## Recent Fish Consumption Studies


1) Burger, J; Stephens, WL, Jr.; Boring, CS; et al. (1999) Factors in exposure assessment: ethnic and socioeconomic differences in fishing and consumption of fish caught along the Savannah River. Risk Anal 19(3):427-438.

2) May, H; Burger, J. (1996) Fishing in a polluted estuary: fishing behavior, fish consumption, and potential risk. Risk Anal 16(4):459-471.

3) Jacobs, HL; Kahn, HD; Stralka, KA; et al. (1998) Estimates of per capita fish consumption in the U.S. based on the continuing survey of food intake by individuals (CSFII). Risk Anal 18(3):283-291.

4) U.S. EPA (Environmental Protection Agency). (1999) Asian & Pacific Islander seafood consumption study in King County, WA. Region 10; Seattle, Washington; EPA 910/R-99-003. Available from: http://www.epa.gov/r10earth/offices/oea/risk/r0riskhh.htm.

5) Toy, KA; Polissar, NL; Liao, S; et al. (1996) A fish consumption survey of the Tulalip and Squaxin Island tribes of the Puget Sound region. Tulalip Tribes, Department of Environment, 7615 Totem Road, Margsville, WA 98271.

6) Wilson, ND; Shear, NM; Paustenbach, DJ; et al. (1998) The effect of cooking practices on the concentration of DDT and PCB compounds in the edible tissue of fish. J Expo Anal Environ Epidemiol 8(3):423-440.

Burger, J; Stephens, WL, Jr.; Boring, CS; et al. (1999) Factors in exposure assessment: ethnic and socioeconomic differences in fishing and consumption of fish caught along the Savannah River. Risk Anal 19(3):427-438.



Burger et al. analyzed the differences in fishing rates and fish consumption of 258 people as a function of age, education, ethnicity, employment history, and income, and tested the assumption that the average consumption of fish is less than the recreational value of 19 kg/year that is assumed by risk assessors.

A total of 268 people were interviewed, both on shore and on land, who were fishing on the Savannah River. Interviews were conducted from April 3 until November 22, 1997 and each person was interviewed only once. Ten of the 268 individuals approached refused the interview, usually because they did not have the time to participate. The questionnaire contained questions on fishing behavior, fish consumption patterns, cooking patterns, warnings and safety of eating the fish, and personal demographics. Nonparametric analysis of variance yielding an $x^2$ statistic were used in order to examine the differences among groups. An ANOVA analysis with Duncan Multiple Range Test was used to identify which groups differed from each other. Multiple regression procedures were used to determine the contribution of each independent variable to various dependent variables of interest, such as total ounces of fish consumed per year.

Eighty-nine percent of those interviewed were men, 70% were white, 28% were black, and 2% were other. In the counties adjacent to the stretch of river where the interviews were conducted, 34% of the population is black, compared with Georgia and South Carolina where 28% of the population is black. The age of persons interviewed ranged from 16 to 82 years old. Most of those interviewed were men; however, most indicated that their wives and children ate fish as often as they did, and their children began eating fish at 3-5 years of age, depending on the species of fish.

Fishing behavior and consumption rates for the study population are shown in Table 2. The average consumption rate for people fishing along this stretch of the Savannah River was 1.4 kg of fish per month.

Significant differences were found in nearly all measures of fishing behavior, consumption, and cooking methods as a function of ethnicity, income and education. These measures, as a function of ethnicity, are shown in Table 4. Figure 3 shows that blacks ate larger portions of fish and ate fish more often than did whites. There were few significant differences in fishing behavior, consumption, and cooking methods as a function of income, although people with lower incomes ate fish significantly more often than those with higher incomes. Fishermen who had not graduated from high school ate fish more often, consumed more fish per month and per year, and deep fried their fish more often.

Figure 4 shows the distribution of people consuming fish per year by race in pounds and kilograms. The researchers found that the annual fish consumption rate for fishermen along the Savannah River ranged up to 49.1 kg/year (mean of 2.82 kg) for blacks and 9.5 kg/year (mean of 1.17 kg) for whites.

These results indicate that some fishermen are exceeding South Carolina's recommended adult consumption limits (from 1 to 4.7 lbs (0.45-2.14 kg) of largemouth bass per month (up to 25.7 kg/year) and from 1.5 lbs (680 g) to no limit for other fish).

Limitations with this study are that the sample size is small and it is not representative of the general population. These data may be useful for estimating exposures from fish consumption in the study area when site-specific data are not available. The authors noted that "the general use of demographics to determine potential risk of fish consumption patterns for specific waters may seriously miss the mark." They further noted that site-specific information on both demographics and fish consumption (rate of fish consumption and quantity of fish consumed per meal) are needed. They also find that understanding the distribution of the exposure variables rather than just the parameters is important. Examining only averages gives biases toward a low estimate.

Table 2. Mean and Standard Error of Select Questions Asked of Fishermen Along the Savannah River[a]

| | Mean | Range |
|---|---|---|
| Number of years fished | 31 ± 1 | (1-73) |
| Years fished Savannah River | 24 ± 1 | (1-73) |
| Distance traveled (km) | 37 ± 7 | (2-960) |
| How often they eat fish/month | 3.61 ± 0.28 | (0-24) |
| Serving size of fish (g) | 376.1 ± 5.45 | (0-625) |
| Fish/month (kg) | 1.46 ± 0.13 | (0-9.55) |
| Fish/year (kg) | 17.60 ± 1.51 | (0-114.5) |
| Percent that deep fry | 82 ± 2 | (0-100) |
| Percent that eat whole fish | 85 ± 2 | (50-100) |
| Age | 43 ± 1 | (16-82) |
| Years of schooling | 12 ± 0.1 | (6-18) |
| Income | $21,491 ± $758 | ($0 - $60,000) |

[a] Burger et al. (1999).

Table 4. Differences as a Function of Ethnicity for Fishermen
Interviewed Along the Savannah River[a]
(mean ± SE (range))

| | Black | White | Kruskal-Wallix $x^2$ *(p)*[b] |
|---|---|---|---|
| Number interviewed | 72 (28%) | 180 (70%) | |
| Number of years fished | 34 ± 2 (1-73) | 31 ± 1 (1-70) | NS[c] |
| Years fished Savannah River | 24 ± 2 (1-73) | 24 ± 1 (1-70) | NS |
| Distance traveled (km) | 15 ± 1 (5-32) | 42 ± 9 (2-960) | 5.84 (0.02) |
| How often they eat fish/month | 5.37 ± 0.57 (0-20) | 2.88 ± 0.30 (2-24) | 16.97 (0.001) |
| Serving size of fish (g) | 387 ± 10.2 (0-597) | 370.53 ± 6.60 (199-625) | 3.73 (0.05) |
| Fish/month (kg) | 2.13 ± 0.24 (0-7.96) | 1.17 ± 0.14 (0-9.56) | 12.38 (0.001) |
| Fish/year (kg) | 25.55 ± 2.92 (0-95.46) | 14.03 ± 1.70 (0-114.5) | 12.35 (0.001) |
| Percent that deep fry | 81 ± 4 (0-100) | 75 ± 2 (0-100) | NS |
| Percent that eat whole fish | 79 ± 4 (0-100) | 64 ± 3 (0-100) | 8.46 (0.004) |
| Age | 47 ± 2 (23-77) | 42 ± 1 (16-82) | NS |
| Years of schooling | 12 ± 0.3 (3-18) | 12 ± 0.1 (5-18) | 12.99 (0.002) |
| Income | \$18,571 ± \$1,140 (\$0 - \$49,000) | \$22,431 ± \$957 (\$0 - \$60,000) | 7.69 (0.006) |

[a] Burger et al. (1999).
[b] Based on the Kruskal-Wallis nonparametric analysis of variance.
[c] NS = not significant

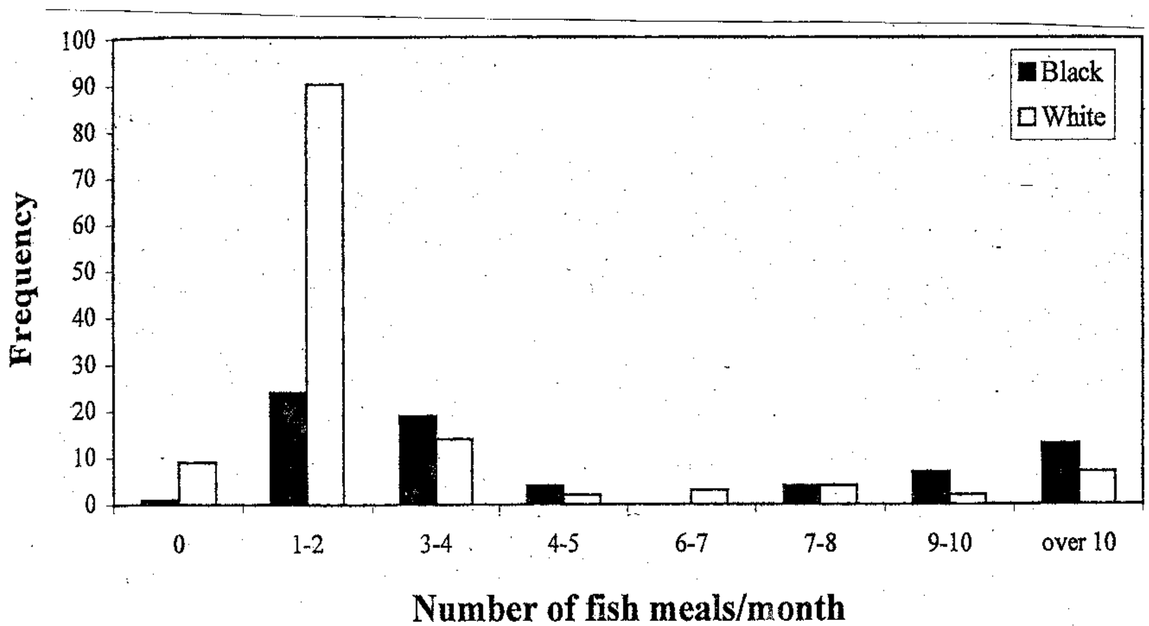


Figure 3. Number of Fish Meals Eaten Per Month by Race (Burger et al., 1999)

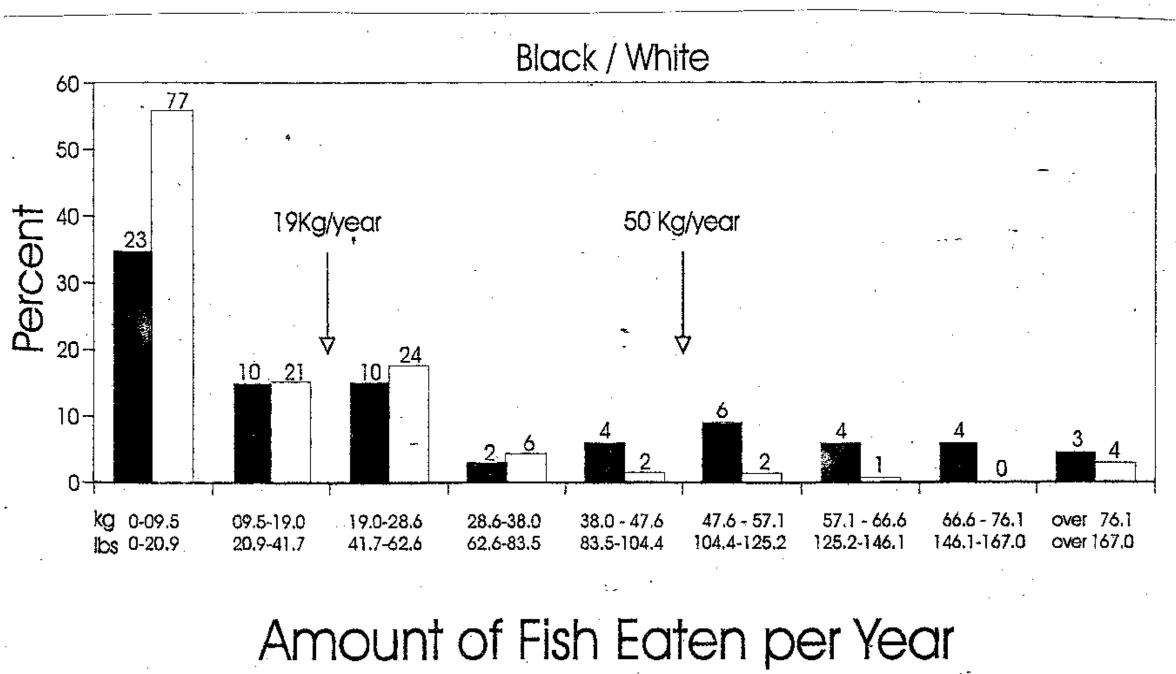


Figure 4. Amount of Fish Consumed Per Year By Race
(19 kg/year and 50 kg/year are the values used by South Carolina in its
risk assessment for recreational and subsistence fishermen) (Burger et al., 1999)

May, H; Burger, J. (1996) Fishing in a polluted estuary: fishing behavior, fish consumption, and potential risk. Risk Anal 16(4):459-471.
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May and Burger (1996) examined the relationship between perception of the safety of fish and fish consumption habits of urban fishermen at sites in coastal New Jersey including a polluted estuary (Arthur Kill) and adjacent coastal waters (Raritan Bay and the New Jersey shore). At the time of this study, advisories had been issued by the New York State Department of Health for the Arthur Kill estuary, of not more than one meal (230 g) of fish/month, and a maximum of six blue crabs/week. The New Jersey Department of Environmental Protection had issued advisories for the Arthur Kill estuary of one meal/week for bluefish and eels, and no consumption of striped bass or blue crabs. New Jersey also issued an advisory for striped bass of one meal/week in the Raritan Bay and New Jersey shore regions. The investigators analyzed whether fishermen were aware of the advisories and how they perceived the risk in eating fish they caught; and whether they were exposed to deleterious levels of toxics in fish and if risk perception matched the severity of the hazard.

Data were collected from fishermen on public piers and marinas in Elizabeth, Carteret, Sewaren, and Perth Amboy townships of the Arthur Kill estuary; from two sites on the south side of Raritan Bay, and at two sites on the New Jersey shore. Sampling procedures consisted of interviewing fishermen and crabbers. Interviews were conducted from mid-May to the end of September in the Arthur Kill estuary, and from July 15 to August 26 in the Raritan Bay and the New Jersey shore. A total of 318 fishermen were interviewed; 214 in the Arthur Kill estuary (168 fishermen, 49 on boats, and 46 crabbers), 60 in the Raritan bay (fishermen only, 33 on boats), and 44 at the New Jersey shore (fishermen only, 18 on boats).

Table 1 presents a comparison of people fishing at these three sites. It presents data for the number of times fish was eaten per month and the serving size. The authors reported that the interviewees were predominantly male (89 percent in Arthur Kill, 96 percent on the Raritan Bay, and 86 percent at the New Jersey shore). Ages of the interviewees varied significantly between regions with averages ranging from 35.5 at the New Jersey shore to 48.2 in the Arthur Kill estuary. Data were also collected on the proportion of fishermen who lived locally. Most of the fishermen in the Arthur Kill estuary were local residents (85 percent), while in the Raritan Bay and the New Jersey shore the proportion of local residents was 27 percent and 25 percent, respectively. Fishermen in the Arthur Kill estuary fished more frequently, averaging over eight times per month, than those in either of the other two regions. The average number of fish eaten in a month was 4.8 and little variation was reported between regions.

Figure 1 presents the occupational composition of fishermen interviewed at the Arthur Kill, the Raritan Bay and the New Jersey shore. The distribution of occupations between the three regions differed significantly. The percent of fishermen who were retired was highest in the Arthur Kill, and the percentage of white-collar workers was highest at the New Jersey shore.

Table 2 presents the perception of health risk by fishermen and crabbers in the three New Jersey study regions. Data on crabbers were only available for the Arthur Kill site. Although 60 percent of the fishermen and crabbers in the Arthur Kill estuary reported hearing warnings about consuming fish in these waters, 70 percent of fishermen and 76 percent of crabbers reported consuming their catch. Significantly fewer fishermen in the Raritan Bay and the New Jersey shore had heard warnings (28 percent and 30 percent, respectively), and more fishermen indicated that they ate their catch (88 percent and 82 percent, respectively). In all of the regions, the fishermen thought that the fish were safe to eat. Most people heard warnings through newspapers and magazines, while 20 percent of fishermen in the Arthur Kill estuary mentioned posted signs as a source of warning. Figure 1 presents the percentage of the fish/crabs eaten that were self-caught by fishermen and crabbers in the Arthur Kill estuary.

The fishermen's knowledge of 21 fish species was also tested to determine if the knowledge base that these fishermen used to estimate risk was correct. Table 3 presents knowledge of fish species and habitat as a percentage of correct responses. The greatest disparities occurred for haddock, pickerel, tilefish, and striped bass. Fishermen in the Raritan Bay had more correct responses than fishermen in Arthur Kill and the New Jersey shore. The fish species with the highest percentage of correct responses (>95 percent) were common marine species (shark, bluefish, tuna, flounder, and swordfish), while the fish species with a noticeably low percentage of correct responses (<12%) was a freshwater commercial fish (tilapia).

Average and worst case consumption rates for fish in the Arthur Kill estuary were determined to be 1584 and 6600 g/month (52.8 and 220 g/day), respectively; for crabs, these consumption rates were 5624 and 24320 g/month (187 and 810 g/month). Based on these data, potential risks to fishermen and crabbers were determined for PCBs (Table 4).

The results of the study indicated that a significant number of individuals were exceeding the consumption advisories for these waters, despite their awareness of the advisories.

A strength of this study is that it provides consumption data for fishermen and crabbers at sites in coastal New Jersey. A limitation associated with this data set is that consumption rates might have been overestimated as a result of over sampling of frequent anglers. Also, since the fishermen were interviewed only once, extrapolation of their consumption habits may be biased. The real exposure for these fishermen may be lower than what is presented in this survey because the fishermen may not accurately recollect the amount of fish they ate.

Table 1. Comparison of People Fishing at Arthur Kill, Raritan Bay, and New Jersey Shore[a,b]

| | Arthur Kill | Raritan Bay | NJ Shore | $x^2$ *(p)* |
|---|---|---|---|---|
| No. of Interviews | 168 | 60 | 44 | – |
| Age | 48.2 ± 1.4 (11-83) | 47.7 ± 2.2 (14-82) | 35.5 ± 1.9 (11-62) | 18.6 (0.0001) |
| No. People in Group | 1.5 ± 0.1 (1-4) | 1.5 ± 0.1 (1-3) | 1.6 ± 0.1 (1-5) | NS[c] |
| No. Times Fish/Month | 8.8 ± 0.6 (0-30) | 5.7 ± 0.8 (0-25) | 5.6 ± 1.0 (0-25) | 17.5 (0.0002) |
| No. Times Fish Eaten/Month | 4.8 ± 0.3 (0-24) | 4.6 ± 0.4 (0-16) | 4.3 ± 0.5 (0-16) | NS |
| Serving Size (ounces) | 11.5 ± 0.5 (0-32) | 10.3 ± 0.5 (0-16) | 10.6 ± 0.8 (0-30) | NS |

[a] May and Burger (1996).

[b] Given are means and standard error; range is given in parentheses.

[c] NS = Not significant.

Table 2. Perception of Health Risk of Fishermen and Crabbers, as Percentage Responding Yes[a]

| | Arthur Kill Fishermen | Raritan Bay Fishermen | NJ Shore Fishermen | $X^2$ *(p)* (for regions)[b] | Arthur Kill Crabbers | Arthur Kill Foot Fishermen | Arthur Kill Boat Fishermen | $X^2$ *(p)* |
|---|---|---|---|---|---|---|---|---|
| Number of interviews | 168 | 60 | 44 | – | 46 | 119 | 49 | – |
| Is the water safe? | 66 | 75 | 93 | 15.5 (=0.004) | 65 | 56 | 90 | 28.7 (<0.0001) |
| Are the fish safe to eat? | 61 | 87 | 91 | 24.6 (<0.0001) | 78 | 47 | 94 | 31.9 (<0.0001) |
| Heard any warnings about eating the fish here? | 60 | 28 | 30 | 25.2 (<0.0001) | 61 | 60 | 61 | NS[d] |
| Do you eat you catch? | 70 | 88 | 82 | 8.9 (=0.012) | 76 | 61 | 94 | 18.5 (<0.0001) |

[a] May and Burger (1996).

[b] Significance values are given for differences between responses of fishermen in the three regions.

[c] Significance values are given for differences between responses of Arthur Kill foot and boat fishermen.

[d] NS = Not significant.

Table 3. Knowledge of Fish Species and Habitat, Showing Percent of Correct Responses Overall and in Each of Three New Jersey Study Regions[a,b]

| Fish Species | All Regions | Arthur Kill | Raritan Bay | NJ Shore | $X^2$ *(p)* |
|---|---|---|---|---|---|
| Shark (*Carcharhinus* spp.) | 98.7 | 98.5 | 98.3 | 100 | NS[c] |
| Bluefish (*Pomatomus saltatrix*) | 98.7 | 98 | 100 | 100 | NS |
| Tuna (*Thunnus* spp.) | 97.3 | 97 | 98.3 | 97.7 | NS |
| Flounder (*Paralichthys dentatus*) | 96.7 | 97.5 | 98.3 | 90.7 | NS |
| Swordfish (*Xiphias gladius*) | 95.3 | 93.4 | 100 | 97.7 | NS |
| Cod (*Gadus* spp.) | 94 | 93.9 | 95 | 93 | NS |
| Snapper (*Lutianus griseus*) | 92.4 | 93.4 | 90 | 90.7 | NS |
| Bass (*Microterus salmoides*) | 92 | 91.4 | 91.7 | 95.3 | NS |
| Striped Bass[b] (*Morone saxatilis*) | 91.7 | 93.4 | 96.7 | 79.7 | 15.4 (<0.0001) |
| Trout (*Cristivomer* spp.) | 84.4 | 81.3 | 90 | 90.7 | NS |
| Halibut[b] (*Hippoglossus* spp.) | 79.7 | 75.8 | 88.3 | 86 | NS |
| Catfish (*Ictalurus punctatus*) | 78.7 | 77.8 | 83.3 | 76.7 | NS |
| Carp (*Cyprinus carpio*) | 77.1 | 75.8 | 81.7 | 76.7 | NS |
| Haddock[b] (*Melanogrammus* spp.) | 75.1 | 69.2 | 93.3 | 76.7 | 14.4 (<0.0001) |
| Pickerel[b] (*Esox* spp.) | 74.8 | 69.7 | 91.7 | 74.4 | 11.8 (<0.01) |
| Hake* (*Merluccius* spp.) | 66.8 | 65.2 | 78.3 | 58.1 | NS |
| Tilefish[b] (*Lopholatilus* spp.) | 66.4 | 63.6 | 80 | 60.5 | 6.3 (<0.05) |
| Yellow-tail[b] (*Bairdiella chrysura*) | 66.1 | 62.1 | 71.1 | 76.7 | NS |
| Perch (*Morone americana*) | 65.1 | 62.6 | 75 | 62.8 | NS |
| Salmon[b] (*Salmo* spp.) | 58.8 | 62.6 | 56.7 | 44.2 | NS |
| Tilapia (*Tilapia* spp.) | 6.6 | 6.6 | 3.3 | 11.6 | NS |

[a] May and Burger (1996).

[b] Indicates species for which the difference in correct response was greater than 10% between at least two regions.

[c] NS = Not significant.

Table 4. Sources of Information on Warnings in Three Regions of New Jersey, Expressed as Percentages[a,b]

| | Arthur Kill | Raritan Bay | NJ Shore |
|---|---|---|---|
| None heard | 40 | 72 | 70 |
| Newspapers/magazines | 39 | 25 | 21 |
| Signs | 20 | 2 | 0 |
| Word of mouth | 11 | 2 | 5 |
| Radio/TV | 6 | 2 | 7 |

[a] May and Burger (1996).

[b] People could have had multiple sources.

Table 5. Average Consumption of Fish and Crabs for Fishermen and Crabbers in the Arthur Kill[a]

| Component | Fish | | Crabs | |
|---|---|---|---|---|
| | Average Consumption | Worst Case | Average Consumption | Worst Case |
| Grams consumed/month | 1,584 | 6,600 | 5,624 | 24,320 |
| Grams consumed/day[b] | 52.8 | 220 | 187 | 810 |

[a] May and Burger (1996).

[b] Computed from monthly rate. Most fishermen did not fish during the winter, so that these values mainly reflect fish and crab consumption during the warmer months.

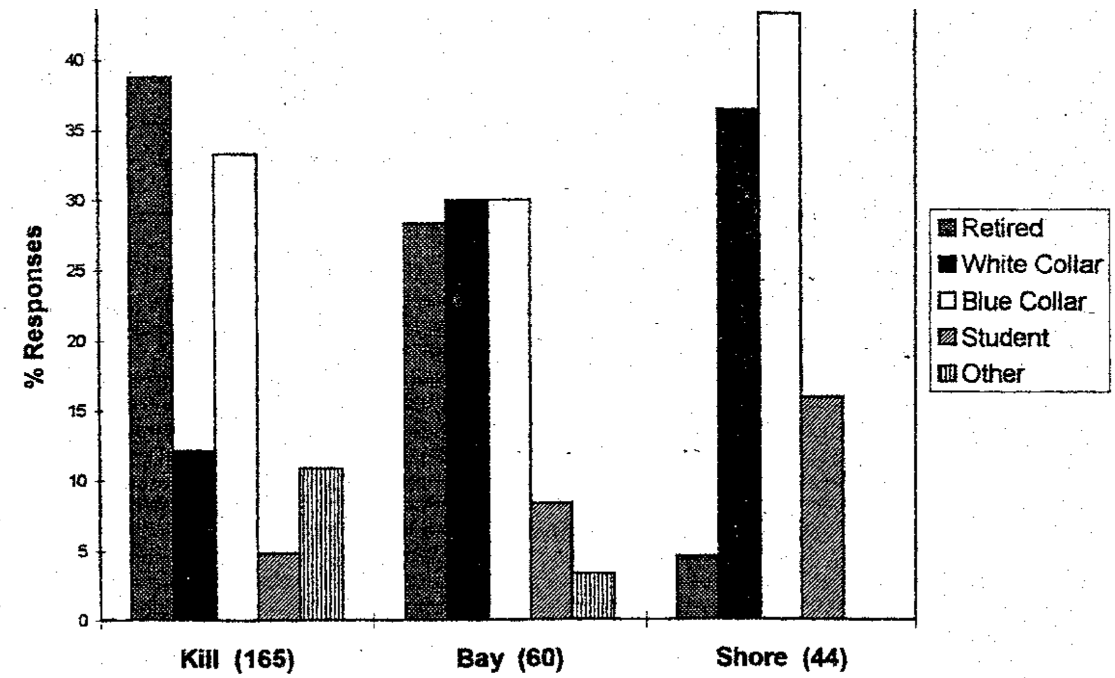


Figure 1. Occupational Composition of Fishermen Interviewed in the Arthur Kill, Raritan Bay, and New Jersey Shore (total number of responses for each region is given in parentheses) (May and Burger, 1996)

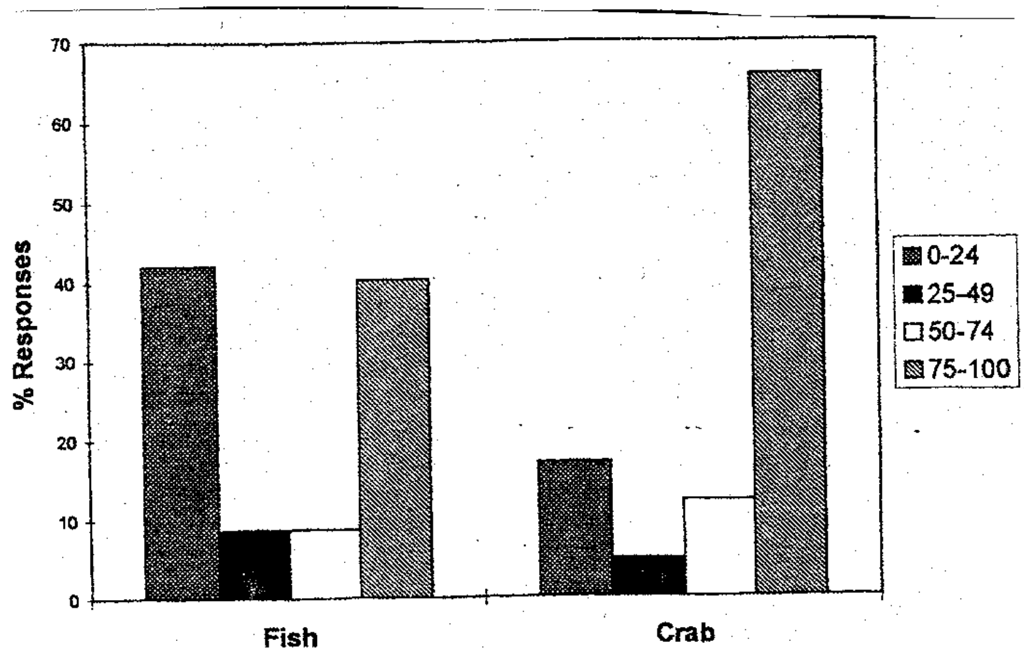


Figure 2a. Percentage of the Fish/Crabs Eaten That Are Self-caught by Fishermen and Crabbers in the Arthur Kill (legend is assumed to provide age ranges) (May and Burger, 1996)

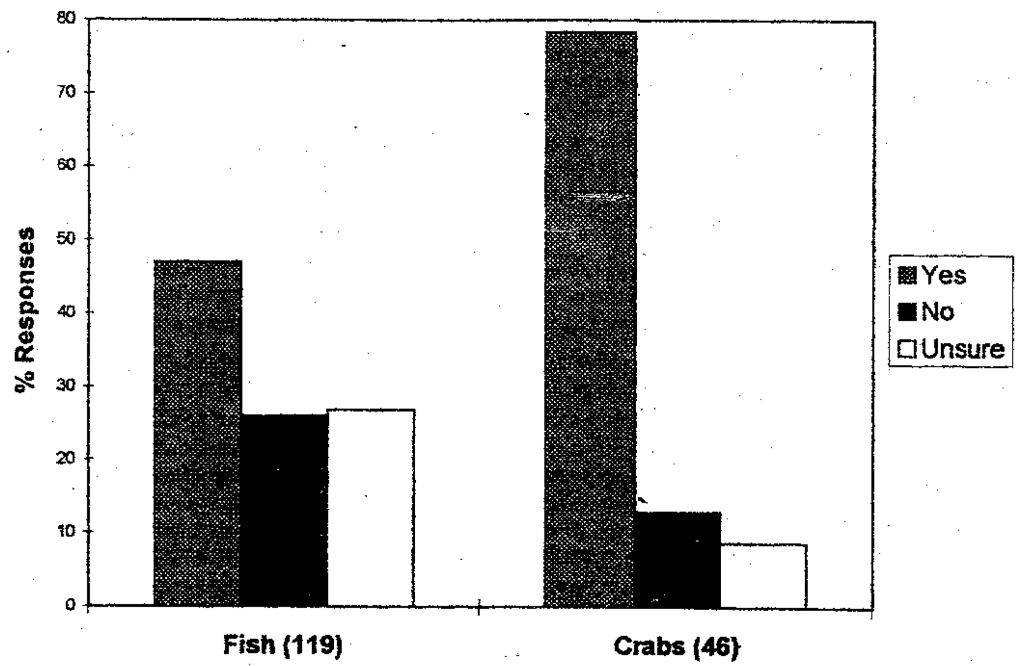


Figure 2b. Comparison of Responses by Fishermen and Crabbers to Whether the Fish/Crabs in the Arthur Kill are Safe
(total number of responses for each group is given in parentheses)
(May and Burger, 1996)

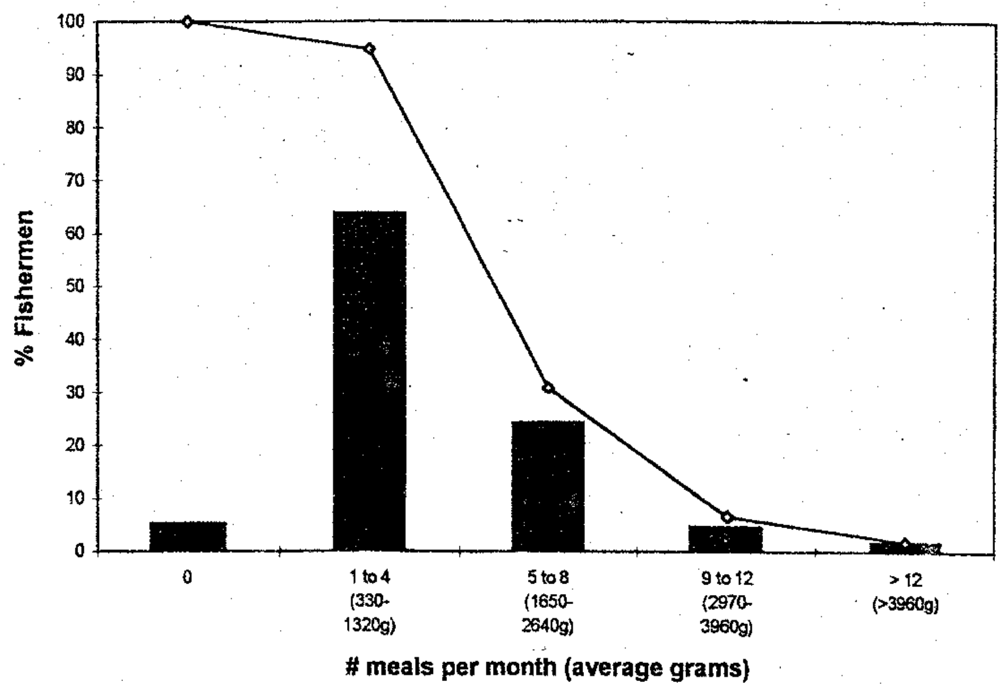


Figure 3. Meals of Fish Consumed per Month by Fishermen in the Arthur Kill.
Line Shows Cumulative Total.
(May and Burger, 1996)

Jacobs, HL; Kahn, HD; Stralka, KA; et al. (1998) Estimates of per capita fish consumption in the U.S. based on the continuing survey of food intake by individuals (CSFII). Risk Anal 18(3):283-291.
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Jacobs et al. (1998) estimated daily average per capita fish consumption by age and gender using data from the 1989, 1990, and 1991 Continuing Survey of Food Intake by Individuals (CSFII). The CSFII is conducted annually by the U.S. Department of Agriculture (USDA) and information is collected for individuals in the 48 conterminous states. Data collection for each CSFII survey starts in April of the given year and is completed in March of the following year. Approximately 25 percent of the interviews are conducted in each of four consecutive calendar quarters. Survey respondents provide 3 days of dietary recall data.

The CSFII surveys consist of two samples: a basic sample and a low-income sample. Individuals in all households are eligible for the basic sample. However, only households with gross incomes at or below 130 percent of the Federal poverty threshold were included in the low-income sample. Data from both samples (basic and low-income) were used to develop the overall fish consumption estimates. The total sample size for the combined three years of data was 11,912 individuals. For the 1989, 1990, and 1991 basic samples, the survey response rates were 46, 40, and 43 percent, respectively. For the 1989, 1990, and 1991 low-income samples, the survey response rates were 53, 41, and 47 percent, respectively.

Point and interval estimates of the mean, 50th, 75th, 90th, 95th, and 99th percentiles of the distribution of per capita fish consumption were determined from the CSFII data. These estimates were generated by gender and age for three fish categories: freshwater/estuarine finfish and shellfish, marine finfish and shellfish, and total finfish and shellfish. The age categories were: 14 years or younger, 15 through 44 years, and 45 years and older. Analyses were run using SAS statistical software. Estimates were generated as follows:

- Means using ratio estimation techniques;
- Variances using Taylor series approximations of the deviation of mean estimates from their expected values; and
- Percentiles from the empirical cumulative distribution.

Empirical cumulative distributions of daily average per capita fish consumption are shown in Figure 1 (inserts show detailed view of the upper tail of distribution). The data show that of the respondents, 80 percent did not consume freshwater/estuarine fish, 70 percent did not consume marine fish, and more than 60 percent did not consume fish during the 3-day study period. Distributions estimated by age and gender of per capita fish consumption for each fish habitat are shown in Tables 1, 2, and 3. All fish consumption rate estimates are based on the weight of fish in its “as consumed” condition.

Table 1 presents the estimated mean consumption rates of freshwater/estuarine finfish and shellfish for males, females, and total population in the 48 conterminous states. The mean consumption rate of freshwater/estuarine finfish and shellfish was estimated for the total population at 4.71 grams/person/day. The estimated mean consumption rate of freshwater/estuarine finfish and shellfish for males of all ages was 5.46 grams/person/day, as opposed to 4.02 grams/person/day for females of all ages. Males ages 45 or older had the highest consumption rate at 7.12 grams/person/day.

Table 2 presents the estimated mean consumption rates of marine finfish and shellfish for males, females, and total population in the 48 conterminous states. The estimated mean consumption rate of marine finfish and shellfish for the total population was 10.94 grams/person/day. The estimated mean consumption rate of marine finfish and shellfish for males of all ages was 11.58 grams/person/day, as opposed to 10.10 grams/person/day for females of all ages. Males ages 15-44 has the highest consumption rate at 13.33 grams/person/day.

Table 3 presents the estimated mean consumption rates for all finfish and shellfish for males, females, and total population in the 48 conterminous states. The estimated mean consumption rate of all finfish and shellfish for the total population was 15.65 grams/person/day. The estimated mean total fish consumption rate for males of all ages was 17.31 grams/person/day, while the estimated mean total fish consumption rate for females of all ages was 3.18 grams/person/day less, at 14.13 grams/person/day. Males ages 45 years or older had the highest estimated mean total fish consumption rate at 20.45 grams/person/day.

Limitations of this study included the following: (1) the 3-day survey time period is too brief to estimate an individual's usual intake, and (2) the survey only included the 48 conterminous states leaving out Alaska and Hawaii, which could result in an underestimate of per capita fish consumption for the entire U.S. population.

Table 1. Daily Average per Capita Estimates of Freshwater and Estuarine Finfish and Shellfish Consumption Rates[a]
Mean, 75th, 90th, 95th, and 99th Percentiles

| Gender | Age | Sample Size | Mean (90% C.I.) | Grams/Person/Day | | | |
|---|---|---|---|---|---|---|---|
| | | | | 75th % (90% B.I.)[b] | 90th % (90% B.I.)[b] | 95th % (90% B.I.)[b] | 99th % (90% B.I.)[b] |
| Females | 14 or under | 1,431 | 1.58 (1.06-2.10) | 0.00 (0.00-0.00) | 1.44 (0.00-4.07) | 12.51 (6.00-14.20) | 36.09 (28.53-43.20) |
| | 15-44 | 2,891 | 4.28 (3.55-5.02) | 0.00 (0.00-0.00) | 10.90 (8.79-13.84) | 28.80 (26.26-33.53) | 70.87 (64.74-90.56) |
| | 45 or older | 2,340 | 5.27 (4.21-6.32) | 0.00 (0.00-0.00) | 18.72 (15.19-22.12) | 34.67 (29.17-39.38) | 85.35 (71.71-100.50) |
| | All ages | 6,662 | 4.02 (3.43-4.61) | 0.00 (0.00-0.00) | 10.66 (8.11-13.19) | 28.11 (23.14-31.27) | 71.98 (60.38-86.40) |
| Males | 14 or under | 1,546 | 2.17 (1.32-3.02) | 0.00 (0.00-0.00) | 0.99 (0.21-6.67) | 14.94 (11.88-22.33) | 48.72 (37.48-52.29) |
| | 15-44 | 2,151 | 6.14 (5.08-7.19) | 0.00 (0.00-0.00) | 18.19 (10.21-24.20) | 48.61 (35.42-54.65) | 96.32 (85.60-115.75) |
| | 45 or older | 1,553 | 7.12 (5.87-8.38) | 0.00 (0.00-0.31) | 22.67 (19.28-17.83) | 46.62 (41.27-58.01) | 103.07 (86.41-125.11) |
| | All ages | 5,250 | 5.46 (4.81-6.11) | 0.00 (0.00-0.00) | 16.05 (12.41-19.30) | 40.29 (35.92-43.73) | 86.40 (78.37-103.07) |
| Both Sexes | 14 or under | 2,977 | 1.88 (1.36-2.40) | 0.00 (0.00-0.00) | 1.31 (0.00-4.33) | 13.90 (9.32-15.05) | 40.77 (35.15-44.82) |
| | 15-44 | 5,042 | 5.17 (4.46-5.87) | 0.00 (0.00-0.00) | 13.88 (12.05-17.21) | 36.21 (28.64-47.31) | 86.14 (74.67-96.67) |
| | 45 or older | 3,893 | 6.11 (5.20-7.02) | 0.00 (0.00-0.00) | 21.48 (16.69-23.33) | 40.55 (35.80-47.31) | 88.18 (85.33-103.07) |
| | All ages | 11,912 | 4.71 (4.17-5.25) | 0.00 (0.00-0.00) | 12.62 (10.91-13.98) | 32.16 (29.81-35.15) | 82.45 (77.17-86.40) |

a Estimates are based on the weight of fish in its "as consumed" (i.e., prepared) condition.

b Percentile bootstrap intervals (B.I.) were estimated using the percentile bootstrap method with 1,000 replications. Source of data: the combined 1989, 1990, and 1991 USDA Continuing Survey of Food Intakes by Individuals (CSFII).

Source: Jacobs et al., 1998.

Table 2. Daily Average per Capita Estimates of Marine Finfish and Shellfish Consumption Rates[a]
Mean, 75th, 90th, 95th, and 99th Percentiles

| Gender | Age | Sample Size | Mean (90% C.I.) | Grams/Person/Day | | | |
|---|---|---|---|---|---|---|---|
| | | | | 75th % (90% B.I.)[b] | 90th % (90% B.I.)[b] | 95th % (90% B.I.)[b] | 99th % (90% B.I.)[b] |
| Females | 14 or under | 1,431 | 6.60 (5.16-8.05) | 0.30 (0.00-9.15) | 24.84 (18.67-31.20) | 37.32 (32.27-42.05) | 87.05 (63.26-112.06) |
| | 15-44 | 2,891 | 9.97 (8.94-11.01) | 11.27 (6.99-14.00) | 36.83 (31.42-41.99) | 55.53 (47.67-59.59) | 105.32 (96.98-112.00) |
| | 45 or older | 2,340 | 12.59 (11.36-13.82) | 18.65 (15.24-20.09) | 42.92 (38.92-47.66) | 63.85 (57.27-72.36) | 103.09 (91.61-121.52) |
| | All ages | 6,662 | 10.10 (9.27-10.93) | 12.02 (11.21-12.84) | 36.97 (34.86-37.33) | 55.54 (51.67-56.98) | 102.01 (97.67-110.69) |
| Males | 14 or under | 1,546 | 7.25 (5.72-8.79) | 0.00 (0.00-2.60) | 24.85 (19.92-33.85) | 49.89 (42.09-56.45) | 92.64 (65.87-132.39) |
| | 15-44 | 2.151 | 13.33 (11.89-14.77) | 16.09 (12.84-18.64) | 52.73 (48.34-55.80) | 71.49 (63.99-80.00) | 116.51 (106.06-143.31) |
| | 45 or older | 1,553 | 13.32 (11.73-14.92) | 16.28 (12.84-21.02) | 50.39 (47.13-53.33) | 64.51 (61.64-74.58) | 116.86 (106.93-144.94) |
| | All ages | 5.250 | 11.85 (10.75-12.95) | 11.44 (8.41-12.84) | 47.13 (44.52-49.80) | 64.50 (62.46-67.53) | 113.94 (103.47-130.00) |
| Both Sexes | 14 or under | 2,977 | 6.93 (5.63-8.23) | 0.00 (0.00-3.00) | 24.88 (22.64 -28.08) | 42.07 (38.15-48.96) | 91.64 (68.59-112.06) |
| | 15-44 | 5,042 | 11.58 (10.55-12.60) | 12.83 (9.32-15.06) | 44.24 (39.84-46.70) | 62.18 (57.88-69.72) | 110.07 (103.50-120.49) |
| | 45 or older | 3,893 | 12.92 (11.85-13.98) | 18.47 (16.14-18.67) | 46.51 (38.98-50.97) | 64.19 (60.67-72.00) | 113.33 (104.59-119.53) |
| | All ages | 11,912 | 10.94 (10.14-11.73) | 12.00 (9.33-12.84) | 39.51 (37.29-42.91) | 59.62 (57.03-61.84) | 106.84 (104.59-114.55) |

a Estimates are based on the weight of fish in its "as consumed" (i.e., prepared) condition.

b Percentile bootstrap intervals (B.I.) were estimated using the percentile bootstrap method with 1,000 replications. Source of data: the combined 1989, 1990, and 1991 USDA Continuing Survey of Food Intakes by Individuals (CSFII).

Source: Jacobs et al., 1998.

Table 3. Daily Average per Capita Estimates of All Finfish and Shellfish Consumption Rates[a]
Mean, 75th, 90th, 95th, and 99th Percentiles

| Gender | Age | Sample Size | Mean (90% C.I.) | Grams/Person/Day | | | |
|---|---|---|---|---|---|---|---|
| | | | | 75th % (90% B.I.)[b] | 90th % (90% B.I.)[b] | 95th % (90% B.I.)[b] | 99th % (90% B.I.)[b] |
| Females | 14 or under | 1,431 | 8.19 (6.53-9.84) | 7.87 (0.96-13.94) | 32.28 (26.78-37.33) | 43.09 (37.99-51.55) | 95.19 (63.26-113.96) |
| | 15-44 | 2,891 | 14.25 (12.96-15.55) | 18.65 (18.09-22.72) | 47.13 (41.95-55.83) | 71.58 (64.74-82.11) | 120.84 (110.69-132.79) |
| | 45 or older | 2,340 | 17.86 (16.19-19.52) | 26.93 (23.33-28.07) | 56.70 (54.13-62.99) | 81.94 (74.63-88.23) | 130.51 (122.02-140.21) |
| | All ages | 6,662 | 14.13 (13.07-15.18) | 18.67 (18.09-20.38) | 46.44 (43.63-49.67) | 70.23 (67.27-73.91) | 120.22 (112.06-126.07) |
| Males | 14 or under | 1,546 | 9.42 (7.60-11.25) | 8.45 (3.50-11.67) | 34.85 (27.77-42.09) | 52.85 (49.93-62.50) | 98.36 (71.74-132.39) |
| | 15-44 | 2.151 | 19.46 (17.75-21.18) | 27.99 (24.56-31.55) | 68.60 (65.74-74.70) | 93.65 (85.60-96.96) | 149.07 (142.73-154.41) |
| | 45 or older | 1,553 | 20.45 (18.41-22.49) | 30.30 (27.31-33.20) | 64.44 (61.33-69.27) | 87.21 (85.33-100.19) | 168.49 (143.78-174.55) |
| | All ages | 5.250 | 17.31 (16.04-18.59) | 23.10 (20.56-25.54) | 60.23 (56.91-62.99) | 85.69 (80.61-93.32) | 143.91 (135.35-154.15) |
| Both Sexes | 14 or under | 2,977 | 8.82 (7.39-10.24) | 8.42 (4.31-11.50) | 32.88 (27.97-37.11) | 50.95 (44.64-53.86) | 98.33 (86.40-113.96) |
| | 15-44 | 5,042 | 16.74 (15.54-17.94) | 22.72 (19.29-24.87) | 57.88 (56.00-60.85) | 84.59 (79.91-90.83) | 138.21 (122.84-149.15) |
| | 45 or older | 3,893 | 19.03 (17.54-20.52) | 28.00 (26.71-29.79) | 61.32 (56.00-65.74) | 86.21 (77.42-94.70) | 143.91 (131.21-171.37) |
| | All ages | 11,912 | 15.65 (14.67-16.63) | 20.61 (18.67-22.69) | 52.02 (51.38-56.00) | 78.34 (75.21-80.56) | 133.46 (125.27-140.21) |

a Estimates are based on the weight of fish in its "as consumed" (i.e., prepared) condition.
b Percentile bootstrap intervals (B.I.) were estimated using the percentile bootstrap method with 1,000 replications. Source of data: the combined 1989, 1990, and 1991 USDA Continuing Survey of Food Intakes by Individuals (CSFII).

Source: Jacobs et al., 1998.

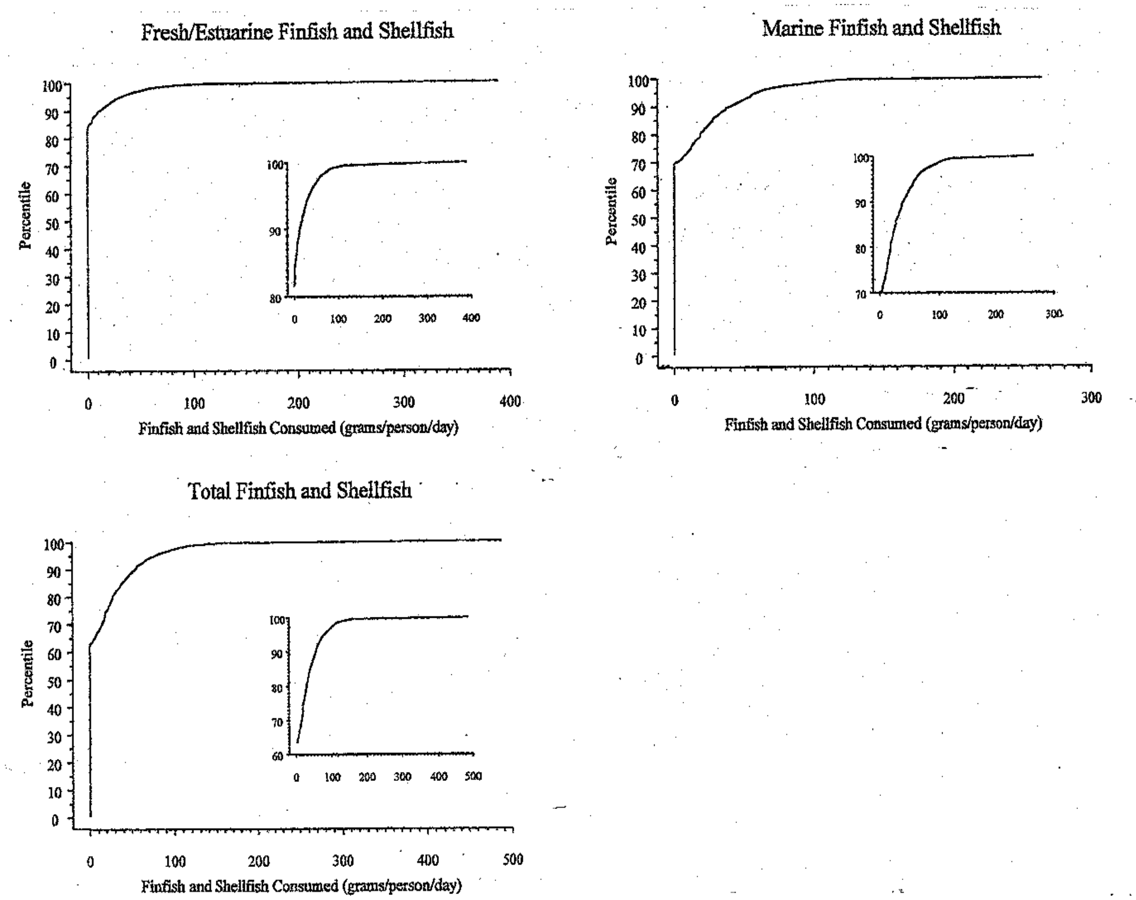


Figure 1. Empirical Cumulative Distributions of Daily Average per Capita Fish Consumption by the U.S. Population: Fresh/Estuarine, Marine, and Total Fish

Note: Data used are from the Combined 1989, 1990, 1991 USDA Continuous Survey of Food Intakes by Individuals (CSFII)

Source: Jacobs et al., 1998.

U.S. EPA (Environmental Protection Agency). (1999) Asian & Pacific Islander seafood consumption study in King County, WA. Region 10; Seattle, Washington; EPA 910/R-99-003. Available from: http://www.epa.gov/r10earth/offices/oea/risk/r0riskhh.htm.

This study was conducted to obtain seafood consumption rates, species, and seafood parts consumed, and cooking methods used for the Asian and Pacific Islander (API) community. Participants were seafood consumers who were first or second generation members of the API ethnic group, 18 years of age or older, and lived in King County, Washington. API's represent one of the most diverse and rapidly growing immigrant populations in the United States. In 1997 API's (166,000) accounted for 10% of King County's population, an increase from 8% in 1990. Between 1990 and 1997, the total population of King Country increased by 9% while the population of API's increased by 43% (State of Washington Population Trends, 1998).

This study was conducted in three phases. Phase I (planning phase) focused on identifying target ethnic groups and developing appropriate questionnaires in the language required for each ethnic group. Phase II focused on characterizing seafood consumption patterns for 10 API ethnic groups (Cambodian, Chinese, Filipino, Hmong, Japanese, Korean, Laotian, Mien, Samoan, and Vietnamese) within the study area. Phase III focused on developing culturally appropriate health messages on risks related to seafood consumption and disseminating this information for the API community. The majority of the 202 respondents (89%) were first generation (i.e., born outside the U.S.). There were slightly more women (53%) than men (47%) and 35% lived under the 1997 Federal Poverty Level (FPL).

In general, it was found that API members consumed seafood at a very high rate. As shown in Table 1, the mean overall consumption rate for all seafood combined was 1.891 grams/per kilogram body weight/day (g/kg/day), with a median consumption rate of 1.439 g/kg/day. The predominant seafood consumed was shellfish (46% of all seafood). The API community consumed more shellfish (average consumption rate of 0.867 g/kg/day) than all finfish combined (an average rate of 0.819g/kg/day). Within the category of finfish, pelagic fish were consumed most by the API members, mean of 0.382 g/kg/day (median 0.215 g/kg/day), followed by anadromous fish with a mean consumption rate of 0.201 g/kg/day (median 0.093 g/kg/day). The mean consumption for freshwater fish was 0.110 g/kg/day (median 0.043 g/kg/day), and bottom fish was 0.125 g/kg/day (median 0.047 g/kg/day). Individuals in the lowest income level (under the FPL) consumed more seafood than those in higher income levels (1-2, 2-3, and >3 times the FPL), but the difference was not statistically significant.

In an effort to capture the participants consuming large quantities of seafood, the survey participants were classified as higher (n=44) or lower (n=158) consumers of shellfish or finfish based on their consumption rates being ≥75th (higher) or ≤75th (lower) percentile. Table 2 shows that people in the >55 years old category had the greatest percentage for high consumers of finfish; they had approximately the same percentage as other age groups for shellfish. The Japanese had a greater percentage (52%) for higher finfish consumers and Vietnamese (50%) were in the higher shellfish consumer category.

Table 3 presents seafood consumption rates by ethnicity. In general, members of the Vietnamese and Japanese communities had the highest overall consumption rate, averaging 2.627 g/kg/day (median 2.384 g/kg/day) and 2.182 g/kg/day (median 1.830 g/kg/day), respectively.

Table 4 presents consumption rates by gender. The mean consumption rate for all seafood for women was 1.807 g/kg/day (median 1.417 g/kg/day) and 1.710 g/kg/day (median 1.257 g/kg/day) for men.

Salmon and tuna were the most frequently consumed finfish. More than 75% of the respondents consumed shrimp, crab, and squid. These data are presented in Table 5. Table 6 presents the parts of finfish consumed by ethnicity. For all survey participants, the head, bones, eggs, and other organs were consumed 20% of the time. Fillet without skin was consumed 45% of the time and fillet with skin, 55% of the time. Consumption patterns of shellfish parts are shown in Table 7 (bivalves) and Table 8 (nonbivalves). Consumption patterns varied depending on the type of shellfish.

Preparation methods were also surveyed in the API community (Table 9). The survey covered two categories of preparation methods: (1) baked, broiled, roasted, or poached and (2) canned, fried, raw, smoked, or dried. The respondents most frequently prepared their finfish and shellfish using the bake, boiled, broiled, roasted, or poached method, averaging 65% and 78%, respectively, for these preparation methods.

The benefit of this research is that it can be used to improve API specific risk assessments. API community members consume greater amounts of seafood than the general population and these consumption patterns may pose a health risk if the consumed seafood is contaminated with toxic chemicals. Because the survey was based on recall, the authors selected 20 respondents for a follow-up re-interview. Its purpose was to assess the reliability of the responses. The results of the re-interview suggests that, based on the difference in means between the original and re-interview responses, the estimated consumption rates this study are reliable.

One limitation associated with this study is that it is based on a relatively small number of respondents within each ethnic group. Therefore, extrapolation of data to other ethnic groups should be used with caution. Further study of the consumption patterns and preparation methods for the Hmong, Laotian, Mien, and Vietnamese communities is also needed because of potential health risks from contaminated seafood.

Table 1. Consumption Rates of API Community Members[a]

| Category | N | Median (g/kg/d) | Mean (g/kg/d) | Percentage of Consumption [b] | S.E. | 95% LCI (g/kg/d) | 95% UCI (g/kg/d) | 90%tile (g/kg/d) |
|---|---|---|---|---|---|---|---|---|
| Anadromous Fish | 202 | 0.093 | 0.201 | 10.6% | 0.008 | 0.187 | 0.216 | 0.509 |
| Pelagic Fish | 202 | 0.215 | 0.382 | 20.2% | 0.013 | 0.357 | 0.407 | 0.829 |
| Freshwater Fish | 202 | 00.43 | 0.110 | 5.8% | 0.005 | 0.101 | 0.119 | 0.271 |
| Bottom Fish | 202 | 0.047 | 0.125 | 6.6% | 0.006 | 0.113 | 0.137 | 0.272 |
| Shellfish Fish | 202 | 0.498 | 0.867 | 45.9% | 0.023 | 0.821 | 0.913 | 1.727 |
| Seaweed/Kelp | 202 | 0.014 | 0.084 | 4.4% | 0.005 | 0.075 | 0.093 | 0.294 |
| Miscellaneous Seafood | 202 | 0.056 | 0.121 | 6.4% | 0.004 | 0.112 | 0.130 | 0.296 |
| All Finfish | 202 | 0.515 | 0.818 | 43.3% | 0.023 | 0.774 | 0.863 | 1.638 |
| All Fish | 202 | 1.363 | 1.807 | 95.6% | 0.042 | 1.724 | 1.889 | 3.909 |
| All Seafood | 202 | 1.439 | 1.891 | 100.0% | 0.043 | 1.805 | 1.976 | 3.928 |

[a] 95% LCI = 95% lower confidence interval bound; 95% UCI = 95% upper confidence interval. The confidence interval was computed based on the Student's t-distribution. Rates were weighted across ethnic groups.

[b] Percentage of consumption = the percent of each category that makes up the total (i.e., 10.6% of total fish eaten was anadromous fish).

Source: U.S. EPA, 1999.

Table 2. Demographic and Seafood Preparation Characteristics of "Higher" and "Lower" Seafood Consumers

| | | All Finfish | | Shellfish | |
|---|---|---|---|---|---|
| | n | Lower Consumers (%) | Higher Consumers [a] (%) | Lower Consumers (%) | Higher Consumers [b] (%) |
| Female | 107 | 76 | 24 | 71 | 29 |
| Male | 95 | 81 | 19 | 79 | 21 |
| 18-29 | 78 | 85 | 15 | 73 | 27 |
| 30-54 | 85 | 79 | 21 | 78 | 22 |
| 55+ | 39 | 64 | 36 | 72 | 28 |
| Cambodian | 20 | 90 | 10 | 70 | 30 |
| Chinese | 30 | 83 | 17 | 70 | 30 |
| Filipino | 30 | 80 | 20 | 87 | 13 |
| Japanese | 29 | 48 | 52 | 79 | 21 |
| Korean | 22 | 91 | 9 | 68 | 32 |
| Laotian | 20 | 75 | 25 | 75 | 25 |
| Mien | 10 | 90 | 10 | 90 | 10 |
| Hmong | 5 | 100 | 0 | 100 | 0 |
| Samoan | 10 | 100 | 0 | 100 | 0 |
| Vietnamese | 26 | 69 | 31 | 50 | 50 |
| Non-fishermen | 136 | 82 | 18 | 76 | 24 |
| Fishermen | 66 | 71 | 29 | 73 | 27 |
| | | Lower Consumers[c] (%) | Higher Consumers[d] (%) | Lower Consumers[e] (%) | Higher Consumers[f] (%) |
| Fillet with Skin | | 52 | 51 | | |
| Fillet w/o Skin | | 41 | 44 | | |
| Head/Bone/Organ | | 20 | 19 | | |
| Bake, Boil, etc. | | 58 | 72 | 76 | 79 |
| Canned, Fried, etc. | | 36 | 24 | 22 | 21 |
| Purchased | | 75 | 82 | 86 | 93 |
| Caught | | 25 | 18 | 14 | 7 |

a Higher Consumer: >75%tile = 1.144 g/day/kg
b Higher Consumer: >75%tile = 1.072 g/day/kg
c n=158
d n=44
e n=151
f n=51

Source: U.S. EPA, 1999.

Table 3. Seafood Consumption Rates by Ethnicity[a]

| Category | Ethnicity | Sample Size (n) | Mean | S.E. | 10%tile | Median | 90%tile | % with Non-zero Consump-tion | Consumers (%) | 95% LCI | 95% UCI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Anadromous Fish (p<0.001) | Cambodian | 20 | 0.118 | 0.050 | 0.000 | 0.030 | 0.453 | 18 | 90 | 0.014 | 0.223 |
| | Chinese | 30 | 0.193 | 0.052 | 0.012 | 0.066 | 0.587 | 30 | 100 | 0.086 | 0.300 |
| | Filipino | 30 | 0.152 | 0.027 | 0.025 | 0.100 | 0.384 | 29 | 96.7 | 0.098 | 0.206 |
| | Japanese | 29 | 0.374 | 0.056 | 0.086 | 0.251 | 0.921 | 29 | 100 | 0.261 | 0.488 |
| | Korean | 22 | 0.091 | 0.026 | 0.007 | 0.048 | 0.248 | 22 | 100 | 0.037 | 0.146 |
| | Laotian | 20 | 0.187 | 0.064 | 0.002 | 0.069 | 0.603 | 18 | 90 | 0.054 | 0.321 |
| | Mien | 10 | 0.018 | 0.008 | 0.000 | 0.011 | 0.080 | 7 | 70 | 0.000 | 0.036 |
| | Hmong | 5 | 0.059 | 0.013 | n/a | 0.071 | n/a | 5 | 100 | 0.026 | 0.091 |
| | Samoan | 10 | 0.067 | 0.017 | 0.012 | 0.054 | 0.185 | 10 | 100 | 0.030 | 0.104 |
| | Vietnamese | 26 | 0.124 | 0.026 | 0.017 | 0.072 | 0.349 | 26 | 100 | 0.071 | 0.176 |
| | All Ethnicity (1) | 202 | 0.201 | 0.008 | 0.016 | 0.093 | 0.509 | 194 | 96 | 0.187 | 0.216 |
| Pelagic Fish (p<0.001) | Cambodian | 20 | 0.088 | 0.021 | 0.000 | 0.061 | 0.293 | 17 | 85 | 0.044 | 0.131 |
| | Chinese | 30 | 0.325 | 0.068 | 0.022 | 0.171 | 0.824 | 30 | 100 | 0.187 | 0.463 |
| | Filipino | 30 | 0.317 | 0.081 | 0.051 | 0.132 | 0.729 | 30 | 100 | 0.151 | 0.482 |
| | Japanese | 29 | 0.576 | 0.079 | 0.132 | 0.429 | 1.072 | 29 | 100 | 0.415 | 0.737 |
| | Korean | 22 | 0.313 | 0.056 | 0.073 | 0.186 | 0.843 | 22 | 100 | 0.196 | 0.429 |
| | Laotian | 20 | 0.412 | 0.138 | 0.005 | 0.115 | 1.061 | 20 | 100 | 0.124 | 0.700 |
| | Mien | 10 | 0.107 | 0.076 | 0.000 | 0.09 | 0.716 | 7 | 70 | -0.064 | 0.277 |
| | Hmong | 5 | 0.093 | 0.028 | n/a | 0.090 | n/a | 5 | 100 | 0.021 | 0.164 |
| | Samoan | 10 | 0.499 | 0.060 | 0.128 | 0.535 | 0.792 | 10 | 100 | 0.365 | 0.633 |
| | Vietnamese | 26 | 0.377 | 0.086 | 0.059 | 0.208 | 0.956 | 26 | 100 | 0.201 | 0.553 |
| | All Ethnicity (1) | 202 | 0.382 | 0.013 | 0.046 | 0.215 | 0.829 | 196 | 97 | 0.357 | 0.407 |
| Freshwater Fish (p<0.001) | Cambodian | 20 | 0.139 | 0.045 | 0.000 | 0.045 | 0.565 | 18 | 90 | 0.045 | 0.232 |
| | Chinese | 30 | 0.084 | 0.023 | 0.000 | 0.015 | 0.327 | 24 | 80 | 0.037 | 0.131 |
| | Filipino | 30 | 0.132 | 0.034 | 0.018 | 0.086 | 0.273 | 30 | 100 | 0.062 | 0.202 |
| | Japanese | 29 | 0.021 | 0.006 | 0.000 | 0.007 | 0.071 | 20 | 69 | 0.010 | 0.032 |
| | Korean | 22 | 0.032 | 0.015 | 0.000 | 0.008 | 0.160 | 13 | 59.1 | 0.002 | 0.062 |
| | Laotian | 20 | 0.282 | 0.077 | 0.002 | 0.099 | 1.006 | 18 | 90 | 0.122 | 0.442 |
| | Mien | 10 | 0.097 | 0.039 | 0.007 | 0.070 | 0.407 | 10 | 100 | 0.010 | 0.184 |
| | Hmong | 5 | 0.133 | 0.051 | n/a | 0.081 | n/a | 5 | 100 | 0.002 | 0.263 |
| | Samoan | 10 | 0.026 | 0.007 | 0.000 | 0.025 | 0.061 | 9 | 90 | 0.011 | 0.041 |
| | Vietnamese | 26 | 0.341 | 0.064 | 0.068 | 0.191 | 1.036 | 26 | 100 | 0.209 | 0.472 |
| | All Ethnicity (1) | 202 | 0.110 | 0.005 | 0.000 | 0.043 | 0.271 | 173 | 85.6 | 0.101 | 0.119 |

Table 3. Seafood Consumption Rates by Ethnicity[a] (continued)

| Category | Ethnicity | Sample Size (n) | Mean | S.E. | 10%tile | Median | 90%tile | % with Non-zero Consump-tion | Consumers (%) | 95% LCI | 95% UCI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bottom Fish (p<0.001) | Cambodian | 20 | 0.045 | 0.025 | 0.000 | 0.003 | 0.114 | 10 | 50 | -0.006 | 0.097 |
| | Chinese | 30 | 0.082 | 0.026 | 0.004 | 0.033 | 0.212 | 28 | 93.3 | 0.028 | 0.135 |
| | Filipino | 30 | 0.165 | 0.043 | 0.001 | 0.103 | 0.560 | 27 | 90 | 0.078 | 0.253 |
| | Japanese | 29 | 0.173 | 0.044 | 0.023 | 0.098 | 0.554 | 28 | 96.6 | 0.083 | 0.263 |
| | Korean | 22 | 0.119 | 0.026 | 0.000 | 0.062 | 0.270 | 19 | 86.4 | 0.064 | 0.173 |
| | Laotian | 20 | 0.066 | 0.031 | 0.000 | 0.006 | 0.173 | 13 | 65 | 0.000 | 0.131 |
| | Mien | 10 | 0.006 | 0.003 | 0.000 | 0.00 | 0.026 | 4 | 40 | -0.001 | 0.013 |
| | Hmong | 5 | 0.036 | 0.021 | n/a | 0.024 | n/a | 3 | 60 | -0.017 | 0.088 |
| | Samoan | 10 | 0.029 | 0.005 | 0.008 | 0.026 | 0.058 | 10 | 100 | 0.018 | 0.040 |
| | Vietnamese | 26 | 0.102 | 0.044 | 0.000 | 0.030 | 0.388 | 21 | 80.8 | 0.013 | 0.192 |
| | All Ethnicity (1) | 202 | 0.125 | 0.006 | 0.000 | 0.047 | 0.272 | 163 | 80.7 | 0.113 | 0.137 |
| Shellfish Fish (p<0.001) | Cambodian | 20 | 0.919 | 0.216 | 0.085 | 0.695 | 2.003 | 20 | 100 | 0.467 | 1.370 |
| | Chinese | 30 | 0.985 | 0.168 | 0.176 | 0.569 | 2.804 | 30 | 100 | 0.643 | 1.327 |
| | Filipino | 30 | 0.613 | 0.067 | 0.188 | 0.505 | 1.206 | 30 | 100 | 0.477 | 0.750 |
| | Japanese | 29 | 0.602 | 0.089 | 0.116 | 0.401 | 1.428 | 29 | 100 | 0.419 | 0.784 |
| | Korean | 22 | 1.045 | 0.251 | 0.251 | 0.466 | 2.808 | 22 | 100 | 0.524 | 1.566 |
| | Laotian | 20 | 0.898 | 0.259 | 0.041 | 0.424 | 2.990 | 19 | 95 | 0.357 | 1.439 |
| | Mien | 10 | 0.338 | 0.113 | 0.015 | 0.201 | 1.058 | 10 | 100 | 0.086 | 0.590 |
| | Hmong | 5 | 0.248 | 0.014 | n/a | 0.252 | n/a | 5 | 100 | 0.212 | 0.283 |
| | Samoan | 10 | 0.154 | 0.024 | 0.086 | 0.138 | 0.336 | 10 | 100 | 0.100 | 0.208 |
| | Vietnamese | 26 | 1.577 | 0.260 | 0.247 | 1.196 | 4.029 | 26 | 100 | 1.044 | 2.110 |
| | All Ethnicity (1) | 202 | 0.867 | 0.023 | 0.168 | 0.498 | 1.727 | 201 | 99.5 | 0.821 | 0.913 |
| Seaweed/Kelp (p<0.001) | Cambodian | 20 | 0.002 | 0.001 | 0.000 | 0.000 | 0.008 | 7 | 35 | 0.000 | 0.004 |
| | Chinese | 30 | 0.062 | 0.022 | 0.001 | 0.017 | 0.314 | 29 | 96.7 | 0.016 | 0.107 |
| | Filipino | 30 | 0.009 | 0.004 | 0.000 | 0.000 | 0.025 | 15 | 50 | 0.002 | 0.016 |
| | Japanese | 29 | 0.190 | 0.043 | 0.019 | 0.082 | 0.752 | 29 | 100 | 0.101 | 0.279 |
| | Korean | 22 | 0.200 | 0.050 | 0.011 | 0.087 | 0.686 | 21 | 95.5 | 0.096 | 0.304 |
| | Laotian | 20 | 0.004 | 0.003 | 0.000 | 0.000 | 0.013 | 6 | 30 | -0.001 | 0.009 |
| | Mien | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0 | 0 | 0.000 | 0.000 |
| | Hmong | 5 | 0.002 | 0.001 | n/a | 0.001 | n/a | 3 | 60 | 0.000 | 0.004 |
| | Samoan | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0 | 0 | 0.000 | 0.000 |
| | Vietnamese | 26 | 0.017 | 0.012 | 0.000 | 0.000 | 0.050 | 6 | 23.1 | -0.008 | 0.043 |
| | All Ethnicity (1) | 202 | 0.084 | 0.005 | 0.000 | 0.014 | 0.294 | 116 | 57.4 | 0.075 | 0.093 |

Table 3. Seafood Consumption Rates by Ethnicity[a] (continued)

| Category | Ethnicity | Sample Size (n) | Mean | S.E. | 10%tile | Median | 90%tile | % with Non-zero Consump-tion | Consumers (%) | 95% LCI | 95% UCI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Miscellaneous Fish (p<0.001) | Cambodian | 20 | 0.113 | 0.026 | 0.000 | 0.087 | 0.345 | 18 | 90 | 0.058 | 0.168 |
| | Chinese | 30 | 0.081 | 0.021 | 0.003 | 0.030 | 0.201 | 30 | 100 | 0.038 | 0.123 |
| | Filipino | 30 | 0.083 | 0.025 | 0.016 | 0.043 | 0.182 | 30 | 100 | 0.032 | 0.134 |
| | Japanese | 29 | 0.246 | 0.036 | 0.032 | 0.206 | 0.620 | 29 | 100 | 0.173 | 0.139 |
| | Korean | 22 | 0.092 | 0.031 | 0.004 | 0.047 | 0.307 | 21 | 95.5 | 0.028 | 0.156 |
| | Laotian | 20 | 0.074 | 0.021 | 0.000 | 0.025 | 0.225 | 15 | 75 | 0.029 | 0.118 |
| | Mien | 10 | 0.015 | 0.008 | 0.000 | 0.002 | 0.063 | 7 | 70 | 0.003 | 0.033 |
| | Hmong | 5 | 0.019 | 0.014 | n/a | 0.008 | n/a | 4 | 80 | 0.018 | 0.055 |
| | Samoan | 10 | 0.076 | 0.028 | 0.003 | 0.045 | 0.276 | 10 | 100 | 0.014 | 0.138 |
| | Vietnamese | 26 | 0.089 | 0.013 | 0.013 | 0.087 | 0.184 | 25 | 96.2 | 0.062 | 0.115 |
| | All Ethnicity (1) | 202 | 0.121 | 0.004 | 0.005 | 0.056 | 0.296 | 189 | 93.6 | 0.112 | 0.130 |
| All Finfish (p<0.001) | Cambodian | 20 | 0.390 | 0.098 | 0.061 | 0.223 | 1.379 | 20 | 100 | 0.185 | 0.594 |
| | Chinese | 30 | 0.683 | 0.133 | 0.114 | 0.338 | 2.024 | 30 | 100 | 0.412 | 0.954 |
| | Filipino | 30 | 0.766 | 0.148 | 0.268 | 0.452 | 1.348 | 30 | 100 | 0.464 | 1.067 |
| | Japanese | 29 | 1.144 | 0.124 | 0.194 | 1.151 | 2.170 | 29 | 100 | 0.890 | 1.398 |
| | Korean | 22 | 0.555 | 0.079 | 0.180 | 0.392 | 1.204 | 22 | 100 | 0.391 | 0.719 |
| | Laotian | 20 | 0.947 | 0.204 | 0.117 | 0.722 | 2.646 | 20 | 100 | 0.523 | 1.372 |
| | Mien | 10 | 0.228 | 0.117 | 0.034 | 0.097 | 1.160 | 10 | 100 | -0.032 | 0.488 |
| | Hmong | 5 | 0.319 | 0.073 | n/a | 0.268 | n/a | 5 | 100 | 0.131 | 0.507 |
| | Samoan | 10 | 0.621 | 0.059 | 0.225 | 0.682 | 0.842 | 10 | 100 | 0.490 | 0.751 |
| | Vietnamese | 26 | 0.944 | 0.171 | 0.188 | 0.543 | 2.568 | 26 | 100 | 0.593 | 1.296 |
| | All Ethnicity (1) | 202 | 0.818 | 0.023 | 0.166 | 0.515 | 1.638 | 202 | 100 | 0.774 | 0.863 |
| All Fish (p<0.001) | Cambodian | 20 | 1.421 | 0.274 | 0.245 | 1.043 | 3.757 | 20 | 100 | 0.850 | 1.993 |
| | Chinese | 30 | 1.749 | 0.283 | 0.441 | 1.337 | 4.206 | 30 | 100 | 1.172 | 2.326 |
| | Filipino | 30 | 1.462 | 0.206 | 0.660 | 1.137 | 2.423 | 30 | 100 | 1.041 | 1.883 |
| | Japanese | 29 | 1.992 | 0.214 | 0.524 | 1.723 | 3.704 | 29 | 100 | 1.555 | 2.429 |
| | Korean | 22 | 1.692 | 0.275 | 0.561 | 1.122 | 3.672 | 22 | 100 | 1.122 | 2.262 |
| | Laotian | 20 | 1.919 | 0.356 | 0.358 | 1.467 | 4.147 | 20 | 100 | 1.176 | 2.663 |
| | Mien | 10 | 0.580 | 0.194 | 0.114 | 0.288 | 1.967 | 10 | 100 | 0.149 | 1.012 |
| | Hmong | 5 | 0.585 | 0.069 | n/a | 0.521 | n/a | 5 | 100 | 0.407 | 0.764 |
| | Samoan | 10 | 0.850 | 0.078 | 0.363 | 0.879 | 1.188 | 10 | 100 | 0.676 | 1.025 |
| | Vietnamese | 26 | 2.610 | 0.377 | 0.653 | 2.230 | 6.542 | 26 | 100 | 1.835 | 3.385 |
| | All Ethnicity (1) | 202 | 1.807 | 0.042 | 0.480 | 1.363 | 3.909 | 202 | 100 | 1.724 | 1.889 |

Table 3. Seafood Consumption Rates by Ethnicity[a] (continued)

| Category | Ethnicity | Sample Size (n) | Mean | S.E. | 10%tile | Median | 90%tile | % with Non-zero Consump-tion | Consumers (%) | 95% LCI | 95% UCI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Seafood (p<0.001) | Cambodian | 20 | 1.423 | 0.274 | 0.245 | 1.043 | 3.759 | 20 | 100 | 0.851 | 1.995 |
| | Chinese | 30 | 1.811 | 0.294 | 0.452 | 1.354 | 4.249 | 30 | 100 | 1.210 | 2.411 |
| | Filipino | 30 | 1.471 | 0.206 | 0.660 | 1.135 | 2.425 | 30 | 100 | 1.050 | 1.892 |
| | Japanese | 29 | 2.182 | 0.229 | 0.552 | 1.830 | 3.843 | 29 | 100 | 1.714 | 2.650 |
| | Korean | 22 | 1.892 | 0.294 | 0.608 | 1.380 | 4.038 | 22 | 100 | 1.281 | 2.503 |
| | Laotian | 20 | 1.923 | 0.356 | 0.400 | 1.467 | 4.147 | 20 | 100 | 1.181 | 2.665 |
| | Mien | 10 | 0.580 | 0.194 | 0.114 | 0.288 | 1.967 | 10 | 100 | 0.149 | 1.012 |
| | Hmong | 5 | 0.587 | 0.069 | n/a | 0.521 | n/a | 5 | 100 | 0.410 | 0.765 |
| | Samoan | 10 | 0.850 | 0.078 | 0.363 | 0.879 | 1.188 | 10 | 100 | 0.676 | 1.025 |
| | Vietnamese | 26 | 2.627 | 0.378 | 0.670 | 2.384 | 6.613 | 26 | 100 | 1.851 | 3.404 |
| | All Ethnicity (1) | 202 | 1.891 | 0.043 | 0.521 | 1.439 | 3.928 | 202 | 100 | 1.805 | 1.976 |

a All consumption rates in g/kg body weight/d.
Weighted by population percentage.
Note: p-value is based on Kruskal Wallis test.
***Consumption Rate*** - Seafood species were categorized into seven groups: anadromous, pelagic, freshwater, bottom, shellfish, seaweed/kelp, and miscellaneous seafood.

Source: U.S. EPA, 1999.

Table 4.  Consumption Rates by Gender for All Asian and Pacif Islander Community

| Category | Female | | | | Male | | | |
|---|---|---|---|---|---|---|---|---|
| | n | Mean (g/kg/d) | SE | Median (g/kg/d) | n | Mean (g/kg/d) | SE | Median (g/kg/d) |
| Anadromous Fish (p=0.8) | 107 | 0.165 | 0.022 | 0.076 | 95 | 0.169 | 0.024 | 0.080 |
| Pelagic Fish (p=0.4) | 107 | 0.349 | 0.037 | 0.215 | 95 | 0.334 | 0.045 | 0.148 |
| Freshwater Fish (p=1.0) | 107 | 0.131 | 0.021 | 0.054 | 95 | 0.137 | 0.023 | 0.054 |
| Bottom Fish (p=0.6) | 107 | 0.115 | 0.019 | 0.040 | 95 | 0.087 | 0.017 | 0.034 |
| Shellfish (p=0.8) | 107 | 0.864 | 0.086 | 0.432 | 95 | 0.836 | 0.104 | 0.490 |
| Seaweed/Kelp (p=0.5) | 107 | 0.079 | 0.018 | 0.005 | 95 | 0.044 | 0.010 | 0.002 |
| Miscellaneous Seafood (p=0.5) | 107 | 0.105 | 0.013 | 0.061 | 95 | 0.104 | 0.015 | 0.055 |
| All Finfish (p=0.8) | 107 | 0.759 | 0.071 | 0.512 | 95 | 0.726 | 0.072 | 0.458 |
| All Fish (p=0.5) | 107 | 1.728 | 0.135 | 1.328 | 95 | 1.666 | 0.149 | 1.202 |
| All Seafood (p=0.4) | 107 | 1.807 | 0.139 | 1.417 | 95 | 1.710 | 0.152 | 1.257 |

P-values are based on Mann-Whitney test.

Source: U.S. EPA, 1999.

Table 5. Types of Seafood Consumed/Respondents Who Consume (%)

| Type of Seafood | (%) |
|---|---|
| Anadromous Fish | |
| Salmon | 93 |
| Trout | 61 |
| Smelt | 45 |
| Salmon Eggs | 27 |
| Pelagic Fish | |
| Tuna | 86 |
| Cod | 66 |
| Mackeral | 62 |
| Snapper | 50 |
| Rockfish | 34 |
| Herring | 21 |
| Dogfish | 7 |
| Snowfish | 6 |
| Freshwater Fish | |
| Catfish | 58 |
| Tilapia | 45 |
| Perch | 39 |
| Bass | 28 |
| Carp | 22 |
| Crappie | 17 |
| Bottom Fish | |
| Halibut | 65 |
| Sole/Flounder | 42 |
| Sturgeon | 13 |
| Suckers | 4 |
| Shellfish | |
| Shrimp | 98 |
| Crab | 96 |
| Squid | 82 |
| Oysters | 71 |
| Manila/Littleneck Clams | 72 |
| Lobster | 65 |
| Mussel | 62 |
| Scallops | 57 |
| Butter Clams | 39 |
| Geoduck | 34 |
| Cockles | 21 |
| Abalone | 15 |
| Razor Clams | 16 |
| Sea Cucumber | 15 |
| Sea Urchin | 14 |
| Horse Clams | 13 |
| Macoma Clams | 9 |
| Moonsnail | 4 |
| Seaweed/Kelp | |
| Seaweed | 57 |
| Kelp | 29 |

Source: U.S. EPA, 1999.

Table 6. Parts of Finfish Consumed by Ethnicity

| | n | Fillet with Skin | Fillet Without Skin | Head, Bones, Eggs, Organs |
|---|---|---|---|---|
| Cambodian | 20 | 64% | 36% | 34% |
| Chinese | 30 | 55% | 45% | 27% |
| Filipino | 29 | 59% | 41% | 26% |
| Japanese | 29 | 30% | 70% | 10% |
| Korean | 15 | 50% | 50% | 1% |
| Laotian | 18 | 42% | 58% | 4% |
| Mien | 9 | 67% | 33% | 23% |
| Hmong | 5 | 100% | 0% | 90% |
| Samoan | 10 | 45% | 55% | 11% |
| Vietnamese | 25 | 78% | 22% | 18% |
| All Ethnicity | 190 | 55% | 45% | 20% |

Source: U.S. EPA, 1999.

Table 7.  Shellfish Consumption (Bivalves)

| Shellfish | Average Percentage of Eating Specific Parts of Shellfish | | | | |
|---|---|---|---|---|---|
| | % Consumers (n) | Whole | Whole w/Stomach Removed | Whole with Siphon Removed | Whole with Stomach and Siphon Removed |
| Manila/littleneck clams | 72 (145) | 77 | 10 | 4 | 9 |
| Oysters | 71 (142) | 88 | 5 | 4 | 3 |
| Mussles | 62 (125) | 89 | 6 | 4 | 1 |
| Scallops | 57 (115) | 71 | 4 | 1 | 24 |
| Butter clams | 39 (78) | 76 | 14 | 3 | 6 |
| Geoduck clams | 34 (68) | 24 | 40 | 2 | 35 |
| Cockles | 21 (42) | 64 | 12 | 9 | 14 |
| Razor clams | 16 (33) | 58 | 21 | 0 | 21 |
| Abalones | 15 (30) | 53 | 23 | 2 | 22 |
| Horse clams | 13 (27) | 48 | 22 | 0 | 30 |
| Macoma clams | 9 (19) | 63 | 26 | 0 | 11 |

Source: U.S. EPA, 1999.

Table 8. Non-Bivalve Shellfish Consumption

| Species | % Consumers (n) | Whole | Body/Meat/Eggs/ Muscles Only | Tissue Parts Consumed |
|---|---|---|---|---|
| Shrimps | 98 (196) | 21 | 78 | Body and head versus meat only |
| Crabs | 96 (192) | 43 | 57 | Crab meat and butter[a] versus meat only |
| Squids | 82 (165) | 22 | 78 | Whole squid versus body and tentacles only |
| Lobsters | 65 (131) | 16 | 84 | Whole body and head versus body only |
| Sea Cucumbers | 15 (31) | 26 | 74 | Whole body versus muscle only |
| Sea Urchins | 14 (29) | 24 | 76 | Whole body versus eggs only |
| Moon Snails | 4 (8) | 38 | 62 | Whole body versus muscle only |

a The "butter" is defined as yellowish liquid and soft tissue comprised of cooked gastrointestinal tract which includes the hepatopancreas and stomach.

Source: U.S. EPA, 1999.

Table 9. Fish Preparation Methods

| | Finfish | | | Shellfish | | |
|---|---|---|---|---|---|---|
| | n | Baked, Boiled, Broiled, Roasted, or Poached | Canned, Fried, Raw, Smoked, or Dried | n | Baked, Boiled, Broiled, Roasted, or Poached | Canned, Fried, Raw, Smoked, or Dried |
| Cambodian | 20 | 54 | 46 | 20 | 65 | 35 |
| Chinese | 30 | 79 | 21 | 30 | 82 | 18 |
| Filipino | 30 | 58 | 42 | 30 | 77 | 23 |
| Japanese | 29 | 79 | 22 | 29 | 68 | 32 |
| Korean | 15 | 57 | 42 | 15 | 89 | 11 |
| Laotian | 19 | 59 | 41 | 19 | 79 | 16 |
| Mien | 8 | 74 | 26 | 8 | 88 | 13 |
| Hmong | 5 | 50 | 50 | 5 | 60 | 40 |
| Samoan | 10 | 52 | 48 | 10 | 50 | 50 |
| Vietnamese | 25 | 67 | 33 | 25 | 92 | 8 |
| All Ethnicity | 191 | 65 | 35 | 200 | 78 | 22 |

Source: U.S. EPA, 1999.

Toy, KA; Polissar, NL; Liao, S; et al. (1996) A fish consumption survey of the Tulalip and Squaxin Island tribes of the Puget Sound region. Tulalip Tribes, Department of Environment, 7615 Totem Road, Margsville, WA 98271.

This survey was conducted to determine the fish and shellfish consumption rates of the Tulalip and Squaxin Island tribes living in the Puget Sound. These two Indian tribes were selected nonrandomly to represent the expected range of fishing and fish consumption activities of tribes in the Puget Sound region.

A survey was conducted to describe fish consumption for Puget Sound tribal members over the age of 18, and their dependents ages five and under, in terms of their consumption rate of anadromous, pelagic, bottom fish, and shellfish in grams per kilogram body weight per day (See Table 1 for species grouping used in interviewing). The survey focused on the frequency of fish and shellfish consumption (number of fish meals eaten per day, per week, per month, or per year) over a one-year period and the portion size of each meal. Data were also collected on fish parts consumed, preparation methods, patterns of acquisition for all fish and shellfish consumption (including seasonal variations in consumption), and children's consumption rates. Interviews were conducted between February 25 and May 15, 1994. A total of 190 tribal members, ages 18 years old and older, and 69 children between the ages birth and 5 years old, were surveyed on consumption of 52 species. The response rate was 77 percent for the Squaxin Island tribe and 76 percent for the Tulalip tribes.

The survey results showed that adults of both tribes consumed fish at a high rate (Table 2). The mean and median consumption rates for all forms of fish combined were 0.89 and 0.55 g/kg/day for the Tulalip tribes and 0.89 and 0.52 g/kg/day for the Squaxin Island tribe, respectively (Table 3). As shown in Table 4, consumption per body weight varied by gender (males consumed more as indicated by mean and median consumption). The median rates for the Tulalip Tribes were 53 g/day for males and 34 g/day for females, while the rates were 66 g/day for males and 25 g/day for females for the Squaxin Island tribe (Table 5). Among adults consumption generally followed a curvilinear pattern, with greater median consumption in the age range of 35-64 years old and lower consumption in the age range of 18-34 years old and 65 years old and over (Table 6). No consistent pattern of consumption by income was found for either tribe (Table 7).

The mean and median consumption rates for children, age birth to 5 years old, were 0.53 and 0.17 g/kg/day, respectively, which were significantly lower than those of adults, even when the consumption rate was adjusted for body weight (Table 8). Squaxin Island children tended to consume more fish than Tulalip children (mean 0.825 g/kg/day vs. 0.239 g/kg/day). A minority of consumers ate fish parts that are considered to have a higher concentration of toxins: skin, head, bones, eggs, and organs (Table 9), and for the majority of consumers, fish were prepared (baking, boiling, broiling, roasting, poaching) and eaten in a manner that tends to reduce intake of contaminants (Table 10). Most anadromous fish and shellfish were obtained by harvesting in the Puget Sound area rather than by purchasing, though sources of harvesting varied between the tribes (Table 11).

The advantage of this study is that the data can be used to improve how exposure assessments are conducted for populations that are high consumers of fish and shellfish and to identify cultural characteristics that may place tribal members at disproportionate risk to chemical contamination.

The survey of Tulalip and Squaxin Island tribes showed considerably higher consumption rates for both adults and children than the 0.09 g/kg/day reported for the general population by SRI International in their 1980 report entitled, "NPD Fish Consumption Survey, 1973-1974." The median total fish consumption rate for women of both tribes was four to five times higher than the rate (6.5 g/day) recommended as a national default value used by the EPA. For males of both tribes, the median consumption rate was eight to ten times higher than the recommended national default value.

One limitation associated with this study is that data from the Tulalip and Squaxin Island tribes may be representative of consumption rates of these specific tribes. Fish consumption rates, habits, and patterns can vary among tribes and other sub-populations. The authors noted that the total fish consumption rates were similar for both tribes; however, consumption pattern by fish species and other factors differed. In some instances, these differences were statistically significant. Another limitation is that the distribution presented in this study is skewed toward higher rates, and it might be more appropriate to use the $90^{th}$ or $95^{th}$ percentiles for analysis of risk rather than means or medians. There might also be a possible bias due to the time the survey was conducted; many species in the survey are seasonal, and although the survey was designed to solicit annual consumption rates, respondents may have weighed their responses toward the interview period. For example, because of the timing of the survey, respondents may have overestimated their annual consumption of shellfish and underestimated their annual consumption of salmon.

Table 1. Species Grouping Used in Interviewing

| Group A (Anadromous) | Group B (Pelagic) | Group C (Bottom) | Group D (Shellfish) | Group E | Group F (Other) |
|---|---|---|---|---|---|
| Salmon: | Cod | Halibut | Clams | Canned Tuna* | Trout* |
| Chinook | Pollock | Sole/Flounder | (Manila/Littleneck) | | Geoduck** |
| Pink | Sablefish | Sturgeon | Horse Clam | | Limpets** |
| Sockeye | Rockfish | | Butter Clam | | Lobster** |
| Coho | Greenling | | Cockles | | Bullhead** |
| Chum | herring | | Mussels | | Manta Ray** |
| Unidentified | Spiny | | Oysters | | Razor |
| Steelhead | Dogfish | | Shrimp | | Clam** |
| Smelt | Perch | | Dungeness Crab | | Chitons** |
| | | | Red Rock Crab | | Octopus** |
| | | | Moon Snail | | Abalone** |
| | | | Scallops | | Chitons** |
| | | | Squid | | Barnacles** |
| | | | Sea Urchin | | Crayfish** |
| | | | Sea Cucumber | | Mackeral*** |
| | | | Sea Urchin | | Shark*** |
| | | | | | Skate**** |
| | | | | | Eel**** |
| | | | | | Grunters**** |

* Consumption rate was added to the "other" group for reporting (see text).
** Consumption rate was added to the shellfish group for reporting.
*** Consumption rate was added to the pelagic group for reporting.
**** Consumption rate was added to the bottom group for reporting.

Source: Toy et al., 1996.

Table 2. Descriptive Characteristics

| Adults | | |
|---|---|---|
| | Tulalip Tribes (n = 73) | Squaxin Island Tribe (n = 17) |
| Gender (%) | | |
| Male | 58 | 56 |
| Female | 43 | 44 |
| Age (%) | | |
| 18-34 | 37 | 46 |
| 35-64 | 55 | 44 |
| 65+ | 8 | 9 |
| Household Income (%) | | |
| <15,000 | 46 | 49 |
| ≥15,000 | 54 | 51 |
| Weight (kg) mean ± s.d. | | |
| Male* | 86 ± 19 | 93 ± 17 |
| Female | 76 ± 16 | 68 ± 14 |

| Children | | |
|---|---|---|
| | Tulalip Tribes (n = 21) | Squaxin Island Tribe (n = 48) |
| Gender (%) | | |
| Boys | 57 | 40 |
| Girls | 43 | 40 |
| Age (mo.) mean ± s.d. | 33 ± 17 | 32 ± 18 |
| Source of Information on Child (%) | | |
| Mother | 43 | 46 |
| Father | 38 | 33 |
| Other | 19 | 21 |

n varies slightly due to missing values. Percentages might not add to 100 due to rounding.
* $p < 0.05$ comparing two tribes (Wilcoxon-Mann-Whitney test).

Source: Toy et al., 1996.

Table 3. Percentiles and Mean of Adult Tribal Member Consumption Rates (g/kg/day)

| | 5% | 50% | 90% | 95% | SE | Mean | 95% CI |
|---|---|---|---|---|---|---|---|
| Tulalip Tribes (n = 73) | | | | | | | |
| Anadromous fish | 0.006 | 0.190 | 1.429 | 2.114 | 0.068 | 0.426 | (0.297, 0.555) |
| Pelagic fish | 0.000 | 0.004 | 0.156 | 0.234 | 0.008 | 0.036 | (0.021, 0.051) |
| Bottom fish** | 0.000 | 0.008 | 0.111 | 0.186 | 0.007 | 0.033 | (0.020, 0.046) |
| Shellfish** | 0.000 | 0.153 | 1.241 | 1.5296 | 0.059 | 0.362 | (0.250, 0.474) |
| Total finfish | 0.010 | 0.284 | 1.779 | 2.149 | 0.072 | 0.495 | (0.359, 0.631) |
| Other fish:+* | 0.000 | 0.000 | 0.113 | 0.264 | 0.008 | 0.031 | (0.016, 0.046) |
| Total fish | 0.046 | 0.552 | 2.466 | 2.876 | 0.111 | 0.889 | (0.679, 1.099) |
| Squaxin Island Tribe (n = 117) | | | | | | | |
| Anadromous fish | 0.016 | 0.308 | 1.639 | 2.182 | 0.069 | 0.590 | (0.485, 0.695) |
| Pelagic fish | 0.000 | 0.003 | 0.106 | 0.248 | 0.009 | 0.043 | (0.029, 0.057) |
| Bottom fish** | 0.000 | 0.026 | 0.176 | 0.345 | 0.010 | 0.063 | (0.048, 0.078) |
| Shellfish** | 0.000 | 0.065 | 0.579 | 0.849 | 0.027 | 0.181 | (0.140, 0.222) |
| Total finfish | 0.027 | 0.383 | 1.828 | 2.538 | 0.075 | 0.697 | (0.583, 0.811) |
| Other fish:+* | 0.000 | 0.000 | 0.037 | 0.123 | 0.003 | 0.014 | (0.009, 0.019) |
| Total fish | 0.045 | 0.524 | 2.348 | 3.016 | 0.088 | 0.891 | (0.757, 1.025) |
| Both Tribes Combined (weighted) | | | | | | | |
| Anadromous fish | 0.010 | 0.239 | 1.433 | 2.085 | 0.042 | 0.508 | (0.425, 0.591) |
| Pelagic fish | 0.000 | 0.004 | 0.112 | 0.226 | 0.005 | 0.040 | (0.029, 0.050) |
| Bottom fish** | 0.000 | 0.015 | 0.118 | 0.118 | 0.005 | 0.048 | (0.038, 0.058) |
| Shellfish** | 0.000 | 0.115 | 0.840 | 1.308 | 0.030 | 0.272 | (0.212, 0.331) |
| Total finfish | 0.017 | 0.317 | 1.751 | 2.188 | 0.045 | 0.596 | (0.507, 0.685) |
| Other fish:+* | 0.000 | 0.000 | 0.049 | 0.145 | 0.004 | 0.023 | (0.015, 0.030) |
| Total fish | 0.047 | 0.531 | 2.312 | 2.936 | 0.064 | 0.890 | (0.765, 1.015) |

* $p < 0.05$

** $p < 0.01$ comparing two tribes (Wilcoxon-Mann-Whitney test).

Source: Toy et al., 1996.

Table 4. Median and Mean Consumption Rates by Gender (g/kg/day) Within Each Tribe

| | Tulalip Tribe | | | | Squaxin Island Tribe | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Median | Mean | 95% CI | N | Median | Mean | 95% CI |
| Shellfish | | | | | | | | |
| Male | 42 | 0.158 | 0.370 | (0.215, 0.525) | 65 | 0.100 | 0.202 | (0.149, 0.255) |
| Female | 31 | 0.153 | 0.353 | (0.192, 0.514) | 52 | 0.038 | 0.155 | (0.093, 0.217) |
| Total finfish | | | | | | | | |
| Male | 42 | 0.414 | 0.559 | (0.370, 0.748) | 65 | 0.500 | 0.707 | (0.576, 0.838) |
| Female | 31 | 0.236 | 0.409 | (0.218, 0.600) | 52 | 0.272 | 0.684 | (0.486, 0.882) |
| Total fish[a] | | | | | | | | |
| Male | 42 | 0.623 | 0.959 | (0.666, 1.252) | 65 | 0.775[b] | 0.926 | (0.771, 1.081) |
| Female | 31 | 0.472 | 0.794 | (0.499, 1.089) | 52 | 0.353 | 0.847 | (0.614, 1.080) |

a Total fish includes anadromous, pelagic, bottom shellfish, finfish, and other fish.
b $p < .05$ for difference in consumption rate by gender within a tribe (Wilcoxon-Mann-Whitney test).

Source: Toy et al., 1996.

Table 5. Median Consumption Rate for Total Fish by Gender and Tribe (g/day)

| | Tulalip Tribes | Squaxin Island Tribe |
|---|---|---|
| Male | 53 | 66 |
| Female | 34 | 25 |

Source: Toy et al., 1996.

Table 6. Percentiles of Adult Consumption Rates by Age (g/kg/day)

| Ages | Tulalip Tribes | | | | Squaxin Island Tribe | | |
|---|---|---|---|---|---|---|---|
| | 5% | 50% | 90% | 95% | 50% | 90% | 95% |
| Shellfish | | | | | | | |
| 18-34 | 0.00 | 0.181 | 1.163 | 1.676 | 0.073 | 0.690 | 1.141 |
| 35-49 | 0.00 | 0.161 | 1.827 | 1.836 | 0.073 | 0.547 | 1.094 |
| 50-64 | 0.00 | 0.173 | 0.549 | 0.549 | 0.000 | 0.671 | 0.671 |
| 65+ | 0.00 | 0.034 | 0.088 | 0.088 | 0.035 | 0.188 | 0.188 |
| Total finfish | | | | | | | |
| 18-34 | 0.013 | 0.156 | 1.129 | 1.956 | 0.289 | 1.618 | 2.963 |
| 35-49 | 0.002 | 0.533 | 2.188 | 2.388 | 0.383 | 2.052 | 2.495 |
| 50-64 | 0.156 | 0.301 | 1.211 | 1.211 | 0.909 | 3.439 | 3.439 |
| 65+ | 0.006 | 0.176 | 0.531 | 0.531 | 0.601 | 2.049 | 2.049 |
| Total fish[a] | | | | | | | |
| 18-34 | 0.044 | 0.571 | 2.034 | 2.615 | 0.500 | 2.385 | 3.147 |
| 35-49 | 0.006 | 0.968 | 3.666 | 4.204 | 0.483 | 2.577 | 3.053 |
| 50-64 | 0.190 | 0.476 | 11.586 | 1.586 | 1.106 | 3.589 | 3.589 |
| 65+ | 0.050 | 0.195 | 0.623 | 0.623 | 0.775 | 2.153 | 2.153 |

a Total fish includes anadromous, pelagic, bottom, shellfish, finfish, and other fish.

Source: Toy et al., 1996.

Table 7. Median Consumption Rates by Income (g/kg/day) Within Each Tribe

| Income | Tulalip Tribes | Squaxin Island Tribe |
|---|---|---|
| | Median Rate | Median Rate |
| Shellfish | | |
| <= $10,000 | 0.143 | 0.078 |
| $10,001 - $15,000 | 0.071 | 0.121 |
| $15,001 - $20,000 | 0.144 | 0.072 |
| $20,001 - $25,000 | 0.202 | 0.000 |
| $25,001 - $35,000 | 0.416 | 0.030 |
| $35,001 + | 0.175 | 0.090 |
| Total finfish | | |
| <= $10,000 | 0.235 | 0.272 |
| $10,001 - $15,000 | 0.095 | 0.254 |
| $15,001 - $20,000 | 0.490 | 0.915 |
| $20,001 - $25,000 | 0.421 | 0.196 |
| $25,001 - $35,000 | 0.236 | 0.387 |
| $35,001 + | 0.286 | 0.785 |
| Total fish | | |
| <= $10,000 | 0.521 | 0.476 |
| $10,001 - $15,000 | 0.266 | 0.432 |
| $15,001 - $20,000 | 0.640 | 0.961 |
| $20,001 - $25,000 | 0.921 | 0.233 |
| $25,001 - $35,000 | 0.930 | 0.426 |
| $35,001 + | 0.607 | 1.085 |

Source: Toy et al., 1996.

Table 8. Mean, 50th, and 90th Percentiles of Consumption Rates
for Children Age Birth to Five Years (g/kg/day)

| | Mean (S.E.) | 95% CI | 50% | 90% |
|---|---|---|---|---|
| | Tulalip Tribes (n = 21) | | | |
| Shellfish | 0.125 (0.056) | (0.014, 0.236) | 0.000 | 0.597 |
| Total finfish | 0.114 (0.030) | (0.056, 0.173) | 0.060 | 0.290 |
| Total, all fish | 0.239 (0.077) | (0.088, 0.390) | 0.078 | 0.738 |
| | Squaxin Island Tribe (n = 48) | | | |
| Shellfish | 0.228 (0.053) | (0.126, 0.374) | 0.045 | 0.574 |
| Total finfish | 0.250 (0.063) | (0.126, 0.374) | 0.061 | 0.826 |
| Total, all fish | 0.825 (0.143) | (0.546, 1.105) | 0.508 | 2.056 |
| | Both Tribes Combined (weighted) | | | |
| Shellfish | 0.177 (0.039) | (0.101, 0.253) | 0.012 | 0.574 |
| Total finfish | 0.182 (0.035) | (0.104, 0.251) | 0.064 | 0.615 |
| Total, all fish | 0.532 (0.081) | (0.373, 0.691) | 0.173 | 1.357 |

Source: Toy et al., 1996.

Table 9. Mean Percent Consumption of Specified Fish Parts

| | Tulalip Tribes | Squaxin Island Tribe |
|---|---|---|
| Anadromous fish | (n = 72) | (n = 117) |
| Eat fillet with skin (%) * | 41 | 26 |
| Eat head, bones, eggs, organs, skin (%) | 8 | 11 |
| Pelagic fish | (n = 38) | (n = 62) |
| Eat fillet with skin (%) ** | 21 | 3 |
| Eat head, bones, eggs, organs, skin (%) | 3 | 0 |
| Bottom fish | (n = 44) | (n = 93) |
| Eat fillet with skin (%) ** | 16 | 3 |
| Eat head, bones, eggs, organs, skin (%) | 0 | 0 |

Limited to those consuming specified fish group. The percent is the mean stated percent of the time that consumers reported eating the specified part, including only those who consume the specified parts.

* $p < 0.05$
** $p < 0.01$ comparing tribes (Wilcoxon-Mann-Whitney test).

Source: Toy et al., 1996.

Table 10. Mean Percent Specified Preparation Methods: Mean (%) ± S.D.

| | Tulalip Tribes | Squaxin Island Tribe |
|---|---|---|
| Anadromous fish | (n = 72) | (n = 117) |
| Bake, boil, broil, roast, or poach | 64 ± 4 | 56 ± 3 |
| Canned, fried, raw, smoked, or dried | 36 ± 4 | 44 ± 3 |
| Pelagic fish | (n = 38) | (n = 62) |
| Bake, boil, broil, roast, or poach | 50 ± 8 | 54 ± 6 |
| Canned, fried, raw, smoked, or dried | 50 ± 8 | 46 ± 6 |
| Bottom fish | (n = 44) | (n = 94) |
| Bake, boil, broil, roast, or poach | 55 ± 6 | 62 ± 4 |
| Canned, fried, raw, smoked, or dried | 45 ±6 | 37 ± 4 |
| Shellfish | (n = 61) | (n = 80) |
| Bake, boil, broil, roast, or poach | 66 ± 4 | 69 ± 3 |
| Canned, fried, raw, smoked, or dried | 34 ± 4 | 31 ± 3 |
| Utilization of boiled water of shellfish+ | (n = 61) | (n = 86) |
| Throw out | 59% | 59% |
| Use in cooking** | 3% | 21% |
| Drink | 41% | 41% |

Limited to those consuming specified fish group. Percent is the mean among consumers of stated percent of time they use the specified preparation method.

+ Percentages do not add to 100 because respondents may have multiple answers.
* $p < 0.05$
** $p < 0.01$ comparing tribes (Wilcoxon-Mann-Whitney or Chi-squared test).

Source: Toy et al., 1996.

Table 11. Mean Percent of Sources of Fish Consumed: Mean (%) ± S.D.

| | Tulalip Tribes | Squaxin Island Tribe |
|---|---|---|
| Anadromous fish | (n = 72) | (n = 117) |
| Grocery stores | 4 ± 2 | 6 ± 1 |
| Restaurants | 7 ± 2 | 3 ± 1 |
| Caught in Puget Sound** | 72 ± 3 | 80 ± 3 |
| Caught outside Puget Sound* | 17 ± 2 | 11 ± 2 |
| Pelagic fish | (n = 38) | (n = 62) |
| Grocery stores | 28 ± 7 | 30 ± 5 |
| Restaurants | 41 ± 8 | 21 ± 5 |
| Caught in Puget Sound | 28 ± 7 | 23 ± 5 |
| Caught outside Puget Sound*** | 4 ± 3 | 25 ± 5 |
| Bottom fish | (n = 44) | (n = 94) |
| Grocery stores | 23 ± 6 | 26 ± 4 |
| Restaurants | 29 ± 6 | 17 ± 4 |
| Caught in Puget Sound*** | 39 ± 7 | 13 ± 33 |
| Caught outside Puget Sound*** | 6 ± 3 | 41 ± 5 |
| Shellfish | (n = 61) | (n = 79) |
| Grocery stores* | 9 ± 3 | 13 ± 3 |
| Restaurants | 14 ± 3 | 16 ± 3 |
| Caught in Puget Sound** | 73 ± 5 | 62 ± 4 |
| Caught outside Puget Sound*** | 4 ± 2 | 7 ± 2 |

Limited to those consuming specified fish group. Percent is the mean among consumers of stated percent of time they use the specified preparation method.
Percentages may not add to 100 due to rounding.
"Other" fish was omitted from this table.
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$ between the tribes (Wilcoxon-Mann-Whitney test).

Source: Toy et al., 1996.

Wilson, ND; Shear, NM; Paustenbach, DJ; et al. (1998) The effect of cooking practices on the concentration of DDT and PCB compounds in the edible tissue of fish. J Expo Anal Environ Epidemiol 8(3):423-440.

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This paper reanalyzed data from 14 recent studies, in order to enable risk assessors to adjust the concentrations of total DDT (tDDT) and PCBs in edible fish tissue to account for reductions as a result of cooking. Cooking methods evaluated were deep frying, boiling, smoking, broiling, and baking. Table 1 presents the published studies that were evaluated in this study. The authors evaluated percent reductions in tDDT and PCBs as a reduction in the mass (total micrograms) of tDDT and PCBs per mass of fish (the authors express concentrations of DDD, DDE, and DDT collectively as tDDT). Data from the 14 studies were compiled and evaluated to develop summary statistics and distributions of percent reduction by cooking method. The interquartile range (the difference between the 25$^{th}$ and 75$^{th}$ percentile) was used as an indicator of the variation within each data set. Empirical cumulative distribution functions were selected for all cooking methods and compounds based on percentiles of the data. The cooking loss data were further evaluated by analyzing the effect of cooking with skin-on versus skin-off, initial chemical concentration in the raw fillet, and percent lipid content of the raw fillet by using least squares linear regression.

Reductions in mass and concentration of tDDT and PCBs were seen in all previously published data considered in this study. Available data from the 14 studies on the influence of cooking on reductions in levels of tDDT and PCBs in fish indicate that cooking can substantially decrease the amounts of these chemicals.

Figure 1 presents the average, median, 75$^{th}$ percentile, and 25$^{th}$ percentile percent reduction in tDDT and PCBs for each cooking method. Specifically, the mean reductions in tDDT ranged from 16 percent for baking to 55 percent for microwaving. For PCBs, the mean reductions ranged from 26 percent for microwaving to 68 percent for boiling. Interquartile ranges for reductions of tDDT ranged from 16 percent for smoking to 36 percent for boiling, while for reductions of PCBs, interquartile ranges were calculated as 15 percent for smoking to 53 percent for boiling. On average, the highest reductions in tDDT mass were associated with microwaving, but only one study was conducted using this method. The next highest reductions in tDDT were for deep frying, boiling, smoking, broiling, and baking, respectively. Percent reductions were as follows:

- Deep frying: 2.8 - 81
- Boiling: 7.4 - 71
- Smoking: 27 - 53
- Broiling: 4.3 - 54
- Baking: 6 - 34

On average, the highest reductions in PCB mass were associated with boiling fish in water, and of the three studies that evaluated boiling, reductions in PCB mass ranged from 10 percent to 87 percent. Table 2 presents the distributions calculated for the percent reduction in tDDT and PCBs for each cooking method except for microwaving.

The percent reduction of tDDT and PCBs were evaluated as a function of initial chemical mass and lipid content of the raw fillet. The results of the least squares regression analysis performed on the data are presented in Table 3. For all cooking methods except for boiling and frying, the percent reduction of tDDT was not found to be significantly related to the lipid content of the raw fillet . Similarly, when percent reduction and initial chemical mass was compared, the relationship was only statistically significant for boiling For PCBs, the relationship between the initial chemical mass and percent reduction was significant only for broiling, and slightly significant relationships were seen between the percent reduction and the fillet lipid content for baking and broiling.

The results of this analysis suggest that skin-removal or retention, the lipid content, and initial chemical mass in the fillet are not good indicators of cooking method effectiveness. The effect of skin removal could only be examined quantitatively using data obtained from Zabik et al. (1995), which showed that skin removal was not significantly related to a reduction in the total mass of tDDT and PCBs. In the case of the weak correlation between lipid content and chemical reduction due to cooking, this might be due to the limited data set used in this study because several authors have hypothesized that the percent reduction in lipophilic chemicals should increase as the lipid content of the fillet increases. The weak significance of initial chemical mass as a predictor suggests that the initial mass of chemical in the raw fillet does not change the effectiveness of the cooking method, but this conclusion will only hold when amounts of tDDT and PCBs are within the range of the initial chemical mass analyzed.

Incorporation of cooking loss factors is an important factor in exposure assessments, and assessments that fail to incorporate loss of chemicals during cooking are likely to overestimate exposure and associated human health risks. The authors suggest that assessments of fish consumption, the concentration of tDDT and PCBs that can occur during cooking should be adjusted since baking, frying, broiling, boiling, smoking, and microwaving all effectively reduce the concentration of tDDT and PCBs in fish tissue.

A site-specific study was also presented on the cooking loss factors using data on the preferred cooking methods of Santa Monica Bay area anglers eating white croaker. This was presented as a means to illustrate how the distributions presented in this study can be used in the risk assessment process. Table 4 presents the probability of respondents using each cooking method based on reported frequencies and the associated cooking loss distribution for tDDT and PCBs. Figures 2 and 3 present the resulting overall distributions for tDDT and PCBs losses due to cooking. The results confirm that most Santa Monica Bay area anglers effectively reduce their consumption of tDDT and PCBs in fish through their normal cooking practices.

A limitation associated with the study is that it failed to identify a consistent pattern of relationships among reductions for the various cooking methods and chemicals. This suggests that variation in aspects of cooking method (e.g., duration of cooking, temperature, size, and shape of the fillet, etc.) may be as important as the cooking method itself in exploring losses associated with cooking. The authors suggested that losses may be due to evaporation of the chemical or extraction of the chemical from fish tissue to cooking fluids.

Table 1. Summary of Published Studies Evaluating Reductions in DDT and PCB Compounds from Cooking

| Study | Chemical(s) Evlauated[a] | Results Used in Quatitative Analysis? | Species | Method(s) | Source of Fish |
|---|---|---|---|---|---|
| Armbruster et al., 1987 | PCBs | No; estimate of mass loss not possible | Striped Bass | Bake, broil, fry, poach, microwave, boil | Long Island Sound |
| Armbruster et al., 1989 | PCBs | No; estimate of mass loss not possible | Bluefish | Bake, broil, fry, poach | Atlantic Ocean near Long Island |
| Cichy et al., 1979 | PCBs | No; inappropriate method | Lake Trout | Irradiate and broil | Hancock, MI |
| Lee and Lee, 1985 | DDT | No; inappropriate method | Loach | Dry, boil, steam, roast, broil | Kinhae area, Korea |
| Puffer & Gossett, 1983 | DDT, PCB | Yes | White Croaker | Pan fry | Santa Monica Bay, Orange County |
| Reinert et al., 1972 | DDT and DDE | Yes | Yellow Perch<br>Bloaters | Fry, bake, broil<br>Brine, smoke, fry, broil | Lake Michigan<br>Lake Michigan |
| Skea et al., 1981 | DDE, Aroclor 1254 | Yes | Brown Trout<br>Smallmouth Bass | Smoke, broil<br>Bake, deep fry | Lake Ontario<br>Lake Ontario |
| Smith et al., 1973 | DDT, DDE, Aroclor 1248, Aroclor 1254 | Yes | Chinook, Coho, Salmon | Bake, poach, bake in bag | Manistee River, MI |
| Trotter et al., 1988 | DDT, DDE, Aroclor 1254 | Yes | Bluefish | Bake | Buzzards Bay, New Bedford, Plymouth, MA |
| Zabik et al., 1979 | tDDT, Aroclor 1254 | Yes | Trout | Bake, broil, microwave | Keweenaw Peninsula, MI |
| Zabik et al., 1982 | DDD, DDE, PCBs | No; estimate of mass loss not possible | Carp | Poach, roast, deep fat fry, charbroil, microwave | Saginaw Bay |
| Zabik et al., 1995a | tDDT, PCBs | Yes | Walleye<br>White Bass | Bake, charbroil, deep fat fry<br>Pan fry | Lakes Erie, Huron, Michigan<br>Lakes Erie, Huron |
| Zabik et al., 1995b | DDT, DDE, DDD, PCBs | Yes | Chinook salmon<br>Carp | Bake, charbroil, score & charbroil, can<br>Pan fry, deep fat fry | Lakes Huron, Michigan<br>Lakes Erie, Huron |
| Zabik et al., 1996 | DDT, DDE, DDD, PCBs | Yes | Trout | Bake, charbroil, salt boil, smoke | Lakes Huron, Michigan, Ontario, Superior |

a tDDT refers to total DDT which is collectively DDD, DDE, and DDT.

Source: Wilson, et al., 1998.

Table 2. Distribution of Percent Reduction in tDDT and PCBs from Cooking

| | Cooking Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PCBs[a] | | | | | tDDT[b] | | | | |
| Percentile | Bake | Boil | Broil | Fry | Smoke | Bake | Boil | Broil | Fry | Smoke |
| 0.05 | 0.036 | 0.037 | 0.071 | 0.044 | 0.054 | 0.020 | 0.025 | 0.044 | 0.060 | 0.080 |
| 0.10 | 0.074 | 0.075 | 0.14 | 0.087 | 0.11 | 0.041 | 0.048 | 0.083 | 0.12 | 0.15 |
| 0.15 | 0.11 | 0.11 | 0.20 | 0.13 | 0.16 | 0.061 | 0.076 | 0.13 | 0.18 | 0.25 |
| 0.20 | 0.14 | 0.15 | 0.26 | 0.18 | 0.21 | 0.082 | 0.10 | 0.17 | 0.24 | 0.33 |
| 0.25 | 0.18 | 0.19 | 0.32 | 0.22 | 0.27 | 0.10 | 0.13 | 0.20 | 0.29 | 0.41 |
| 0.30 | 0.19 | 0.28 | 0.33 | 0.24 | 0.29 | 0.12 | 0.16 | 0.24 | 0.31 | 0.42 |
| 0.35 | 0.21 | 0.39 | 0.35 | 0.27 | 0.31 | 0.13 | 0.18 | 0.27 | 0.33 | 0.44 |
| 0.40 | 0.22 | 0.48 | 0.36 | 0.29 | 0.34 | 0.14 | 0.20 | 0.31 | 0.36 | 0.45 |
| 0.45 | 0.23 | 0.58 | 0.38 | 0.31 | 0.36 | 0.15 | 0.23 | 0.34 | 0.38 | 0.46 |
| 0.50 | 0.25 | 0.68 | 0.40 | 0.33 | 0.37 | 0.16 | 0.25 | 0.38 | 0.39 | 0.47 |
| 0.55 | 0.28 | 0.69 | 0.42 | 0.35 | 0.38 | 0.18 | 0.30 | 0.40 | 0.41 | 0.49 |
| 0.60 | 0.30 | 0.70 | 0.44 | 0.37 | 0.39 | 0.21 | 0.35 | 0.41 | 0.42 | 0.51 |
| 0.65 | 0.33 | 0.70 | 0.47 | 0.39 | 0.40 | 0.23 | 0.40 | 0.43 | 0.43 | 0.53 |
| 0.70 | 0.36 | 0.71 | 0.49 | 0.41 | 0.41 | 0.26 | 0.44 | 0.44 | 0.44 | 0.55 |
| 0.75 | 0.39 | 0.72 | 0.52 | 0.46 | 0.46 | 0.29 | 0.49 | 0.46 | 0.48 | 0.58 |
| 0.80 | 0.50 | 0.78 | 0.61 | 0.56 | 0.57 | 0.44 | 0.60 | 0.57 | 0.57 | 0.66 |
| 0.85 | 0.62 | 0.83 | 0.71 | 0.66 | 0.69 | 0.58 | 0.70 | 0.68 | 0.68 | 0.75 |
| 0.90 | 0.75 | 0.89 | 0.81 | 0.76 | 0.79 | 0.72 | 0.80 | 0.79 | 0.79 | 0.84 |
| 0.95 | 0.89 | 0.94 | 0.90 | 0.88 | 0.89 | 0.85 | 0.90 | 0.90 | 0.89 | 0.92 |

a Calculated using the following equations in @Risk (Palisade Corp., 1996): Baking: RiskCumul(0,1{0.18,0.25,0.39}, {0.25,0.5,0.75}); Broiling: RiskCumul(0,1{0.32,0.40,0.52}, {0.25,0.5,0.75}); Smoking: RiskCumul(0,1{0.27,0.37,0.41}, {0.25,0.5,0.75}); Boiling: RiskCumul(0,1{0.19,0.68,0.72}, {0.25,0.4,0.75}); Frying: RiskCumul(0,1{0.22,0.32,0.42}, {0.25,0.5,0.75}).

b Calculated using the following equations in @Risk (Palisade Corp., 1996): Baking: RiskCumul(0,1{0.11,0.16,0.27}, (0.24,0.4,0.75}); Broiling: RiskCumul(0,1{0.20,0.39,0.45}, {0.24,0.5,0.75}); Smoking: RiskCumul(0,1{0.42,0.47,0.58}, {0.24,0.5,0.75}); Boiling: RiskCumul: (0,1{0.13,0.25,0.49}, {0.25,0.5,0.75}); Frying: RiskCumul(0,1{0.29,0.39,0.45}, {0.25,0.5,0.75}).

Source: Wilson, et al., 1998.

Table 3. Significance of Correlation Between the Percent Reduction in tDDT and PCBs and Initial Chemical Mass and Percent Lipid[a]

| Method | Percent Reduction in tDDT vs | | Percent Reduction in PCBs vs | |
|---|---|---|---|---|
| | Initial Chemical Mass | Lipid Content | Initial Chemical Mass | Lipid Content |
| Bake | NS [b] | NS | NS | 0.024 |
| Boil | NS | 0.012 | NA [c] | NA |
| Broil | NS | NS | 0.016 | 0.047 |
| Fry | <0.001 [d] | <0.001 [d] | NS | NS |
| Smoke | NS | NS | NA | NA |

a Value in tables are *p*-values for test of hypothesis that there is a correlation between percent reduction and initial mass or lipid content. The smaller the *p*-value, the smaller the likelihood that our finding of nonzero correlation is due to chance alone.
b NS = Correlation not significantly different from zero; *p*-value >0.05.
c NA = Not analyzed. No regression performed due to insufficient data.
d Not significant ($p > 0.05$) when two potentially outlying values removed.

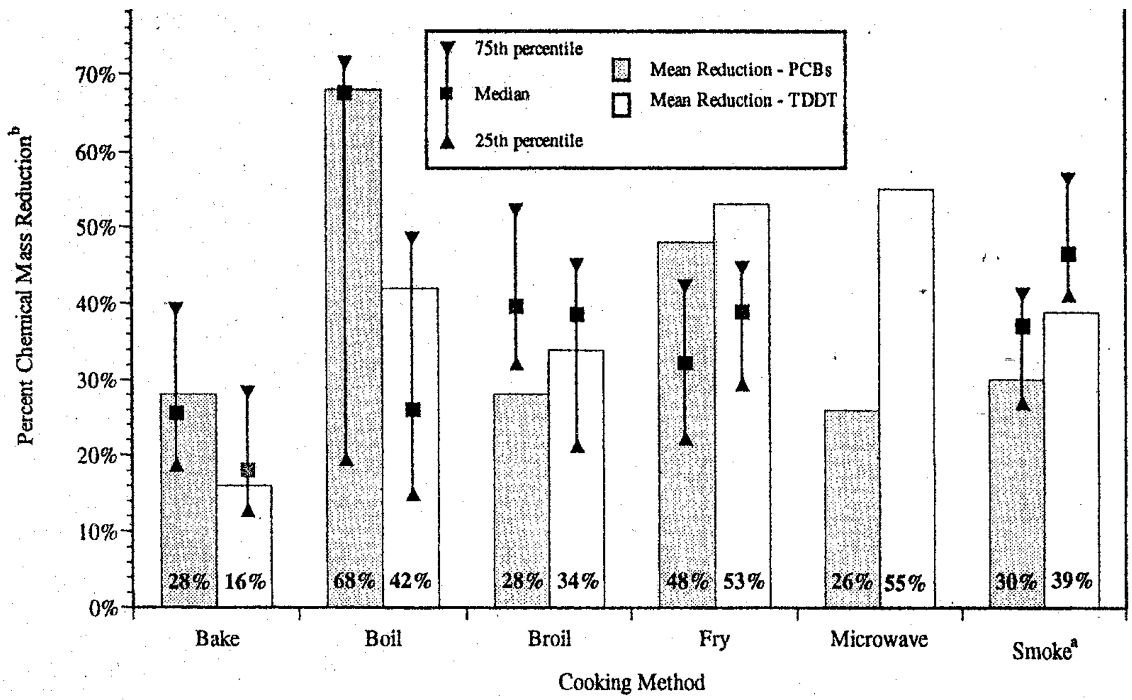
Source: Wilson, et al., 1998.

Table 4. Cooking Methods Used by Santa Monica Bay Area Anglers Consuming White Croaker

| Cooking Method | Probability of Use | Cooking Loss Distribution[a] |
|---|---|---|
| Soup | 0.017 | 0 [b] |
| Raw | 0.007 | 0 [b] |
| Smoke | 0.007 | Smoke |
| Ceviche | 0.007 | 0 [b] |
| Bake | 0.044 | Bake |
| Boil | 0.044 | Boil |
| Steam | 0.044 | Boil |
| Broil | 0.084 | Broil |
| BBQ | 0.084 | Broil |
| Fry | 0.663 | Fry |

a Indicate distribution for method displayed in Table 2.
b No reduction in tDDT or PCBs assumed for this method.

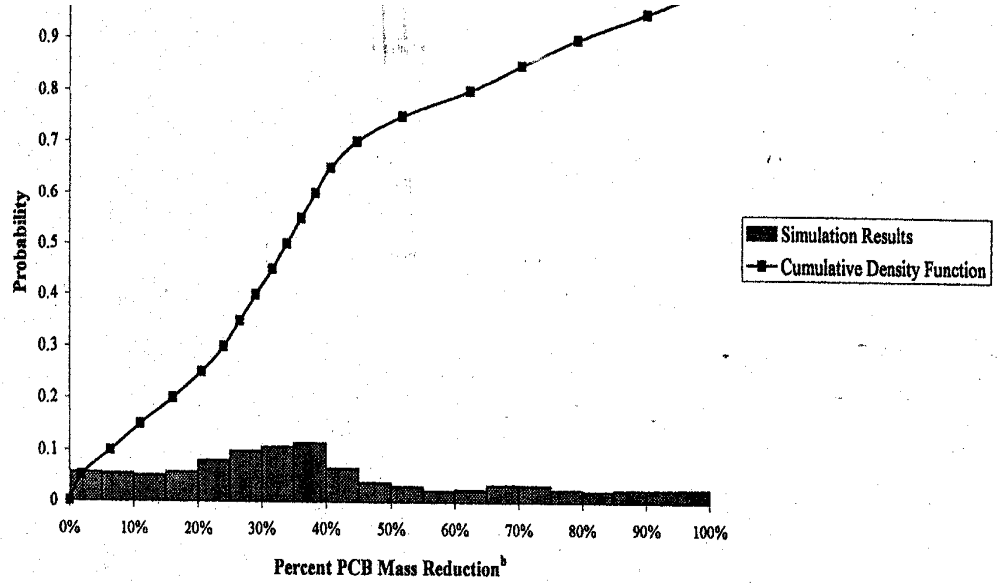
Source: Wilson, et al., 1998.




a For PCBs, minimum and maximum plotted in lieu of 25th and 75th percentiles.
b Calculated as: (initial chemical mass - final chemical mass) / initial chemical mass.

Figure 1. Percent Reductions in tDDT and PCBs After Cooking

Source: Wilson, et al., 1998.




a Cooking includes the following methods: soup, raw, smoke, ceviche, bake, boil, steam, broil, BBQ, and fry
b Calculated as: (initial PCB mass - final PCB mass) / (initial PCB mass).

Figure 2. Percent Reduction Due to Cooking[a] in Mass of PCBs in White Croaker for Santa Monica Bay Area Anglers

Source: Wilson, et al., 1998.