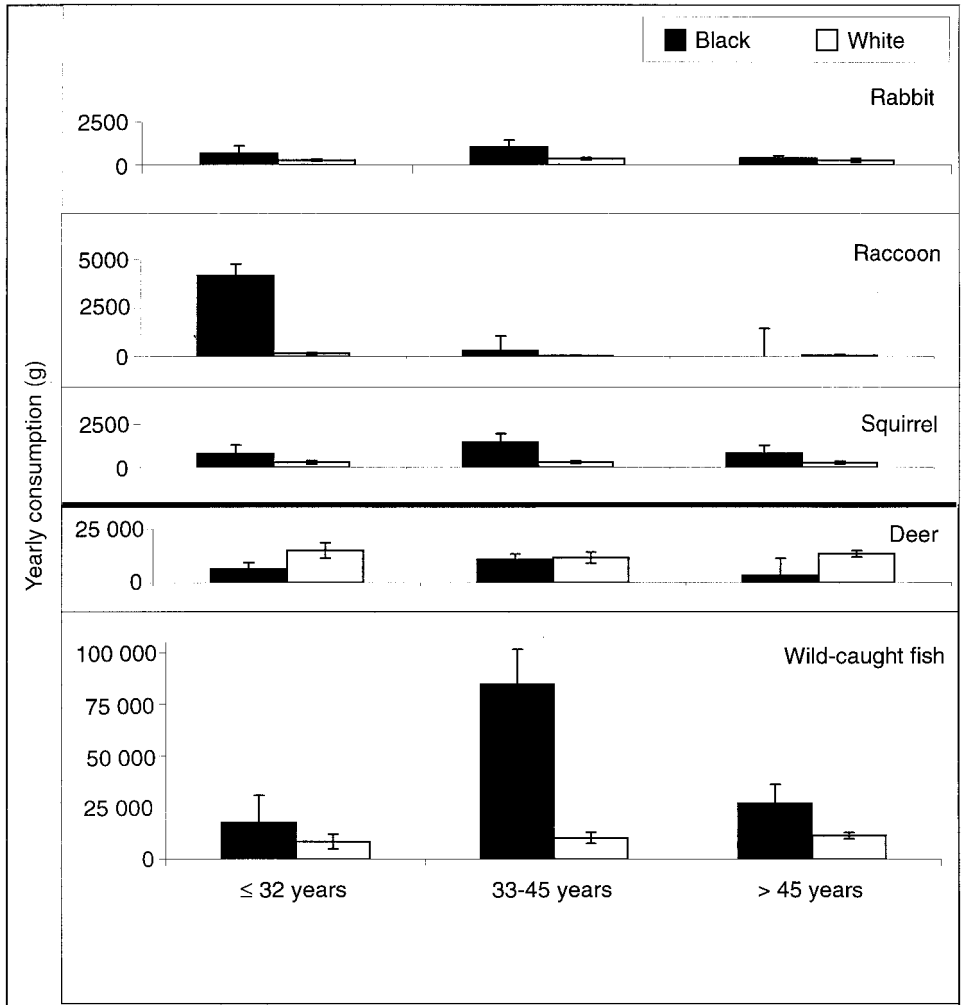


Figure 6. Relationship of age and ethnicity for yearly consumption (g) of different types of wild-caught fish and game for people interviewed. Shown is mean (bar) plus or minus standard error.

fish consumption because of oversampling of frequent anglers. However, Meredith & Malvestuto (1996) reported that per capita fish consumption in Alabama, derived from detailed interviews, averaged 30 g and 33 g per day, depending upon the survey methods. In contrast, the fish consumption rate in the USA, based on the Continuing Survey of Food Intake by Individuals, and conducted by the United States Department of Agriculture (USDA), was 15.65 g per day, with the upper 95th percentile being 78.34 g per day (Jacobs *et al.*, 1998). Ebert *et al.* (1993) found that the annual average consumption of freshwater fish for Maine anglers was only 3.7 g per day. At the other extreme, Cerdeira *et al.* (1997) reported an average per capita consumption of fish of 369 g per day for a fishing community in Brazil.

In this study we determined overall consumption patterns for a broad range of types of meats and fish, not just fish. Consumption patterns varied by ethnicity, particularly for wild-caught fish and game, indicating that computing consumption patterns for populations overall without taking into account ethnic

differences will underestimate consumption for some, and overestimate it for others. Thus, we do not present overall consumption rates, but examine them by ethnicity. Partly, these consumption data support the sociological finding that fishing plays a more important role in the social lives of blacks in some communities than in whites in the same communities (Toth & Brown, 1997).

In general, seasonal patterns of fish consumption are not examined because most studies simply examine overall fish consumption per day. However, in this study, we found clear seasonal differences in the consumption of both fish and deer, with fish consumption being higher in the summer. Similarly, Gerstenberger *et al.* (1997) found that fish were consumed at higher rates from April to July by Native Americans fishing in the Great Lakes.

Consumption Patterns and Income

The data in this study indicate that income was the greatest contributor to variations in consumption of wild-caught fish and game, as well as a relationship in consumption patterns between ethnicity and income. The latter relationship varied for different types of fish and meat. Most types of wild-caught fish and meat (except deer) were consumed primarily by black respondents with low incomes. Deer, on the other hand, was not consumed by low-income blacks. Partly, these differences may reflect the fact that fishing equipment is less expensive than hunting equipment, precluding low-income people from the latter sport. There may also be some degree of social exclusion. If we had only data on deer and self-caught fish, this explanation might suffice. However, low-income blacks consumed significantly higher amounts of all other wild-caught foods (rabbit, raccoon and squirrel) than all other groups, suggesting that economic need and cultural factors may play a more prominent role. Further, since these species are also hunted with guns, it suggests that guns are available for hunting by this group, although the same guns are not used for all types of game. This suggests other factors may be at play, such as cultural or social differences in preferences (Toth & Brown, 1997).

While the quantities of rabbit, raccoon and squirrel are not great, together they account for about 10%, and wild-caught-fish accounts for about 70%, of the meat and fish diet of low-income blacks (see Figure 5). These are not insignificant percentages. In contrast, deer accounts for about 25% of the meat and fish diet of high-income blacks. These kinds of exposure data, not normally available, indicate large differences in the potential exposure of people as a function of ethnicity and income, and that exposure scenarios must take the interaction of these factors into account.

Ethnic Differences in Consumption Patterns

Some people are at greater risk than others from their diet; the National Health Interview Survey showed that whites eat a more varied diet than blacks (Patterson *et al.*, 1995). The consumption of wild-caught foods is potentially more risky because these foods are not subject to inspection by the federal government, and some fish and game contain contaminants that exceed the allowable limits (EPA, 2000).

Several studies have examined the risks from consuming wild-caught fish, and have reported that Native Americans (Fleming *et al.*, 1995; Harris & Harper, 1998; Burger, 1999b), blacks (Fleming *et al.*, 1995; Toth & Brown, 1997;

Burger *et al.*, 1999b) and Hispanics (Burger *et al.*, 1999a), among others, are more at risk than whites because of higher-consumption patterns. In this study of people attending a sportsmen's show in South Carolina, we found that total consumption of meat and fish was significantly higher for black respondents than whites. Consumption of all wild-caught fish and game averaged 63 kg per year for blacks, but only 26.4 kg per year for whites. For blacks, wild-caught fish and game accounted for 50% of their consumption of meat and fish, while for whites it accounted for only 32% of their meat and fish diet. Thus, if wild-caught fish and game have higher contaminant loads than commercial meats and fish (see below), then blacks are more at risk than whites. However, there are positive benefits to the consumption of wild-caught fish and game in that they are often lower in fat and provide a healthy source of protein (Kimbrough, 1991; Horn, 1992; Ebert, 1996; Egeland & Middaugh, 1997), although there are some studies which do not show a positive effect of fish consumption on cardiovascular disease (Morris *et al.*, 1995).

Further, there were significant differences in the types of wild game and fish eaten. Deer and self-caught fish were the most commonly consumed wild game in this study; whites consumed significantly more deer, and blacks consumed significantly more self-caught fish. These differences may reflect both cultural preferences and economic differences. In several studies we have conducted in the region (Burger *et al.*, 1997, 1998b, 1999b), blacks engaged in higher rates of fishing than whites. However, the differences may also reflect differences in time and costs associated with hunting and fishing. Fishing poles are cheaper than guns and hunting permits, and it is relatively easy to go down to a nearby river and fish for an hour in the early morning or evening, while hunting may require a greater time commitment.

Geographical Differences in Proportion of People Eating Wild Game

In this study a high percentage of people ate a wide variety of wild-caught fish and game. Similar data were gathered for Lewiston, Idaho, another population centre in an otherwise rural area (Burger, 1999a), and for American Indians attending a rodeo at Fort Hall, Idaho (Burger, 1999b). The game available differed, but there was some overlap in the species present. Remarkably, the percentage of people who ate different wild-caught game was similar in South Carolina and Lewiston for deer (78% vs. 76%), wild-caught fish (78% vs. 74%) and waterfowl (25% vs. 32%), although squirrel was higher in South Carolina (25% vs. 4%). As might be expected, a higher percentage of American Indians ate deer (95%), waterfowl (49%) and squirrel (38%) than other people sampled above, but rates of eating self-caught fish (79%) were similar (Burger, 1999b). These data indicate that in widely separated geographical areas, roughly the same percentage of people are eating the same species of game, when they are available.

Risk from Fish and Game at the SRS and Environs

Risk is a function of both exposure and levels of contaminants in the fish and game in question. The main contaminants of concern for the SRS and environs are radionuclides and mercury. There is controlled hunting on the SRS, largely for deer (Sanchez & Burger, 1998). Radionuclides and mercury are

monitored in the deer, and the levels are sufficiently low not to pose a human health risk.

The main concern is for fish from the Savannah River. The states of South Carolina and Georgia have issued consumption advisories from the river based on mercury, although caesium (^{137}Cs) is also a concern (Georgia Department of Natural Resources, 1999; SCDHEC, 2000). Burger *et al.* (2001a) examined mercury in fish from the Savannah River, where people regularly fish. There were significant species difference in mercury levels, with bowfin (*Amia calva*) having the highest levels, followed by large-mouth bass (*Micropterus salmoides*) and pickerel (*Esox niger*); sunfish (*Lepomis* spp.) had the lowest levels. Their risk assessment indicated that white fishermen at or below the median fish consumption level exceed the Hazard Index for bass and bowfin, while black people at the median consumption level exceed the Hazard Index for all fish except eel, bluegill and redbreast (Burger *et al.*, 1999b). Computing another scenario where every fish contributes equally, black fishermen at the median consumption level exceeded the Hazard Index, while white fishermen exceeded it at the mean, but not the median consumption, level. Their assessments suggest that over half of the black fishermen were exceeding the Hazard Index for most fish, and white fishermen who consume fish at the average consumption level were also exceeding the Hazard Index. They also examined the percentage of each fish species that exceeded the levels at which many states and countries suggest that people do not eat the fish (0.5 parts per million (p.p.m.) and 1.0 p.p.m. depending on jurisdiction): over 80% of bowfin, 38% of bass and 21% of those sampled exceeded 0.5 p.p.m. (Burger *et al.*, 2001a).

There is also some off-site contamination of ^{137}Cs in the Savannah River watershed due to low-level releases from past nuclear production on the SRS (Cummins *et al.*, 1991; Carlton *et al.*, 1994). Burger *et al.* (2001b) examined the levels of ^{137}Cs in fish from the Savannah River (where there is fishing) and in Steel Creek in the SRS (where it is not allowed). For six of eight species of fish collected from the Savannah River, there were no differences in ^{137}Cs levels in muscle from fish collected above, along or below the SRS. The fish from Steel Creek had significantly higher levels (by about an order of magnitude) of ^{137}Cs in fish muscle than those collected in the Savannah River. However, no fish from either Steel Creek or the Savannah River had ^{137}Cs levels above the European Economic Community limit for fresh meat of 0.6 Bq/g. Burger *et al.* (2001b) calculated lifetime cancer risk using the cancer slope factor of $3.2 \times 10^{-11}/\text{pCi}$ and using mean ^{137}Cs concentrations and median fish consumption for 70 years for black males, the group with the highest consumption; the excess lifetime risk associated with the eight species of fish in the Savannah River ranged from 9.0×10^{-7} to 1.0×10^{-5} . The same calculation for fish from Steel Creek gave risk estimates from 1.4×10^{-5} to 8.0×10^{-5} . However, the 95% confidence limits for consumption by blacks was about 70 kg per year. Black fishermen consuming that amount of bass from Steel Creek would sustain a lifetime risk of 3.1×10^{-4} , while the same consumption of Savannah River bass yielded a risk estimate of 1.5×10^{-5} (Burger *et al.*, 2001b). Thus, there is some significant risk from consuming fish with respect to ^{137}Cs .

Reducing Risk

The people interviewed in this study were attendees at a sportsmen's event, and thus might be expected to be more inclined to consume wild-caught fish and

game than the general public. Accordingly, the rates of consumption of wild game were quite high overall, as well as for specific types of fish and game. Nearly 80% of those interviewed ate deer and wild-caught fish, and deer (6% for blacks and 16% for whites) and wild-caught fish (40% for blacks and 12% for whites) made up an important component of their meat and fish consumption. Fish of all types makes up 42% of the diet of blacks, and 19% of the diet of whites, in the Palmetto sample.

The risk from consuming wild-caught fish and game depends upon the levels of contaminants in these foods, the tissues eaten, the rates of consumption and the methods of cooking. The levels of contaminants in wild-caught fish and game vary, depending upon where the items were caught, the size or age of the animal (older and larger individuals usually have higher levels than smaller and younger individuals) (Bull *et al.*, 1981), the tissues consumed (i.e. some contaminants concentrate in fat tissues) (Dellinger *et al.*, 1995) and methods of cooking (i.e. stewing results in maximum exposure) (Clarkson, 1990; Morgan *et al.*, 1996).

Reducing risk may be a function of altering the places where people hunt and fish, the species they eat, the tissues they eat and preparation methods, rather than reducing the amount of wild game they eat, or may be a function of simply providing risk information. As Toth & Brown (1997) indicate, hunting and fishing serve a wide variety of social needs, suggesting that the small risk from contaminants is only one of a wide variety of factors that determine whether people will hunt or fish, and whether they will eat wild-caught game.

Only about half of the blacks who were interviewed had heard about any consumption advisories, while 75% of whites had (Table 9). Even so, a very small percentage said that they, or their spouses, changed fish consumption patterns during pregnancy. Similarly, in a study in the Florida Everglades, Fleming *et al.* (1995) indicated that people did not change their consumption habits as a result of advisories. In contrast, MacDonald & Boyle (1997) found that 25% changed their fishing behaviour as a result of advisories. Since one of the main adverse health effects from consumption of contaminated fish involves developmental deficits in fetuses and young children, it is worrisome that not everyone has heard about consumption advisories and that women do not change their fish consumption patterns during pregnancy. Since high fish consumption in this study was related to ethnicity and income, with low-income blacks consuming nearly 3 times as much self-caught fish as low-income whites, any adverse health effects from contaminant burdens in fish are being borne disproportionately by low-income blacks.

These conclusions must be tempered with the positive benefits of having sufficient protein, as well as the positive effects of consumption of fish and fish oils (Horn, 1992; Daviglus *et al.*, 1997; Egeland & Middaugh, 1997) and social benefits (Toth & Brown, 1997). The latter cannot be overestimated, since provid-

Table 9. Ethnic differences in percentage of respondents who reported hearing warnings, changing behaviour and smoking

Characteristic	Black	White	Contingency χ^2 (<i>p</i>)
Percentage who said that they hear warnings	50.0	75.7	11.8 (0.001)
Percentage who said that they or their spouse changed fish consumption patterns when pregnant	4.35	11.1	1.02 (NS)
Percentage who said that they smoke	36.4	22.6	3.18 (0.08)

NS, Not significant

ing fish for friends, relatives and fish fries is an important aspect of fishing for many people (Toth & Brown, 1997).

Environmental Planning and Management

This paper provides data essential for the exposure assessment phase of risk assessment. The data suggest that for some people in South Carolina, wild-caught game is an important and significant part of their meat and fish diet. They also suggest that wild-caught fish and game make up a significantly greater proportion of the meat and fish diet of blacks, compared with whites. These site-specific data also provide important exposure data to be used in future land use decisions for sites, such as the SRS, and for setting clean-up criteria for lands that might be used for hunting, fishing and other recreational purposes in the future.

The data presented suggest that managers and planners should take into account income, ethnicity and age when (1) conducting exposure assessments, (2) considering consumption patterns for wild-caught fish and game and (3) managing risk from wild-caught fish and game. The data will be especially useful to policy makers and risk managers who are designing consumption advisories, and to risk communicators who must create appropriate hazard and risk information for the appropriate audiences. Planners can use this information in establishing recreational opportunities and providing services for the hunting and fishing public.

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