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A Community-Based Participatory Assessment of Fish Consumption and Dietary Mercury Exposure along the Lower James River, Virginia USA

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A Community-Based Participatory Assessment of Fish Consumption and Dietary Mercury Exposure along the Lower James River, Virginia USA

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APPROVAL SHEET

This dissertation is submitted in partial fulfillment of

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DEDICATION

To my Iya Catherine Louise Smith, my Baba Willie Frank Holloman, and my Egungun sitting on both sides

However far a stream flows, it never forgets its origin.
~ Ase' Ase' Ase' O !

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Now at the end of this long and arduous journey, I pause to remember and acknowledge those who have supported me along the way. Mo juba Olodumare. Mo juba gbobo Orisa.

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ABSTRACT

The use of community-based participatory research (CBPR) methods to conduct environmental exposure assessments provides valuable insight about disparities in fish consumption and contaminant exposure. Ninety-five community-specific fish consumption surveys were administered to low-income African American women (ages 16-49) residing in the Southeast community of Newport News, Virginia, USA, in 2008. The mean fish consumption rate for the women surveyed was 147.8 g/day (95% CI: 117.6-185.8), a rate substantially higher than the mean fish consumption rate reported for U.S. women (1.8 g/day 95% CI: 1.51-2.04). Through collaborative partnerships established between current researchers and The Moton Community House (a local community center), African American women (ages 16 – 49 yrs) from the same community were surveyed in 2010 to assess the reproducibility and consistency of fish consumption patterns (ingestion rates, exposure frequencies, weight, and fish consumption rates), and the reliability of the survey responses. Fish consumption patterns were reproducible and the survey responses were reliable. Comparison between years revealed that fish consumption patterns remained consistent over time. In addition, the high fish consumption rate estimated in 2008 was reaffirmed in 2010 with a rate (134.9 g/day; 95% CI: 88-207 g/day) not materially different and still considerably higher than mean fish consumption rates reported for U.S. women.

Daily mercury intake rates were estimated using consumption data from 2008 and three consumption scenarios (canned white, canned light, and no tuna) due to confirmed differences in mercury concentration between canned white and light tuna. Arithmetic mean daily mercury intake rates were 0.284 ug/kg-bw/day (95% CI: 0.229 - 0.340 ug/kg-bw/day) using canned white tuna, 0.212 ug/kg-bw/day (95% CI: 0.165 - 0.259 ug/kg-bw/day) using light tuna, and 0.197 ug/kg-bw/day (95% CI: 0.151 - 0.243 ug/kg-bw/day) using no tuna. Probabilistic estimations of dietary mercury exposure for African American women (ages 16-49) from the Southeast Community were generated and compared to point estimates. Four different consumption scenarios were assumed, representing 1) no, 2) light, 3) both light and white, and 4) white tuna consumption. The probabilistic models generated lower dietary mercury intake rates than the point estimations, under these consumption scenarios. Arithmetic mean daily mercury intake rates (95% CI) for the probabilistic models were 0.149 (±0.003), 0.148 (±0.003), 0.172 (±0.004), and 0.202 (±0.004) ug/kg-bw/day, respectively for no, light, both, and white tuna consumption. Reducing the amount of fish consumed in probabilistic models resulted in lower dietary mercury exposures for each consumption scenario. At a rate that was a quarter of what was normally consumed, the percentages of exposures that exceeded the US EPA's oral RfD for mercury were 14%, 13%,18%, and 25% respectively for no, light, both, and white tuna consumption. In this community we learned that even though African American women in Southeast Newport News, Virginia are not subsistence fishers, they consume seafood at a subsistence fisher rate. In addition, estimates of dietary mercury exposure were high enough to warrant concern.

A Community-Based Participatory Assessment of Fish Consumption and Dietary Mercury Exposure along the Lower James River, Virginia USA

INTRODUCTION

The field of environmental risk analysis was created out of the need to manage and regulate ecological and human health risk by way of risk assessment, management, and communication. US EPA (1992) defines risk as the probability of a specified adverse effect occurring. Recently, researchers have called for a more holistic understanding of scientific (risk assessment, management, and communication) and social (i.e. cultural, economic, and political) perspectives as it relates to risk (Macgill and Siu 2004, 2005). One answer to this call is the infusion of community-based participatory research (CBPR) techniques in the process of environmental risk analysis. Over the last two decades, the field of public health has established alternative approaches to research that involves community members, organizational representatives, and researchers in all aspects of research in the process known as CBPR (Israel et al., 1998). Composed of three major overlapping components, CBPR involves participatory research, education, and social action (Leung et al., 2004). Within this framework, CBPR provides a mechanism for community members to actively participate as equal partners with researchers in problem definition, information collection, data analysis, and dissemination of information pertaining to environmental hazards affecting their community (Minkler, 2000).

The environmental justice movement consistently advocates that people of color and the poor have greater participation in research and decision-making as it relates to contaminant exposure because they often bear the burden of adverse effects (National

Environmental Justice Advisory Council (NEJAC), 2002). In 1994 President Clinton issued Executive Order 12898, "Federal Action to Address Environmental Justice in Minority Populations and Low-income Populations," which required Federal agencies to make achieving environmental justice part of its mission. Even though CBPR is very beneficial to environmental risk analysis (and communities bearing disproportional environmental burdens), these methods are seldom used by many Federal and State agencies. The assimilation of CBPR methods with environmental risk assessments might provide Federal and State agencies with a more holistic understanding as to why disparities in the consumption of contaminated finfish and shellfish (further referred to as fish) exist. Such disparities have created issues of environmental injustice (NEJAC, 2002) and by law (EO 12898) should be adequately addressed by Federal agencies. Consequently, as it relates to fish consumption and contaminant exposure, many Federal programs, policies, and activities continue to fall short in fulfilling Executive Order 12898 (OIG 2004).

It is imperative that research used to create and implement environmental policy effectively address and include people of color and the poor. Traditionally however, such research is designed within a framework that addresses the general US population and makes assumptions (valid or not) about US subpopulations (e.g. subsistence fishers, ethnic minorities, or recreational anglers). This is especially true as it relates to the development of fish advisories and consumption limit strategies. Exposure data used to set aquatic environmental standards often rely on parameter values that mirror the characteristics and practices of the general US population (NJEAC, 2002). Typically, such values do not reflect the characteristics and practices of minority and low-income populations (NJEAC, 2002). In addition, the estimation of fish consumption and contaminant exposure in US subpopulations is greatly influenced by an assessor's perception and the selection of parameter values used to estimate exposure. Thus for Federal and State assessors, narrowly held perceptions of certain US subpopulations and the selection of parameter values could result in environmental policies and standards that do not effectively protect all US populations.

In 2004, the US EPA and Food and Drug Administration (US FDA) jointly developed fish consumption advice for one specific contaminant, mercury (US EPA/FDA, 2004). This joint effort reflected an understanding that human exposure to mercury contaminated fish involves the consumption of both commercial and noncommercial items. Mercury poses a human-health risk because of the adverse neurodevelopmental effects that have been linked with exposure. Methylmercury (MeHg), the predominant form of mercury associated with fish, is known for its neurotoxicity and developmental toxicity (National Research Council (NRC), 2000; Castoldi et al., 2008). In addition, some studies have linked methylmercury exposure from fish consumption to cardiovascular toxicity (Salonen et al., 1995; Guallar et al., 2002; Virtanen et al., 2005; Roman et al., 2011) while others have found no associations (Ahlqwist et al., 1999; Hallgren et al., 2001; Yoshizawa et al., 2002; Mozaffarian 2009; Mozaffarian et al., 2011). Studies have found mercury concentrations in the blood and hair of one US subpopulation (African Americans) to be higher than other populations (Schober et al., 2003; CDC, 2001 and 2005; Mahaffey et al., 2009). However, peer-reviewed publications focused exclusively on African American fish consumption patterns and contaminant exposures are scarce (Weintraub and Birnbaum, 2008) and cultural and lifestyle factors influencing such exposures are rarely defined (Beehler et al., 2001; Cecelski, 2001; Weintraub and Birnbaum, 2008). Thus, assessments addressing fish consumption and potential dietary mercury exposure and risks are warranted.

The overarching goal of this dissertation was the application of community-based participatory research (CBPR) techniques with traditional exposure assessment methods to generate scientifically sound and socially relevant exposure information for a US subpopulation. Through collaborative partnerships established between current researchers and a local community center (The Moton Community House), the CBPR approach was used to explore fish consumption and dietary mercury exposure for African American women of childbearing age (ages 16 – 49 yrs) residing along the southern portion of the James River in the Southeast Community of Newport News, Virginia, USA (Figure 1). The three primary research chapters presented herein were written in formats specific for journal publication. Chapter one, summarizes the results of the community-specific fish consumption survey that was administered during April – May 2008 to African American women (ages 16-49) residing in the Southeast community of Newport News, Virginia. Of particular interest was determination of ingestion rates (IR, g/meal) and exposure frequencies (EF, meals/year and meals/day) in order to estimate seafood consumption rates (CR, g/day), as well as the major sources (grocery/seafood market, self-caught, restaurant) of the seafood items consumed. Chapter two presents the results of five main objectives. Specific objectives were to: 1) assess the reproducibility of the

East End Fish Consumption Survey, 2) quantify the reliability of the responses used to estimate fish consumption rates, 3) assess the consistency of fish consumption patterns in the community, 4) determine mercury concentrations in commonly consumed fish items, and 5) generate deterministic (point) estimates of daily mercury intake. The third and final chapter characterizes dietary mercury exposure by probabilistically modeling mercury intake for African American women (ages 16 – 49 yrs) residing in the Southeast Community of Newport News, Virginia. In addition, consumption scenarios aimed at reducing dietary mercury exposure are also explored.

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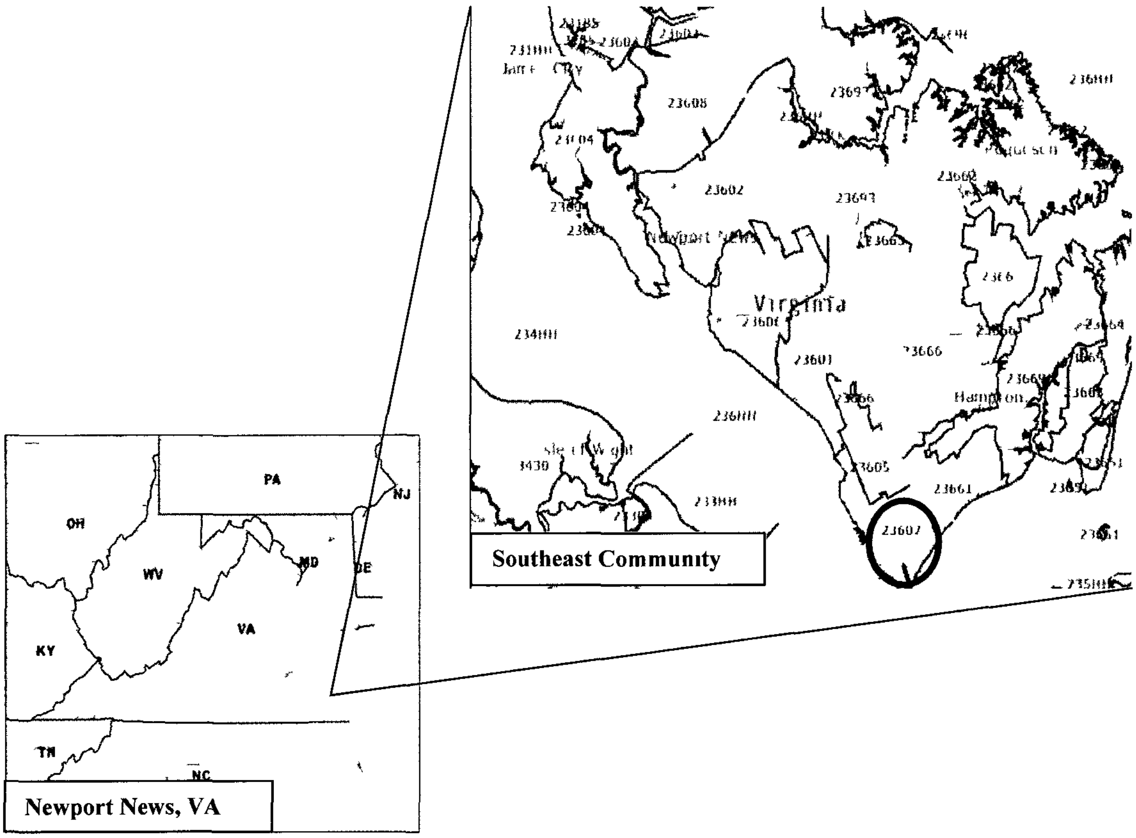
FIGURE 1



General location of the Southeast Community of Newport News, VA. The community (encircled in red) is located in the US Postal Zip zone of 23607.

CHAPTER 1

A Community-Based Assessment of Seafood Consumption along the Lower James River, Virginia, USA: Potential Sources of Dietary Mercury Exposure

ABSTRACT

The use of community-based participatory research (CBPR) methods to conduct environmental exposure assessments provides valuable insight about disparities in seafood consumption and contaminant exposure. Ninety-five community-specific seafood consumption surveys were administered to low-income African American women (ages 16-49) residing in the Southeast community of Newport News, Virginia, USA, for the purpose of assessing potential dietary mercury exposure. Only the results of the seafood consumption surveys are presented in this manuscript. Approximately 65% of the women surveyed do not fish; however, 83% had consumed seafood within the last seven days. Whiting, shrimp, and canned tuna were the three items most frequently consumed. Ninety-three percent of the women surveyed stated that grocery/seafood markets were the main sources of the seafood items generally consumed. The mean seafood consumption rate for the women surveyed was 147.8 g/day (95% CI: 117.6-185.8), a rate substantially higher than the mean seafood consumption rate reported for U.S. women (1.8 g/day 95% CI: 1.51-2.04). Shrimp, croaker, and blue crab were the top three seafood items with the highest summed amount (g/day) consumed. There was no significant association between demographic variables (age, income, education, and weight) and total number of seafood items listed, ingestion rate (g/meal), exposure frequency (meals/year), and seafood consumption rate (g/day). By using CBPR to assess seafood consumption in this community we learned that even though women in Southeast Newport News, Virginia are not subsistence fishers, they consume seafood at a subsistence fisher rate. Of the three seafood items most frequently consumed, canned tuna potentially plays a significant role in dietary mercury exposure for women in this community. Future work includes determining mercury concentrations in seafood items consumed and generating community-specific statements of dietary mercury risks.

1. INTRODUCTION

The environmental justice movement consistently advocates that people of color and the poor have greater participation in research and decision-making as it relates to contaminant exposure because they often bear the burden of adverse effects (National Environmental Justice Advisory Council (NEJAC), 2002). However, exposure information used to set environmental health standards is often not reflective of many minority and low-income communities (NEJAC, 2002). The integration of community-based participatory research (CBPR) techniques with conventional exposure assessment methods provides the poor and people of color opportunities to equitably participate in environmental research and decision-making that generates exposure information more reflective of their communities. Fundamental principles of CBPR: 1) recognizes community as an unit of identity, 2) builds on strengths and resources within the community, 3) facilitates collaborative, equitable involvement of all partners in all phases of the research, 4) integrates knowledge and intervention for mutual benefit of all partners, 5) promotes a co-learning and empowering process that attends to social inequalities, 6) involves a cyclical and iterative process, 7) addresses health from both positive and ecological perspectives, 8) disseminates findings and knowledge gained to all partners, and 9) involves a long-term commitment by all partners (Israel, 2000). It is understood that the degree to which any research effort achieves one or any combination of these principles is dependent upon the context, purpose and participants involved (Israel, 2000).

At the heart of successful models of CBPR, a clear distinction is made between conducting research "in" a community where community members have limited, if any, involvement and is mainly researcher-driven (Israel, 2000) versus participatory research where community members, organizational representatives, and researchers operate as equal partners in all phases of the research process (Israel et al., 1998; Minkler, 2000; O'Fallen and Dearry, 2002; Leung et al., 2004; Minkler et al., 2006; Terrell et al., 2008; Nelson et al., 2009). Therefore, attempts of integrating CBPR with traditional exposure assessments should strive for equability between researchers and communities in the problem definition, information collection, data analysis, and dissemination of contaminant exposure information. The use of CBPR methods to investigate seafood consumption and risk of contaminant exposure has generated scientifically sound, socially relevant and community-specific exposure information that provides greater insight about exposure disparities. For example, in the Greenpoint/Williamsburg neighborhood of Brooklyn New York, CBPR methods used to investigate cumulative exposures and subsistence fishing revealed a potentially serious cancer risk that would have likely been ignored by the U.S. Environmental Protection Agency (U.S. EPA) if it was not for the community specific data (Corburn, 2002).

Disparities in seafood consumption and contaminant exposure may exist because of the consumption of more seafood annually and more seafood meals of larger servings (Burger et al., 1999 and 2001; Sechena et al., 1999; NEJAC, 2002; Corburn, 2002; Gibson and McClafferty, 2005). Such disparities may also be greatly influenced by cultural and lifestyle factors that ultimately determine which seafood items are consumed and how it is prepared (Judd et al., 2004; NEJAC, 2002). Minority targeted seafood consumption assessments generally focus on Asians, Pacific Islanders, or Native Americans (e.g. Toy et al., 1996; Sechena et al., 1999 and 2003; Duncan, 2000; Judd et al., 2004). African Americans also experience higher exposures to contaminated seafood than the average U.S. consumer (Burger et al., 1999 and 2001, Center for Disease Control (CDC), 2001 and 2005; Schober et al., 2003; Gibson and McClafferty, 2005). However, peer-reviewed publications focused exclusively on African American seafood consumption patterns and contaminant exposures are scarce (Weintraub and Birnbaum, 2008) and cultural and lifestyle factors influencing such exposures are rarely defined (Beehler et al., 2001; Cecelski, 2001; Weintraub and Birnbaum, 2008).

The consumption of seafood is the most common exposure pathway for mercury (National Research Council (NRC), 2000; Mahaffey et al., 2008). The amounts and types of seafood consumed vary among geographical locations of the United States (NRC, 2000; Mahaffey et al., 2009). Hence, variations in mercury exposure are most likely due to individual seafood consumption patterns (NRC, 2000). Studies have found mercury concentrations in the blood and hair of African Americans to be higher than other populations (Schober et al., 2003; CDC, 2001 and 2005; Mahaffey et al., 2009). Considering that investigations focused exclusively on African American seafood consumption patterns and contaminant exposure are not well established in peer-reviewed literature, assessments addressing seafood consumption and potential dietary mercury exposure and risks are warranted.

This work applied CBPR techniques with traditional exposure assessment methods to generate scientifically sound and socially relevant seafood consumption and dietary mercury exposure information for low-income, African American women (ages 16 – 49 yrs) residing along the southern portion of the James River in Virginia, USA. Findings are summarized of only the community-specific seafood consumption survey administered during April – May 2008 to 95 African American women (ages 16-49) residing in the Southeast community of Newport News, Virginia. Of particular interest was determination of ingestion rates (IR, g/meal) and exposure frequencies (EF, meals/year and meals/day) in order to estimate seafood consumption rates (CR, g/day), as well as the major sources (grocery/seafood market, self-caught, restaurant) of the seafood items consumed. This information, coupled with mercury concentrations, will be used to probabilistically define daily mercury intake (mg/kg bw-day) and generate risk statements for low-income African American women residing in Southeast Newport News, Virginia.

2. MATERIALS AND METHODS

2.1. Community Partnerships:

Located along the southern portion of the James River, Newport News has 180,150 residents of whom 54% are White and 39% African American (US Census, 2000). African Americans make up approximately 87% of the population residing in the Southeast community of Newport News (US Census, 2000). Partnerships were created with the Moton Community House and Heal-Thy Generations: A Southeast Health

Movement, a local community center and health coalition known for its dedication to improving the health and quality of life for residents in the Southeast community. Through these partnerships, 10 African-American women, representative of the population of interest (low-income African American women of the Southeast community), were recruited to participate on a Community Advisory Council (CAC). The women of CAC were recruited by personal announcement and recommendations from the executive director of the Moton Community House and members of Heal-Thy Generations. The council was established to provide the necessary community-specific guidance for only this research endeavor. Members met periodically and were compensated for their time. Formal meeting procedures included agendas and an attendance policy in which women were only compensated for meetings they attended.

2.2. Survey Design and Implementation:

The initial draft of the Southeast Seafood Consumption Survey was based on modifications to fish consumption surveys used in the Asian and Pacific Islander Seafood Consumption Study in King County, WA (Sechena et. al., 1999) and the Elizabeth and Lower James River Angler Survey (Gibson and McClafferty, 2005). This draft was submitted to CAC and refined, finalized, and submitted to the Protection of Human Subjects Committee (PHSC) at the College of William and Mary. The final version of the Southeast Seafood Consumption Survey complied with appropriate ethical standards, and was exempted from a formal PHSC review.

Ninety-five surveys were administered among ten different sites located throughout the Southeast community during April and May 2008. Sites were randomly selected from a list of locations suggested by CAC and sampled during the five-day work week between 10:00 AM to 5:00 PM. Participants were conveniently sampled and compensated for completing the survey. To prevent women from taking multiple surveys, the same individual administered the seafood consumption survey. In addition, upon completion of the survey, women were given coupons that were numbered and stamped with a raised seal that had to be redeemed in order to receive their compensation. This also assisted in preventing women from taking multiple surveys and duplicating coupons issued.

The survey was structured to gain insight about the IR (g/meal), EF (meals/day or meals/year), CR (g/day), and sources of the seafood items consumed for African American women (ages 16- 49) residing in the Southeast community. Traditionally, the amount of seafood consumed (IR) is determined by asking one to select approximately how much (generally between 1.5 -16 oz) of a particular item is consumed. The CAC advised that the use of these amounts without some visual aid would be confusing; therefore, visual aids were used.

2.3. Visual Aids:

The main concepts for the visual aids were derived from the Asian and Pacific Islander Seafood Consumption Study in King County, WA (Sechena et al., 1999). The CAC provided a list of seafood items thought to be commonly consumed by women in the Southeast community. This list was divided into 13 groups based on advice that the groups must represent a similar body shape of the seafood item in question but, did not have to be the exact item to evoke recognition of portion sizes (Table 1; Sechena et al., 1999). The CAC also advised that the visuals be presented as cooked items; therefore, real items were used and prepared based on cooking methods suggested by CAC. Once prepared, items were individually vacuum sealed, labeled, and refrigerated until used. Weights (g) associated with uncanned seafood items (e.g. fresh fish) were based on the cooked weights of the items. Weights (g) associated with canned seafood items (e.g. canned tuna) were based on the weight given on the can label. All seafood items used represented individual portion sizes.

2.4. Determination of IR, EF, and CR:

Participants were asked to list up to 11 seafood items they consume and select the portion size generally consumed for each item listed. Participants were then asked how many of the individual portion size selected would be consumed during one meal setting. The amount consumed (IR, g/meal) was determined by the number of individual portions consumed during one meal setting multiplied by the weight of the portion size selected. The IR used in analysis was determined by multiplying the IR obtained by percent yield (14, 20, 28, and 25% respectively) of edible meat for blue crab (*Callinectes sapidus*), lobster (*Homarus americanus*), snow crab leg (*Chinoecetes opilio* or *C. bairdi*), and dungeness crab (*Cancer magister*) because weights used for portion sizes were based on whole items.

To determine EF, the women were given the option to answer how many times per week or per month they consumed each particular seafood item they listed. Depending upon how the women answered, time per week was multiplied by 52 (weeks/year) and time per month by 12 (months/year) to determine meals/year (EF_y). The

EF_y was then divided by 365 to obtain the number of meals consumed daily (EF_d, meals/day). The EF_d was used in the calculation of seafood consumption rates (g/day).

For each participant, if IR or EF_y was not determined for a particular item listed, it was considered to be censored. Out the 784 seafood items listed, only 41 were censored for IR and only eight censored for EF_y. Values for all censored data were obtained by one of two methods thought to assist in reducing uncertainty in the value selected. First, if the summed frequency (total number of women) for the particular item was three or greater, a value for the censored datum was randomly selected based on probability data collected for IR or EF_y for that particular item in question. For the second method, when little or no information was available (less than or equal to three women total), the value for the censored datum was randomly selected using Crystal Ball 11.1.1.1.00 (Oracle, Redwood Shores, CA) in which a uniform distribution was assumed for IR or EF_y. Information used to generate the uniform distribution was based on data collected and data reported in the peer-reviewed literature that was most reflective of the women in this community. Once values were obtained for all censored data, IR and EF_y (converted to EF_d) were used to calculate seafood consumption rates (CR).

The IR (g/meal) was multiplied by EF_d (meal/day) to determine seafood consumption rates (CR, g/day). This was done for each seafood item listed by a participant. The CR was then summed for each participant to get a total seafood consumption rate. The mean seafood consumption rate was calculated using the summed CR for each of the 95 women.

2.5. Statistical Analysis:

The SAS version 9.1 software (SAS Institute Inc, Cary, NC) was used for all statistical analysis. The mean seafood consumption rate was presented in terms of a geometric mean because the results of seafood consumption rates for the 95 women were not normally distributed. A nonparametric Kendall τ procedure was used to assess correlations between demographic variables (age, income, education, and weight) and total number of seafood items listed, summed ingestion rate (g/meal), summed exposure frequency (meals/year), and summed seafood consumption rate (g/day).

3. RESULTS

3.1. Study population:

The response rate for agreeing to take the survey was approximately 70% (104 out of a total of 149 women). Six surveys were terminated because of age (younger than 16 years older than 49 years), lack of parental permission, or interviewee resided outside of the area of interest. Three surveys were not included in the final analysis because it was later discovered that they did not live in the area of interest. Of the 95 women surveyed, approximately 13% (95% CI: 6-19%) had not completed high school nor received a General Equivalency Diploma (GED), 76% (95% CI: 67 -85%) completed high school, GED or vocational training, 9% (95% CI: 3-15%) completed college (2 or 4 year program), and 2% (95% CI: 0-5%) completed a graduate program. Approximately 77% (95% CI: 68-85%) of the women had household incomes of $0 - $20,000, 16%

(95% CI: 8-23%) had household incomes of $20,001 - $35,000, and 7% (95% CI: 2-13%) had household incomes of $35,001 - $45,000+.

3.2. Seafood Consumption Patterns:

Sixty-five percent (95% CI: 56 – 75%) of the participants (95 women) reported that they do not fish; however, 83% (95% CI: 75 – 91%) had consumed seafood within seven days prior to being interviewed. The most common seafood items consumed within seven days prior to being interviewed were shrimp (*Penaeus,spp,* 24% of 168 items listed); whiting (*Merlangius, spp,* 20%); canned tuna (*Thunnus alalunga* or *Katsuwonus pelamis* 8%); blue crab (*Callinectes sapidus*, 7%), and croaker (*Micropogonias undulates,* 7%). Eighty-five percent of the women reported consuming the most amount of seafood during the spring, summer, and fall months (Table 2); whereas, 47% reported consuming the least amount of seafood during the fall, winter, spring months and the winter, spring, and summer months (Table 2).

The most commonly consumed seafood items were whiting, shrimp, tuna, snow crab legs (*Chinoecetes opilio* or *C. bairdi*), blue crab and croaker (Figure 1). Of the784 consumed seafood items, approximately 93 % (95% CI: 91-95%) came from grocery/seafood markets, 4% (95% CI: 2-5%) were self-caught, 3% (95% CI: 2-4%) were from restaurants, and 1% (95% CI: 0-1%) did not report the source. The women reported that they fillet their fish most of the time (42% of 95 women, 95% CI: 32-52%), sometime (37%, 95% CI: 27 - 48%) and never (21%, 95% CI: 13- 29%).

Eighty-seven percent (of 95 women, 95% CI: 81 – 94%) reported they pan/deep fry their seafood most of the time, 11% (95% CI: 4 – 17%) reported sometime, and 2% (95% CI: 0 – 5%) reported never. Over half of the women (52% of 95 women, 95% CI: 41 – 62%) never reuse the oil/fat from cooking although, 36% (95% CI: 26 – 46%) reported that they do reuse the oil/fat most of the time and 13% (95% CI: 6 – 19%) reported sometime.

3.3. Seafood Consumption Rate:

For each seafood item listed by the women, the amount consumed (g/day) was summed to estimate the total amount of seafood ingested daily (Figure 2). The items with the largest total amount consumed (> 1000 g/day) were shrimp, croaker, blue crab, whiting, snow crab legs, tuna (canned), spot, and mackerel (*Scomberomorus Cavalla*) cakes (Figure 2). The unadjusted consumption rates (distribution was not normal) range from 1.52 g/day to 1327 g/day. The geometric mean seafood consumption rate was 147.8 g/day (5.2 oz/day) with 95% confidence intervals of 117.6 -185.8 g/day (4.1 - 6.6 oz/day). There was no significant ($\alpha = 0.05$) association between demographic variables (age, income, education, and weight) and total number of seafood items listed (Tau b coefficient = 0.01, 0.00, 0.16, 0.06 respectively; p = 0.86, 0.98, 0.06, and 0.40 respectively), summed ingestion rate (τ b coefficient = -0.02, 0.03, 0.13, 0.06 respectively; p = 0.73, 0.67, 0.09, and 0.39 respectively), summed exposure frequency (τ b coefficient = -0.02, -0.02, 0.06, 0.01 respectively; p = 0.73, 0.78, 0.45, and 0.85 respectively), and summed seafood consumption rate (τ b coefficient = -0.05, 0.05, 0.09, 0.04 respectively; p = 0.47, 0.50, 0.22, and 0.59 respectively).

4. DISCUSSION

The use of CBPR (community-based participatory research) techniques to conduct exposure assessments offers Federal and State agencies, as well as communities, a unique approach in generating scientifically sound, socially relevant, and community-specific exposure information. Parameter uncertainty, the most readily recognized source of uncertainty quantified in risk assessments, is caused by lack of specific knowledge and can be reduced by collecting more and higher quality data (U.S. EPA, 2001). As it relates to fish consumption, many agencies have applied exposure characteristics, susceptibilities, and co-risk factors of the general population (NJEAC, 2002). Such application can have significant implications for those whose exposure characteristics are markedly different then the general population. For example, Silver et al. (2007) suggested that the consumption of contaminated fish can have disproportionate impacts on low-income, non-white groups in California's Sacramento-San Joaquin Delta due to higher fish consumption and lower advisory awareness. By using CBPR techniques, exposure assessments are enhanced with community-specific knowledge that increases the quality of data collected and reduces parameter uncertainty in risk estimates.

This study employed CBPR methods to assess seafood consumption for women of child bearing age (16-49) in a coastal, low-income, African American community. To our knowledge, this is the first study that quantified seafood (fish and shellfish) consumption exclusively in a low-income community of African American women (age 16-49). It should be noted, that because of the relatively small, convenient sample design, it is difficult to generalize our results to women outside of this community. In addition, we did not account for variation and difficulty of dietary recalls in this community. A verification study is underway to address these issues and quantify the uncertainty of responses obtained from the survey.

Seafood consumption in our study was similar to what has been reported for low-income women (Bienenfeld et al., 2003; Silver et al., 2007). In this study, the percentage of women consuming whiting (83%), shrimp (81%) and canned tuna (79%) was comparable to Silver et al. (2007) for shrimp (86%) and canned tuna (79%), and higher than Bienenfeld et al. (2003) for whiting (45%) and tuna (fresh and canned, 38%). The high consumption of commercial seafood coincided with what was reported by Silver et al. (2007).

Burger et al. (1999) suggested that fish consumption studies take into account individual differences in the rate of fish consumption and quantity of fish consumed per meal in order to avoid a downward bias in consumption rate. It was also suggested that by only examining averages (number of meals per week and serving size), the understanding of consumption patterns of those potentially most at risk is incomplete (Burger et al., 1999). If individual differences in fish consumption rates and amounts consumed are not accounted for and averages are used, there is a greater potential for valuable information to be lost through data aggregation. This study collected information on exposure frequencies (how often, EF) and ingestion rates (how much, IR) of individual seafood items reported by each participant and then calculated a consumption rate (CR) for each seafood item listed. For each participant, the consumption rate for individual seafood items was then summed to yield a total seafood consumption rate. By collecting and analyzing consumption information in this manner, consumption rates are more accurate and representative of the individual and hence the distribution in the population. It should be noted however, that our model for determining EF and IR assumes regular and consistent seafood consumption. Such an assumption possibly overestimated our consumption rates.

The geometric mean seafood consumption rate (147.8 g/day) determined in this study is the highest mean seafood consumption rate that has been reported for African American women: 47.7 g/day (Burger et al., 2001), 2.4 g/day (Mahaffey et al., 2004), and 41.2 g/day (Silver et al., 2007). The higher consumption rate is most likely due to how consumption rates were calculated. Accounting for individual differences in exposure frequencies and ingestion rates, and not using averages, could have resulted in the higher estimate. Additionally, the way in which ingestion rates (g/meal) were calculated could have resulted in the higher estimate.

To estimate ingestion rates, many studies first define portion sizes then, have participants select the size generally consumed (Burger et al., 1999; Gibson and McClafferty, 2005; Harris et al., 2008, Silver et al., 2007). The same was done in this study but, a necessary adjustment was made based on recommendations from CAC. Members of CAC stated the total amount ingested for a particular item was not only the portion size, but also how many individual portions were consumed during one meal setting. Therefore, a more accurate reflection of ingestion was the portion size selected multiplied by the number of individual portions consumed during one meal setting. Not making this adjustment would result in underestimation of ingestion rates for this community. Such an adjustment should be considered when determining ingestion rates and is potentially one of the reasons why the consumption rate in this study was higher than rates reported in the literature for African American women (Burger et al., 2001; Mahaffey et al., 2004; Silver et al., 2007).

In comparison to seafood consumption rates reported by Mahaffey et al. (2004) for the general U.S. women (age 16-49) and African American women (age 16 – 49 yrs) populations, the consumption rate in this study was approximately 82 and 62 times higher, respectively (Figure 3). If either of the consumption rates reported by Mahaffey et al. (2004) were used to determine health risks associated with seafood consumption for women in this study, the risk would be grossly underestimated. The same would be true if EPA's default value for the general population (17.5 g/day; U.S. EPA, 2000) or recreational fishers (17.5 g/day; U.S. EPA, 2000) was used (Figure 3). The mean seafood consumption rate for this study (147.8 g/day) most closely resembles EPA's default value for subsistence fishers (142.4 g/day; U.S. EPA, 2000) and that of other minority populations (Figure 3).

EPA (2000) defines subsistence fishers as fishers who rely on noncommercially caught fish and shellfish as a major source of protein in their diets. Asian, Pacific Islander, and Native American communities are often identified as subsistence fisher communities (Judd et al., 2004; NEJAC, 2002; Sechena et al., 1999; Toy et al., 1996; U.S. EPA, 2000). The narrow definition of subsistence and fish consumption (U.S. EPA, 2000) could lead to incorrect assumptions about other populations where fish consumption (be it commercially purchased or self-caught) occurs at a subsistent rate. Based upon EPA's definition, women in this study would not be considered subsistence fishers because, 65% of the women do not fish and 93% of the seafood items consumed come from grocery/seafood markets. However, 83% of the women had consumed seafood within seven days prior to being interviewed, suggesting that even though they are not fishing, seafood is still a major source of protein in their diets. Therefore, we identify women in this study as subsistence fish consumers.

We define subsistence fish consumers as people who rely on noncommercially caught or commercially purchased fish and shellfish as a major source of protein in their diets. The high consumption rate obtained supports the idea that women in this study are subsistence fish consumers. Especially, when compared to mean consumption rates of other subsistence fishing population (Figure 3): Squamish Indian Tribe (213.9 g/day; Duncan, 2000), Asian and Pacific Islanders in King County, Washington (117.2 g/day; Sechena et al., 1999), and Native Alaskans (109 g/day; Nobmann et al., 1992).

The strengths of using CBPR to guide this research was that it helped to establish trust between the community and researchers involved and provided invaluable community knowledge that has enhanced our understanding of our work. Through the partnerships established, the executive director of the Moton Community house and members of CAC equitably participated in the problem definition, information collection and data analysis for this investigation. Results of this work were discussed with CAC to explore possible lifestyle and cultural explanations. Members of CAC conveyed that one possible lifestyle explanation for the high rate of seafood consumption may be due to the promotion of seafood as a healthy alternative to meats high in fat (i.e. pork or beef) usually consumed by women in this community. Culturally, it was suggested that prior the Trans-Atlantic slave trade, many African Americans were part coastal communities along the Western coast of Africa and that a culture of fishing and seafood consumption already existed and was brought with them. In addition, during slavery many African Americans joined indigenous communities (Johnson, 2001) where a culture of fishing and seafood consumption also existed. Members of CAC also noted that in the U.S., during periods of slavery and Jim Crow, fishing provided free food and places of solitude and peace from the inhumane acts of people, the laws, and the regulations of the time. Interestingly, CAC noted that the high rate of purchased commercial seafood may be because it is easily accessible and more convenient for a single mother than actually fishing. As one women stated, “Even though I do not have a lot of money, my time is still valuable and often used towards work. I don’t have the time to fish to feed my family. For me, it is easier and more efficient to purchase fish than spending the time attempting to catch (or not) dinner”

As it relates to dietary mercury exposure and any potential risk, results of this study imply that even though women in this community consume a lot of seafood (147.8 g/day) their risk of mercury exposure may be low. Except for canned tuna, the most common seafood consumed within seven days prior to being interviewed (shrimp, whiting, blue crab, and croaker) and in general (whiting, shrimp, snow crab legs, blue crab, and croaker) have the least amount of mercury of seafood caught and sold commercially (National Research Defense Council (NRDC), 2009). This would suggest that consumption of these items would not place women in the community at high risk of dietary mercury exposure. On the other hand, according to the NRDC (2009), mercury concentrations in canned tuna range from moderate to high, depending on the type (light or albacore (white)) and could potentially play a significant role in dietary mercury exposure for women in this community. Future work includes determining mercury concentrations in seafood items consumed and generating community-specific statements of dietary mercury risks.

The results obtained in this study are potentially bias toward African American women (age 16 – 49 yrs) in the Southeast Community of Newport News, Virginia with low incomes. Because the surveys were administered during normal business working hours (9 AM to 5 PM), the results may also be bias toward women who do not work. Finally, the seasonality in seafood consumption may have biased consumption rates upwardly. Participants in this study were surveyed during April and May, months that correspond to when the women consumed the most amount of seafood. If the survey was administered during months that corresponded to when the women consumed the least amount of seafood, the mean seafood consumption rate may have been lower. Currently, surveys are being administered to define this potential bias.

5. CONCLUSION

The use of CBPR greatly improves exposure assessments by providing community-specific information. Community-specific information increases data quality and reduces parameter uncertainty for those estimating risk. Through the CBPR approach we learned that ingestion rates (g/meal) are not only the selected portion size but, more importantly, how many of the individual portions are consumed during one meal setting. In addition, even though women in this study are not subsistence fishers, they are subsistence fish consumers.

Women in this community have high seafood consumption rates which could have significant implications for exposure of contaminants associated with seafood (i.e. mercury or polychlorinated biphenyls) With the exception of canned tuna, seafood items commonly consumed suggest that women in this community are at low risk of dietary mercury exposure. However, the consumption of canned tuna could potentially place women in this community at a higher risk. Future work will determine mercury concentrations in seafood items consumed and generate community-specific statements of dietary mercury risks.

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TABLE 1.

Group	Description
A	Whole body, e.g., croaker, spot, perch
B	Slender fillets, e.g., whiting, trout, catfish
C	Patties/Cakes, e.g., salmon, mackerel, crab
D	Scallops
E	Shrimp
F	Mussels, clams, oysters
G	Snow crab legs
H	Whole blue crabs
I	Salmon steak
J	Broad fillets, e.g., catfish, flounder
K	Tilapia
L	Canned fish, e.g., sardines, herring
M	Canned tuna

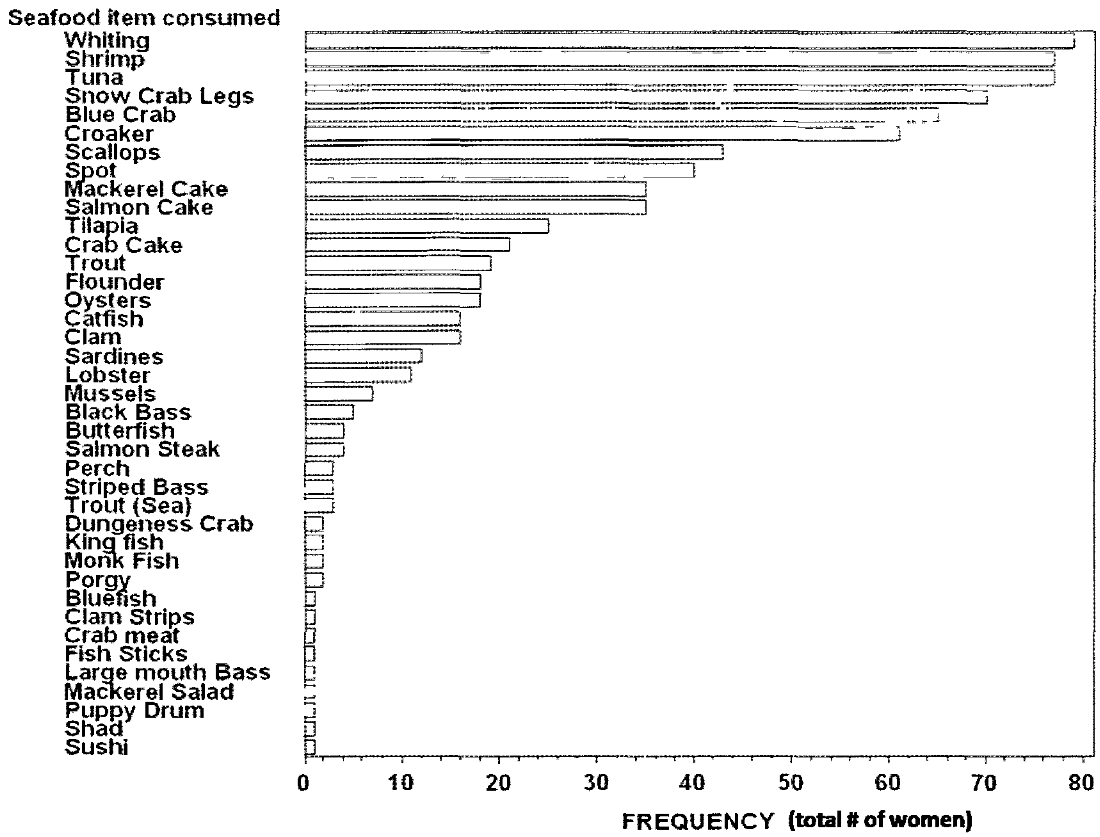
List of groups used for visual aids.

TABLE 2.

	N	%	95% CI
Months that seafood items are consumed the most			
Spring-Fall (Mar. – Dec.)	81	85%	78 – 93%
Winter-Summer (Dec. – Sep.)	8	8%	2 – 14%
Fall-Spring (Sep. – Jun.)	4	4%	0.1 – 8%
All Year (Jan. – Dec.)	2	2%	0 – 5%
Total	95	100%	
Months that seafood items are consumed the least			
Fall-Spring (Sep. – Jun.)	44	47%	37 – 58%
Winter-Summer (Dec. – Sep.)	44	47%	37 – 58%
Spring-Fall (Mar. – Dec.)	5	5%	0.7 – 10%
Total	93	100%	

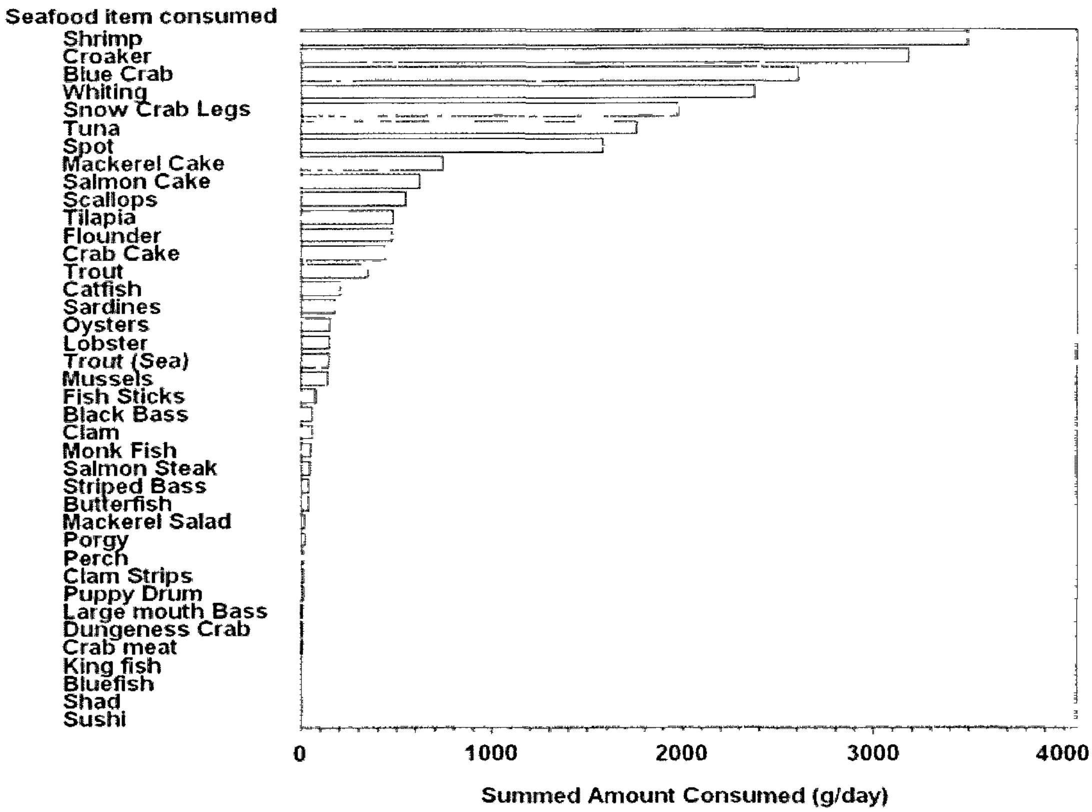
The percentage of women reporting the months when the most and least amount of seafood is consumed.

FIGURE 1.



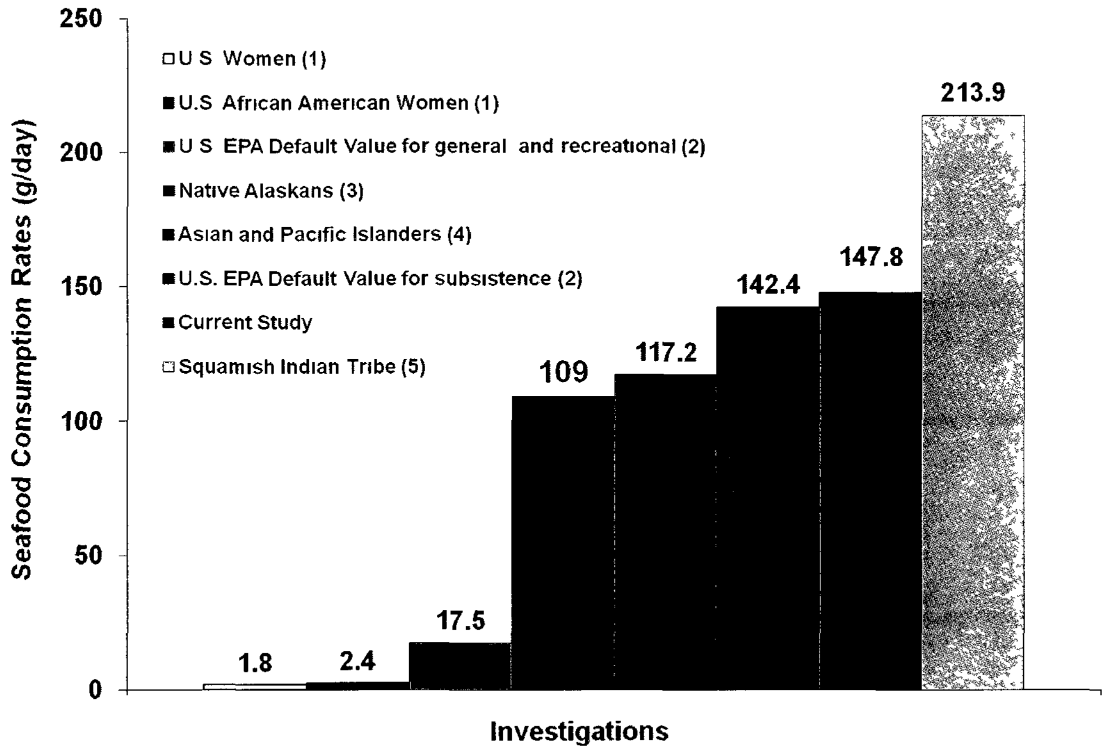
Consumption frequency of the seafood items generally consumed (n = 95 women). Mercury concentrations have been determined for whiting (*Merlangius spp.*), shrimp (*Penaeus spp.*), tuna (*Thunnus alalunga* and *Katsuwonus pelamis*), snow crab legs (*Chinoecetes opilio* or *C. bairdi*), blue crab (*Callinectes sapidus*), croaker (*Micropogonias undulates*), scallops (*Placopecten magellanicus*), spot (*Leiostomus xanthurus*), mackerel (*Scomberomorus Cavalla*) cakes, salmon (*Oncorhynchus gorbuscha*) cakes, tilapia (*Oreochromis spp.*), crab (*Callinectes sapidus*) cake, trout (*Oncorhynchus spps, Salvelinus spp* or *Salmo trutta*), flounder (*Paralichthys dentatus* or *Pleuronectes americanus*) oysters (*Crassostrea virginica* or *C . gigas*), catfish (*Ictalurus punctatus, I. furcatus, Pylodictis olivaris,* or *Ameiurus catus*), clams (*Protothaca staminea, Mya arenaria, Saxidomus giganteus,* or *Mercenaria mercenaria,*), sardines (*Clupea harengus*), lobster (*Homarus americanus*) and mussels (*Mytilus edulus*).

FIGURE 2.



The summed amount consumed (g/day) of seafood items generally consumed by the women surveyed (n=95).

FIGURE 3.



Comparison of seafood consumption rates between current study and other investigations ([1]Maheffey et al., 2004 [2]US EPA, 2000 [3]Nobmann et al. 1992 [4]Sechena et al., 1999, [5]Duncan, 2000).

CHAPTER 2

Expanding Perceptions of Subsistence Fish Consumption: Evidence of High Commercial Fish Consumption and Dietary Mercury Exposure in an Urban Coastal Community

ABSTRACT

Through collaborative partnerships established between current researchers and The Moton Community House (a local community center), African American women (ages 16 – 49 yrs) from the Southeast Community of Newport News, Virginia, USA were surveyed to assess the reproducibility and consistency of fish consumption patterns (ingestion rates, exposure frequencies, weight, and fish consumption rates) derived from a community-specific fish consumption survey. Women were also surveyed to assess the reliability of the survey responses, and to estimate daily mercury intake. Fish consumption patterns were reproducible and the survey responses were reliable. Comparison between years revealed that fish consumption patterns remained consistent over time. In addition, the high fish consumption rate estimated in 2008 (147.8 g/day; 95% CI: 117.6-185.8 g/day) was reaffirmed with a rate (134.9 g/day; 95% CI: 88-207 g/day) not materially different and still considerably higher than mean fish consumption rates reported for U.S. women. Daily mercury intake rates were estimated using consumption data from 2008 and three consumption scenarios (canned white, canned light, and no tuna) due to confirmed differences in mercury concentration between canned white and light tuna. Arithmetic mean daily mercury intake rates were 0.284 ug/kg-bw/day (95% CI: 0.229 - 0.340 ug/kg-bw/day) using canned white tuna, 0.212 ug/kg-bw/day (95% CI: 0.165 - 0.259 ug/kg-bw/day) using light tuna, and 0.197 ug/kg-bw/day (95% CI: 0.151 - 0.243 ug/kg-bw/day) using no tuna. Approximately 58% - 73% of the daily mercury intake rates for African American women in the Southeast Community exceeded US EPA's oral reference dose (RfD) of 0.10 ug/kg-bw/day for mercury. In addition, 2% of the rates exceeded a level (1.00 ug/kg-bw/day) documented to produce adverse health effects. Past and current investigations confirmed that even though women in this community were not subsistence fishers, they are subsistence fish consumers.

1. INTRODUCTION

The estimation of finfish and shellfish (further referred to as fish) consumption and contaminant exposure in US subpopulations (e.g. subsistence fishers, ethnic minorities, or recreational anglers) can be greatly influenced by an assessor's perception and the selection of parameter values used to estimate exposure; especially, in subpopulations where peer reviewed publications and exposure data are limited, and an assessor is left to their own "best" judgment. Due to limited exposure data for certain US subpopulations (e.g., ethnic minorities), Federal and State default values are often used when estimating fish consumption and contaminant exposure (e.g. mercury, polychlorinated biphenyls, or endocrine disrupters) in these populations. However, more thought and consideration needs to be given when selecting such values because they typically are not reflective of many US subpopulations and are based on both consumers and non consumers of fish as oppose to only fish consumers (National Environmental Justice Advisory Council (NEJAC), 2002). For Federal and State assessors, narrowly held perceptions of certain subpopulations could lead to incorrect assumptions of fish consumption and contaminant exposure that in turn could result in environmental policies and standards that do not effectively protect these subpopulations.

Subsistence fishers are generally defined as those that rely on non-commercially caught fish as a major source of protein to their diet (US Environmental Protection Agency (US EPA), 2000a, 2000b). In the US, subsistence fishers represent subpopulations that are potentially highly exposed to contaminated fish and exhibit the highest fish consumption rates reported, as suggested by US EPA's default consumption rate for subsistence fishers (142.4 g/day) and peer reviewed publications (Toy et al., 1996; Sechena et al., 1999 and 2003; Duncan, 2000; Judd et al., 2004). The high fish consumption rates exhibited by subsistence fishers strongly support the use of the adjective "subsistence" in describing their fish consumption patterns; although, subsistence fish consumers are often only thought of as individuals with high consumption rates who "fish" for, instead of "purchase," fish. This perception of subsistence fish consumers (and consumption), currently held by many exposure and risk assessors, stymies the use of the adjective "subsistence" to also describe subpopulations that do not fish but whose consumption of fish provides a major source of protein to their diet, is commercially purchased, and is comparable to that of subsistence fishers. Recently we suggested that currently held perceptions of subsistence fish consumers (and consumption) be broaden to include other subpopulations populations with comparable subsistence fish consumption patterns and contaminant exposures (Holloman and Newman, 2010). We define subsistence fish consumers broadly as those who rely on noncommercially caught or commercially purchased fish as a major source of protein in their diets (Holloman and Newman, 2010).

In 2004, the US EPA and Food and Drug Administration (US FDA) jointly developed fish consumption advice for one specific contaminant, mercury (US EPA/FDA, 2004). This joint effort reflected an understanding that human exposure to mercury contaminated fish involves the consumption of both commercial and noncommercial items. Mercury poses a human-health risk because of the adverse neurodevelopmental effects that have been linked with exposure. Methylmercury

(MeHg), the predominant form of mercury associated with fish, is known for its neurotoxicity and developmental toxicity (National Research Council (NRC), 2000; Castoldi et al., 2008). In addition, some studies have linked methylmercury exposure from fish consumption to cardiovascular toxicity (Salonen et al., 1995; Guallar et al., 2002; Virtanen et al., 2005; Roman et al., 2011) while others have found no associations (Ahlqwist et al., 1999; Hallgren et al., 2001; Yoshizawa et al., 2002; Mozaffarian, 2009; Mozaffarian et al., 2011). To protect humans against chronic and developmental mercury toxicity, US EPA developed an oral reference dose (RfD) of 0.10 ug/kg-bw/day, an estimate of a daily oral exposure that is likely to be without an appreciable risk of adverse health effects over a lifetime (US EPA, 2001a, 2001b).

In the US, African Americans represent a subpopulation whose dietary mercury exposure may potentially be underestimated due to misperceptions about subsistence fish consumption. Numerous studies continue to report that African Americans have higher fish consumption rates and associated contaminant exposures than the general US population or other subpopulations such as recreational anglers (e.g., Burger et al., 1999; Burger et al., 2001; Mahaffey et al., 2004; Gibson and McClafferty, 2005; Derrick et al., 2008; Shilling et al., 2008; Mahaffey et al., 2009; McGraw and Waller, 2009; Holloman and Newman, 2010; Shilling et al., 2010). However, peer-reviewed publications remain limited regarding African American fish consumption patterns and contaminant exposures (Weintraub and Birnbaum, 2008; Derrick et al., 2008; McGraw and Waller, 2009; Holloman and Newman, 2010) and cultural and lifestyle factors influencing such exposures (Beehler et al., 2001; Cecelski, 2001; Weintraub and Birnbaum, 2008).

Through collaborative partnerships established between current researchers and a local community center (The Moton Community House), a community-based participatory research (CBPR) approach was used to explore fish consumption and dietary mercury exposure for African American women of childbearing age (ages 16 – 49 yrs) residing in the Southeast Community of Newport News, Virginia, USA. During April and May 2008, we administered a community-based fish consumption survey to African American women (n = 95) for the purpose of estimating fish consumption patterns (Holloman and Newman 2010). Our results suggest that even though African American women in this community are not subsistence fishers, they are subsistence fish consumers and that their consumption of commercially purchased items is high enough to warrant concerns of dietary mercury exposure (Holloman and Newman, 2010).

The goals of the present investigation were to confirm that the consumption survey used to estimate fish consumption patterns was reproducible and to estimate dietary mercury exposures for African American women (ages 16 - 49 yrs) residing in the Southeast Community of Newport News, Virginia. Specific objectives were to: 1) assess the reproducibility of the East End Fish Consumption Survey, 2) quantify the reliability of the responses used to estimate fish consumption rates, 3) assess the consistency of fish consumption patterns in the community, 4) determine mercury concentrations in commonly consumed fish items, and 5) generate deterministic (point) estimates of daily mercury intake. We hypothesized that fish consumption rates for African American women in the Southeast Community were greater than US EPA default values. We also hypothesized that daily mercury exposures, as well as percentage of the population exceeding US EPA's oral RfD for mercury, for African American women in this community were higher than reported estimates and exceedances for general US women.

2. MATERIALS AND METHODS

2.1. Survey Design

The 2010 East End Fish Consumption Survey was based on the consumption survey administered during April and May 2008 (Holloman and Newman, 2010). The East End Fish Consumption Survey was designed to estimate the ingestion rate (IR, g/meal), exposure frequency (EF, meals/year), and consumption rate (CR, g/day) of individual fish (finfish and shellfish) items consumed by, and the body weight (Wgt, kg) of, low-income African American women residing in the Southeast Community of Newport News, Virginia, USA Methods previously published (Holloman and Newman, 2010) were used in determining IR, EF, and CR, for the current survey. All questions asked in the 2008 survey were included in the 2010 version of the East End Fish Consumption Survey.

Changes in the 2010 version of the East End Fish Consumption Survey included the use of different visual aids, clarification of cooking methods, and an additional question used to quantify reliability of responses. It was noted that the validity of the estimates (i.e., Wgt, IR, EF, and CR) was important but was quantified not due to limited resources. In the current survey, 68 new individual fish items were vacuum sealed and used based on visual aid methods previously published (Holloman and Newman, 2010). For clarification of cooking methods, the same questions asked in 2008 were asked in the current survey but separately for fish and shellfish. To assess the reliability of the responses given by the participants, they were asked initially to state consumption information for all fish items they listed then at the end of the survey, they were asked to restate consumption information pertaining specifically to the first fish item listed. A measure of concordance between the two responses (beginning and end) was determined and used as a relative measure of reliability in responses given by the participants.

2.2. Sample Size and Recruitment

The number of women used to assess the consistency of fish consumption and reproducibility of the East End Fish Consumption Survey was based on confidence interval precision using SAS PROC POWER (Version 9.2 software; SAS Institute Inc, Cary, NC). We were interested in confidently detecting a difference between 2010 estimates for IR, EF, and Wgt that was at most, 30% of the 2008 mean estimates. Because of the nonnormality in the IR, EF, and Wgt distributions obtained in 2008, log transformed data were used in the calculation of sample size. Sample sizes for IR, EF, and Wgt were calculated and the results of the three variables compared. It was determined that 12 women would be sufficient to achieve the desired precision. A total of 12 participants were conveniently recruited throughout the Southeast community of Newport News, Virginia. Inclusion criteria for participation were that participants (1) resided in the Southeast community of Newport News, VA, (2) considered themselves an African American or Black woman between the ages of 16 - 49 years, and (3) consumed fish. None of the selected women had participated in the 2008 survey.

We attempted to assess reproducibility by administering the survey to the same 12 women, four separate times during February 2010 – June 2010. This time frame was selected because we also wanted to simultaneously examine seasonality of fish consumption, representing winter/spring (February/April 2010) and spring/summer (May/June 2010) consumption. However, the number of participants (12) needed to confidently achieve the desired precision for assessing reproducibility was only attained during May 2010. In June 2010, the month with the next highest number of participants, only nine out of the 12 women were able to take the survey. Therefore, subsequent analysis for reproducibility only focused on data collected during May and June 2010 for nine women (with the understanding that differences in 2010 less than 30% of the 2008 estimates may not confidently be detected), and seasonality was not analyzed. To assess the consistency of fish consumption patterns (IR, EF, and CR), the 12 women in the current study were surveyed during a time (the month of May) comparable to when women in 2008 were surveyed (Holloman and Newman, 2010), and data between the two were compared.

2.3. Determination of Mercury Concentrations

2.3.1 Sample Collection

A total of 39 different types of fish were listed as items consumed by women in the Southeast Community of Newport News, Virginia (Holloman and Newman, 2010); however, all items were not analyzed for mercury due to time, availability, and resources. Out of the 39 items listed, a total of 24 fish items were selected for mercury determination (Table 1). Fish items selected were based on: 1) ten or more women surveyed in 2008 (Holloman and Newman, 2010) consuming a particular item (n =19), 2) the potential of an item having elevated mercury concentrations due to species' trophic ecology and availability of the item in local grocery stores and fish markets (n = 2), and 3) three randomly selected fish items consumed by 9 or less of the women (n = 3).

For each of the 24 fish items, ten samples were selected from local grocery stores and fish markets. Grocery stores and fish markets were selected for sampling because 93% of fish items consumed by women in 2008 came from stores and markets where as only 4% of items consumed were self-caught (Holloman and Newman, 2010). Selection of the store or market to purchase the item was based on the cumulative probability of all stores and markets listed by women in 2008 (Holloman and Newman, 2010). For one of the items (lobster), in addition to being purchased at a grocery store/fish market, four out of the ten samples were selected from a local restaurant because of the high probability of lobsters being consumed at restaurants. Also for trout (n = 19), the only species available in the selected stores and markets was sea trout which was why trout (sea) (n = 3) was denoted with an asterisk in Table 1. Once at the store or market, all of the different brands and types (fresh, frozen, canned) of the particular item were listed and a random number table was used to select an item from this list. If a store or market did not carry the particular fish item, another store/market was selected as previously mentioned and the process repeated.

2.3.2 Sample Preparation and Analysis

Once collected, individual items were cut in half. One half of the item was processed and analyzed in its unprepared (raw or straight out of the can with no further preparation required) state; the other was cooked, processed, and analyzed in its prepared (further preparation required) state. Based on cooking and cleaning methods previously determined (Holloman and Newman, 2010) all cooked finfish was breaded (with skin on) and pan/deep fried, and all cooked shellfish was boiled/steamed and the shell removed before homogenizing. The halves were homogenized and placed into tared acid washed (10% HNO_3) polypropylene bottles. The sample bottle was reweighed and the weight of the bottle with the sample recorded. The unprepared and prepared halves were freeze-dried to constant weight and then wet: dry weight ratios calculated.

Total mercury concentrations (mg/kg, ppm) of dried samples were determined using a Milestone DMA-80 Direct Mercury Analyzer (Shelton, CT). The method detection limit (MDL) and limit of quantification (LOQ) for the DMA-80 were 0.0001 and 0.0005 mg/kg for 0.05 g of tissue, respectively. Results were converted to a wet weight concentration (mg/kg) by dividing the dry weight concentration by the wet: dry ratio. All mercury concentrations used in determining mercury exposure were the converted wet weight concentrations (mg/kg, ppm).

2.3.3 Quality Control and Quality Assurance

Standard curves were generated using different amounts of DORM-3, certified standard reference material from the National Research Council of Canada. To assess analytical quality of each analytical session, the certified standard reference material TORT-2 was used to establish control charts in which four replicates of the reference material (two in the beginning, one in the middle, and one at the end) were analyzed during each session. Based on the planned use of the data (i.e., estimating daily mercury intake), a recovery of± 6% for the TORT-2 reference material was deemed acceptable as the control chart upper and lower limits. Mean mercury concentrations (wet weight, mg/kg,) for all fish items analyzed were well above the method detection limit (0.0001 mg/kg) and limit of quantification (0.0005 mg/kg; Table 3). For the entire analytical process, the mean percent recovery for the certified standard reference material, TORT 2, was 103% (±2%).

2.4. Daily Mercury Intake

A deterministic (point) estimate of daily mercury intake (mg/kg-bw/day) was generated for low income African American women (ages 16 – 49 yrs) in Southeast Newport News, Virginia using consumption data generated from women surveyed in 2008 (Holloman and Newman, 2010) along with mercury data generated from the current investigation. Other mercury data were obtained from the peer reviewed literature and state databases (Table 4). Specifically, fish consumption rates (g/day converted to kg/day) were multiplied by mean mercury concentrations (mg/kg) yielding an amount of mercury consumed (mg/day) for individual fish items listed. For each of the 95 women, the amounts of mercury consumed for individual fish items listed were summed yielding a total (summed) amount which was then divided by the woman's weight (kg). Because only 93 out of the 95 women reported their weight, 93 daily mercury intake rates (mg/kg-bw/day) were estimated and ranked. Transformed ranks (Blom, 1958) and cumulative proportions of daily mercury intake (mg/kg-bw/day) were plotted. In addition, because canned tuna (not differentiating between type of canned tuna) was the only type of tuna that the women stated consuming in 2008 (Holloman and Newman, 2010) and known differences in mercury concentrations between types of canned tuna (white and light; Burger and Gochfeld, 2004), three estimates of mercury intake were generated. These three estimates represented the consumption of fish that included either canned "white", "light", or "no" tuna.

2.5. Statistical Analysis

SAS 9.2 (SAS Institute Inc, Cary, NC) was used for all statistical analyses and probability values less than 0.05 were deemed significant. Data from the 2010 East End Fish Consumption Survey were not normally distributed. Therefore, a nonparametric Kendall τ procedure was used to assess correlations between demographic variables (age, income, education, and body weight) and total number of fish items listed, summed ingestion rate (IR, g/meal), summed exposure frequency (EF, meals/year), and summed fish consumption rate (CR, g/day). In addition, geometric estimates for means, standard deviations, and 95% confidence intervals were determined for summed IR, EF, and CR, and for body weight

Data from the nine out of 12 women surveyed in May and June 2010 were compared to assess the reproducibility of the consumption survey to estimate IR, EF, CR, and body weight (kg, Wgt) for African American women (ages 16 – 49 yrs) in the Southeast Community. A nonparametric two sample Wilcoxon Rank Sum test (two-sided) was performed using NPAR1WAY SAS procedures to generate a rank sum statistic (W_{RS}) along with associated p-values. Significant probabilities suggested that the underlying distributions of IR, EF, CR, and Wgt differed significantly between May and June surveys and that the survey could not reproduce such estimates.

For consumption information requested twice within the survey, a measure of concordance between responses was determined and used to quantify the reliability of survey responses (i.e., for meal size, meals/year, and portion size) used to estimate IR, EF, CR, and Wgt. The validity of the estimate itself (i.e., IR, EF, CR, and Wgt) was not quantified. Because the response data was not normally distributed, nonparametric procedures were employed and the Kendall τ-b coefficient was generated. This statistic was used as the quantitative measure of reliability for responses used to estimate IR, EF, CR, and Wgt.

To assess the consistency of fish consumption patterns (IR, EF, and CR) for African American women (ages 16 – 49 yrs) in the Southeast Community, data from 2008 (Holloman and Newman, 2010) was compared with current May 2010 data. A nonparametric two sample Wilcoxon Rank Sum test (two-sided) was also performed using NPAR1WAY SAS procedures to generate a rank sum statistic (W_{RS}) and associated probabilities (p-values). Significant probabilities suggested that the underlying distributions of IR, EF, CR, and Wgt differed significantly between years and that the fish consumption patterns for African American women in the Southeast were not consistent through time. Fish consumption patterns for African American women in the Southeast Community were also compared to US EPA default values for the general population, recreational anglers, and subsistence fishers and the higher estimate was determined.

Mercury concentration data was not normally distributed; therefore, difference in mercury concentrations between raw and cooked samples were also analyzed using nonparametric procedures. A Wilcoxon signed rank test was performed using PROC UNIVARIATE to estimate the signed ranked statistic (W_{SR}). The hypothesis that the median difference between raw and cooked samples is equal to zero was rejected for all items with significant probability values thus suggesting that the underlying distributions between raw and cooked samples differed.

Nonparametric methods were used to compare the three daily mercury intake rates (white tuna, light tuna, or no tuna). A Kruskal-Wallis test was performed and a χ^2 statistic generated using the NPAR1WAY SAS procedure to determine if a difference among the intake rates existed. A probability value less than 0.05 was deemed significant and suggested that a difference among the three intake rates existed. Cumulative proportions of daily mercury intake rates were plotted and compared to US EPA's oral reference dose (RfD) for mercury (0.10 ug/kg-bw/day). The percentage of intake rates exceeding the oral RfD was determined and compared to national estimates of exceedances.

3. RESULTS

3.1. Reproducibility, reliability, and consistency of fish consumption patterns

Fish consumption data (IR, EF, CR, and Wgt) for the nine out of 12 participants who took the survey during May and June 2010 were used to assess the reproducibility of the consumption survey. Comparisons revealed no significant difference ($p > 0.05$) in underlying distributions of IR ($W_{RS} = 87$, $p = 0.93$), EF ($W_{RS} = 91$, $p = 0.70$), CR ($W_{RS} = 92$ $p = 0.60$), and Wgt ($W_{RS} = 86$, $p = 1.00$) between May and June 2010 for the nine participants. Measures of concordance (Kendall τ-b) used to assess the reliability of participant survey responses were high (Kendall τ-b > 0.80) for May (n=12) and June (n=9) 2010. For May 2010, Kendall τ-b coefficients were 0.92 (95% CI: 0.76 – 1.00) for meal size, 0.95 (95% CI: 0.85 – 1.00) for meals/year, and 1.0 (95% CI: 1.00 – 1.00) for portion size. For June 2010, Kendall τ-b coefficients were 1.00 for meal size, meals/year, and portion size.

Data used to assess the consistency of fish consumption patterns was obtained during May 2010, a time similar to that for the 2008 survey (April and May). All of the women (n = 12) surveyed in 2010 had completed high school, GED or vocational training and had household incomes of $0 - $20,000. There was no significant association (p >0.05) between demographic variables (age, income, education, and weight) and total number of fish items listed (Kendall τ = 0.12, 0.28, -0.10, -0.08 respectively; p = 0.62, 0.30, 0.71, and 0.72 respectively) and summed IR (Kendall τ = 0.14, 0.33, 0.26, 0.17 respectively; p = 0.53, 0.19, 0.31, and 0.45 respectively). There was a significant association between the demographic variable age and summed EF (Kendall τ = 0.5; p = 0.02), and summed CR (Kendall τ = 0.46; p = 0.04); however, there was no significant association between the other demographic variables (income, education, and weight) and summed EF (Kendall τ = 0.19, -0.21, -0.02 respectively; p = 0.47, 0.41, and 0.94 respectively) and summed CR (Kendall τ = 0.33, 0.17, 0.24 respectively; p = 0.19, 0.52, and 0.30 respectively).

Fish consumption data was not normally distributed therefore, geometric means for Wgt and the sums of IR, EF, and CR were reported (Table 2). Comparison between years for fish consumption data (Figure. 1 A-D) revealed no significant difference ($p < 0.05$) in underlying distributions of IR (W_{RS} = 653, p = 0.96), EF (W_{RS} = 519, p = 0.21), CR (W_{RS} = 561 p = 0.40), and Wgt (W_{RS} = 599, p = 0.71) between 2008 and 2010.

3.2. Mercury Concentration of Commonly Consumed Fish Items

Mercury concentrations ranged between 0.001 – 0.327 mg/kg for unprepared (raw or straight from the can) items and 0.012 – 0.177 mg/kg for prepared (cooked) items. In general, prepared items were higher in concentration than unprepared items. Out of the 20 fish items in which a comparison of median differences between prepared and unprepared concentrations could be made, median differences were significantly greater than zero for 14 of the items (Table 3). Median differences were significantly greater than zero for shrimp croaker, blue crab, whiting, salmon cake, scallops, tilapia, flounder, crab cake, catfish, lobster, black bass, and butterfish. For sea trout, the median difference was significantly greater than zero with a borderline p value (0.049).

3.3. Deterministic Estimates of Daily Mercury Intake

For women surveyed in 2008, arithmetic mean daily mercury intake rates were 0.284 ug/kg-bw/day (95% CI: 0.229 - 0.340) using canned white tuna, 0.212 ug/kg-bw/day (95% CI: 0.165 - 0.259) using light tuna, and 0.197 ug/kg-bw/day (95% CI: 0.151 - 0.243) using no tuna. The mean ranks of daily mercury intake rates were significantly different among the choice of tuna used ($\chi^2 = 8.60$; p = 0.01). For approximately 58% - 73% of the cases, daily mercury intake rates for low income African American women in Southeast Newport News, VA, would exceed US EPA's oral reference dose (RfD) of 0.10 ug/kg-bw/day for mercury (Figure 2). In addition, for approximately 2% of cases, women in this community would exceed a level (10*RfD for mercury; 1.00 ug/kg-bw/day) documented to produce adverse health effects (Figure 2).

4. DISCUSSION

4.1. East End Fish Consumption Survey

In the field of nutritional epidemiology, there are numerous methods to assess the validity and reproducibility of estimates derived from fish consumption surveys (Shatenstein et al., 1999; Mina et al., 2007; Birgisdottir et al., 2008). We understand the importance of validating estimates (IR, EF, CR, and Wgt) derived from the East End Fish Consumption Survey; however, due to limited resources we were only able to assess the reproducibility of the estimates and the reliability of the responses used to generate the estimates. For reproducibility, results revealed no difference in the underlying distributions of IR, EF, CR, and Wgt between May and June 2010 for the nine women surveyed thereby implying that the survey was able to reproduce the estimates. A difference between May and June estimates may have existed but, was not detected because the number of participants (n=12) needed to confidently detect such difference (at most 30% of the 2008 estimates) was not achieved. However, if such a difference existed, it would be marginal in comparison to the more illuminating differences between estimates for African American women in the Southeast Community and US. EPA default values for the general population and recreational anglers. Thus, even with the possibility of the estimates between May and June being different, such a difference still does not overshadow the fact that the survey was able to reproduce the substantially higher estimates exhibited by women in this community.

Reliability of the responses used to generate the fish consumption estimates was not assessed in 2008; however, data collected in 2010 (May and June) did suggest that responses used in generating estimates were highly reliable and similar to the responses given 2008 (Holloman and Newman, 2010). For both May and June, the measures of concordance (Kendall τ-b) were 0.92 and 1.00 respectively for meal size, 1.00 respectively for portion size, and 0.95 and 1.00 respectively for meals/year. Such high measures of concordances (>0.80) strongly implies that responses in 2010 were reliable and that the same may have been true for responses given in 2008; thus for our purposes we assumed that responses given in 2008 were reliable as well.

Comparisons of estimates between the years (2008 and only May 2010) strongly suggest that fish consumption patterns of African American women in the Southeast were consistent through time. Seasonality was not able to be addressed but can play a significant role in fish consumption for women in this community. Both of the surveys were administered during late spring (April and May) and therefore may only be reflective of consumption during that season. Thus, because the current and past (Holloman and Newman, 2010) investigations assumed regular and consistent consumption, fish consumption estimates generated for African American women in the Southeast are potentially overestimated.

As noted earlier, the validity of IR, EF, CR, and Wgt should be investigated and could be addressed by using dietary records or recalls in which consumption estimates generated by the survey are compared with estimates generated by the records or recalls (Masson et al., 2003). The use of biomarkers (e.g. hair and blood mercury) could also be used to assess the validity of estimates derived from fish consumption surveys. Biomarkers provide a more accurate estimate of actual fish consumption as well as a method free from errors associated with dietary records (e.g. food consumption diaries) or recollections, e.g. 24 hour recall (Mina et al., 2007).

The lack of validating IR, EF, CR, and Wgt potentially means that the estimates may not be accurate and precise reflections of fish consumption for African American women in this community. However, based on current conclusions that: 1) the survey consistently estimated ingestion rate (g/meal), exposure frequency (meal/year), fish consumption rate (g/day), and body weight (kg), 2) the responses used to generate such estimates were highly reliable, and 3) estimates derived from the survey were reproducible, we assumed the estimates generated in 2008 and currently were reasonable reflections of fish consumption patterns during late spring and early summer for African American women in the Southeast Community.

4.2. Evidence of high subsistence fish consumption

The high fish consumption rate (147.8 g/day) obtained in 2008 for African American women residing in this urban costal community (Holloman and Newman, 2010) was also reconfirmed with results of the current investigation. The mean fish consumption rate of women surveyed in the current investigation (134.9 g/day) was not materially different from women surveyed in 2008; however, it was considerably higher than US EPA default values reported for the general population and recreational angler (17.5 g/day), and more similar to the default value for subsistence fishers (142g/day).

In estimating ingestion rates, a necessary adjustment was made based on the understanding that the total amount ingested for a particular item was not only the portion size (g/meal), but also how many individual portions (meal size) were consumed during one meal setting (Holloman and Newman, 2010). Such an adjustment should be considered when estimating ingestion rates and was calculated by multiplying the portion size selected by the number of individual portions consumed during one meal setting (Holloman and Newman, 2010). For African American women in this community, not making this adjustment would result in underestimation of ingestion rates and is potentially one of the reasons why consumption rates were higher.

Additionally, as noted in an earlier publication (Holloman and Newman, 2010), the manner in which rates were calculated (using individual differences in exposure frequencies and ingestion rates instead of averages) likely contributed to the higher consumption rate estimates. For each individual surveyed in 2008, the IR for each item listed was summed and used to represent a summed ingestion rate (g/meal) for the individual. Thus, the IR reported in Table 2 is the mean of the summed ingestion rates for the 95 individuals surveyed in 2008 (Holloman and Newman, 2010) and not the mean of mean ingestion rates which, explains why this estimate seems extremely high. Women surveyed in 2008 and 2010 could list up to 11 fish items and on average listed 8 items for both years. To get a rough estimate of mean ingestions rates, the summed ingestion rates could be divided by the average number of fish items listed (e.g., the mean of summed IR for 2008 (1366g/meal) / mean # of items listed (8) = 171 g/meal).

It has been suggested that not taking into account species specific differences in fish consumption potentially biases estimates downward (Burger et al., 1999). On the other hand, others have suggested that such a "species specific" approach tends to overestimate fish consumption patterns (Lincoln et al., 2011). For May 2010, consumption rates (CR, g/day) based on a question specific to fish meals consumed within seven days of taking the survey were generated and compared to the mean summed CR generated from the listing of all fish consumed. Comparisons revealed that the estimate based on the seven day question was lower (84 g/day; 95% CI: 32 – 219 g/day) than the mean summed CR estimate (134 g/day; 95% CI: 88 -207 g/day), however, not significantly lower. Similar to work highlighting this difference (Lincoln et al., 2011), we believe that true fish consumption for women in this community lies somewhere between the two estimates (7 day CR and summed CR).

Based on the women surveyed in 2008, African American women (ages 16 - 49 yrs) from this urban coastal community would not be considered subsistence fishers (hence subsistence fish consumers) because 65% of the women surveyed did not fish and 93% of the fish items consumed came from grocery/fish markets (Holloman and Newman, 2010). However, the women consumed fish at a rate (147.8 g/day; Holloman and Newman, 2010) comparable to rural subsistence fishing population such as the Squamish Indian Tribe (213.9 g/day; Duncan, 2000), Asian and Pacific Islanders in King County, Washington (117.2 g/day; Sechena et al., 1999), and Native Alaskans (109 g/day; Nobmann et al., 1992). In addition, 83% of the women surveyed had consumed fish within seven days of being interviewed (Holloman and Newman, 2010). Such fish consumption patterns were also confirmed with results of the current investigation in which 75% (95% CI: 46 - 100 %) of the women surveyed in 2010 did not fish and 90 % of the items consumed came from grocery stores (53%; 95 % CI: 43 - 63%) and fish markets (37%; 95% CI: 27 - 47%). Sixty-seven percent (95% CI: 35 - 98%) of the women had consumed fish seven days prior to being interviewed. Collectively, this evidence strongly suggests that African American women from the Southeast Community of Newport News are subsistence fish consumers and rely on commercially caught fish as a major source of protein in their diets (Holloman and Newman, 2010).

4.3. Preparation of Fish and Mercury Concentration

Mean mercury concentrations for the fish items analyzed were comparable to other mean estimates reported for commercial fish items (Sunderland, 2007; McKelvey et al., 2010; US FDA, 2011a, 2011b). The higher mercury concentrations (statistically significant in many cases) for items prepared (cooked) versus unprepared (raw) were similar to differences reported in the literature (Morgan et. al, 1997; Burger et al., 2003). Noting the difference in mercury concentration between cooked versus raw fish items, it has been suggested that food preparation factors be used in estimating mercury exposure (Morgan et al, 1997; Burger et al., 2003). Preparation factors (mercury concentration in cooked item/mercury concentration in raw item; Burger et al., 2003) for the current investigation ranged from 1.1 (perch) to 1.6 (croaker) for fish and from 1.2 (snow crab legs) to 1.5 (crab cake) for shellfish, compared to 1.5 to 1.8 for largemouth bass (Burger et al., 2003) and 1.3 to 1.6 for walleye and lake trout (Morgan et al., 1997). Factors obtained in the current investigation also coincided with the suggestion that a preparation conversion factor of 2 would be a suitable, protective default value (Burger et al., 2003). As highlighted by Burger et al. (2003), the process of cooking fish (particularly deep frying) causes moisture loss, but no mercury loss which results in an increase in mercury concentration in the cooked fish relative to the raw fish sample. This is the most plausible explanation as to why mercury concentrations were higher in cooked fish items than in raw items.

No adjustments were made using a preparation food conversion factor to estimate mercury intake because amount consumed and mercury concentrations were based on cooked items. Burger et al. (2003) warned that assessors who do not take cooking methods into account, but use raw fish contaminant data, may be overestimating safe consumption levels and underestimating actual exposure. Thus, the lack of clearly stating what type of data (prepared/cooked data) was used to generate consumption estimates and mercury concentrations can create serious risk communication issues. For the current investigation, estimates of meal size and amount consumed were based on cooked items except for canned tuna, clams, oysters, and sardines in which estimates were based on how the items are normally consumed in this community, unprepared (straight from the can with no further cooking preparation). Mercury concentrations were also based on cooked items except for canned tuna, clam, oysters, and sardines in which concentrations were based on no further preparation (i.e. frying). As noted earlier, if fish consumption estimates are based on cooked items but, an assessor calculates exposure based on raw fish contaminant data, such estimates would underestimate actual exposure (Burger et al., 2003). For the current investigation, because the estimation of fish consumption and mercury exposure were based on cooked items, it was believed that calculated exposure estimates were more reflective of the actual daily mercury intake for women in the community.

4.4. Daily Mercury Intake: Evidence of high exposure

The mean mercury consumption per day (mg Hg /day;) using white tuna (0.02 mg Hg/day), light tuna (0.015 mg Hg/day), and no tuna (0.014 mg Hg/day) was similar to means reported for minority anglers from California's Central Valley Delta (African American: 0.02 mg Hg/day; Southeast Asian: 0.02 mg Hg/day; Asian/Pacific Islander: 0.02 mg Hg/day; Hispanic: 0.01 mg Hg/day; Native American: 0.02 mg Hg/day) (Shilling et al., 2010). Daily mercury intake rates for no, light, and white tuna consumption (0.197, 0.212, and 0.284 ug/kg-bw/day respectively) were significantly higher than national estimates reported for general US women (0.02 ug/kg-bw/day; 95% CI: 0.02 - 0.03 ug/kg-bw/day; Mahaffey et al., 2004) and for non-Hispanic Black women (0.05 ug/kg-bw/day; 95% CI: 0.01 - 0.09 ug/kg-bw/day; Mahaffey et al., 2004). However, current mercury intake rates more closely resembled the median rates of fishing populations such as fluvial lake fish eaters in Canada (0.80 and 0.14 ug/kg-bw/day; Abdelouahab et al. 2008), and mean rates of subsistence fishing populations such as the Tulalip native population in Washington State, US (0.11 – 0.20 ug/kg-bw/day), the Squaxin Island native population in Washington State, US (0.11 – 0.22 ug/kg-bw/day) , and the Suquamish native population in Washington State, US (0.16 –

0.25 ug/kg-bw/day; Mariën and Patrick, 2001). This evidence strongly supports earlier conclusions that African American women in the Southeast Community of Newport News, Virginia are subsistence fish consumers (Holloman and Newman, 2010) and suggests that dietary mercury exposure among these women is high.

Exposure to mercury from the consumption of fish can produce both chronic and developmental toxicity effects in humans (US EPA 2001a, 2001b). To protect humans against such mercury toxicity, US EPA developed an oral reference dose (RfD) of 0.10 ug/kg-bw/day, an estimate of a daily oral exposure that is likely to be without an appreciable risk of adverse health effects over a lifetime (US EPA, 2001a, 2001b). This RfD was based on cord blood measurements and is associated with a blood mercury (BHg) concentration of 5.8 ug/l (NRC, 2000; US EPA, 2001a, 2001b). The percentage of women exceeding US EPA's oral RfD was high for all three estimates (white, light, and no tuna) with more than 50% of the estimates exceeding this threshold. These exceedances were approximately 2 - 3 times higher than what was reported in general (29%) and specifically for African American (36%), Hispanic (25%), Asians (42%) and Native American (27%) low income women in California's Sacramento-San Joaquin Delta (Silver et al., 2007). These exceedances were also considerably greater than recent national BHg exceedances for general US women (ages 16 – 49 yrs, 4.7 %; Mahaffey et al., 2009) and for African American women (4.1%; Mahaffey et al., 2009).

The oral RfD, 0.10 ug/kg-bw/day, is a conservative estimate meant to be protective of all components of populations including susceptible subgroups and is not associated with measureable health effects. However, ten times the oral RfD for mercury is an intake estimate that has resulted in measurable health effects (US EPA, 2001a, 2001b). The percentage of women exceeding this estimate (1.00 ug/kg-bw/day) was approximately 2% for the current investigation. This was comparable to the 5% of consumers found to be exceeding this estimate in California's Central Valley Delta (Shilling et al., 2010). Collectively, the estimates of daily mercury intake and the proportion of women exceeding US EPA's oral RfD provide strong evidence that African American women in the Southeast Community of Newport News, Virginia might be highly exposed to mercury through the consumption of fish.

5. CONCLUSION

It is erroneous to compare mean fish consumption of fish consumers with means of general populations that includes both consumers and non consumers of fish; however, many Federal and State agencies use default values based on such *per capita* estimates to describe fish consuming populations as well as setting environmental standards and policies to protect them (NEJAC, 2002). Assessors need to be more aware of their perceptions associated with certain subpopulations and their selection of parameter estimates used to characterize fish consumption in these populations, especially when exposure data is limited. Narrow perceptions and incorrect assumptions of fish consumption and contaminant exposure for many US subpopulations has lead to serious issues of environmental injustices regarding risk management and communication whereby non protective standards and polices have been implemented (and communicated), and the burden of exposure reduction has placed solely on the individual and population (NEJAC, 2002).

Through the collaborative partnership established between our research team and the Moton Community House, critical insights were gained about fish consumption patterns and dietary mercury exposure for low income African American women residing in the Southeast Community of Newport News, Virginia. One critical insight was that fish consumption rates for women in this community were the highest rates reported for African American women and supported the evidence that fish consumption among women of this ethnicity was high compared to general population. Another insight was that the sources of the fish items consumed by women in this community were mainly from commercial sources (grocery store or fish market), not noncommercial sources (fishing).

Results from the past (Holloman and Newman, 2010) and current investigations confirmed that, even though women in this community are not subsistence fishers, they consume fish at a subsistence fisher rate. It is conceivable how a lifestyle factor such as subsistence fish consumption would have significant impacts on dietary mercury exposure and results from the current investigation confirms this to be true for women in this community. Noteworthy is the potential environmental injustice issue arising from current perceptions of subsistence fish consumption held by many charged with assessing and regulating exposure to contaminated fish. Assessors viewing subsistence fish consumption only in relation to items fished for, instead of purchased, may unintentionally overlook or make incorrect assumptions about populations who are not subsistence fishers, but nonetheless, consume commercial fish at a subsistence rate. African American women residing in the urban costal community of Southeast Newport News, Virginia is one example of such a population.

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TABLE 1.

List of commonly consumed fish items (finfish and shellfish) and the frequency of women consuming the items. Items with an asterisk (*) refer to the fish items selected for total mercury analysis (24 out of 39 items).

Common Names of Fish Items Consumed	Number of Women Consuming Items (n= 95)
1. Whiting*	79
2. Shrimp*	77
3. Tuna*	77
4. Snow Crab Legs*	70
5. Blue Crab*	65
6. Croaker*	61
7. Scallops*	43
8. Spot*	40
9. Mackerel Cake*	35
10. Salmon Cake*	35
11. Tilapia*	25
12. Crab Cake*	21
13. Trout*	19
14. Flounder*	18
15. Oysters*	18
16. Catfish*	16
17. Clam*	16
18. Sardines*	12
19. Lobster*	11
20. Mussels	7
21. Black Bass*	5
22. Butterfish*	4
23. Salmon Steak	4
24. Perch*	3
25. Striped Bass*	3
26. Trout (Sea)*	3
27. Dungeness Crab	2
28. King fish	2
29. Monk Fish	2
30. Porgy*	2
31. Bluefish	1
32. Clam Strips	1
33. Crab meat	1
34. Fish Sticks	1
35. Largemouth Bass	1
36. Mackerel Salad	1
37. Puppy Drum	1
38. Shad	1
39. Sushi	1

TABLE 2.

	N	Mean	SD	95% CI
East End Fish Consumption Survey 2010				
May				
Ingestion Rate (IR, g/meal)	12	1366	1.46	1074 – 1737
Exposure Frequency (EF, meal/year)	12	269	1.57	201 – 358
Fish Consumption Rate (CR, g/day)	12	135	1.96	88 – 207
Weight (kg)	12	71	1.16	64 - 78
June				
Ingestion Rate (IR, g/meal)	9	1427	1.59	997 – 2042
Exposure Frequency (EF, meal/year)	9	249	1.59	174– 356
Fish Consumption Rate (CR, g/day)	9	128	1.86	79 – 206
Weight (kg)	9	70	1.11	64 - 76
East End Fish Consumption Survey 2008				
Ingestion Rate (IR, g/meal)	95	1288	1.75	1149 – 1443
Exposure Frequency (EF, meal/year)	95	259	2.39	259 – 370
Fish Consumption Rate (CR, g/day)	95	148	3.08	118 – 186
Weight (kg)	93	73	1.25	69 – 76

Geometric mean, standard deviation, and 95% confidence interval for ingestion rate, exposure frequency, fish consumption rate, and body weight of women surveyed in 2008 and 2010 (present study).

TABLE 3.

Arithmetic mean (± standard deviation) and median mercury concentrations (mg/kg) and for unprepared (raw/ straight out of the can) and prepared (fried or steamed) fish items. (*) refers to items with a median difference between unprepared and prepared that was significantly greater than zero.

Fish Items (finfish & shellfish)	Unprepared N	Unprepared Mean (± SD)	Unprepared Median	Prepared N	Prepared Mean (+/- SD)	Prepared Median
Whiting*	10	0 046 (± 0 029)	0 034	10	0 066 (± 0 038)	0 054
Shrimp*	9	0 021 (± 0 014)	0 016	10	0 023 (± 0 017)	0 018
Canned Tuna (white)	5	0 327 (± 0 072)	0 361			
Canned Tuna (light)	5	0 056 (± 0 052)	0 035			
Snow Crab Legs	10	0 103 (± 0 056)	0 077	10	0 114 (± 0 057)	0 086
Blue Crab*	9	0 053 (± 0 021)	0 053	10	0 057 (± 0 022)	0 057
Croaker*	10	0 079 (± 0 029)	0 080	10	0 127 (± 0 059)	0 134
Scallops*	10	0 012 (± 0 005)	0 013	10	0 018 (± 0 009)	0 020
Spot	10	0 021 (± 0 013)	0 014	10	0 022 (± 0 011)	0 018
Mackerel Cake	10	0 043 (± 0 011)	0 041	10	0 047 (± 0 010)	0 046
Salmon Cake*	10	0 022 (± 0 008)	0 019	10	0 027 (± 0 011)	0 025
Tilapia*	10	0 012 (± 0 014)	0 002	10	0 012 (± 0 014)	0 002
Crab Cake*	10	0 033 (± 0 025)	0 020	10	0 045 (± 0 025)	0 035
Trout (Sea)*	10	0 119 (± 0 103)	0 088	10	0 134 (± 0 111)	0 108
Flounder*	10	0 069 (± 0 048)	0 056	10	0 081 (± 0 051)	0 071
Oysters	10	0 025 (± 0 014)	0 021			
Catfish*	10	0 015 (± 0 021)	0 006	10	0 020 (± 0 029)	0 006
Clam	10	0 001 (± 0 004)	0 009			

TABLE 3 continued.

Fish Items (finfish & shellfish)	Unprepared			Prepared		
	N	Mean (± SD)	Median	N	Mean (+/- SD)	Median
Sardines	10	0 029 (± 0 013)	0 032			
Lobster*	6	0 072 (± 0 016)	0 067	10	0 092 (± 0 026)	0 090
Black Bass*	10	0 115 (± 0 032)	0 101	10	0 161 (± 0 038)	0 149
Butterfish*	10	0 072 (± 0 010)	0 072	10	0 100 (± 0 027)	0 099
Ocean Perch	10	0 175 (± 0 124)	0 108	10	0 177 (± 0 142)	0 107
Striped Bass	4	0 109 (± 0 043)	0 101	4	0 135 (± 0 046)	0 126
Porgy	10	0 122 (± 0 026)	0 122	10	0 133 (± 0 037)	0 138

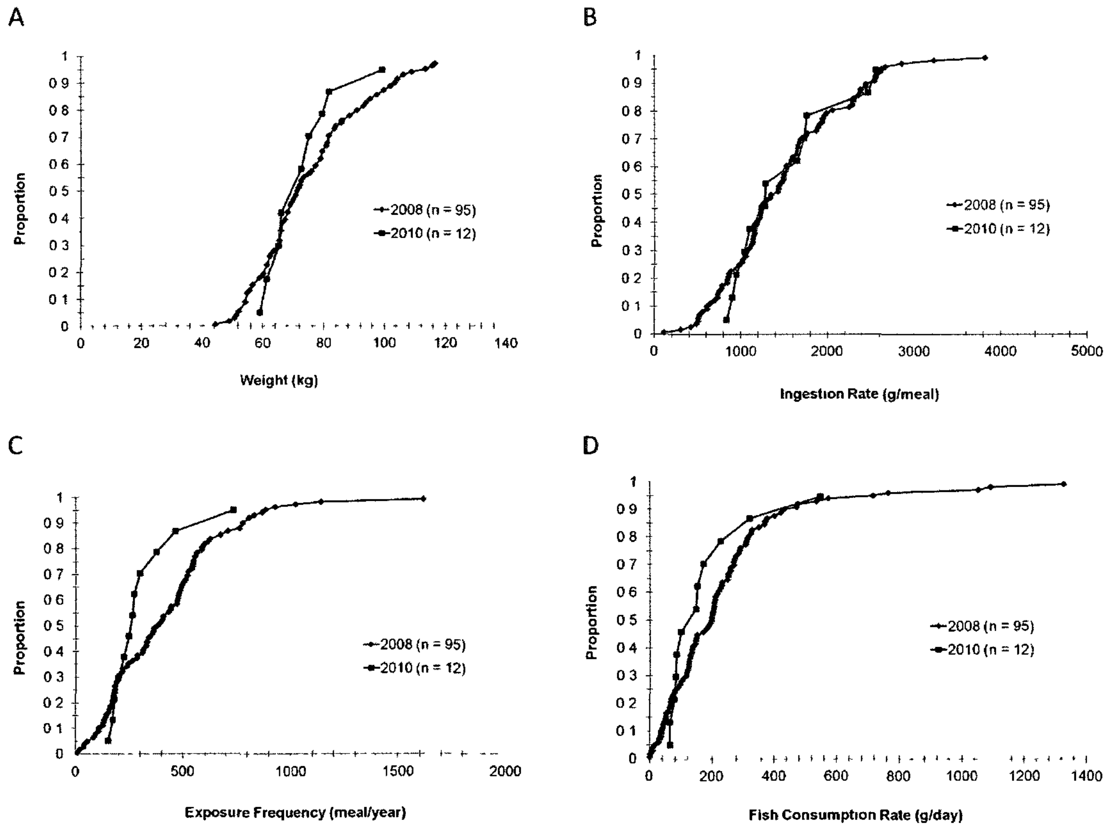
Arithmetic mean (± standard deviation) and median mercury concentrations (mg/kg) and for unprepared (raw/ straight out of the can) and prepared (fried or steamed) fish items. (*) refers to items with a median difference between unprepared and prepared that was significantly greater than zero.

TABLE 4.

Species	Mean (mg/kg)	Reference
Mussels	0.080	Sunderland 2007
Salmon Steak	0.040	Sunderland 2007
Trout (Sea) [a]	0.140	Current Study
Dungeness Crab	0.260	Sunderland 2007
King fish [b]	0.150	Sunderland 2007
Monk Fish	0.180	Sunderland 2007
Bluefish	0.340	Sunderland 2007
Clam Strips [c]	0.010	Current Study
Crab meat	0.060	Sunderland 2007
Fish Sticks [d]	0.100	Sunderland 2007
Largemouth Bass	0.690	Peles et al. 2006
Mackerel Salad [e]	0.047	Current Study
Puppy Drum [f]	0.020	VA DEQ 2008
Shad	0.020	Sunderland 2007
Sushi [g]	0.474	Lowenstein et al. 2010

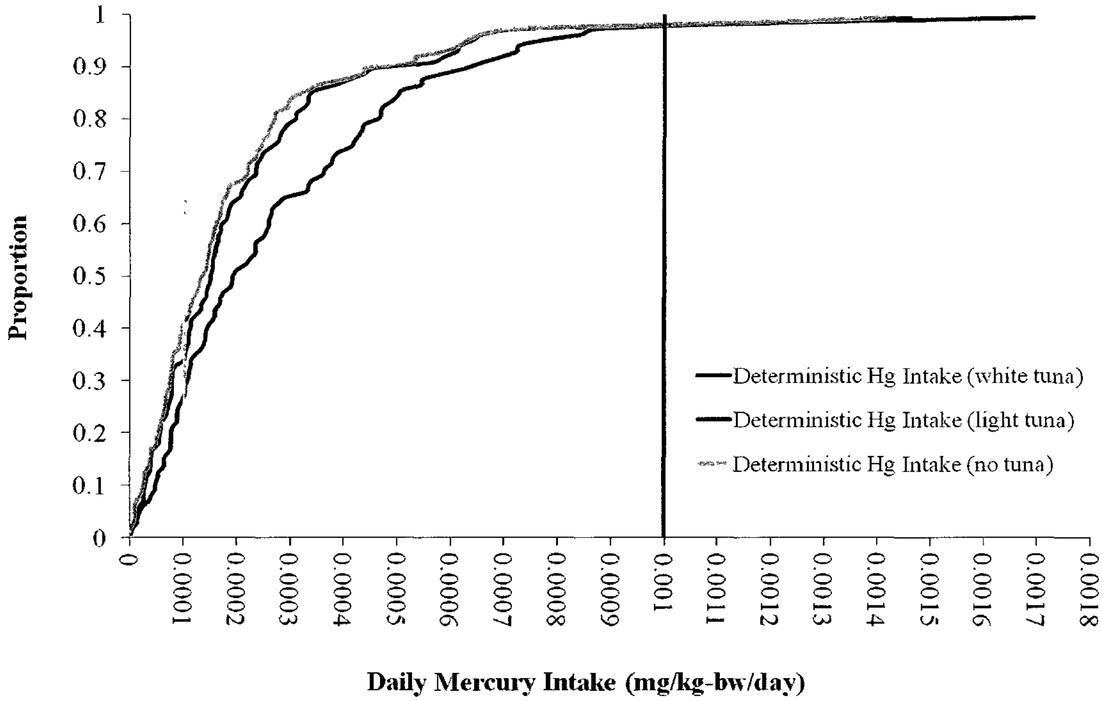
List of mercury concentrations (wet weight) used in calculation of daily mercury intake for species not collected for mercury analysis. [a] *Used mercury concentration for sea trout from current study.* [b] *Used mercury concentration for king mackerel from referenced study.* [c] *Used mercury concentration for clam from current study.* [d] *Used mercury concentration for cod from referenced study.* [e] *Used mercury concentration for mackerel from current study.* [f] *Used mercury concentration for red drum (Chesapeake Bay Small Coastal Drainage - Lower Chesapeake Bay) from referenced study.* [g] *Used mercury concentration for yellow fin tuna from referenced study.*

FIGURE 1.



Comparison of fish consumption patterns estimated using data collected in 2008 and 2010: A) Weight (wtg, kg), B) Ingestion rate (IR, g/meal). C) Exposure Frequency (EF, meal/year), and D) Fish Consumption rate (CR, g/day).

FIGURE 2.



Proportion of deterministic daily mercury intake rates (mg/kg-bw/day) using canned white tuna, light tuna, and no tuna. Yellow line = US EPA's oral reference dose for mercury (0.0001 mg/kg-bw/day). Red line = intake estimate that has resulted in measurable health effects (0.001mg/kg-bw/day).

CHAPTER 3

A Probabilistic Characterization of Dietary Mercury Exposure in an Urban Coastal Community

ABSTRACT

Through collaborative partnerships established between current researchers and The Moton Community House, probabilistic estimations of dietary mercury exposure for African American women (ages 16-49) from the Southeast Community of Newport News, Virginia, USA were generated and compared to previously published point estimates for the same population. Four different consumption scenarios were assumed, representing 1) no, 2) light, 3) both light and white, and 4) white tuna consumption. The probabilistic models generated lower dietary mercury intake rates than the point estimations, under these consumption scenarios. Arithmetic mean daily mercury intake rates (95% CI) for the probabilistic models were 0.149 (±0.003), 0.148 (±0.003), 0.172 (±0.004), and 0.202 (±0.004) ug/kg-bw/day, respectively for no, light, both, and white tuna consumption. Median daily mercury intake rates for the same consumption scenarios were 0.106, 0.107, 0.120, and 0.143 ug/kg-bw/day respectively. Under all consumption scenarios, an African American woman in the Southeast Community with mean or median dietary mercury intake could experience adverse health effects. For all consumption scenarios, more than half of African American women in the Southeast Community had exposures that exceeded US EPA's oral RfD for mercury (0.10 ug/kg-bw/day). The percentages of estimates that exceeded an oral RfD for mercury that results in measurable health effects (1.00 ug/kg-bw/day) ranged between 0.22 – 0.71% for all four consumption scenarios. Reducing the amount of fish consumed in probabilistic models resulted in lower dietary mercury exposures for each consumption scenario. At a rate that was a quarter of what was normally consumed, the percentages of exposures that exceeded the US EPA's oral RfD for mercury were 14%, 13%,18%, and 25% respectively for no, light, both, and white tuna consumption

1. INTRODUCTION

It is well established that ethnic minority and low-income communities experience higher mean exposures to contaminated fish and shellfish (further referred to as fish) than general US populations (Toy et al., 1996; Burger et al., 1999; Sechena et al., 1999; Burger et al., 2001; National Environmental Justice Advisory Council (NEJAC), 2002; Gibson and McClafferty, 2005; Derrick et al., 2008; Shilling et al., 2008; Mahaffey et al., 2009a; McGraw and Waller, 2009; Holloman and Newman, 2010; Shilling et al., 2010). Such disparities have been linked to the consumption of more fish annually and larger fish servings (Burger et al., 1999, 2001; Sechena et al., 1999; NEJAC, 2002; Corburn, 2002; Gibson and McClafferty, 2005; Holloman and Newman, 2010). Theses disparities have also been linked to cultural and lifestyle factors (Beehler et al., 2001; Cecelski, 2001; NEJAC, 2002; Judd et al., 2004; Weintraub and Birnbaum, 2008) such as subsistence fishing (Duncan, 2000; Sechena et al., 1999; Nobmann et al., 1992; Mariën and Patrick, 2001) or subsistent fish consumption (Holloman and Newman, 2010, *in press*). In the US, one subpopulation that continues to experience higher than average exposures to contaminated fish is African Americans (Burger et al. 1999, 2001; CDC 2001; Corburn, 2002; Schober et al., 2003; CDC, 2005; Gibson and McClafferty, 2005, Derrick et al., 2008; Shilling et al., 2008; McGraw and Waller, 2009; Holloman and Newman, 2010, *in press*; Shilling et al., 2010).

The consumption of fish is the most common exposure pathway for human mercury exposure (NRC, 2000). Due to the higher consumption of fish, African Americans may be more at risk of adverse health effects associated with dietary mercury exposure than the general US population. Exposure to mercury can cause numerous health effects although, human carcinogenicity remains inconclusive, effects on human immune system are poorly understood, and reproductive effects have not been fully evaluated (NRC, 2000). Some researchers suggest that the cardiovascular system is a likely site of mercury toxicity (Salonen et al., 1995; Sørensen et al., 1999; NRC, 2000; Guallar et al., 2002) but others have found no associations (Ahlqwist et al., 1999; Hallgren et al., 2001; Yoshizawa et al., 2002). On the other hand, neurodevelopmental effects caused by mercury exposure have been well established (Harada, 1995; Marsh et al., 1987; Myers et al., 1995a-c; Grandjean et al., 1995, 1997,1999; NCR, 2000; US EPA, 2001b; Castoldi et al., 2008). To protect humans against chronic and developmental mercury toxicity, US EPA developed an oral reference dose (RfD) of 0.10 ug/kg-bw/day, an estimate of a daily oral exposure that is likely to be without an appreciable risk of adverse health effects over a lifetime (US EPA, 2001).

Dietary mercury exposure can be estimated using either bio-markers (e.g. blood or hair) or exposure equations. Bio-markers provide a more accurate estimate of mercury exposure but often require more resources to generate such estimates. For African Americans, mercury concentrations in the blood and hair have been reported higher than other populations (CDC, 2001; Schober et al., 2003; CDC, 2005; Mahaffey et al., 2009a). On the other hand, the quantification of mercury exposure using exposure equations involves estimating contaminant concentrations and calculating contaminant intake rates (US EPA, 1999), and does not require the collection of human biological materials. Traditionally with exposure equations, a point estimate approach is used to calculate intake rates in which single values, such as a mean, characterizes variables in the exposure equations (US EPA, 2001c). The use of such an approach provides a limited understanding of variability and does not fully define exposure (US EPA, 2001c).

In communities disproportionately impacted by the consumption of contaminated fish, employing a point estimate approach potentially masks valuable information necessary to insightfully characterize exposure. Instead, the use of a probabilistic approach highlights information about variation in contaminant exposure in addition to information about uncertainty in the exposure estimate. Specifically, probability distributions for one or more variables are used in an exposure equation in order to quantitatively characterize the variability and/or uncertainty in the exposure estimate (US EPA, 2001c). One of the most common probabilistic methods, Monte Carlo simulation, combines probability distributions of key variables in an exposure equation along with the remaining variables to generate probability distributions of exposures (US EPA, 2001c).

Through collaborative partnerships established between current researchers and a local community center (The Moton Community House), community-based participatory research (CBPR) methodology was used to explore fish consumption and dietary mercury exposure for African American women of childbearing age (ages 16 - 49 yrs) residing in the Southeast Community of Newport News, Virginia, USA (Holloman and Newman, 2010, *in press*). Results of this collaborative effort suggested that women in this urban costal community consumed fish at a subsistence rate and that the majority of the items consumed came from commercial markets (Holloman and Newman, 2010, *in press*). In addition, distributions of point estimates revealed that more than half of the ninety-three women surveyed exceeded US EPA's oral RfD for mercury (Holloman and Newman, *in* *press*) and that such exceedances were considerably greater than equivalent blood-mercury exceedances for general US women (ages 16 – 49 yrs, 4.7 %; Mahaffey et al., 2009a) and for African American women (4.1%; Mahaffey et al., 2009a).

The main goal of this work was to better characterize dietary mercury exposure by probabilistically modeling mercury intake for African American women (ages 16 – 49 yrs) residing in the Southeast Community of Newport News, Virginia. Consumption scenarios aimed at reducing dietary mercury exposure were also explored. Ultimately, through collaborative efforts and meaningful partnerships, it is our goal to facilitate the community's development of their own strategies for defining and managing health risks associated with dietary mercury exposure.

2. MATERIALS AND METHODS

2.1. Quantification of dietary mercury exposure

2.1.1. Determination of fish consumption patterns and mercury concentrations

To quantify mercury exposure, the magnitude, frequency and duration of fish consumption were determined for African American women (age 16 – 49 yrs) residing in the Southeast Community of Newport News, VA. A community-based fish consumption survey (East End Fish Consumption Survey) was developed to estimate the ingestion rate (IR, g/meal), exposure frequency (EF, meals/year), and consumption rate (CR, g/day) of individual fish items consumed by, and the weight (Wgt, kg) of low-income African American women residing in the Southeast Community. The survey was administered during April and May 2008 (Holloman and Newman, 2010) and estimates of IR, EF, CR, and Wgt were assessed for reproducibility, reliability, and consistency in 2010 (Holloman and Newman, *in press*). Total mercury concentrations (mg/kg) were determined for the 24 most prominent fish items listed (out of a total of 39 items) by the 95 women surveyed in 2008 (Holloman and Newman, 2010). Details of sample preparation, analysis, and quality control and quality assurance for determining mercury concentrations were reported in Holloman and Newman (*in press*)

2.1.2. Point and probabilistic parameter estimations

Distributions of point estimated daily mercury intakes (mg/kg-bw/day) were generated for African American women using consumption data generated from women surveyed in 2008 (Holloman and Newman, 2010) along with mercury data generated from Holloman and Newman (*in press*), peer reviewed literature (Peles et al., 2006; Sunderland, 2007; Lowenstein et al., 2010), and federal databases (US FDA, 2009a, 2009b). Because the type of canned tuna was not defined in the survey and differences are present between canned light and white tuna mercury concentrations, three different distributions of daily mercury intake were generated that represented the consumption of no tuna, canned light tuna, and canned white tuna. Details of the procedures used to generate point estimates were previously published by Holloman and Newman (*in press*).

Distributions of probabilistic mercury exposures were generated for the same population, using the same consumption data that generated the point estimates. Forecasting software Oracle Crystal Ball© 2010 (Redwood Shores, CA) was used to simulate fish consumption patterns and estimate daily mercury intake. For our model, five variables were used to determine daily mercury intake: 1) fish consumption rate (CR, g/day), 2) body weight (Wgt, kg), 3) ingestion rate (IR, g/meal), 4) exposure frequency (EF, meals/day), and 5) mercury concentrations (mg/kg), used to determine the amount of mercury consumed (mg). Similar to point estimates, consumption scenarios representing canned tuna consumption were generated; however, four scenarios were created: 1) no tuna, 2) only light tuna, 3) both white and light tuna (50/50 chance), and 4) only white tuna.

2.1.3. Monte Carlo Simulations

To begin simulations, a fish consumption rate was selected from a custom probability distribution created using the 95 fish consumption rates generated in 2008 (Holloman and Newman, 2010). Once selected, this rate served as the maximum consumption rate for that simulation trial. A total of 10,000 trials were used for each consumption scenario. A random number generator was used to select a fish or shellfish from a list created from cumulative probabilities of fish and shellfish consumed by women surveyed in 2008 (Holloman and Newman, 2010). Based on fish consumption data collected in 2008 (Holloman and Newman, 2010), separate custom probability distributions or point estimates were produced for ingestion rate (IR) and exposure frequency (EF). For IR and EF, custom distributions were created only for fish items in which two or more women stated consuming the item. Point estimates were used for the other remaining fish items in which only one woman stated consuming it.

Once a fish item was selected, IR (kg/meal) was multiplied by EF (meal/day) to obtain a consumption rate (CR, kg/day). Consumption rate was then multiplied by mercury concentration (mg/kg) to obtain an amount of mercury consumed (mg/day). For the variable mercury concentration (mg/kg), custom probability distributions were produced for all fish and shellfish previously analyzed for mercury (Holloman and Newman, *in press*). Point estimates were used for the other remaining mercury concentrations which came from the peer reviewed literature (Peles et al., 2006; Sunderland, 2007; Lowenstein et al., 2010) and federal databases (US FDA, 2009a, 2009b). For each trial, up to 20 fish items were randomly selected, and the corresponding CR and amount of mercury consumed were summed until the summed CR was equal or greater than the maximum consumption rate allowed for that trial. If the summed CR was greater than the maximum amount, the difference was determined and used to adjust the summed amount of mercury consumed.

The summed amount of consumed mercury was used as the total amount of mercury ingested daily in the model. For each consumption scenario, forecasts were generated, the amount of mercury consumed per day was normalized to kg of body weight (mg/kg-bw/day), and distributions of mercury exposures were produced. The body weight (kg) used to standardize the amount of mercury consumed was selected from a custom probability distribution based on data collected in 2008 (Holloman and Newman, 2010). Data obtained from all Monte Carlo simulations were used in subsequent analysis.

2.1.4. Statistical Analysis

For point estimates, mercury intakes were ranked and the proportions transformed using a Blom transformation (Blom, 1958) in order to generate cumulative proportions of daily mercury intake (mg/kg-bw/day). For probabilistic estimates, percentiles generated from Monte Carlo simulations were ranked and the proportions transformed in the same manner to generate cumulative proportions. Confidence intervals (95%) were also generated for cumulative proportions of daily mercury intake. The formula for the normal approximation interval ($p \pm Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}}$) was used where p was the proportion for the rank, Z is 1.96, and n was the sample size (n = 93 and 100 for point and probabilistic estimates, respectively). Cumulative proportions and corresponding confidence intervals were plotted and compared for both point and probabilistic intake estimates. Plotted distributions were also compared to the US EPA's oral reference dose (RfD) for mercury (0.10 ug/kg-bw/day) and an oral RfD that has resulted in measurable health effects (1.0 ug/kg-bw/day).

2.2. Characterization of dietary exposure and consumption scenarios aimed at reducing exposure

Probabilistic estimates were used in characterizing both individual and population mercury exposures for African American women in the Southeast Community. Mean and median estimates generated from the Monte Carlo simulations were used to characterize individual exposures and assess if a woman with such intakes might suffer adverse health effects due to dietary mercury exposure. To characterize population exposure, the proportion of intakes from the simulations that exceeded the US EPA's oral reference dose (RfD) for mercury (0.10 ug/kg-bw/day) was determined. In addition, the proportion of estimates that exceeded an oral RfD that has resulted in measurable health effects (1.0 ug/kg-bw/day) was determined.

Once the individual and population distributions for dietary mercury intakes were generated, consumption scenarios aimed at reducing exposures were explored. The number of trials per simulation was reduced to 1, 000 and compared to results using 10,000 trials. Because of immaterial differences in estimates generated, subsequent simulations exploring mercury reduction only contained 1,000 trials per simulation.

Specifically, the fish consumption rate used in each of the consumption scenarios (no tuna, light tuna, both light and white. tuna and white tuna) was reduced to ¾, ½, and ¼ of the original fish consumption rate, respectively. Individual and population exposures were characterized for each of the consumption scenarios in the same manor mentioned above for each reduced consumption rate.

3. RESULTS

3.1 Point and probabilistic estimations

Comparison of point and probabilistic intakes revealed that the probabilistic estimates were somewhat lower than the point estimates, regardless of consumption scenarios (Figure 1A-C). However, comparison of the 95 % confidence intervals for both estimates suggested that the differences in the estimates were not significant and that the probabilistic estimates adequately reflected dietary mercury exposure for African American women in the Southeast Community (Figure 1A-C). For the consumption scenario labeled both tuna, only probabilistic estimates were generated and compared to point estimates for the scenarios, no tuna, light tuna, and white tuna (Figure 1D). The probabilistic estimate for both tuna was very similar to point estimates for no tuna and light tuna consumption and not significantly lower than the point estimate for white tuna (Figure 1D).

Comparison of the Monte Carlo simulations suggested that the consumption of no tuna and light tuna generated similar daily mercury intake estimates and that the consumption of both tuna and white tuna yielded higher estimates (Figure 2). Arithmetic mean daily mercury intake rates (95% CI) for the probabilistic models were 0.149

(±0.003), 0.148 (±0.003), 0.172 (±0.004), and 0.202 (±0.004) ug/kg-bw/day, respectively for no, light, both, and white tuna consumption. Median daily mercury intake rates for the same consumption scenarios were 0.106, 0.107, 0.120, and 0.143 ug/kg-bw/day respectively. Sensitivity analysis of the consumption scenarios revealed that out of all the variables used for each model, fish consumption rate (g/day) had the greatest influence on daily mercury intake estimates for no tuna (rank correlation = 0.36, contribution to variance = 45%), light tuna (rank correlation = 0.38, contribution to variance = 46%), both tuna (rank correlation = 0.35, contribution to variance = 46%), and white tuna (rank correlation 0.35, contribution to variance = 43%) consumption.

3.2 Dietary mercury exposure

Under the scenario of no tuna consumption, both the mean and median exposures exceeded US EPA's oral RfD for mercury (0.1 ug/kg-bw/day, Table 1). The mean and median exposures for the remaining consumption scenarios also exceeded this limit. Thus, under the any of the consumption scenarios, an African American woman in the Southeast Community with mean or median intake estimates may suffer adverse health effects due to fish consumption and dietary mercury exposure (Table 1).

For all consumption scenarios, more than half of African American women in the Southeast Community exceeded US EPA's oral RfD for mercury (Figure 3A-D). The proportion of exceedances was similar for no tuna (.52) and light tuna (.52) consumption. However, the inclusion of white tuna in the fish diet of African American women in the Southeast Community slightly increased the proportion of exceedances for both (.55) and white (.59) tuna consumption. The proportion of estimates that exceeded an oral RfD for mercury that has resulted in measurable health effects (1.0 ug/kg-bw/day) was less than .01 for all four consumption scenarios.

3.3 Reduction of dietary mercury exposures

Reducing the amount of fish consumed (the variable fish consumption rate, g/day) in the Monte Carlo simulations resulted in lower dietary mercury intake for each consumption scenario (no tuna, light tuna, both tuna, and white tuna; Table 2). For an individual consuming both tuna with mean or median intake, she would have to consume at ¼ the fish consumption rate to have an exposure that was below the US EPA oral RfD for mercury (Table 2). At this consumption rate (¼), the proportions of estimates that exceeded US EPA's oral RfD for mercury (under all consumption scenarios) were 0.14, 0.13, 0.18, and 0.25 respectively for no tuna, light tuna, both tuna, or white tuna consumption (Figure 4). The proportion of estimates that exceeded an oral RfD for mercury that has resulted in measurable health effects was 0. 001 and 0.0004 respectively, for no tuna and white tuna consumption. For the scenarios light and both tuna consumption, all estimates were below this RfD (Figure 4).

4. DISCUSSION

4.1. Point and Probabilistic Estimates

The consideration of variability and uncertainty is important when estimating exposures. Variability refers to differences that cannot be reduced or eliminated but can be better characterized with more data. On the other hand, uncertainty (caused by lack of knowledge) can be reduced by collecting both quality data and more data (US EPA, 2001c). Sources of variability in our exposures included variability in mercury concentrations in the fish (mg/kg), ingestion rates (g/meal), exposure frequencies (meals/year), consumption rate (g/day), and body weight (kg). Sources of uncertainty included, parameter uncertainty, model uncertainty, and scenario uncertainty. Parameter uncertainty is the most readily recognized source of uncertainty quantified in exposure assessments (US EPA, 2001c).

Issues of uncertainty provided the context of why community-based participatory research (CBPR) methodology was the framework for our research endeavors (Holloman and Newman, 2010). The most effective and efficient way we reduced uncertainty associated with estimating fish consumption patterns and dietary mercury exposure of African American women in the Southeast Community was through partnerships created and maintained with community stakeholders (e.g. The Moton Community House and community residents) and researchers. Collectively, our efforts increased the quality of the data obtained and our certainty associated with our estimates of fish consumption and dietary mercury exposure (Holloman and Newman 2010, *in press*). Therefore we were highly confident in the utility of: 1) the assumptions used in parameter estimations, 2) the use of the exposure model created, and 3) the selection of consumption scenarios used.

The distribution of individual point estimates for 93 women surveyed in 2008 (Holloman and Newman, *in press*) provided a general measure of population variability in dietary mercury intake for African American women in the Southeast Community of Newport News, Virginia. For the three consumption scenarios, no tuna, light tuna, and white tuna, the ranges of intakes were 0.000 to 1.41ug/kg-bw/day, 0.001 to 1.46 ug/kg-bw/day, and 0.002 to 1.69 ug/kg-bw/day respectively. Approximately half of the 93 point estimates were equal to or higher than mean and median estimates of daily mercury intake for all three consumption scenarios. Distributions of the 93 exposures suggested that African American women in the Southeast Community might experience adverse health effects due to fish consumption and dietary mercury exposure. This was strongly supported by the observation that mean and median estimates for all consumption scenarios were above US EPA's oral reference dose (RfD) for mercury.

The distributions of point estimates also provided exposure estimates of actual women (n = 93) from the community and were used in determining if the probabilistic models accurately simulated fish consumption and dietary mercury exposure. Based on comparison of the two methods, the probabilistic models estimated lower intakes; however, such differences were immaterial given the intent of our endeavors. Thus for our purposes, probabilistic distributions were deemed the most useful depictions of dietary exposure for African American women in the Southeast Community.

The custom probability distributions assumed in the probabilistic simulations represented variability within each of the five variables (fish consumption rate, body weight, ingestion rate, exposure frequency, and mercury concentration) used to estimate mercury exposure. Therefore, our probabilistic distributions specifically were intended to represent the variability, not uncertainty, in dietary mercury exposure for African American women in the Southeast Community. Fish consumption rates (g/day) contributed the most to the variance in exposures for all consumption scenarios. Recall that in our simulations, this assumption served as the maximum fish consumption rate for an individual (trial). Thus, the magnitude of incorrectly assuming (and modeling) fish consumption rates for African American women in the Southeast Community could have serious consequences (such as underestimation of mercury exposure). Because we used

CBPR (community-based participatory research) techniques to help reduce uncertainty (parameter, model, scenario) in our estimations of fish consumption patterns (Holloman and Newman 2010, *in press*), we were confident that the assumptions used and exposures estimated during the simulations were sufficiently reflective of African American women in the Southeast Community.

4.2. Characterization of dietary mercury exposure

As previously mentioned, probabilistic distributions were used to characterize daily mercury exposures for African American women (ages 16 – 49 yrs) in the Southeast Community of Newport News, Virginia. Individual exposures were placed in the context of position within a probabilistic distribution of intakes. We selected mean and median estimates to represent "individual daily exposures" within the population and asked 1) if African American individuals in the Southeast Community might experience adverse health effects due to the fish they consume and dietary mercury intake, and 2) what was the mean individual exposure? For all consumption scenarios (no, both, light, and white tuna consumption), results indicated that African American women in the Southeast Community with mean or median exposures might experience adverse health effects due to the amount of mercury ingested from fish and shellfish consumed.

Similar to point estimates (Holloman and Newman, *in press*), mean and median exposures for all probabilistic consumption scenarios (Table 1) were higher than recent national estimates reported for general US women (0.022 ug/kg-bw/day; 95% CI: 0.021 - 0.024 ug/kg-bw/day; Mahaffey et al., 2009b) and for non-Hispanic Black women (0.022 ug/kg-bw/day; 95% CI: 0.020 - 0.024 ug/kg-bw/day; Mahaffey et al., 2009b). Probabilistic mean and median exposures also more closely resembled the mercury intake rates of subsistence fishing populations (Abdelouahab et al., 2008; Mariën and Patrick, 2001). This supported earlier conclusions (Holloman and Newman 2010, *in press*) that dietary mercury exposure for African American women in the Southeast Community of Newport News is high enough to warrant concern.

The US EPA derived an estimate of daily oral mercury intake (oral reference dose (RfD) = 0.1 ug/kg-bw/day) that is likely to be without an appreciable risk of adverse health effects over a lifetime, in order protect humans against chronic and developmental mercury toxicity (US EPA, 2001a). This RfD was based on cord blood measurements and is equivalent to a blood mercury (BHg) concentration of 5.8 ug/l and a hair concentration of 1.0 ug/g (NCR, 2000; US EPA, 2001a, 2001b). We estimated what proportion of African American women in the Southeast Community exceeded the US EPA oral RfD for mercury.

For all of the consumption scenarios, the percentage of African American women in the Southeast Community that exceeded the US EPA oral RfD for mercury was greater than 50%. In this community, approximately one out of two women might develop adverse health effects due to exposure. Such exceedances were approximately 11 - 14 times higher than national BHg exceedances for general US women and for African American women (4.7 and 4.1% respectively; Mahaffey et al., 2009a). These exceedances were also approximately 6 to 7 times higher than oral RfD exceedances for a population of women anglers in the Wyoming (7.9%; Johnson and Snow, 2007) and 2 times higher than low income minority women from California's Sacramento-San Joaquin Delta (29%; Silver et al., 2007). Approximately 1out of 455 African American women from the Southeast Community exceeded an oral RfD for mercury that has resulted in measurable health effects (1.0 ug/kg-bw/day) for no and light tuna consumption. Approximately 1 out of 303 and 1 out of 141 African American women exceeded this RfD for both and white tuna consumption, respectively. This was lower than the 5% of women found to be exceeding this oral RfD in California's Central Valley Delta (Shilling et al., 2010).

Dietary mercury exposure and proportions of intake exceedances in the US can vary depending upon regionally were one lives (Northeast, South, West and Midwest) and proximity to the coast (Mahaffey et al., 2009a). In the US, regions with the highest dietary mercury exposure are the Northeast and the South (Mahaffey et al., 2009a). In addition, communities of coastal areas experience higher exposures than those of inland areas (Mahaffey et al., 2009a). Regionally, African American women in the Southeast Community of Newport News, Virginia reside in the Southern region of the US, along the Atlantic Coast. When compared to 30 - day mercury intake estimates from the South and from the Atlantic Coast, mean intakes for African American women in the Southeast Community were greater than national averages and 95th percentiles (Mahaffey et al., 2009b). In addition, the proportion of African American women in the Southeast Community exceeding US EPA's RfD's for mercury was higher than national exceedances (Mahaffey et al., 2009a). However, when compared to exceedances from a study focusing on anglers in the South (Louisiana) along the Gulf Coast (40%; Lincoln et al., 2011) the percentages of exceedances were more similar. Such similarity in exceedances, compared to national exceedances, highlights the importance of using community (region) specific data to estimate dietary mercury intake and that great thought and consideration should be given to ensure that data used reflects the population of interest.

4.3. Reducing dietary mercury exposure

Fish consumption rates contributed to over half of the variance for all distributions of daily mercury intake generated. Comparison of all four consumption scenarios (no, light, both, and white tuna consumption) suggested that the elimination of canned tuna from the diet of African American women in the Southeast Community would generate the lowest estimate of dietary mercury exposure; however, the amount of mercury ingested would still be high enough to warrant concern. Especially considering that for no tuna consumption, that mean or median individuals would exceed limits assumed to be without an appreciable risk of adverse health effects over a lifetime and that half of the women in the Southeast Community would also exceeds such limits.

Because of the high contribution to the variance, explorations of dietary mercury reduction focused on the amount of fish (g/day) assumed in the models. The amount of fish assumed was reduced by 75, 50, and 25% to determine 1) if reducing the amount of consumed fish lowered dietary mercury exposure and 2) the magnitude of reduction necessary to generate mean and median estimates below the US EPA's oral RfD for mercury. Reducing the amount of fish consumed did reduce dietary mercury exposure for African American women in the Southeast (Table 2). For African American women consuming fish at a rate ¾ of what was normally consumed, mean and median estimates of daily mercury intakes (for all consumption scenarios) remained above the US EPA's oral RfD for mercury. At a rate ½ of what was normally consumed, mean and median estimates for not consuming any canned tuna were below the US EPA's oral Rfd;

however, the inclusion of canned tuna (light, both, or white) increased mean intakes above this RfD while median estimates remained below. In order to generate mean and median exposures below 0.10 ug/kg-bw/day (for all consumption scenarios) a woman would have to consume fish at a rate ¼ of what was normally consumed.

Any fish consumption advice aimed at reducing dietary mercury exposure must also consider the nutritional benefits from such consumption. On average, African American women in the Southeast Community consume fish at a rate of 147.8 g/day (5.2 oz/day; Holloman and Newman, 2010). Reducing this rate to a quarter of the normal amount would reduce dietary mercury exposure; however, some of the nutritional benefits associated with fish and shellfish consumption might also be reduced. One of the most recognized nutritional benefits from fish consumption is the intake of two polyunsaturated fatty acids (Omega-3 and Omega-6 fatty acids) that the body cannot synthesize and must be ingested in order to meet human physiological demands (Genuis, 2008). Omega-6 fatty acids are mainly derived from plant sources where as fish and shellfish are the most common sources of omega-3 fatty acids. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are two omega-3 fatty acids that have received a lot of attention because of protective effects against coronary heart disease (CHD; Kris-Etherton et al., 2002; Domingo et al., 2007) as well as their importance in proper fetal development (Domingo et al., 2007; Genuis, 2008).

Fish and shellfish that were analyzed for mercury (Holloman and Newman, *in press*) were also analyzed for omega-3 and omega-6 fatty acids. Analysis of these results is currently underway. When comparing mercury concentrations of fish items commonly consumed by African American women in the Southeast Community (Holloman and

Newman, *in press*), with omega-3 fatty acid concentrations reported in the literature (Mahaffey et al., 2008), salmon and mackerel had the highest amounts of EPA + DHA (1.59 and 1.79 g/100g of fish respectively; Mahaffey et al., 2008) and relatively low mercury concentrations (27.1 and 47.2 ug/kg respectively; Holloman and Newman, *in press*). Therefore, for an African American woman in the Southeast Community, the consumption of salmon and mackerel may provide the highest amounts of omega-3 fatty acids with the lowest mercury concentrations.

5. CONCLUSION

Subsistence fish consumers are generally defined as those that rely on non-commercially caught fish as a major source of protein to their diet (US EPA, 2000a, 2000b). Recently, we suggested that current perceptions of subsistence fish consumption potentially overlooked and underestimated the contribution of commercially consumed fish to the diet of certain ethnic minorities and low-income communities therefore, potentially underestimating its contribution to dietary mercury exposure (Holloman and Newman, 2010, *in press*). Through our collaborative, community-based participatory research endeavors, we identified a subpopulation of African American women of childbearing age (ages 16 – 49 yrs) whose fish intake from commercial markets and dietary mercury exposures were high enough to warrant concern. The difference between national mercury exposure estimates and that of African American women in the Southeast Community strongly emphasized the importance of using community specific data when making assumptions about a population. This difference also highlighted and confirmed the existence of a subpopulation of women in the US that disproportionally experience higher exposures to mercury. It is our goal to facilitate strategies and solutions that are aimed at reducing mercury exposure in this community.

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TABLE 1.

Consumption Scenarios	Intake (ug/kg-bw/day)	Cumulative Proportion	Proportion 95% CI
No tuna			
Average	0.149	0.60	0.51 – 0.70
Median	0.106	0.50	0.40 – 0.59
90th Percentile	0.345	0.89	0.83 – 0.95
95th Percentile	0.446	0.94	0.90 – 0.99
99th Percentile	0.729	0.98	0.96 – 1.00
Light tuna			
Average	0.148	0.60	0.51 – 0.70
Median	0.107	0.50	0.40 – 0.59
90th Percentile	0.343	0.89	0.83 – 0.95
95th Percentile	0.439	0.94	0.90 – 0.99
99th Percentile	0.677	0.98	0.96 – 1.00
Both tuna			
Average	0.172	0.60	0.51 – 0.70
Median	0.120	0.50	0.40 – 0.59
90th Percentile	0.402	0.89	0.83 – 0.95
95th Percentile	0.530	0.94	0.90 – 0.99
99th Percentile	0.813	0.98	0.96 – 1.00
White tuna			
Average	0.202	0.61	0.51 – 0.70
Median	0.143	0.50	0.40 – 0.59
90th Percentile	0.488	0.89	0.83 – 0.95
95th Percentile	0.613	0.94	0.90 – 0.99
99th Percentile	0.929	0.98	0.96 – 1.00

Daily mercury intake estimates (ug/kg-bw/day) and associated cumulative proportions and 95% confidence intervals for the four consumption scenarios (N = 10,000 trials per simulation). Average cumulative proportions were associated with the largest intake estimate less than or equal to the average estimate. US EPA's oral RfD for mercury is 0.10 ug/kg-bw/day

TABLE 2.

Daily mercury intake estimates (ug/kg-bw/day) and associated cumulative proportions and 95% confidence intervals using ¾, ½, and ¼ the normal seafood consumption rate (g/day, N = 1,000 trails per simulation). Average cumulative proportions were associated with the largest intake estimate less than or equal to the average estimate.

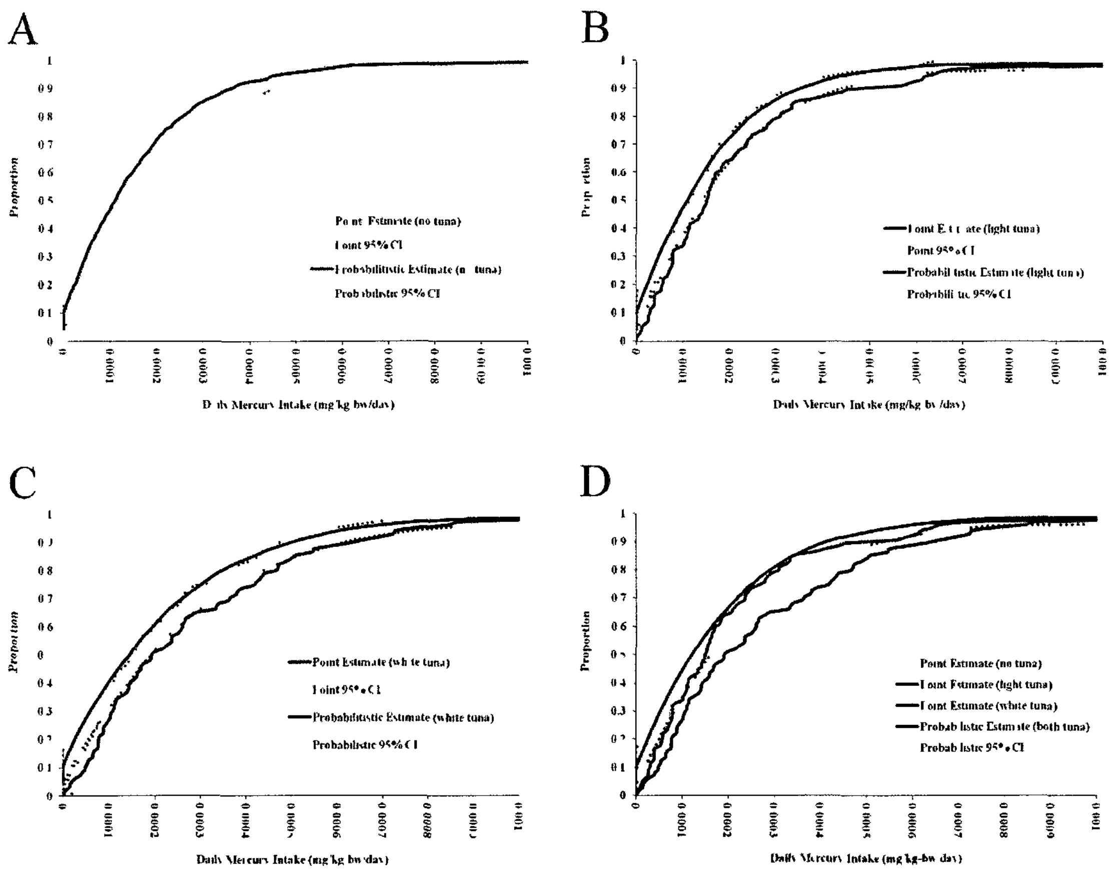
Consumption Scenarios	Intake (ug/kg-bw/day)	Cumulative Proportion	Proportion 95% CI
	¾ Consumption Rate		
No tuna			
Average	0.125	0.61	0.52 – 0.71
Median	0.088	0.50	0.40 – 0.59
90th Percentile	0.286	0.89	0.83 – 0.95
95th Percentile	0.370	0.94	0.90 – 0.99
99th Percentile	0.659	0.98	0.96 – 1.00
Light tuna			
Average	0.126	0.61	0.52 – 0.71
Median	0.092	0.50	0.40 – 0.59
90th Percentile	0.274	0.89	0.83 – 0.95
95th Percentile	0.365	0.94	0.90 – 0.99
99th Percentile	0.633	0.98	0.96 – 1.00
Either tuna			
Average	0.149	0.62	0.53 – 0.72
Median	0.104	0.50	0.40 – 0.59
90th Percentile	0.354	0.89	0.83 – 0.95
95th Percentile	0.473	0.94	0.90 – 0.99
99th Percentile	0.690	0.98	0.96 – 1.00
White tuna			
Average	0.170	0.59	0.50 – 0.69
Median	0.118	0.50	0.40 – 0.59
90th Percentile	0.400	0.89	0.83 – 0.95
95th Percentile	0.521	0.94	0.90 – 0.99
99th Percentile	0.778	0.98	0.96 – 1.00
	½ Consumption Rate		
No tuna			
Average	0.094	0.64	0.55 – 0.74
Median	0.061	0.50	0.40 – 0.59
90th Percentile	0.217	0.89	0.83 – 0.95
95th Percentile	0.316	0.94	0.90 – 0.99
99th Percentile	0.533	0.98	0.96 – 1.00
Light tuna			
Average	0.090	0.63	0.54 – 0.73
Median	0.060	0.50	0.40 – 0.59
90th Percentile	0.202	0.89	0.83 – 0.95
95th Percentile	0.283	0.94	0.90 – 0.99
99th Percentile	0.481	0.98	0.96 – 1.00
Either tuna			
Average	0.104	0.64	0.55 – 0.74
Median	0.068	0.50	0.40 – 0.59
90th Percentile	0.230	0.89	0.83 – 0.95
95th Percentile	0.349	0.94	0.90 – 0.99
99th Percentile	0.614	0.98	0.96 – 1.00
White tuna			
Average	0.132	0.63	0.54 – 0.73
Median	0.084	0.50	0.40 – 0.59
90th Percentile	0.321	0.89	0.83 – 0.95
95th Percentile	0.404	0.94	0.90 – 0.99
99th Percentile	0.702	0.98	0.96 – 1.00

TABLE 2 continued.

Consumption Scenarios	Intake (ug/kg-bw/day)	Cumulative Proportion	Proportion 95% CI
	¼ Consumption Rate		
No tuna			
Average	0.049	0.67	0.58 – 0.77
Median	0.028	0.50	0.40 – 0.59
90th Percentile	0.118	0.89	0.83 – 0.95
95th Percentile	0.166	0.94	0.90 – 0.99
99th Percentile	0.304	0.98	0.96 – 1.00
Light tuna			
Average	0.052	0.68	0.59 – 0.78
Median	0.031	0.50	0.40 – 0.59
90th Percentile	0.121	0.89	0.83 – 0.95
95th Percentile	0.162	0.94	0.90 – 0.99
99th Percentile	0.322	0.98	0.96 – 1.00
Either tuna			
Average	0.061	0.66	0.57 – 0.76
Median	0.035	0.50	0.40 – 0.59
90th Percentile	0.154	0.89	0.83 – 0.95
95th Percentile	0.218	0.94	0.90 – 0.99
99th Percentile	0.323	0.98	0.96 – 1.00
White tuna			
Average	0.079	0.66	0.56 – 0.75
Median	0.047	0.50	0.40 – 0.59
90th Percentile	0.189	0.89	0.83 – 0.95
95th Percentile	0.285	0.94	0.90 – 0.99
99th Percentile	0.433	0.98	0.96 – 1.00

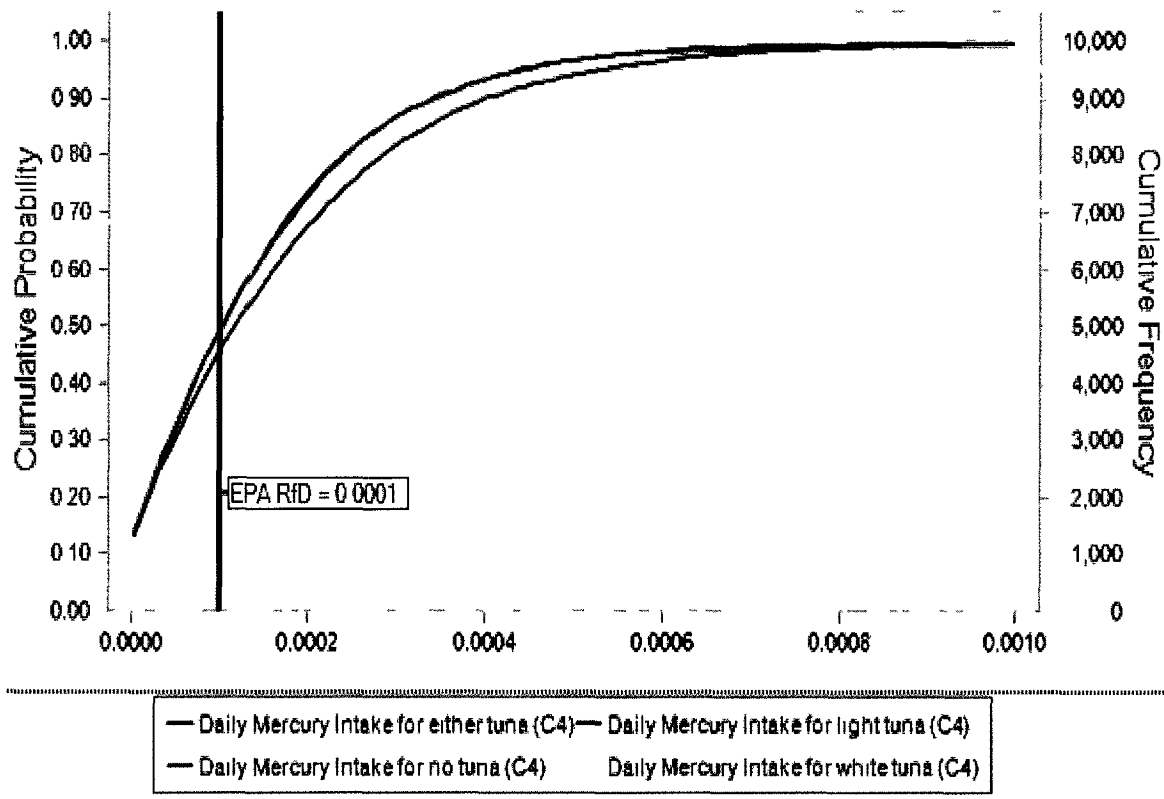
Daily mercury intake estimates (ug/kg-bw/day) and associated cumulative proportions and 95% confidence intervals using ¾, ½, and ¼ the normal seafood consumption rate (g/day, N = 1,000 trails per simulation). Average cumulative proportions were associated with the largest intake estimate less than or equal to the average estimate.

FIGURE 1.



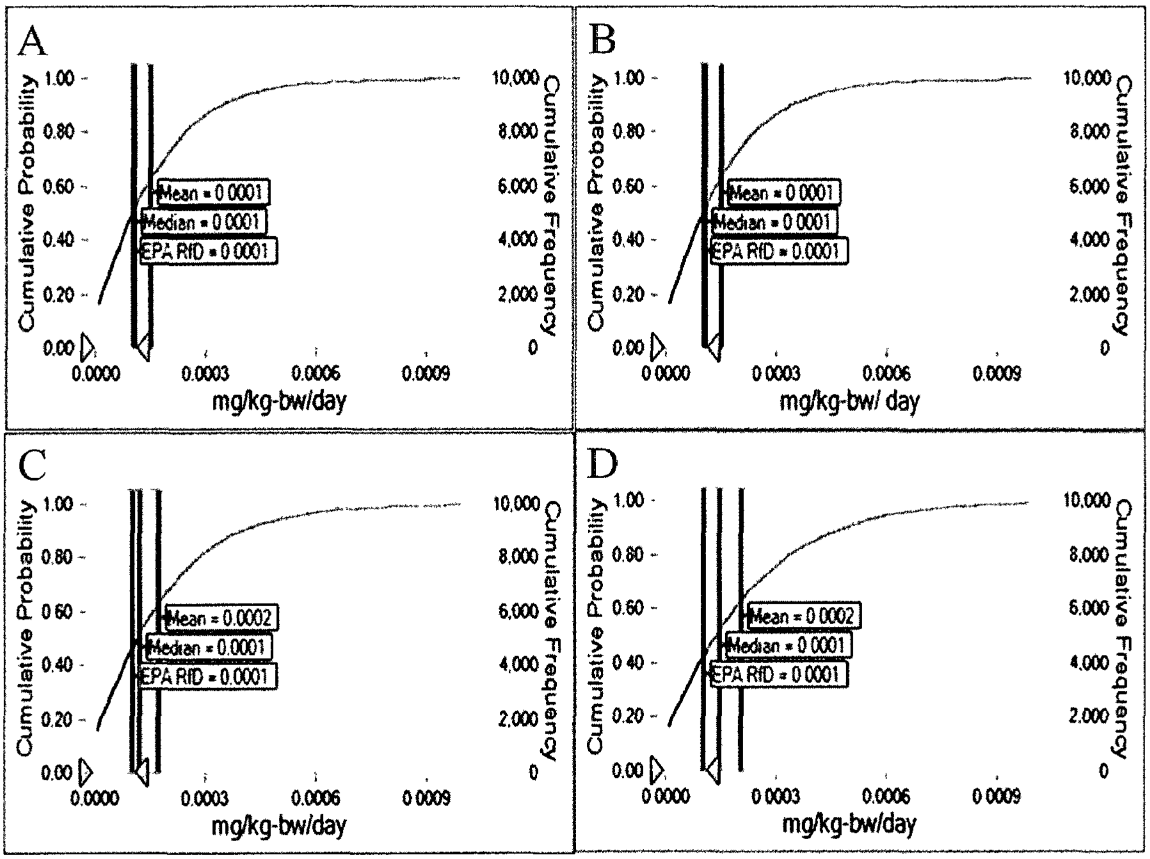
Comparison of point and probabilistic distributions of daily mercury intake. For point estimations n = 93. For probabilistic estimations n =10,000. Consumption scenarios: A) no tuna, B) light tuna, C) white tuna, and D) both tuna.

FIGURE 2.



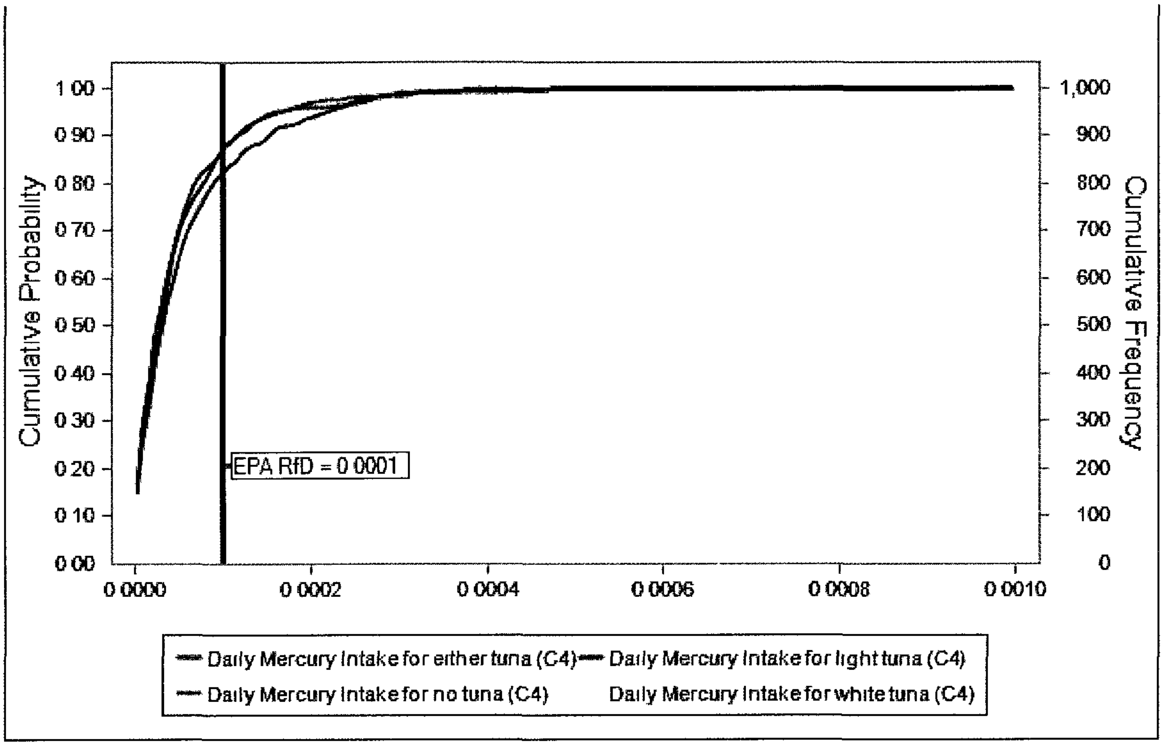
Comparison of probabilistic distributions of daily mercury intake for all four consumption scenarios: no, light, both (either), and white tuna consumption. N = 10, 000 for each scenario.

FIGURE 3.



Probabilistic distributions of daily mercury exposures for the four consumption scenarios: A) no tuna, B) light tuna, C) both tuna, and D) white tuna. N = 10, 000 for each scenario.

FIGURE 4.



Comparison of probabilistic distributions of daily mercury intake at 25% of the normal consumption rate for African American women in the Southeast Community. N = 1,000 for each scenario.

CONCLUSION

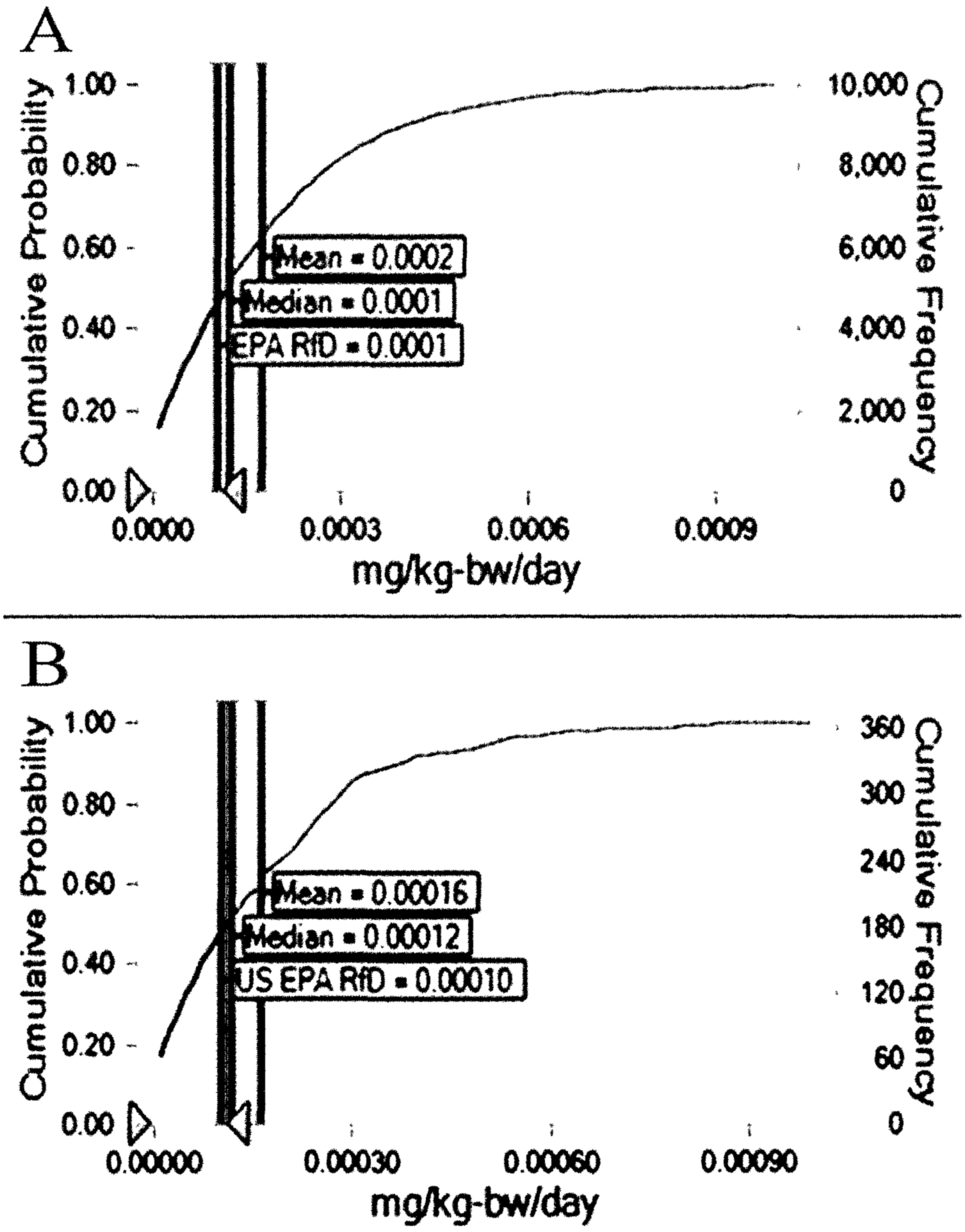
The use of CBPR greatly improves exposure assessments by providing community-specific information. Community-specific information increases data quality and reduces parameter uncertainty for those estimating risk. Through the CBPR approach we learned that ingestion rates (g/meal) are not only the selected portion size but, more importantly, how many of the individual portions are consumed during one meal setting. In addition, even though women in this study were not subsistence fishers, they were subsistence fish consumers.

Assessors need to be more aware of their perceptions associated with certain subpopulations and their selection of parameter estimates used to characterize fish consumption in these populations, especially when exposure data is limited. Narrow perceptions and incorrect assumptions of fish consumption and contaminant exposure for many US subpopulations has lead to serious issues of environmental injustices regarding risk management and communication whereby non protective standards and polices have been implemented (and communicated), and the burden of exposure reduction has placed solely on the individual and/or population. Through the collaborative partnership established between our research team and the Moton Community House, critical insights were gained about fish consumption patterns and dietary mercury exposure for low income African American women residing in the Southeast Community of Newport News, Virginia. Noteworthy is the potential environmental injustice issue arising from current perceptions of subsistence fish consumption held by many charged with assessing and regulating exposure to contaminated fish. Assessors viewing subsistence fish consumption only in relation to items fished for, instead of purchased, may unintentionally overlook or make incorrect assumptions about populations who are not subsistence fishers, but nonetheless, consume commercial fish at a subsistence rate.

The custom probability distributions assumed in the probabilistic simulations represented variability within each of the five variables (fish consumption rate, body weight, ingestion rate, exposure frequency, and mercury concentration) used to estimate mercury exposure. Therefore, our probabilistic distributions specifically were intended to represent the variability, not uncertainty, in daily dietary mercury exposure for African American women in the Southeast Community. We also understood that our probabilistic estimates did not represent a mean daily mercury exposure; therefore, using the 10,000 daily estimates obtained for both tuna, we modeled consumption for one year (365 days/trails) and compared this with the daily exposures obtained for both tuna (Figure 1). The mean daily mercury exposures were slightly lower than the daily exposures; however for our purpose, this difference was immaterial. Thus, it was concluded that an African American women in the Southeast Community who consumed fish for a year would still have a mean exposure that was above US EPA's oral RfD for mercury and may experience adverse health effects due to consumption.

Through our endeavors, we identified a subpopulation of African American women of childbearing age (ages 16 – 49 yrs) whose fish intake from commercial markets and dietary mercury exposures were high enough to warrant concern. The difference between national mercury exposure estimates and that of African American women in the Southeast Community strongly emphasized the importance of using community specific data when making assumptions about a population. Future work will entail determining fatty acid concentrations in the fish items that were analyzed for mercury. Ultimately, it is our goal to facilitate strategies and solutions that are aimed at reducing mercury exposure in this community.

FIGURE 1.



For consumption scenario both tuna, comparison of A) daily mercury exposure (n = 10,000) and B) mean daily mercury exposure (n= 365).

VITA

Erica Lynette Holloman

I was born in Atlanta Georgia on May 8, 1977 to the proud parents, Catherine Smith and Willie Holloman. Since childhood, I knew that I wanted to be a scientist and began pursuing my scientific dreams early in life. I graduated from Riverwood High School in May 1995 and matriculated to Hampton University in Hampton Virginia that summer. I earned a B.S. in Marine and Environmental Science from Hampton University in December 1998. I received a M.S. in Biology with a concentration in Environmental Science from Hampton University in August 2001. I entered the doctoral program at the College of William & Mary, Virginia Institute of Marine Science (VIMS), School of Marine Science in August 2004. While at VIMS, I was in the department of Environmental and Aquatic Animal Health and my research program focused on Environmental Risk Assessment.