TABLE OF CONTENTS

LIST OF TABLES

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10 INTAKE OF FISH AND SHELLFISH

10.1 INTRODUCTION

Contaminated finfish and shellfish are potential sources of human exposure to toxic chemicals. Pollutants are carried in the surface waters, but also may be stored and accumulated in the sediments as a result of complex physical and chemical processes. Consequently, finfish and shellfish are exposed to these pollutants and may become sources of contaminated food. Exposure to some contaminants may be of concern for children because they may be less able to metabolize, detoxify, and excrete these substances (Moya, 2004).

Accurately estimating exposure to a toxic chemicals among a population that consumes fish from a polluted water body requires an estimation of intake rates of the caught fish by both fishermen and their families. Commercially caught fish are marketed widely, making the prediction of an individual's consumption from a particular water body or contaminant source difficult. Since the catch of recreational and subsistence fishermen is not "diluted" by fish from other water bodies, these individuals and their families represent the population that is most vulnerable to exposure by intake of contaminated fish from a specific location. This chapter focuses on intake rates of fish. Note that in this section the term fish refers to both finfish and shellfish. Intake rates for the general population, and recreational and Native American fishing populations are addressed, and data are presented for intake rates for both marine and freshwater fish, when available.

Survey data on fish consumption have been collected using a number of different approaches which need to be considered when interpreting the results. Typical surveys seek to draw inferences about a larger population from a smaller sample of that population. This larger population, from which the survey sample is taken and to which the results of the survey are generalized, is denoted the target population of the survey. In order to generalize from the sample to the target population, the probability of being sampled must be known for each member of the target population. This probability is reflected in weights assigned to survey respondents, with weights being inversely proportional to sampling probability. When all members of the target population have the same probability of being sampled, all weights can be set to one and essentially ignored. For example, in a mail or phone study of licensed anglers, the target population is generally all licensed anglers in a particular area, and in the studies presented, the sampling probability is essentially equal for all target population members. In a creel study (i.e., a study in which fishermen are interviewed while fishing), the target population is anyone who fishes at the locations being studied; generally, in a creel study, the probability of being sampled is not the same for all members of the target population. For instance, if the survey is conducted for one day at a site, then it will include all persons who fish there daily, but only about 1/7 of the people who fish there weekly, 1/30th of the people who fish there monthly, etc. In this example, the probability of being sampled (or inverse weight) is seen to be proportional to the frequency of fishing. However, if the survey involves interviewers revisiting the same site on multiple days, and persons are only interviewed once for the survey, then the probability of being in the survey is not proportional to frequency; in fact, it increases less than proportionally with frequency. At the extreme of surveying the same site every day over the survey period with no re-interviewing, all members of the target population would have the same probability of being sampled regardless of fishing frequency, implying that the survey weights should all equal one. On the other hand, if the survey protocol calls for individuals to be interviewed each time an interviewer encounters them (i.e., without regard to whether they were previously interviewed), then the inverse weights will again be proportional to fishing frequency, no matter how many times interviewers revisit the same site. Note that when individuals can be interviewed multiple times, the results of each interview are included as separate records in the data base and the survey weights should be inversely proportional to the expected number of times that an individual's interviews are included in the data base.

The U.S. EPA has prepared a review of and an evaluation of five different survey methods used for obtaining fish consumption data. They are:

- Recall-Telephone Survey;
- Recall-Mail Survey;
- Recall-Personal Interview;
- Diary; and
- Creel Census.

The reader is referred to U.S. EPA (1998) *Guidance for Conducting Fish and Wildlife Consumption Surveys* for more detail on these survey methods and their advantages and limitations. The type of survey used, its design, and any weighting factors used in estimating consumption should be considered when interpreting survey data for exposure assessment purposes. For surveys used in this handbook, respondents are typically adults who have

reported on fish intake for children living in their households.

The recommendations for fish and shellfish ingestion rates are provided in the next section, along with a summary of the confidence ratings for these recommendations. The recommended values are based on the key study identified by U.S. EPA for this factor. Following the recommendations, the studies on fish ingestion among the general population (Section 10.3), marine recreational angler households (Section 10.4), freshwater recreational households (Section 10.5), and Native American populations (Section 10.6) are summarized. Information is provided on the key study that forms the basis for the fish and shellfish intake rate recommendations. Relevant data on ingestion of fish and shellfish are also provided. These studies are presented to provide the reader with added perspective on the current state-of-knowledge pertaining to ingestion of fish and shellfish among children. Information on serving size (Section 10.7), and other factors (Section 10.8) are also presented.

10.2 RECOMMENDATIONS

Considerable variation exists in the mean and upper percentile fish consumption rates obtained from the studies presented in this chapter. This can be attributed largely to the type of water body (i.e., marine, estuarine, freshwater) and the characteristics of the survey population (i.e., general population, recreational, Native American), but other factors such as study design, method of data collection, and geographic location also play a role. Based on these study variations, fish consumption studies were classified into the following categories:

- General Population (total, marine, freshwater/estuarine);
- ? Recreational Marine Intake;
- Recreational Freshwater Intake; and
- Native American Populations

For exposure assessment purposes, the selection of intake rates for the appropriate category (or categories) will depend on the exposure scenario being evaluated.

Fish consumption rates are recommended for various ages of children in the general population, based on the key study presented in Section 10.3.1. The key study for estimating mean fish intake among the general population is the U.S. EPA (2002) analysis of data from the U.S. Department of Agriculture (USDA) Continuing Survey of Food Intake among Individuals (CSFII) 1994-1996, 1998. Per capita and consumer-only values for children ages 3 to < 6, 6 to <11, 11 to < 16, and 16 to < 18 years, by habitat (i.e., marine, freshwater/estuarine, or total fish), are shown in Table 10-1. It should be noted, however, that the key general population study presented in this chapter pre-dated the age groups recommended by U.S. EPA in *Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants* (U.S. EPA, 2005). Thus, recommended values were not available for children less than 3 years old or 18 to < 21. The confidence ratings for the fish intake recommendations for the general population are presented in Table 10-2. Note that the fish intake values presented in Table 10-1 are reported as uncooked fish weights. The CSFII 1994-1996, 1998 recipe files were used to convert, for each fish-containing food, the as-eaten fish weight consumed into an uncooked equivalent weight of fish. This is important because the concentrations of the contaminants in fish are generally measured in the uncooked samples. Assuming that cooking results in some reductions in weight (e.g., loss of moisture), and the mass of the contaminant in the fish tissue remains constant, then the contaminant concentration in the cooked fish tissue will increase. In terms of calculating the dose, actual consumption may be overestimated when intake is expressed on an uncooked basis, but the actual concentration may be underestimated when it is based on the uncooked sample. The net effect on the dose would depend on the magnitude of the opposing effects on these two exposure factors. On the other hand, if the "as-prepared" (i.e., as-consumed) intake rate and the uncooked concentration are used in the dose equation, dose may be underestimated since the concentration in the cooked fish is likely to be higher, if the mass of the contaminant remains constant after cooking. Therefore, it is more conservative and appropriate to use uncooked fish intake rates. If concentration data can be adjusted to account for changes after cooking, then the "as-prepared" (i.e., as-consumed) intake rates are appropriate. However, data on the effects of cooking on contaminant concentrations are limited and assessors generally make the conservative assumption that cooking has no effect on the contaminant mass. Both "as-prepared" (i.e., as-consumed) and uncooked general population fish intake values are presented in this handbook so that the assessor can choose the intake data that best matches the concentration data that are being used.

The CSFII data on which the general population recommendations are based, are short-term survey data and could not be used to estimate the distribution over the long term. Also, it is important to note that a limitation

associated with these data is that the total amount of fish reported by respondents included fish from all sources (e.g., fresh, frozen, canned, domestic, international origin). The CSFII surveys did not identify the source of the fish consumed. This type of information may be relevant for some assessments. It should also be noted that because these recommendations are based on 1994-1996, 1998 CSFII data, they may not reflect any recent changes that may have occurred in consumption patterns.

Recommended values should be selected that are relevant to the assessment, choosing the appropriate age groups and source of fish (i.e., freshwater/estuarine, marine, and total fish). In some cases a different study or studies may be particularly relevant to the needs of an assessment, in which case results from that specific study or studies may be used instead of the recommended values provided here. For example, it may be advantageous to use available regional or site-specific estimates if the assessment targets a particular region or site. In addition, seasonal, gender, and fish species variations should be considered when appropriate, if data are available.

Recommendations are not provided for recreational marine fish intake, recreational freshwater fish intake, or intake among Native American children because the available data are limited to certain geographic areas and/or tribes and cannot be readily generalized to the U.S. population as a whole. However, data from two relevant recreational marine studies (KCA, 1994 and Alcoa, 1998); two relevant recreational freshwater studies (West et al., 1989 and Benson et al., 2001); and four Native American studies (CRITFC, 1994; Toy et al., 1996; Duncan, 2000; and Polissar et al., 2006) are provided in this chapter. Assessors may use these data, if appropriate to the scenarios being assessed. These studies were performed at various study locations using various age groups of children.

For recreational marine fish intake, the KCA (1994) study was conducted in Delaware using the age groups 0 to 9 years and 10 to 19 years and the Alcoa (1998) study was conducted in Texas using the age groups <6 years and 6 to 19 years. Mean recreational marine fish intake values in the KCA (1994) study were 6 grams/day and 11.4 grams/day for the 0 to 9 years (N = 73) and 10 to 19 years (N = 102), respectively. The Alcoa (1998) study provided mean recreational marine intake values for finfish at 11.4 grams/day for the children <6 years old (N = 320) and 15.6 grams/day for children 6 to 19 years old (N = 749). Mean shellfish values were 0.4 grams/day and 0.7 grams/day for the same age groups, respectively. Readers are referred to the studies provided in Section 10.4 of this chapter to determine if the values presented are applicable to their specific assessment.

For recreational freshwater fish intake, the West et al. (1989) study was conducted in Michigan to estimate intake based on 7-day recall and the frequency of fish meals over each of the four seasons. Based on a U.S. EPA analysis of the data, mean recreational freshwater fish intake rates were 5.6, 7.9, and 7.3 grams/day for children ages 1 to 5 years (N = 121), 6 to 10 years (N = 151), and 11 to 20 years (N = 349), respectively. Benson et al. (2001) reported median freshwater sports-caught fish intake rates of 1.2 and 1.7 grams/day for children, ages 0 to 14 years, in Minnesota (N = 582) and North Dakota (N = 343), respectively. Readers are referred to the studies provided in Section 10.5 of this chapter to determine if the values presented are applicable to their specific assessment.

Fish consumption data for Native American children are very limited, and fish consumption rates, habits, and patterns can vary among tribes and other sub-populations. Therefore, fish intake data for a particular tribe may not be representative of other tribes. Available data on fish consumption among this population is presented in Section 10.6. These data should be used, as appropriate.

Table 10-1. Recommended Values for General Population Fish Intake [a]

Age Group	Per Capita				Consumer Only				Multiple Percentiles	Source
	Mean		95th Percentile		Mean		95th Percentile			
	g/day	g/kg-day	g/day	g/kg-day	g/day	g/kg-day	g/day	g/kg-day		
Total Fish										
3 to < 6 years	7.7	0.43	51	3.0	74	4.2	184	10	See Tables 10-7 through 10-10	U.S. EPA Analysis of CSFII, 1994-96 and 1998. (Rates are for uncooked weight)
6 to < 11 years	8.5	0.28	56	1.9	95	3.2	313*	8.7*		
11 to < 16 years	12	0.23	87	1.5	113	2.2	308*	6.2*		
16 to < 18 years	11	0.16	84	1.3	136*	2.1*	357*	6.6*		
Marine Fish										
3 to < 6 years	5.5	0.31	39	2.3	66	3.7	165	9.3*		
6 to < 11 years	5.6	0.20	38	1.5	78	2.8	202*	8.0*		
11 to < 16 years	7.6	0.15	56	1.3	102	2.0	262*	5.2*		
16 to < 18 years	6.1	0.10	29	0.46	126*	2.0*	353*	6.5*		
Freshwater/Estuarine Fish										
3 to < 6 years	2.2	0.12	12	0.71	40	2.3	129	7.2*		
6 to < 11 years	3.0	0.08	13	0.35	61	1.8	248*	6.2*		
11 to < 16 years	4.3	0.08	26	0.48	71	1.3	199*	4.4*		
16 to < 18 years	4.6	0.07	19	0.29	100*	1.4*	242*	3.3*		

* The sample size does not meet the minimum reporting requirements, as described in the Third Report on Nutrition Monitoring in the United States (LSRO, 1995).

[a] Analysis was conducted prior to Agency' s issuance of *Guidance on Selecting Age groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants* (U.S. EPA 2005). Thus, data were not presented for children less than 3 years old or for 18 to < 21 years.

Table 10-2. Confidence in Recommendations for General Population Fish Intake

General Assessment Factors	Rationale	Rating
Soundness		High
Adequacy of Approach	The survey methodology and the analysis of the survey data were adequate. Primary data were collected and used in a secondary analysis of the data. The sample size was large.	
Minimal (Or Defined) Bias	The survey data were based on recent recall. Data were collected over a short-duration (i.e., 2 days).	
Applicability and Utility		High
Exposure Factor of Interest	The key study focused the exposure factor of interest.	
Representativeness	The survey was conducted nationwide and was representative of the general U.S. population.	
Currency	The most current CSFII 1994-96; 98 data were used.	
Data Collection Period	Data were collected for two non-consecutive days.	
Clarity and Completeness		High
Accessibility	The primary data are accessible through USDA.	
Reproducibility	The methodology was clearly presented; enough information was available to allow for reproduction of the results.	
Quality Assurance	Quality assurance of CSFII data was good; quality control of secondary analysis was good.	
Variability and Uncertainty		Medium
Variability in Population	Full distributions were provided by the key study.	
Uncertainty	The survey was not designed to capture long-term intake and was based on recall. Otherwise, the sources of uncertainty were minimal.	
Evaluation and Review		Medium
Peer Review	The primary data were reviewed by USDA; U.S. EPA review conducted a review of the secondary data analysis for fish intake.	
Number and Agreement of Studies	The number of studies is 1.	
Overall Rating		**High** (mean) **Medium** (upper percentile)

10.3 GENERAL POPULATION STUDIES

10.3.1 Key General Population Study

10.3.1.1 *U.S. EPA 2002 - Estimated Per Capita Fish Consumption in the United States*

U.S. EPA's Office of Water used data from the 1994-96 CSFII and its 1998 Children's Supplement (referred to collectively as CSFII 1994-96, 1998) to generate fish intake estimates. Participants in the CSFII 1994-96, 98 provided two non-consecutive days of dietary data. Respondents estimated the weight of each food that they consumed. Information on the consumption of food was classified using 11,345 different food codes, and stored in a database in units of grams consumed per day. A total of 831 of these food codes related to fish or shellfish; survey respondents reported consumption across 665 of these codes. The fish component (by weight) of the various foods was calculated using data from the recipe file for release 7 of USDA's Nutrient Data Base for Individual Food Intake Surveys. The amount of fish consumed by each individual was then calculated by summing, over all fish containing foods, the product of the weight of food consumed and the fish component (i.e., the percentage fish by weight) of the food. The recipe file also contains cooking loss factors associated with each food. These were used to convert, for each fish-containing food, the as-eaten fish weight consumed into an uncooked equivalent weight of fish. Analyses of fish intake were performed on both an "as-prepared" (i.e., as-consumed) and uncooked basis.

Each fish-related food code was assigned, by U.S. EPA, to a habitat category. The habitat categories included freshwater/estuarine, or marine. Food codes were also designated as finfish or shellfish. Average daily individual consumption (g/day) was calculated, for a given fish type-by-habitat category (e.g., marine finfish), by summing the amount of fish consumed by the individual across the two reporting days for all fish-related food codes in the given fish-by-habitat category and then dividing by 2. Individual daily fish consumption (g/day) was calculated similarly except that total fish consumption was divided by the specific number of survey days the individual reported consuming fish; this was calculated for fish consumers only (i.e., those consuming fish on at least one of the two survey days). The reported body weight of the individual was used to convert consumption in g/day to consumption in g/kg-day.

There were a total of 20,607 respondents in the combined data set who had two-day dietary intake data. A total of 7,429 of these individuals were children between the ages of 3 and 17 years. Data for these children were used in estimating fish intake in g/day. Slightly fewer children were used in the fish intake rates estimated in units of g/kg-day because body weights were not reported for some individuals. Survey weights were assigned to this data set to make it representative of the U.S. population with respect to various demographic characteristics related to food intake. These weights were used to project the estimates for the 7,429 children in the data set to 58,923,560 children in the U.S. population.

U.S. EPA (2002) reported means and estimates of the 90th, 95th, and 99th percentiles of fish intake. Tables 10-3 through 10-10 present these statistics for daily average fish consumption. These data are presented for selected age groups: 3 to 5, 6 to 10, 11 to 15, and 16 to 17 years of age. Tables 10-3 and 10-4 present per capita fish consumption, on an as-consumed basis, in g/day and in mg/kg-day, respectively. Tables 10-5 and 10-6 provide consumer-only fish intake data, on an as-consumed basis, in units of g/day and mg/kg-day, respectively. Tables 10-7 through 10-10 provide per capita and consumer only fish intake data (g/day and mg/kg-day) on an uncooked equivalent basis.

The advantages of this study are that the data used were from the CSFII survey, which had a large sample size and was representative of the U.S. population. The CSFII survey was also designed to give unbiased estimates of food consumption (U.S. EPA, 2002). In addition, through use of the USDA recipe files, the analysis included all fish eaten (i.e., both fish eaten alone and in mixtures).

10.3.2 Relevant General Population Studies

10.3.2.1 *U.S. EPA, 1996 - National Human Activity Pattern Survey (NHAPS)*

The U.S. EPA (1996) collected information for the general population on the duration and frequency of time spent in selected activities and time spent in selected microenvironments via 24-hour diaries as part of the National Human Activity Pattern Survey (NHAPS). Over 9,000 individuals from 48 contiguous states participated in NHAPS. Approximately 4,700 participants also provided information on seafood consumption, with 2,980 responding that they ate seafood (including shellfish, eel, or squid) in the last month. Over 900 of these participants were children between the ages of 1 and 17 years. The survey was conducted between October 1992 and September 1994. Data were collected on the (1) number of people that ate seafood in the last month, (2) the number of

servings of seafood consumed, and (3) whether the seafood consumed was caught or purchased. The participant responses were weighted according to selected demographics such as age, gender, and race to ensure that results were representative of the U.S. population. In order to conform to the standardized age categories used in this handbook, U.S. EPA subsequently accessed the source data from U.S. EPA (1996) and recalculated the relevant statistics using the age categories recommended in *Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants* (U.S. EPA, 2005). The results of U.S. EPA's analysis are shown in Table 10-11.

Intake data were not provided in the survey. However, intake of fish can be estimated using the information on the number of servings of fish eaten from this study and serving size data for each age group from other studies (see Section 10.7.1). Using the mean value for serving size and the number of servings per month from Table 10-11, the age-specific amount of seafood eaten per month can be estimated.

The advantages of NHAPS is that the data were collected for a large number of individuals and are representative of the U.S. general population. However, evaluation of seafood intake was not the primary purpose of the study and the data do not reflect the actual amount of seafood that was eaten. However, using the assumption described above, the estimated seafood intakes from this study are comparable to those observed in the U.S. EPA CSFII analysis. It should be noted that an all inclusive description for seafood was not presented in U.S. EPA (1996) or in the NHAPS data. It is not known if processed or canned seafood and seafood mixtures are included in the seafood category.

10.3.2.2 *Moya et al., 2008 - Estimates of Fish Consumption Rates for Consumers of Bought and Sel-caught fish in Connecticut, Florida, Minnesota, and North Dakota*

Moya et al. (2008) analyzed the raw data from three fish consumption studies to derive fish consumption rates for various age, gender, and ethnic groups, and according to the source of fish consumed (i.e., bought or caught) and habitat (i.e., freshwater, estuarine, or marine). The studies represented data from four states: Connecticut, Florida, Minnesota and North Dakota.

The Connecticut data were collected in 1996/1997 by the University of Connecticut to obtain estimates of fish consumption for the general population, sports fishing households, commercial fishing households, minority and limited income households, women of child-bearing years, and children. Data were obtained from 810 households, representing 2,080 individuals, using a combination of a mail questionnaire that included a 10-day diary, and personal interviews. The response rate for this survey was low (i.e., 6 percent for the general population and 10 percent for anglers), but was considered to be adequate by the study authors (Balcom et al., 1999). Data from this survey were available for 54 children, ages 0 to 15 years.

The Florida data were collected by telephone and in-person interviews by the University of Florida, and represented a random sample of 8,000 households (telephone interviews), and 500 food stamp recipients (in-person interviews). Data from this survey were available for 1,160 children, ages 0 to 15 years. The purpose of the survey was to obtain information on the quantity of fish and shellfish eaten, as well as the cooking method used. Additional information of the Florida survey can be found in Degner et al. (1994).

The Minnesota and North Dakota data were collected by the University of North Dakota in 2000 and represented 1,572 households and 4,273 individuals. Data from this survey were available for 273 children, ages 0 to 15 years (151 in Minnesota and 122 in North Dakota). Data on purchased and caught fish were collected for the general population, anglers, new mothers, and Native American tribes. The survey also collected information of the species of fish eaten. Additional information on this study can be found in Benson et al. (2001).

Moya et al. (2008) utilized the data from these three studies to generate intake rates for three age groups of children (i.e., 1 to <6 years, 6 to <11 years, and 11 to <16 years). These data represented the general population of children in the four states. Recreational fish intake rates were not provided for children, and data were not provided for children according to the source of intake (i.e., bought or caught) or habitat (i.e., freshwater, estuarine, or marine). Tables 10-12 presents the intake rates for the general population of children who consumed fish and shellfish in g/kg-day, as-consumed. Table 10-13 provides information on the fish intake among the sample populations from the four states, based on the source of the fish (i.e., caught or bought). Table 10-14 provides estimated fish intake rates among the general populations and angler populations from Connecticut,

Minnesota, and North Dakota. While the data in Tables 10-13 and 10-14 do not pertain specifically to children, they provide an indication of the proportion of fish consumption that is either caught or bought among the sample population, and similarities and/or differences between fish intake among the general population and anglers.

10.4 MARINE RECREATIONAL STUDIES

10.4.1 Relevant Marine Recreational Studies

10.4.1.1 *KCA Research Division, 1994 - Fish Consumption of Delaware Recreational Fishermen and Their Households*

In support of the Delaware Estuary Program, the State of Delaware's Department of Natural Resources and Environmental Control conducted a survey of marine recreational fishermen along the coastal areas of Delaware between July 1992 and June 1993 (KCA Research Division, 1994). There were two components of the study. One was a field survey of fishermen as they returned from their fishing trips and the second part was a telephone follow-up call. The purpose of the first component was to obtain information on their fishing trips and on their household composition. This information included the method and location of fishing, number of fish caught and kept by species, and weight of each fish kept. Household information included race, age, gender, and number of persons in the household. Information was also recorded as to the location of the angler intercept (i.e., where the angler was interviewed) and the location of the household. The purpose of the second component was to obtain information on the amount of fish caught and kept from the fishing trip and then eaten by the household. The methods used for preparing and cooking the fish were also documented.

The field portion of the study was designed to interview 2,000 anglers. Data were obtained from 1,901 anglers, representing 6,204 household members (KCA Research Division, 1994). A total of 1,717 of these were children between the ages of 0 and 19 years of age. While the primary goal of the study was to collect data on marine recreational fishing practices, the survey included some freshwater fishing and crabbing sites. Followup phone interviews typically occurred two weeks after the field interview and were used to gather information about consumption. Interviewers aided respondents in their estimation of fish intake by describing the weight of ordinary products, for the purpose of comparison to the quantity of fish eaten. Information on the number of fishing trips a respondent had taken during the month was used to estimate average annual consumption rates.

Table 10-15 presents the results of the study for children who consumed fish (i.e., consumers only). Children, ages 0 to 9 years old, had a mean fish consumption rate of 6.0 g/day (N = 73), while children, ages 10 to 19 years old, had a mean fish consumption rate of 11.4 g/day (N = 102). More than half of the study respondents reported that they skinned the fish that they ate (i.e., 450 out of 807 who reported whether they skinned their catch); the majority ate filleted fish (i.e., 617 out of 794 who reported the preparation method used), and over half fried their fish (i.e., 506 out of 875 who reported the cooking method).

One limitation of this study is that information on fish consumption by children is based on anglers' recall of amount of fish eaten. Also, the study was limited to one geographic area and may not be representative of the U.S. population.

10.4.1.2 *Alcoa, 1998 - Draft Report for the Finfish/Shellfish Consumption Study Alcoa (Point Comfort)/Lavaca Bay Superfund Site*

The Texas Saltwater Angler Survey was conducted in 1996/97 to evaluate the quantity and species of finfish and shellfish consumed by individuals who fish at Lavaca Bay. The target population for this study was residents of three Texas counties: Calhoun, Victoria, and Jackson (over 70 percent of the anglers who fish Lavaca Bay are from these three counties). The random sample design specified that the population percentages for the counties should be as follows: 50 percent from Calhoun, 30 percent from Victoria, and 20 percent from Jackson.

Each individual in the sample population was sent an introductory note describing the study and then was contacted by telephone. People who agreed to participate and had taken fewer than six fishing trips to Lavaca Bay were interviewed by telephone. Persons who agreed to participate and had taken more than five fishing trips to Lavaca Bay were sent a mail survey with the same questions. A total of 1,979 anglers participated in this survey, representing a response rate greater than 68 percent. Data were collected from the households for men, women, and children. There were 4,489 records with valid information and of those records, 320 were for small children (less than 6 years old) and 749 records for youths (6 to 19 years old).

The information collected as part of the survey included recreational fishing trip information for November 1996 (i.e., fishing site, site facilities,

distance traveled, number and species caught), self-caught fish consumption (by the respondent, spouse and child, if applicable), opinions on different types of fishing experiences, and socio-demographics. Portion size for shellfish was determined by utilizing the number of shrimp, crabs, oysters, etc. that an individual consumed during a meal and the assumed tissue weight of the particular species of shellfish. Red drum was the most commonly consumed self-caught fish, followed by speckled sea trout, flounder, all other finfish and black drum. For shellfish, the order from highest to lowest amount consumed was oysters, blue crab, and shrimp.

Table 10-16 presents the mean and upper-percentile consumption rates of self-caught fish, expressed as grams per day, for small children (<6 years of age) and youths (ages 6 to 19 years of age). Small children consumed an average of 11.4 grams of finfish per day while youths consumed an average of 15.6 grams daily. Small children consumed an average of 0.4 g/day of shellfish, while youths consumed an average of 0.7 g/day. Note that these data represent the amount of self-caught fish that is consumed from all locations (i.e., not just from Lavaca Bay). Table 10-17 shows the average number of meals consumed by each age group of children and the average portion size in grams (converted from ounces) for these meals. Small children and youths consumed slightly less than three meals per month of finfish and less than one meal per month of shellfish. For finfish, youths consumed an average, per meal, portion size of 187 grams, and small children consumed less than 128 grams per meal. Youths consumed an average shellfish portion size of 71 grams per meal, while small children consumed 57 grams per meal.

The study authors noted that since the survey relied on the anglers' recall of meal frequency and portion, fish consumption may have been overestimated. Also, the study was conducted at one geographic location and may not be representative of the U.S. population.

10.5 FRESHWATER RECREATIONAL STUDIES

10.5.1 Relevant Freshwater Recreational Studies

10.5.1.1 *West et al., 1989 - Michigan Sport Anglers Fish Consumption Survey*

The Michigan Sport Anglers Fish Consumption Survey (West et al., 1989) surveyed a stratified random sample of Michigan residents with fishing licences. The sample was divided into 18 cohorts, with one cohort receiving a mail questionnaire each week between January and May 1989. The survey included both a short term recall component, and a usual frequency component. For the short-term recall component, respondents were asked to identify all household members and list all fish meals consumed by each household member during the past seven days. Information on the source of the fish for each meal was also requested (self-caught, gift, market, or restaurant). Respondents were asked to categorize serving size by comparison with pictures of 8 ounce fish portions; serving sizes could be designated as either "about the same size", "less", or "more" than the size pictured. Data on fish species, locations of self-caught fish and methods of preparation and cooking were also obtained.

The usual frequency component of the survey asked about the frequency of fish meals during each of the four seasons and requested respondents to give the overall percentage of household fish meals that came from recreational sources. A sample of 2,600 individuals were selected from state records to receive survey questionnaires. A total of 2,334 survey questionnaires were deliverable and 1,104 were completed and returned, giving a response rate of 47.3 percent.. The responses represented a total of 621 children between the ages of 1 and 20 years.

U.S. EPA obtained the raw data from the West et al. (1989) survey and analyzed it to estimate mean fish intake rates for children. Only respondents with information on both short term and usual intake were included in this analysis. For the analysis, U.S. EPA modified the serving size weights used by West et al. (1989), which were 5, 8 and 10 ounces, respectively, for portions that were described as less, about the same, and more than the 8 ounce picture. U.S. EPA examined the percentiles of the distributions of fish meal sizes reported in Pao et al. (1982), derived from the 1977-1978 USDA National Food Consumption Survey (NCFS), and observed that a lognormal distribution provided a good visual fit to the percentile data. Using this lognormal distribution, the mean values for serving sizes greater than 8 ounces and for serving sizes at least 10 percent greater than 8 ounces were determined. In both cases, a serving size of 12 ounces was consistent with the Pao et al. (1982) distribution. The weights used in the U.S. EPA analysis then were therefore 5, 8, and 12 ounces for fish meals described as less, about the same, and more than the 8 ounce picture, respectively. It should be noted that the mean serving size from Pao et al. (1982) was about 5 ounces, well

below the value of 8 ounces most commonly reported by respondents in the West et al. (1989) survey.

Table 10-18 displays the mean number of total and recreational fish meals for each household member between age 1 and 20 years based on the seven day recall data. Also shown are mean fish intake rates derived by applying the weights described above to each fish meal. Intake was calculated in units of both grams/day and grams/kg body weight/day. This analysis was restricted to individuals who eat fish and who reside in households reporting some recreational fish consumption during the previous year. About 75 percent of the survey respondents (i.e., licensed anglers) and about 84 percent of the respondents who fished in the prior year reported some household recreational fish consumption.

The advantages of this data set and analysis are that the survey was relatively large and contained both short-term and usual intake data. The response rate of this survey, 47 percent, was relatively low and it was conducted in one geographic location. This study was conducted in the winter and spring months of 1989. This period does not include the summer months when peak fishing activity can be anticipated, leading to the possibility that intake results based on the 7 day recall data may understate individuals' usual (annual average) fish consumption.

10.5.1.2 *Benson et al., 2001 - Fish Consumption Survey: Minnesota and North Dakota*

Benson et al (2001) conducted a fish consumption survey among Minnesota and North Dakota residents. The target population included the general population, licensed anglers, and members of Native American tribes. The survey focused on obtaining the most recent year's fish intake from all sources, including locally caught fish. Survey questionnaires were mailed to potential respondent households. For the entire population, approximately 1,570 surveys were returned completed (out of 7,835 that were mailed out). Information on fish consumption by children was collected if they were a part of a respondent household. Data were collected for a total of 604 children (ages 0 to 14 years) in Minnesota and a total of 375 children (ages 0 to 14 years) in North Dakota. Among these respondents, data on sport-caught fish intake were available for 582 Minnesota children and 343 North Dakota children. Table 10-19 presents the recreational freshwater intake rates for children (ages 0 to 14 years). Rates for both purchased and sports-caught fish are provided. For Minnesota, the 50th percentile sports-caught fish consumption rate was 1.2 grams/day and the 95th percentile rate was 14.6 grams/day. For North Dakota, the 50th percentile sports-caught fish consumption rate was 1.7 grams/day, and the 95th percentile rate was 23.3 grams/day. Intake rates of purchased fish were higher for both Minnesota (3.6 grams/day 50th percentile; 30.9 grams/day 95th percentile) and North Dakota (4.7 grams/day 50th percentile; 42.8 grasm/day 95th percentile).

An advantage of this study is its large overall sample size. A limitation of the study is the broad age range of children used (i.e., 0 to 14 years). Also, the study was limited to two states. Therefore, the results may not be representative of the U.S. population as a whole..

10.6 NATIVE AMERICAN STUDIES

10.6.1 Relevant Native American Studies

10.6.1.1 *Columbia River Inter-Tribal Fish Commission (CRITFC), 1994 - A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin*

The Columbia River Inter-Tribal Fish Commission (CRITFC) (1994) conducted a fish consumption survey among four Columbia River Basin Native American tribes during the fall and winter of 1991-1992. The target population included all adult tribal members who lived on or near the Yakama, Warm Springs, Umatilla or Nez Perce reservations. The survey was based on a stratified random sampling design where respondents were selected from patient registration files at the Indian Health Service. The overall response rate was 69 percent yielding a sample size of 513 tribal members, 18 years old and above. Interviews were performed in person at a central location on the member's reservation. Each participating adult was asked if there were any children 5 years old or younger in his or her household. Those responding affirmatively were asked a set of survey questions about the fish consumption patterns of the youngest child in the household (CRITFC, 1994). Information for 204 children, 5 years old and younger, was provided by participating adult respondents. Consumption data were available for 194 of these children.

Participants were asked to describe and quantify all food and drink consumed during the previous day. They were then asked to identify the months in which they ate the most and the least fish, and the number of fish meals consumed per week

during each of those periods and an average value for the whole year. The typical portion size (in ounces) was determined with the aid of food models provided by the questioner. The next set of questions identified specific species of fish and addressed the number of times per month each was eaten, as well as what parts (e.g., fillet, skin, head, eggs, bones, other) were eaten. Respondents were then asked to identify the frequency with which they used various preparation methods, expressed as a percentage. Respondents sharing a household with a child, aged 5 years or less, were asked to repeat the serving size, eating frequency, and species questions for the child's consumption behavior. All respondents were asked about the geographic origin of any fish they personally caught and consumed, and to identify the major sources of fish in their diet (e.g., self-caught, grocery store, tribe, etc.). Fish intake rates were calculated by multiplying the annual frequency of fish meals by the average serving size per fish meal.

The population sizes of the four tribes were highly unequal, ranging from 818 to 3,872 individuals (CRITFC, 1994). In order to ensure an adequate sample size from each tribe, the study was designed to give nearly equal sample sizes for each tribe. Weighting factors were applied to the pooled data (in proportion to tribal population size) so that the survey results would be representative of the overall population of the four tribes for adults only. Because the sample size for children was considered small, only an unweighted analysis was performed for this population. Based on a desired sample size of approximately 500 and an expected response rate of 70 percent, 744 individuals were selected at random from lists of eligible patients; the numbers from each tribe were approximately equal.

Intake rates were calculated for children for which both the number of fish meals per week and serving size information were available. A total of 49 percent of respondents of the total survey population reported that they caught fish from the Columbia River basin and its tributaries for personal use or for tribal ceremonies and distributions to other tribe members and 88 percent reported that they obtained fish from either self-harvesting, family or friends, at tribal ceremonies or from tribal distributions. Of all fish consumed, 41 percent came from self or family harvesting, 11 percent from the harvest of friends, 35 percent from tribal ceremonies or distribution, 9 percent from stores and 4 percent from other sources (CRITFC, 1994).

Of the 204 children, the total number of respondents used in the analysis varied from 167 to 202, depending on the topic (amount and species consumed, fish meals consumed /week, age consumption began, serving size, consumption of fish parts) of the analysis. The unweighted mean for the age when children begin eating fish was 13.1 months of age (N = 167). The unweighted mean number of fish meals consumed per week by children was 1.2 meals per week (N = 195) and the unweighted mean serving size of fish for children aged five years old and less was 95 grams (i.e., 3.36 ounces) (N = 201). The unweighted percent of fish consumed by children by species was 82.7 percent for salmon, followed by 46.5 percent (N = 202) for trout. The analysis of seasonal intake showed that May and June tended to be high-consumption months and December and January low consumption months. Table 10-20 presents the fish intake distribution for children under 5 years of age (N = 194). The mean intake rate was 19.6 g/day (N = 194) and the 95th percentile was approximately 70 g/day. These mean intake rates include both consumers and non-consumers. These values are based on survey questions involving estimated behavior throughout the year, which survey participants answered in terms of meals per week or per month and typical serving size per meal. Table 10-21 presents consumption rates for children who were reported to consume particular species of fish.

The authors noted that some non-response bias may have occurred in the survey since respondents were more likely to be female and live near the reservation than non-respondents. In addition, they hypothesized that non-consumers may have been more likely to be non-respondents than fish consumers since non-consumers may have thought their contribution to the survey would be meaningless; if such were the case, this study would overestimate the mean intake rate. It was also noted that the timing of the survey, which was conducted during low fish consumption months, may have led to underestimation of actual fish consumption; the authors conjectured that an individual may have reported higher annual consumption if interviewed during a relatively high consumption month and lower annual consumption if interviewed during a relatively low consumption month. Finally, with respect to children's intake, it was observed that some of the respondents provided the same information for their children as for themselves; thereby, the reliability of some of these data is questioned (CRITFC, 1994). The combination of four different tribes' survey responses

into a single pooled data set is somewhat problematic. The data presented in Table 10-20 are unweighted and therefore contain a bias toward the smaller tribes, who were oversampled compared to the larger tribes.

The limitations of this study, particularly with regard to the estimates of children's consumption, result in a high degree of uncertainty in the estimated rates of consumption. However, it is one of a relative few studies aimed at the fish consumption patterns of Native Americans. It should be noted that the selection process for children may be biased because the 204 children included in the study were not selected independently, but were identified through a parent's patient registration file. This indicates that children from larger households would be less likely to be chosen to participate in the study than would be the case if the children themselves, rather than the parents, were randomly selected.

10.6.1.2 *Toy et al., 1996 - A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region*

Toy et al. (1996) conducted a study to determine fish and shellfish consumption rates of the Tulalip and Squaxin Island tribes living in the Puget Sound region. These two Indian tribes were selected on the basis of judgment that they would be representative of the expected range of fishing and fish consumption activities of the fourteen tribes in the region. Commercial fishing is a major source of income for members of both tribes; some members the Squaxin Island tribe also participate in commercial shellfishing. Both tribes participate in subsistence fishing and shellfishing.

Fish consumption patterns for the two tribes were estimated using a survey in which sample sizes were calculated separately for each tribe. This allowed separate analyses to be conducted for each tribe. The appropriate sample size was calculated based on the enrolled population of each tribe and a desired confidence interval of ±20 percent from the mean, with an additional 25 percent added to the total to allow for non-response or unusable data. The target population, derived from lists of enrolled tribal members provided by the tribes, consisted of enrolled tribal members aged 18 years and older and children aged five years and younger living in the same household as an enrolled member. Only members living on or within 50 miles of the reservation were considered for the survey. Each eligible enrolled tribal member was assigned a number, and computer-generated random numbers were used to identify the survey participants. Children were not sampled directly, but through adult members of their household; if one adult had more than one eligible child in his or her household, one of the children was selected at random. This indirect sampling method was necessitated by the available tribal records, but may have introduced sampling bias to the process of selecting children for the study. A total of 190 adult tribal members (ages 18 years old and older) and 69 children between ages birth and 5 years old (i.e., 0 to <6 years) were surveyed about their consumption of 52 fish species in six categories: anadromous, pelagic, bottom, shellfish, canned tuna, and miscellaneous.

Respondents described their consumption behavior for the past year in terms of frequency of fish meals eaten per week or per month, including seasonal variations in consumption rates. Portion sizes (in ounces) were estimated with the aid of model portions provided by the questioner. Data were also collected on fish parts consumed, preparation methods, patterns of acquisition for all fish and shellfish consumption, and children's consumption rates. Interviews were conducted between February and May 1994. The response rate for adults was 77 percent for the Squaxin Island tribe and 76 percent for the Tulalip tribes.

The mean and median consumption rates for children 5 years and younger for both tribes combined were 0.53 and 0.17 g/kg-day, respectively (Table 10-22). Squaxin Island children tended to consume more fish than Tulalip children (mean 0.83 g/kg-day vs. 0.24 g/kg-day). The data were insufficient to allow re-analysis to fit the data to the standard U.S. EPA age categories used elsewhere in this handbook.

One limitation associated with this study is that although data from the Tulalip and Squaxin Island tribes may be representative of consumption rates of children in these specific tribes, fish consumption rates, habits, and patterns can vary among tribes and other sub-populations; as a result, the consumption rates of these two tribes may not be useful as a surrogate for consumption rates of other Native American tribes. Furthermore, there were differences in consumption patterns between the two tribes included in this study; the study provided data for each tribe and for the pooled data from both tribes, but the latter may not be a statistically valid measure for tribes in the region. There might also be a possible bias due to the time the survey was conducted; many species in the survey are seasonal. For example, because of the timing of the survey, respondents may have overestimated annual consumption.

10.6.1.3 *Duncan, 2000 - Fish Consumption Survey of the Squamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region*

The Squamish Tribal Council conducted a study of the Squamish tribal members living on and near the Port Madison Indian Reservation in the Puget Sound region (Duncan, 2000). The study was funded by the Agency for Toxic Substances and Disease Registry (ATSDR) through a grant to the Washington State Department of Health. The purpose of the study was to determine seafood consumption rates, patterns, and habits of the members of the Squamish Tribe. The second objective was to identify cultural practices and attributes that affect consumption rates, patterns and habits of members of the Squamish Tribe.

A systematic random sample of adults, defined as individuals age 16 years and older, were selected from a sorted Tribal enrollment roster. The study had a participation rate of 64.8 percent, which was calculated on the basis of 92 respondents out of a total of 142 potentially eligible adults on the list of those selected into the sample. Consumption data for children under six years of age were gathered through adult respondents who had children in this age group living in the household at the time of the survey. Data were collected for 31 children under six years old.

A survey questionnaire was administered by personal interview. The survey included four parts: (1) 24-hour dietary recall; (2) identification, portions, frequency of consumption, preparation, harvest location of fish; (3) shellfish consumption, preparation, harvest location; and (4) changes in consumption over time, cultural information, physical information, and socioeconomic information. A display booklet was used to assist respondents in providing consumption data and identifying harvest locations of seafood consumed. Physical models of finfish and shellfish were constructed to assist respondents in determining typical food portions. Finfish and shellfish were grouped into categories based on similarities in life history as well as practices of Tribal members who fish for subsistence, ceremonial, and commercial purposes.

Interviewers collected data for 31 children under six years of age. Table 10-23 provides the consumption rates for children in units of g/kg-day for all respondents. Table 10-24 provides consumption rates for consumers only. Because all of the children involved in the study consumed some form of fish, the consumption distribution of all fish is the same in both tables. The mean, median, and 95th percentile consumption rates of all fish were 1.5 g/kg-day, 0.72 g/kg-day, and 7.3 g/kg-day, respectively. These values are significantly greater than those presented for the Tulalip and Squaxin Island tribes (Toy et al., 1996; see Section 10.6.1.2). This disparity illustrates the high degree of variability found between tribes even within a small geographic region (Puget Sound) and indicates that exposure and risk assessors should exercise care when imputing fish consumption rates to a population of interest using data from tribal studies.

A limitation of this study is that the sample size for children was fairly small (31 children). An important attribute of this survey is that it provided consumption rates by individual type of fish and shellfish.

10.6.1.4 *Polissar et al., 2006 - A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region–Consumption Rates for Fish-consumers Only*

Using fish consumption data from the Toy et al. (1996) survey of the Tulalip and Squaxin Island tribes of Puget Sound, Polissar et al. (2006) calculated consumption rates for various fish species groups, considering only the consumers of fish within each group. Weight-adjusted consumption rates were calculated by tribe, age, gender, and species groups. Species groups (anadromous, bottom, pelagic, and shellfish) were defined by life history and distribution in the water column. Data were available for 69 children, birth to <6 years of age; 18 of these children had no reported fish consumption and were excluded from the analysis. Thus, estimated fish consumption rates are based on data for 51 children; 15 from the Tulalip tribe and 36 from the Squaxin Island tribe. Both median and mean fish consumption rates for children within each tribe were calculated in terms of grams per kilogram of body weight per day (g/kg-day). Anadromous fish and shellfish were the groups of fish most frequently consumed by both tribes and genders. The consumption rates for groups of fish differed between the tribes. The distribution of consumption rates was skewed toward large values. The estimated mean consumption rate of all fish was 0.45 g/kg-day for the Tulalip children and 2.9 g/kg-day for the Squaxin Island children (Table 10-25). Table 10-26 presents consumption rates for children by species and gender.

Because this study used the data originally generated by Toy et al. (1996) the advantages and limitations associated with the Toy et al. (1996) study,

as described in Section 10.6.1.2, also apply to this study. However, an advantage of this study is that the consumption rates are based only on individuals who consumed fish within the selected categories.

10.7 SERVING SIZE STUDY

10.7.1 Smiciklas-Wright et al., 2002 - Foods Commonly Eaten in the United States: Quantities Consumed per Eating Occasion and in a Day,1994-1996

Using data gathered in the 1994-96 USDA CSFII, Smiciklas-Wright et al. (2002) calculated distributions for the quantities of canned tuna and other finfish consumed per eating occasion by members of the U.S. population (i.e., serving sizes), over a 2-day period. The estimates of serving size are based on data obtained from 14,262 respondents, ages 2 years and above, who provided 2 days of dietary intake information. A total of 4,939 of these respondents were children, ages 2 to 19 years of age. Only dietary intake data from users of the specified food were used in the analysis (i.e., consumers only data).

Table 10-27 and Table 10-28 present serving size data for canned tuna and other finfish, respectively. These data are presented on an as-consumed basis (grams), and represent the quantity of fish consumed per eating occasion. These estimates may be useful for assessing acute exposures to contaminants in specific foods, or other assessments where the amount consumed per eating occasion is necessary.

The advantages of using these data are that they were derived from the USDA CSFII and are representative of the U.S. population. The analysis conducted by Smiciklas-Wright et al. (2002) accounted for individual foods consumed as ingredients of mixed foods. Mixed foods were disaggregated via recipe files so that the individual ingredients could be grouped together with similar foods that were reported separately. Thus, weights of foods consumed as ingredients were combined with weights of foods reported separately to provide a more thorough representation of consumption. However, it should be noted that since the recipes for the mixed foods consumed by respondents were not provided by the respondents, standard recipes were used. As a result, the estimates of the quantity of some food types are based on assumptions about the types and quantities of ingredients consumed as part of mixed foods.

10.8 OTHER FACTORS TO CONSIDER FOR FISH CONSUMPTION

Other factors to consider when using the available survey data include location, climate, season, and ethnicity of the angler or consumer population, as well as the parts of fish consumed and the methods of preparation. Some contaminants (for example, persistent, bioaccumulative, aand toxic contaminants such as dioxins and polychlorinated biphenyls) have the affinity to accumulate more in certain tissues, such as the fatty tissue, as well as in certain internal organs. The effects of cooking methods for various food products on the levels of dioxin-like compounds have been addressed by evaluating a number of studies in U.S. EPA (2003). These studies showed various results for contamination losses based on the methodology of the study and the method of food preparation. The reader is referred to U.S. EPA (2003) for a detailed review of these studies. Additionally, users of the data presented in this chapter should ensure that consistent units are used for intake rate and concentration of contaminants in fish. The following sections provide information on converting between wet weight and dry weight, and between wet weight and lipid weight.

10.8.1 Conversion Between Wet and Dry Weight

The intake data presented in this chapter is reported in units of wet weight (i.e., as-consumed or uncooked weight of fish consumed per day or per eating occasion). However, data on the concentration of contaminants in fish may be reported in units of either wet or dry weight.(e.g., mg contaminant per gram-dry-weight of fish). It is essential that exposure assessors be aware of this difference so that they may ensure consistency between the units used for intake rates and those used for concentration data (i.e., if the contaminant concentration is measured in dry weight of fish, then the dry weight units should be used for fish intake values).

If necessary, wet weight (e.g., as-consumed) intake rates may be converted to dry weight intake rates using the moisture content percentages presented in Table 10-29 and the following equation:

$$IR_{dw} = IR_{ww}\left[\frac{100 - W}{100}\right] \qquad \text{(Eqn. 10-1)}$$

where:

IR_{dw}	=	dry weight intake rate;
IR_{ww}	=	wet weight intake rate; and
W	=	percent water content.

Alternately, dry weight residue levels in fish may be converted to wet weight residue levels for use with wet weight (e.g., as-consumed) intake rates, as follows:

$$C_{ww} = C_{dw} \left(\frac{100 - W}{100} \right) \qquad \text{(Eqn. 10-2)}$$

where:

C_{ww}	=	wet weight intake rate;
C_{dw}	=	dry weight intake rate; and
W	=	percent water content.

The moisture content data presented in Table 10-29 are for selected fish taken from USDA, 2007.

10.8.2 Conversion Between Wet Weight and Lipid Weight Intake Rates

In some cases, the residue levels of contaminants in fish are reported as the concentration of contaminant per gram of fat. This may be particularly true for lipophilic compounds. When using these residue levels, the assessor should ensure consistency in the exposure assessment calculations by using consumption rates that are based on the amount of fat consumed for the fish product of interest.

If necessary, wet weight (e.g., as-consumed) intake rates may be converted to lipid weight intake rates using the fat content percentages presented in Table 10-29 and the following equation:

$$IR_{lw} = IR_{ww} \left(\frac{L}{100} \right) \qquad \text{(Eqn. 10-3)}$$

where:

IR_{lw}	=	lipid weight intake rate;
IR_{ww}	=	wet weight intake rate; and
L	=	percent lipid (fat) content.

Alternately, wet weight residue levels in fish may be estimated by multiplying the levels based on fat by the fraction of fat per product as follows:

$$C_{ww} = C_{lw} \left(\frac{L}{100} \right) \qquad \text{(Eqn. 10-4)}$$

where:

C_{ww}	=	wet weight intake rate;
C_{lw}	=	lipid weight intake rate; and
L	=	percent lipid (fat) content.

The resulting residue levels may then be used in conjunction with wet weight (e.g., as-consumed) consumption rates. The total fat content data presented in Table 10-29 are for selected fish taken from USDA, 2007.

10.9 REFERENCES FOR CHAPTER 10

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Table 10-3. Per Capita Distribution of Fish (Finfish and Shellfish) Intake
General Population Children Ages 3 to 17 Years - g/day, As-Consumed

Age (years)	Sample Size	Mean (90% CI)	90th % (90% BI)[a]	95th % (90% BI)[a]	99th % (90% BI)[a]
			Freshwater/Estuarine		
Ages 3 to 5	4,391	1.5 (1.2-1.8)	0.1 (0.0-1.0)	5.1 (4.1-6.2)	39 (33-44)
Ages 6 to 10	1,670	2.1 (1.4-2.9)	0.0 (0.0-0.6)	5.9 (3.2-13)	61* (51-86)
Ages 11 to 15	1,005	3.0 (2.2-3.8)	1.4 (0.5-5.5)	18 (15-21)	70* (56-75)
Ages 16 to 17	363	3.4 (1.6-5.3)	0.0 (0.0-1.5)	13* (5.2-29)	81* (42-117)
			Marine		
Ages 3 to 5	4,391	3.7 (3.2-4.3)	11 (10-13)	28 (24-29)	60 (52-71)
Ages 6 to 10	1,670	4.2 (3.5-4.9)	13 (9.7-17)	29 (28-34)	79* (49-84)
Ages 11 to 15	1,005	5.5 (4.2-6.7)	14 (9.8-21)	39 (31-50)	102* (84-114)
Ages 16 to 17	363	4.7 (2.9-6.4)	0.0 (0.0-6.9)	24* (7.8-71)	108* (68-119)
			All Fish		
Ages 3 to 5	4,391	5.2 (4.6-5.8)	19 (15-21)	35 (31-40)	72 (67-81)
Ages 6 to 10	1,670	6.3 (5.3-7.3)	24 (21-27)	40 (34-51)	108* (92-131)
Ages 11 to 15	1,005	8.5 (6.9-10)	28 (25-31)	60 (53-74)	122* (107-132)
Ages 16 to 17	363	8.1 (5.4-11)	19 (7.0-41)	74* (29-90)	142* (108-200)

[a] Percentile intervals were estimated using the percentile bootstrap method with 1,000 bootstrap replications.
* The sample size does not meet minimum reporting requirements as described in the "Third Report on Nutrition Monitoring in the United States" (LSRO, 1995).
CI = Confidence interval.
BI = Bootstrap interval.

Source: U.S. EPA, 2002.

Table 10-4. Per Capita Distribution of Fish (Finfish and Shellfish) Intake
General Population Children Ages 3 to 17 Years - mg/kg-day, As-Consumed

Age (years)	Sample Size	Mean (90% CI)	90th % (90% BI)[a]	95th % (90% BI)[a]	99th % (90% BI)[a]
			Freshwater/Estuarine		
Ages 3 to 5	4,112	83 (67-99)	0 (0-55)	284 (240-353)	2,317 (1,736-2,463)
Ages 6 to 10	1,553	59 (39-79)	0 (0-5)	178 (88-402)	1,662* (1,433-2,335)
Ages 11 to 15	975	53 (42-64)	27 (0-78)	312 (253-390)	1,237* (950-1,521)
Ages 16 to 17	360	49 (23-76)	0 (0-33)	213* (106-390)	1,186* (600-2,096)
			Marine		
Ages 3 to 5	4,112	209 (182-237)	614 (525-696)	1,537 (1,340-1,670)	3,447 (3,274-3,716)
Ages 6 to 10	1,553	150 (123-177)	416 (326-546)	1,055 (969-1,275)	2,800* (2,021-3,298)
Ages 11 to 15	975	109 (84-133)	338 (179-413)	821 (629-1,034)	1,902* (1,537-2,366)
Ages 16 to 17	360	75 (46-103)	0 (0-124)	381* (132-951)	1,785* (1,226-2,342)
			All Fish		
Ages 3 to 5	4,112	292 (259-326)	1,057 (931-1,232)	1,988 (1,813-2,147)	4,089 (3,733-4,508)
Ages 6 to 10	1,553	209 (176-242)	780 (644-842)	1,357 (1,173-1,452)	3,350* (2,725-4,408)
Ages 11 to 15	975	162 (133-191)	570 (476-664)	1,051 (991-1,313)	2,305* (1,908-2,767)
Ages 16 to 17	360	124 (83-165)	261 (110-600)	1,029* (390-1,239)	2,359* (2,096-2,676)

[a] Percentile intervals were estimated using the percentile bootstrap method with 1,000 bootstrap replications.
* The sample size does not meet minimum reporting requirements as described in the "Third Report on Nutrition Monitoring in the United States" (LSRO, 1995).
CI = Confidence interval.
BI = Bootstrap interval.

Source: U.S. EPA, 2002.

Table 10-5. Consumer Only Distribution of Fish (Finfish and Shellfish) Intake
General Population Children Ages 3 to 17 Years - g/day, As-Consumed

Age (years)	Sample Size	Mean (90% CI)	90th % (90% BI)[a]	95th % (90% BI)[a]	99th % (90% BI)[a]
			Freshwater/Estuarine		
Ages 3 to 5	442	27 (23-31)	73 (65-79)	96 (87-110)	159* (136-260)
Ages 6 to 10	147	43 (32-55)	122* (83-187)	187* (115-260)	260* (172-261)
Ages 11 to 15	107	49 (39-59)	127* (104-148)	150* (135-193)	307* (193-384)
Ages 16 to 17	28	76* (59-93)	159* (151-171)	168* (159-484)	372* (171-484)
			Marine		
Ages 3 to 5	682	45 (41-48)	91 (84-105)	119 (102-143)	228* (169-293)
Ages 6 to 10	217	59 (53-66)	129 (112-158)	159* (135-219)	243* (219-292)
Ages 11 to 15	122	72 (60-85)	165* (158-203)	204* (169-227)	246* (214-269)
Ages 16 to 17	37	97* (65-129)	219* (180-238)	238* (180-293)	365* (230-428)
			All Fish		
Ages 3 to 5	834	50 (46-54)	103 (94.5-125)	134 (121-152)	260* (195-293)
Ages 6 to 10	270	71 (64-77)	155 (130-183)	218* (198-261)	281* (260-292)
Ages 11 to 15	172	80 (70-89)	167* (154-193)	209* (206-257)	285* (264-327)
Ages 16 to 17	52	104* (75-133)	201* (167-243)	242* (216-484)	451* (293-484)

[a] Percentile intervals were estimated using the percentile bootstrap method with 1,000 bootstrap replications.
* The sample size does not meet minimum reporting requirements as described in the "Third Report on Nutrition Monitoring in the United States" (LSRO, 1995).
CI = Confidence interval.
BI = Bootstrap interval.

Source: U.S. EPA, 2002.

Table 10-6. Consumer Only Distribution of Fish (Finfish and Shellfish) Intake
General Population Children Ages 3 to 17 Years - mg/kg-day, As-Consumed

Age (years)	Sample Size	Mean (90% CI)	90th % (90% BI)[a]	95th % (90% BI)[a]	99th % (90% BI)[a]
			Freshwater/Estuarine		
Ages 3 to 5	416	1,532 (1,320-1,743)	4,307 (3,472-4,624)	5,257 (4,926-5,746)	10,644* (9,083-12,735)
Ages 6 to 10	132	1,296 (1,004-1,588)	3,453* (2,626-4,671)	4,675* (3,459-8,816)	8,314* (4,684-9,172)
Ages 11 to 15	101	869 (725-1,013)	2,030* (1,628-2,104)	3,162* (2,104-3,601)	4,665* (3,597-7,361)
Ages 16 to 17	28	1,063* (781-1,346)	2,293* (2,096-2,577)	2,505* (2,096-6,466)	5,067* (2,295-6,466)
			Marine		
Ages 3 to 5	640	2,492 (2,275-2,709)	5,303 (4,873-5,930)	6,762 (6,097-7,168)	11,457* (7,432-14,391)
Ages 6 to 10	203	2,120 (1,880-2,361)	4,950 (4,043-5,384)	5,817* (5,333-6,596)	8,092* (6,146-9,184)
Ages 11 to 15	120	1,427 (1,203-1,651)	2,971* (2,858-3,741)	4,278* (3,026-4,766)	5,214* (4,647-5,646)
Ages 16 to 17	37	1,534* (1,063-2,004)	3,602* (2,974-4,685)	4,475* (3,068-4,685)	4,982* (3,467-5,238)
			All Fish		
Ages 3 to 5	779	2,828 (2,608-3,049)	5,734 (5,268-6,706)	7,422 (6,907-8,393)	13,829* (11,349-14,391)
Ages 6 to 10	250	2,375 (2,199-2,551)	5,135 (4,684-5,816)	6,561* (5,404-8,816)	9,179* (8,130-10,485)
Ages 11 to 15	164	1,533 (1,384-1,682)	3,207* (2,945-3,485)	3,925* (3,485-4,764)	5,624* (4,764-6,929)
Ages 16 to 17	52	1,578* (1,187-1,969)	3,468* (2,676-4,752)	4,504* (3,709-6,466)	5,738* (4,752-6,466)

[a] Percentile intervals were estimated using the percentile bootstrap method with 1,000 bootstrap replications.
* The sample size does not meet minimum reporting requirements as described in the "Third Report on Nutrition Monitoring in the United States" (LSRO, 1995).
CI = Confidence interval.
BI = Bootstrap interval.

Source: U.S. EPA, 2002.

Table 10-7. Per Capita Distribution of Fish (Finfish and Shellfish) Intake
General Population Children Ages 3 to 17 Years - g/day, Uncooked Fish Weight

Age (years)	Sample Size	Mean (90% CI)	90th (90% BI)[a]	95th % (90% BI)[a]	99th % (90% BI)[a]
			Freshwater/Estuarine		
Ages 3 to 5	4,391	2.2 (1.8-2.6)	0.1 (0.0-1.5)	12 (10-14)	52 (46-62)
Ages 6 to 10	1,670	3.0 (1.9-4.1)	0.0 (0.0-0.5)	13 (4.8-20)	78* (64-111)
Ages 11 to 15	1,005	4.3 (3.2-5.4)	2.3 (0.1-7.7)	26 (21-29)	95* (83-110)
Ages 16 to 17	363	4.6 (2.2-6.9)	0.0 (0.0-1.9)	19* (13-37)	109* (58-155)
			Marine		
Ages 3 to 5	4,391	5.5 (4.8-6.2)	20 (17-23)	39 (38-41)	82 (73-95)
Ages 6 to 10	1,670	5.6 (4.6-6.5)	19 (14-24)	38 (38-42)	100* (63-111)
Ages 11 to 15	1,005	7.6 (5.9-9.4)	25 (16-35)	56 (45-67)	132* (110-149)
Ages 16 to 17	363	6.1 (3.7-8.4)	0.0 (0.0-9.3)	29* (12-91)	136* (92.0-177)
			All Fish		
Ages 3 to 5	4,391	7.7 (6.9-8.6)	33 (28-34)	51 (46-57)	101 (89.1-111)
Ages 6 to 10	1,670	8.5 (7.1-10)	33 (27-38)	56 (50-70)	144* (117-183)
Ages 11 to 15	1,005	12 (9.7-14)	43 (37-51)	87 (70-103)	171* (148-176.8)
Ages 16 to 17	363	11 (7.0-14)	29 (9.4-49)	84* (42-114)	193* (121-266)

[a] Percentile intervals were estimated using the percentile bootstrap method with 1,000 bootstrap replications.
* The sample size does not meet minimum reporting requirements as described in the "Third Report on Nutrition Monitoring in the United States" (LSRO, 1995).
CI = Confidence interval.
BI = Bootstrap interval.

Source: U.S. EPA, 2002.

Table 10-8. Per Capita Distribution of Fish (Finfish and Shellfish) Intake
General Population Children Ages 3 to 17 Years - mg/kg-day, Uncooked Fish Weight

Age (years)	Sample Size	Mean (90% CI)	90th % (90% BI)[a]	95th % (90% BI)[a]	99th % (90% BI)[a]
			Freshwater/Estuarine		
Ages 3 to 5	4,112	124 (103-146)	0 (0-83)	712 (599-784)	3,091 (2,495-3,475)
Ages 6 to 10	1,553	84 (55-112)	0 (0-1)	354 (116-685)	2,322* (1,856-2,994)
Ages 11 to 15	975	77 (60-94)	20 (0-116)	477 (411-618)	1,610* (1,358-2,203)
Ages 16 to 17	360	65 (30-100)	0 (0-23)	285* (167-491)	1,542* (760-2,767)
			Marine		
Ages 3 to 5	4,112	309 (270-348)	1,108 (984-1,332)	2,314 (2,096-2,481)	4,608 (4,301-5,354)
Ages 6 to 10	1,553	198 (161-235)	600 (474-733)	1,481 (1,310-1,549)	3,684* (2,458-4,353)
Ages 11 to 15	975	153 (117-189)	481 (361-609)	1,251 (808-1,390)	2,381* (2,162-3,207)
Ages 16 to 17	360	98 (58-137)	0 (0-177)	460* (197-1,079)	2,148* (1,648-3,901)
			All Fish		
Ages 3 to 5	4,112	433 (385-482)	1,841 (1,555-1,957)	2,964 (2,790-3,194)	5,604 (5,231-6,135)
Ages 6 to 10	1,553	282 (235-328)	1,045 (745-1,219)	1,854 (1,638-2,175)	4,371* (3,433-5,814)
Ages 11 to 15	975	231 (186-275)	824 (657-952)	1,531 (1,362-1,850)	3,651* (2,745-3,795)
Ages 16 to 17	360	163 (108-219)	406 (145-756)	1,272* (558-1,500)	3,544* (2,767-3,946)

[a] Percentile intervals were estimated using the percentile bootstrap method with 1,000 bootstrap replications.
* The sample size does not meet minimum reporting requirements as described in the "Third Report on Nutrition Monitoring in the United States" (LSRO, 1995).
CI = Confidence interval.
BI = Bootstrap interval.

Source: U.S. EPA, 2002.

Table 10-9. Consumer Only Distribution of Fish (Finfish and Shellfish) Intake
General Population Children Ages 3 to 17 Years - g/day, Uncooked Fish Weight

Age (years)	Sample Size	Mean (90% CI)	90th % (90% BI)[a]	95th % (90% BI)[a]	99th % (90% BI)[a]
			Freshwater/Estuarine		
Ages 3 to 5	442	40 (35-46)	95 (86-102)	129 (120-142)	205* (200-381)
Ages 6 to 10	147	61 (44-79)	157* (117-250)	248* (150-381)	386* (221-401)
Ages 11 to 15	107	71 (58-83)	173* (166-196)	199* (173-296)	392* (296-514)
Ages 16 to 17	28	100* (80-121)	203* (197-248)	242* (206-643)	501* (241-643)
			Marine		
Ages 3 to 5	682	66 (60-71)	125 (114-150)	165 (139-190)	316* (227-390)
Ages 6 to 10	217	78 (67-89)	150 (129-201)	202* (165-317)	350* (223-392)
Ages 11 to 15	122	102 (86-118)	220* (205-265)	262. (227-307)	320* (277-379)
Ages 16 to 17	37	126* (80-171)	281* (241-354)	353* (241-390)	530* (291-650)
			All Fish		
Ages 3 to 5	834	74 (69-79)	149 (136-165)	184 (172-223)	363* (310-391)
Ages 6 to 10	270	95 (85-106)	200 (177-235)	313* (254-381)	387* (381-401)
Ages 11 to 15	172	113.(99-127)	227* (205-296)	308* (271-348)	380* (353-409)
Ages 16 to 17	52	136* (97-174)	242* (206-358)	357* (266-643)	645* (390-650)

[a] Percentile intervals were estimated using the percentile bootstrap method with 1,000 bootstrap replications.
* The sample size does not meet minimum reporting requirements as described in the "Third Report on Nutrition Monitoring in the United States" (LSRO, 1995).
CI = Confidence interval.
BI = Bootstrap interval.

Source: U.S. EPA, 2002.

Table 10-10. Consumer Only Distribution of Fish (Finfish and Shellfish) Intake
General Population Children Ages 3 to 17 Years - mg/kg-day, Uncooked Fish Weight

Age (years)	Sample Size	Mean (90% CI)	90th % (90% BI)[a]	95th % (90% BI)[a]	99th % (90% BI)[a]
			Freshwater/Estuarine		
Ages 3 to 5	416	2,292 (2,012-2,572)	5,852 (4,703-6,068)	7,160 (6,950-7,442)	15,600* (11,877-18,670)
Ages 6 to 10	132	1,830 (1,416-2,245)	4,688* (3,673-5,987)	6,207* (4,767-12,926)	12,365* (6,763-12,926)
Ages 11 to 15	101	1,273 (1,082-1,464)	2,777* (2,091-3,026)	4,419* (3,026-5,522)	5,717* (5,457-9,852)
Ages 16 to 17	28	1,401* (1,058-1,744)	2,971* (2,743-3,692)	3,279* (2,767-8,577)	6,819* (3,221-8,577)
			Marine		
Ages 3 to 5	640	3,689 (3,395-3,982)	7,253 (6,777-8,504)	9,270 (8,415-9,991)	16,100* (11,980-17,989)
Ages 6 to 10	203	2,787 (2,417-3,157)	5,910 (4,813-7,365)	8,001* (6,375-8,707)	10,754* (8,707-12,055)
Ages 11 to 15	120	2,020 (1,741-2,327)	4,224* (3,744-4,781)	5,195* (3,859-6,448)	6,839* (6,076-8,970)
Ages 16 to 17	37	2,007* (1,302-2,712)	4,468* (3,880-7,802)	6,537* (3,991-7,802)	7,886* (4,661-7,958)
			All Fish		
Ages 3 to 5	779	4,198 (3,894-4,502)	8,061 (7,366-9,223)	10,444 (9,475-12,261)	17,874* (15,290-18,670)
Ages 6 to 10	250	3,188 (2,923-3,452)	6,544 (6,013-8,707)	8,654* (7,086-11,756)	12,785* (10,930-13,979)
Ages 11 to 15	164	2,199 (1,950-2,449)	4,387* (3,785-5,522)	6,234* (4,420-7,589)	8,345* (6,076-8,970)
Ages 16 to 17	52	2,066* (1,529-2,603)	3,902* (3,536-7,892)	6,594* (4,661-8,577)	8,210* (7,892-8,577)

[a] Percentile intervals were estimated using the percentile bootstrap method with 1,000 bootstrap replications.
* The sample size does not meet minimum reporting requirements as described in the "Third Report on Nutrition Monitoring in the United States" (LSRO, 1995).
CI = Confidence interval.
BI = Bootstrap interval.

Source: U.S. EPA, 2002.

Table 10-11. Number of General Population Respondents Reporting Consumption of a Specified Number of Servings of Seafood in 1 Month, and Source of Seafood Eaten

Age Group (years)	N	Number of Servings in a Month							Source of Seafood		
		0	1-2	3-5	6-10	11-19	20+	DK	Mostly Purchased	Mostly Caught	DK
0 to <1	34	27	5	2	0	0	0	0	7	0	0
1 to <2	49	30	12	4	2	0	0	1	15	3	1
2 to <3	59	34	12	7	4	1	0	1	24	1	0
3 to <6	169	80	42	26	13	1	1	6	78	8	3
6 to <11	224	117	45	36	12	4	3	7	98	4	5
11 to <16	236	128	50	42	6	1	1	8	98	3	7
16 to <21	220	110	41	37	18	4	2	8	96	5	9

DK = Don't know.
N = Sample size.

Source: U.S. EPA re-analysis of data in U.S. EPA, 1996.

Table 10-12. Fish Consumption Among General Population Children in Four States, Consumers Only, g/kg-day As-Consumed

Age Group (years)	N	Mean	CI	Percentiles						Maximum
				10th	25th	50th	75th	90th	95th	
Connecticut										
1 to <6	14	0.61	0.42-0.81	0.16	0.26	0.55	0.83	1.4	1.6	1.6
6 to <11	22	0.59	0.040-0.77	0.14	0.23	0.47	0.96	1.2	1.3	1.5
11 to <16	18	0.32	0.17-0.46	0.07	0.14	0.19	0.38	0.52	0.84	1.3
Florida										
1 to <6	420	2.3	2.05-2.63	0.5	1.0	1.7	2.8	4.7	6.8	14.6
6 to <11	375	1.1	0.98-1.22	0.28	0.52	0.81	1.4	2.2	3.0	9.4
11 to <16	365	0.85	0.73-0.98	0.20	0.36	0.63	0.99	1.6	2.2	11.0
Minnesota										
1 to <6	46	0.58	0.32-0.85	0.07	0.15	0.46	0.73	1.1	1.8	8.0
6 to <11	42	0.38	0.21-0.54	0.05	0.07	0.25	0.47	1.0	1.4	5.3
11 to <16	63	0.24	0.16-0.31	0.03	0.06	0.21	0.32	0.55	0.59	1.4
North Dakota										
1 to <6	28	0.70	0.24-1.17	0.05	0.12	0.23	0.68	1.6	3.8	6.8
6 to <11	41	0.56	0.31-0.81	0.11	0.21	0.30	0.66	1.2	1.5	4.3
11 to <16	53	0.41	0.23-0.59	0.06	0.12	0.22	0.54	1.0	1.3	2.3

N = Sample size.
CI = Confidence interval.

Source: Moya et al, 2008.

Table 10-13. Fish Consumption Among General Population in Four States According to Caught or Bought Status, g/kg-day As-Consumed

Category	N	Mean	CI	Percentiles						Maximum
				10th	25th	50th	75th	90th	95th	
Connecticut										
Eats Caught Only	1	0.01	-	-	-	-	-	-	-	0.01
Eats Caught and Bought	70	0.49	0.36-0.61	0.10	0.17	0.34	0.75	1.1	1.3	2.2
Eats Bought Only	291	0.48	0.40-0.57	0.06	0.16	0.32	0.61	1.1	1.4	7.0
Florida										
Eats Caught Only	511	0.76	0.66-0.86	0.15	0.30	0.50	0.90	1.7	2.3	7.4
Eats Caught and Bought	701	1.8	1.6-2.1	0.50	0.76	1.2	2.0	3.4	5.1	34
Eats Bought Only	6545	0.85	0.81-0.89	0.18	0.30	0.54	0.98	1.8	2.5	24
Minnesota										
Eats Caught Only	38	0.16	0.05-0.26	0.02	0.03	0.08	0.25	0.37	0.51	0.57
Eats Caught and Bought	555	0.40	0.27-0.52	0.08	0.11	0.23	0.49	0.70	1.3	9.2
Eats Bought Only	200	0.23	0.18-0.28	0.02	0.05	0.14	0.26	0.56	0.91	8.0
North Dakota										
Eats Caught Only	30	0.21	0.09-0.32	0.05	0.09	0.14	0.22	0.33	0.51	1.8
Eats Caught and Bought	359	0.39	0.29-0.49	0.07	0.13	0.23	0.43	0.82	1.3	4.3
Eats Bought Only	157	0.25	0.13-0.36	0.03	0.05	0.10	0.24	0.53	0.97	6.8

N = Sample size.
CI = Confidence interval.

Source: Moya et al., 2008.

Table 10-14. Fish Consumption Among General Population and Anglers in Three States, g/kg-day As-Consumed

Category	N	Mean	Percentiles						
			10th	25th	50th	75th	90th	95th	99th
Connecticut									
Anglers	244	0.66	0.10	0.20	0.40	0.80	1.6	2.1	3.5
General Population	362	0.48	0.07	0.16	0.32	0.63	1.1	1.4	2.4
Minnesota									
Anglers	1,109	0.32	0.05	0.10	0.18	0.34	0.67	0.99	2.2
General Population	793	0.33	0.04	0.10	0.20	0.34	0.65	1.1	1.8
North Dakota									
Anglers	808	0.34	0.05	0.10	0.20	0.39	0.81	1.2	2.0
General Population	546	0.34	0.05	0.09	0.19	0.35	0.74	1.2	2.2

N = Sample size.

Source: Moya et al., 2008.

Table 10-15. Recreational Fish Consumption in Delaware Consumers Only

Age Group	N	Mean consumption (g/day)[a]	Standard Error (%)
0 to 9 years	73	6.0	13.4
10 to 19 years	102	11.4	16.8

[a] Converted from ounces/day; 1 ounce = 28.35 grams.

Source: KCA Research Division, 1994.

Table 10-16. Consumption of Self-Caught Fish by Recreational Anglers
Lavaca Bay, Texas, g/day

Age Group	N	Mean	95% Upper Confidence Limit on Mean	90th or 95th Percentile of Distribution[a]
Finfish				
Small children (<6 years)	320	11.4	14.2	30.3
Youths (6 to 19 years)	749	15.6	17.8	45.4
Shellfish				
Small children (<6 years)	320	0.4	0.6	2.0
Youths (6 to 19 years)	749	0.7	1.0	4.5

[a] The 90th percentile values are presented for finfish. For shellfish, the 95th percentile value is provided because less than 90 percent of the individuals consumed shellfish, resulting in a 90th percentile of zero.

Source: Alcoa, 1998.

Table 10-17. Number of Meals and Portion Sizes of Self-Caught Fish Consumed by Recreational Anglers
Lavaca Bay, Texas

Age Group	Number of Meals		Portion Size (grams)[a]	
	Mean	95% Upper Confidence Limit on Mean	Mean	95% Upper Confidence Limit on Mean
Finfish				
Small children (<6 years)	2.6	3.1	128	133
Youths (6 to 19 years)	2.4	2.7	187	196
Shellfish				
Small children (<6 years)	0.3	0.5	57	68
Youths (6 to 19 years)	0.3	0.4	71	82

[a] Converted from ounces; 1 ounce = 28.35 grams.

Source: Alcoa, 1998.

Table 10-18. Mean Fish Intake Among Individuals Who Eat Fish and Reside in Households With Recreational Fish Consumption - Michigan

Age Group	N	Meals/Week		Intake g/day		Intake g/kg-day	
		All Fish	Recreational Fish	Total Fish	Recreational Fish	Total Fish	Recreational Fish
1 to 5 years	121	0.46	0.22	11.4	5.6	0.74	0.37
6 to 10 years	151	0.49	0.28	13.6	7.9	0.48	0.28
11 to 20 years	349	0.41	0.23	12.3	7.3	0.22	0.12

N = Sample size.

Source: U.S. EPA analysis, using data from West et al., 1989.

Table 10-19. Consumption of Sports-caught and Purchased Fish by Minnesota and North Dakota Children, Ages 0 to 14 Years (g/day)

	N	Percentile			
		50th	75th	90th	95th
Minnesota					
Sports-caught	582	1.2	3.3	8.3	14.6
Purchased		3.6	8.7	19.2	30.9
North Dakota					
Sports-caught	343	1.7	5.1	13.1	23.3
Purchased		4.7	11.6	26.3	42.8

Source: Benson et al., 2001.

Table 10-20. Fish Consumption Rates among Native American Children (age 5 years and under)[a]

Grams/Day	Unweighted Cumulative Percent
0.0	21.1
0.4	21.6
0.8	22.2
1.6	24.7
2.4	25.3
3.2	28.4
4.1	32.0
4.9	33.5
6.5	35.6
8.1	47.4
9.7	48.5
12.2	51.0
13.0	51.5
16.2	72.7
19.4	73.2
20.3	74.2
24.3	76.3
32.4	87.1
48.6	91.2
64.8	94.3
72.9	96.4
81.0	97.4
97.2	98.5
162.0	100

[a] Sample size = 194; unweighted mean = 19.6 grams/day; unweighted standard error = 1.94.

Note: Data are compiled from the Umatilla, Nez Perce, Yakama, and Warm Springs tribes of the Columbia River Basin.

Source: CRITFC, 1994.

Table 10-21. Number of Fish Meal Eaten per Month and Fish Intake Among Native American Children who Consume Particular Species

Species	N	Fish Meals/Month		Intake (g/day)	
		Unweighted Mean	Unweighted SE	Unweighted Mean	Unweighted SE
Salmon	164	2.3	0.16	19	1.5
Lamprey	37	0.89	0.27	8.1	2.8
Trout	89	0.96	0.12	8.8	1.4
Smelt	39	0.40	0.09	3.8	0.99
Whitefish	21	3.5	2.83	21	16
Sturgeon	21	0.43	0.12	4.0	1.3
Walleye	5	0.22	0.20	2.0	1.5
Squawfish	2	0.00	-	0.0	-
Sucker	4	0.35	0.22	2.6	1.7
Shad	3	0.10	0.06	1.1	0.57

SE = Standard error.

Source: CRITFC, 1994.

Table 10-22. Consumption Rates for Native American Children, Age Birth to Five Years (g/kg-day)

Fish Category	Mean (SE)	95% CI	50th percentile	90th percentile
Tulalip Tribes (N = 21)				
Shellfish	0.13 (0.056)	(0.014, 0.24)	0.0	0.60
Total finfish	0.11 (0.030)	(0.056, 0.17)	0.060	0.29
Total, all fish	0.24 (0.077)	(0.088, 0.39)	0.078	0.74
Squaxin Island Tribe (N = 48)				
Shellfish	0.23 (0.053)	(0.13, 0.37)	0.045	0.57
Total finfish	0.25 (0.063)	(0.13, 0.37)	0.061	0.83
Total, all fish	0.83 (0.14)	(0.55, 1.1)	0.51	2.1
Both Tribes Combined (weighted)				
Shellfish	0.18 (0.039)	(0.10, 0.25)	0.012	0.57
Total finfish	0.18 (0.035)	(0.10, 0.25)	0.064	0.32
Total, all fish	0.53 (0.081)	(0.37, 0.69)	0.17	1.4

SE = Standard error.
CI = Confidence interval.
N = Sample size.

Source: Toy et al., 1996.

Table 10-23. Consumption Rates for Native American Children (g/kg-day), All Children (including non-consumers): Individual Finfish and Shellfish and Fish Groups

Group	Species	N	Mean	SE	95% LCL	95% UCL	P5	Median	P75	P90	P95	Maximum
Group E												
	Manila/Littleneck clams	31	0.095	0.051	0.0	0.20	0.0	0.031	0.063	0.18	0.76	1.6
	Horse clams	31	0.022	0.013	0.0	0.048	0.0	0.0	0.006	0.048	0.27	0.35
	Butter clams	31	0.021	0.014	0.0	0.048	0.0	0.0	0.0	0.041	0.25	0.42
	Geoduck	31	0.11	0.041	0.033	0.19	0.0	0.027	0.12	0.25	0.84	1.1
	Cockles	31	0.12	0.079	0.0	0.27	0.0	0.0	0.054	0.24	1.2	2.4
	Oysters	31	0.019	0.012	0.0	0.043	0.0	0.0	0.056	0.058	0.21	0.36
	Mussels	31	0.001	0.001	0.0	0.002	0.0	0.0	0.0	0.0	0.011	0.026
	Moon snails	31	0.000	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
	Shrimp	31	0.093	0.038	0.019	0.17	0.0	0.004	0.059	0.39	0.71	0.98
	Dungeness crab	31	0.30	0.13	0.053	0.55	0.0	0.047	0.17	1.3	2.7	2.8
	Red rock crab	31	0.007	0.003	0.001	0.014	0.0	0.0	0.0	0.046	0.064	0.082
	Scallops	31	0.011	0.006	0.0	0.022	0.0	0.0	0.005	0.031	0.089	0.17
	Squid	31	0.002	0.002	0.0	0.005	0.0	0.0	0.0	0.0	0.0	0.41
	Sea urchin	31	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
	Sea cucumber	31	0.0	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
Group A[a]		31	0.27	0.12	0.043	0.50	0.0	0.063	0.22	0.53	2.1	3.6
Group B[b]		31	0.004	0.002	0.0	0.008	0.0	0.0	0.0	0.015	0.038	0.069
Group C[c]		31	0.13	0.040	0.052	0.21	0.0	0.036	0.21	0.34	0.84	1.0
Group D[d]		31	0.03	0.011	0.008	0.053	0.0	0.010	0.037	0.081	0.19	0.34
Group F[e]		31	0.24	0.075	0.094	0.39	0.0	0.092	0.25	0.68	1.6	1.9
All Finfish		31	0.68	0.17	0.35	1.0	0.026	0.31	0.74	2.1	3.5	4.1
All Shellfish		31	0.80	0.27	0.26	1.3	0.0	0.29	0.80	2.3	5.0	7.9
All Seafood		31	1.5	0.35	0.80	2.2	0.042	0.72	2.0	3.3	7.3	9.1

[a] Group A is salmon, including king, sockeye, coho, chum, pink, and steelhead.
[b] Group B is finfish, including smelt and herring.
[c] Group C is finfish, including cod, perch, pollock, sturgeon, sablefish, spiny dogfish and greenling.
[d] Group D is finfish, including halibut, sole, flounder and rockfish.
[e] Group F includes tuna, other finfish, and all others not included in Groups A, B, C, and D.
N = Sample size.
SE = Standard error
LCL = Lower confidence limit
UCL = Upper confidence limit
P5...P95 = Percentile value.
Note: The minimum consumption for all species and groups was zero, except for "all finfish" and "all seafood." The minimum rate for "all finfish" was 0.023, and for "all seafood" was 0.035.

Source: Duncan, 2000.

Table 10-24. Consumption Rates for Native American Children (g/kg-day), Consumers Only: Individual Finfish and Shellfish and Fish Groups

Group	Species	N	Mean	SE	Median	Percentiles	
						75th	90th
Group E	Manila/Littleneck clams	23	0.13	0.068	0.043	0.066	0.20
	Horse clams	12	0.058	0.032	0.009	0.046	0.31
	Butter clams	6	0.11	0.066	0.032	0.20	-
	Geoduck	22	0.16	0.054	0.053	0.23	0.55
	Cockles	10	0.36	0.23	0.078	0.29	2.2
	Oysters	10	0.060	0.035	0.015	0.074	0.34
	Mussels	1	0.026	-	-	-	-
	Moon snails	0	-	-	-	-	-
	Shrimp	17	0.17	0.064	0.035	0.30	0.62
	Dungeness crab	21	0.44	0.18	0.082	0.305	2.3
	Red rock crab	5	0.046	0.011	0.051	0.067	-
	Scallops	8	0.042	0.019	0.027	0.032	-
	Squid	2	0.033	0.008	0.033	-	-
	Sea urchin	0	-	-	-	-	-
	Sea cucumber	0	-	-	-	-	-
Group A[a]		28	0.300	0.13	0.11	0.25	0.60
Group B[b]		5	0.023	0.012	0.017	0.043	-
Group C[c]		25	0.16	0.048	0.048	0.24	0.49
Group D[d]		17	0.055	0.019	0.033	0.064	0.14
Group F[e] (tuna/other finfish)		24	0.31	0.092	0.18	0.34	1.0
All finfish		31	0.68	0.17	0.31	0.74	2.1
All shellfish		28	0.89	0.30	0.36	0.85	2.5
All seafood		31	1.5	0.35	0.72	2.0	3.4

[a] Group A is salmon, including king, sockeye, coho, chum, pink, and steelhead.
[b] Group B is finfish, including smelt and herring.
[c] Group C is finfish, including cod, perch, pollock, sturgeon, sablefish, spiny dogfish and greenling.
[d] Group D is finfish, including halibut, sole, flounder and rockfish.
[e] Group F includes tuna, other finfish, and all others not included in Groups A, B, C, and D.
N = Sample size.
SE = Standard error.
- = No data.

Source: Duncan, 2000.

Table 10-25. Fish Consumption Rates for Tulalip and Squaxin Island Children Consumers Only (g/kg-day)

Species[a]	N	Mean	SD	Percentiles[b]						
				5th	10th	25th	50th	75th	90th	95th
Squaxin Island Tribe										
Anadromous fish	33	0.39	1.3	0.005	0.006	0.030	0.049	0.13	0.69	0.79
Pelagic fish	21	0.16	0.25	0.010	0.014	0.019	0.044	0.11	0.55	0.71
Bottom fish	18	0.17	0.36	-	0.006	0.014	0.026	0.050	0.48	-
Shellfish	31	2.3	8.6	0.006	0.025	0.050	0.26	0.40	0.77	4.5
Other fish	30	0.58	0.58	0.012	0.051	0.11	0.40	0.57	1.6	1.6
All finfish	35	0.54	1.3	0.005	0.007	0.046	0.062	0.22	1.7	2.3
All fish	36	2.9	8.4	0.012	0.019	0.24	0.70	1.5	2.8	7.7
Tulalip Tribe										
Anadromous fish	14	0.15	0.23	-	0.012	0.026	0.045	0.14	0.33	-
Pelagic fish	7	0.15	0.18	-	-	0.027	0.053	0.17	-	-
Bottom fish	2	0.044	0.005	-	-	-	0.041	-	-	-
Shellfish	11	0.31	0.39	-	0.012	0.034	0.036	0.52	0.80	-
Other fish	1	0.12	0.12	-	-	-	-	-	-	-
All finfish	15	0.31	0.33	-	0.027	0.082	0.133	0.43	0.73	-
All fish	15	0.45	0.53	-	0.066	0.088	0.22	0.60	0.88	-

[a] Anadromous included: salmon, steelhead,and smelt. Pelagic included: cod, pollock, sablefish, rockfish, greenling, herring, spiny dogfish, perch, mackarel, and shark. Bottom included: halibut, sole/flounder, sturgeon, skate, eel, and grunters. Shellfish included: clams, cockles, mussels, oysters, shrimp, crabs, snails, scallops, squid, sea urchins, geoduck, limpets, lobster, bullhead, manta ray, razor clam, chitons, octopus, abalone, barnacles, and crayfish. Other included canned tuna and trout,

[b] Due to the small sample size for some fish groups, some percentiles could not be computed. A percentile was only calculated if it was between 100%*1/(N+1) and 100%*N/(N+1), where N is the number of consumers of a species group.

N = Sample size.

SD = Standard deviation.

\- = No data.

Source: Polissar et al., 2006.

Table 10-26. Fish Consumption Rates by Gender for Tulalip and Squaxin Island Children Consumers Only (g/kg-day)

Species[a]	Gender	N	Mean	SD	Percentiles[b]						
					5th	10th	25th	50th	75th	90th	95th
Squaxin Island Tribe											
Anadromous fish	Male	15	0.70	1.9	-	0.009	0.026	0.062	0.33	1.1	-
	Female	18	0.16	0.25	-	0.005	0.025	0.046	0.090	0.60	-
Pelagic fish	Male	8	0.10	0.14	-	-	0.015	0.058	0.099	-	-
	Female	13	0.18	0.28	-	0.015	0.020	0.040	0.11	0.68	-
Bottom fish	Male	6	0.038	0.057	-	-	0.016	0.020	0.026	-	-
	Female	12	0.24	0.44	-	0.005	0.010	0.028	0.11	0.74	-
Shellfish	Male	13	0.28	0.24	-	0.036	0.047	0.24	0.35	0.46	-
	Female	18	3.8	11.2	-	0.008	0.050	0.23	0.49	1.3	-
Other fish	Male	13	0.84	0.66	-	0.11	0.23	0.45	1.5	1.6	-
	Female	17	0.40	0.46	-	0.013	0.096	0.31	0.49	0.61	-
All finfish	Male	15	0.79	1.9	-	0.009	0.038	0.062	0.52	1.5	-
	Female	20	0.37	0.72	0.005	0.005	0.037	0.071	0.18	1.4	2.1
All fish	Male	15	1.7	2.0	-	0.061	0.48	1.2	1.9	2.4	-
	Female	21	3.7	10.7	0.008	0.014	0.16	0.60	0.92	2.8	16.4
Tulalip Tribe											
Anadromous fish	Male	7	0.061	0.052	-	-	0.023	0.034	0.067	-	-
	Female	7	0.24	0.31	-	-	0.032	0.080	0.20	-	-
Pelagic fish	Male	5	0.11	0.081	-	-	0.044	0.053	0.13	-	-
	Female	2	0.27	0.35	-	-	-	0.017	-	-	-
Bottom fish	Male	0	-	-	-	-	-	-	-	-	-
	Female	2	0.044	0.005	-	-	-	0.041	-	-	-
Shellfish	Male	5	0.14	0.22	-	-	0.012	0.027	0.11	-	-
	Female	6	0.43	0.46	-	-	0.034	0.22	0.65	-	-
Other fish	Male	0	-	-	-	-	-	-	-	-	-
	Female	1	0.12	0.12	-	-	-	-	-	-	-
All finfish	Male	8	0.21	0.18	-	-	0.087	0.13	0.32	-	-
	Female	7	0.43	0.44	-	-	0.045	0.17	0.65	-	-
All fish	Male	8	0.20	0.17	-	-	0.071	0.12	0.23	-	-
	Female	7	0.75	0.67	-	-	0.16	0.49	0.84	-	-

[a] Anadromous included: salmon, steelhead,and smelt. Pelagic included: cod, pollock, sablefish, rockfish, greenling, herring, spiny dogfish, perch, mackarel, and shark. Bottom included: halibut, sole/flounder, sturgeon, skate, eel, and grunters. Shellfish included: clams, cockles, mussels, oysters, shrimp, crabs, snails, scallops, squid, sea urchins, geoduck, limpets, lobster, bullhead, manta ray, razor clam, chitons, octopus, abalone, barnacles, and crayfish. Other included canned tuna and trout,

[b] Due to the small sample size for some fish groups, some percentiles could not be computed. A percentile was only calculated if it was between 100%*1/(N+1) and 100%*N/(N+1), where N is the number of consumers of a species group.

N = Sample size.

SD = Standard deviation.

\- = No data.

Source: Polissar et al., 2006.

Table 10-27. Distribution of Quantity of Canned Tuna Consumed (grams) Per Eating Occasion, by Age and Sex

Age (years)-Sex Group	Mean	SE	Percentiles						
			5th	10th	25th	50th	75th	90th	95th
2 to 5									
Male-Female	38	3	7*	8	15	29	55	73	85*
6 to 11									
Male-Female	57	8	14*	20*	26	49	59	99*	157*
12 to 19									
Male	84*	12*	-	18*	49*	74	97*	162*	-
Female	64	6	14*	18*	28*	56	77*	105*	156*

SE = Standard error.
* Indicates a statistic that is potentially unreliable because of small sample size or large coefficient of variation.
\- Indicates a percentage that could not be estimated.

Source: Smiciklas-Wright et al., 2002 (based on 1994-1996 CSFII data).

Table 10-28. Distribution of Quantity of Other Finfish Consumed (grams) Per Eating Occasion, by Age and Sex

Age (years)-Sex Group	Mean	SE	Percentiles						
			5th	10th	25th	50th	75th	90th	95th
2 to 5									
Male-Female	64	4	8*	16	33	58	77	124	128*
6 to 11									
Male-Female	93	8	17*	31*	50	77	119	171*	232*
12 to 19									
Male	119*	11*	40*	50*	64*	89	170*	185*	249*
Female	89*	13*	20*	26*	47*	67	124*	164*	199*

SE = Standard error.
* Indicates a statistic that is potentially unreliable because of small sample size or large coefficient of variation.

Source: Smiciklas-Wright et al., 2002 (based on 1994-1996 CSFII data).

Table 10-29. Mean Percent Moisture and Total Fat Content for Selected Species

Species	Moisture Content (%)	Total Fat Content (%)	Comments
		FINFISH	
Anchovy, European	73.37	4.84	Raw
	50.30	9.71	Canned in oil, drained solids
Bass, Freshwater	75.66	3.69	Raw
	68.79	4,73	Cooked, dry heat
Bass, Striped	79.22	2.33	Raw
	73.36	2.99	Cooked, dry heat
Bluefish	70.86	4.24	Raw
	62.64	5.44	Cooked, dry heat
Burbot	79.26	0.81	Raw
	73.41	1.04	Cooked, dry heat
Butterfish	74.13	8.02	Raw
	66.83	10.28	Cooked, dry heat
Carp	76.31	5.60	Raw
	69.63	7.17	Cooked, dry heat
Catfish, Channel, Farmed	75.38	7.59	Raw
	71.58	8.02	Cooked, dry heat
Catfish, Channel, Wild	80.36	2.82	Raw
	77.67	2.85	Cooked, dry heat
Cavier, Black and Red	47.50	17.90	--
Cisco	78.93	69.80	Raw
	1.91	11.90	Smoked
Cod, Atlantic	81.22	0.67	Raw
	75.61	0.86	Canned, solids and liquids
	75.92	0.86	Cooked, dry heat
	16.14	2.37	Dried and salted
Cod, Pacific	81.28	0.63	Raw
	76.00	0.81	Cooked, dry heat
Croaker, Atlantic	78.03	3.17	Raw
	59.76	12.67	Cooked, breaded and fried
Cusk	76.35	0.69	Raw
	69,68	0.88	Cooked, dry heat
Dolphinfish	77.55	0.70	Raw
	71.22	0.90	Cooked, dry heat
Drum, Freshwater	77.33	4.93	Raw
	70.94	6.32	Cooked, dry heat
Eel	69.26	11.66	Raw
	59.31	14.95	Cooked, dry heat
Flatfish, Flounder, and Sole	79.06	1.19	Raw
	73.16	1.53	Cooked, dry heat
Grouper	79.22	1.02	Raw, mixed species
	73.36	1.30	Cooked, dry heat
Haddock	79.92	0.72	Raw
	74.25	0.93	Cooked, dry heat
	71.48	0.96	Smoked
Halibut, Atlantic and Pacific	77.92	2.29	Raw
	71.69	2.94	Cooked, dry heat
Halibut, Greenland	70.27	13.84	Raw
	61.88	17.74	Cooked, dry heat
Herring, Atlantic	72.05	9.04	Raw
	64.16	11.59	Cooked, dry heat
	59.70	12.37	Kippered
	55.22	18.00	Pickled
Herring, Pacific	71.52	13.88	Raw
	63.49	17.79	Cooked, dry heat
Ling	79.63	0.64	Raw
	73.88	0.82	Cooked, dry heat

Table 10-29. Mean Percent Moisture and Total Fat Content for Selected Species (continued)

Species	Moisture Content (%)	Total Fat Content (%)	Comments
Lingcod	81.03	1.06	Raw
	75.68	1.36	Cooked, dry heat
Mackerel, Atlantic	63.55	13.89	Raw
	53.27	17.81	Cooked, dry heat
Mackerel, Jack	69.17	6.30	Canned, drained solids
Mackerel, King	75.85	2.00	Raw
	69.04	2.56	Cooked, dry heat
Mackerel, Pacific and Jack	70.15	7.89	Raw
	61.73	10.12	Cooked, dry heat
Mackerel, Spanish	71.67	6.30	Raw
	68.46	6.32	Cooked, dry heat
Milkfish	70.85	6.73	Raw
	62.63	8.63	Cooked, dry heat
Monkfish	83.24	1.52	Raw
	78.51	1.95	Cooked, dry heat
Mullet, Striped	77.01	3.79	Raw
	70.52	4.86	Cooked, dry heat
Ocean Perch, Atlantic	78.70	1.63	Raw
	72.69	2.09	Cooked, dry heat
Perch	79.13	0.92	Raw
	73.25	1.18	Cooked, dry heat
Pike, Northern	78.92	0.69	Raw
	72.97	0.88	Cooked, dry heat
Pike, Walleye	79.31	1.22	Raw
	73.47	1.56	Cooked, dry heat
Pollock, Atlantic	78.18	0.98	Raw
	72.03	1.26	Cooked, dry heat
Pollock, Walleye	81.56	0.80	Raw
	74.06	1.12	Cooked, dry heat
Pompano, Florida	71.12	9.47	Raw
	62.97	12.14	Cooked, dry heat
Pout, Ocean	81.36	0.91	Raw
	76.10	1.17	Cooked, dry heat
Rockfish, Pacific	79.26	1.57	Raw
	73.41	2.01	Cooked, dry heat
Roe	67.73	6.42	Raw
	58.63	8.23	Cooked, dry heat
Roughy, Orange	75.67	0.70	Raw
	66.97	0.90	Cooked, dry heat
Sablefish	71.02	15.30	Raw
	62.85	19.62	Cooked, dry heat
	60.14	20.14	Smoked
Salmon, Atlantic, Farmed	68.90	10.85	Raw
	64.75	12.35	Cooked, dry heat
Salmon, Atlantic, WIld	68.50	6.34	Raw
	59.62	8.13	Cooked, dry heat
Salmon, Chinook	71.64	10.43	Raw
	65.60	13.38	Cooked, dry heat
	72.00	4.32	Smoked
Salmon, Chum	75.38	3.77	Raw
	68.44	4.83	Cooked, dry heat
	70.77	5.50	Drained solids with bone
Salmon, Coho, Farmed	70.47	7.67	Raw
	67.00	8.23	Cooked, dry heat
Salmon, Coho, Wild	72.66	5.93	Raw
	71.50	4.30	Cooked, dry heat
	65.39	7.50	Cooked, moist heat

Table 10-29. Mean Percent Moisture and Total Fat Content for Selected Species (Continued)

Species	Moisture Content (%)	Total Fat Content (%)	Comments
Salmon, Pink	76.35	3.45	Raw
	69.68	4.42	Cooked, dry heat
	68.81	6.05	Canned, solids with bone and liquid
Salmon, Sockeye	70.24	8.56	Raw
	61.84	10.97	Cooked, dry heat
	67.51	7.31	Canned, drained solids with bone
Sardine, Atlantic	59.61	11.45	Canned in oil, drained solids with bone
Sardine, Pacific	66.65	10.46	Canned in tomato sauce, drained solids with bone
Scup	75.37	2.73	Raw
	68.42	3.50	Cooked, dry heat
Sea Bass	78.27	2.00	Raw
	72.14	2.56	Cooked, dry heat
Seatrout	78.09	3.61	Raw
	71.91	4.63	Cooked, dry heat
Shad, American	68.19	13.77	Raw
	59.22	17.65	Cooked, dry heat
Shark, mixed species	73.58	4.51	Raw
	60.09	13.82	Cooked, batter-dipped and fried
Sheepshead	77.97	2.41	Raw
	69.04	1.63	Cooked, dry heat
Smelt, Rainbow	78.77	2.42	Raw
	72.79	3.10	Cooked, dry heat
Snapper	76.87	1.34	Raw
	70.35	1.72	Cooked, dry heat
Spot	75.95	4.90	Raw
	69.17	6.28	Cooked, dry heat
Sturgeon	76.55	4.04	Raw
	69.94	5.18	Cooked, dry heat
	62.50	4.40	Smoked
Sucker, white	79.71	2.32	Raw
	73.99	2.97	Cooked, dry heat
Sunfish, Pumpkinseed	79.50	0.70	Raw
	73.72	0.90	Cooked, dry heat
Surimi	76.34	0.90	-
Swordfish	75.62	4.01	Raw
	68.75	5.14	Cooked, dry heat
Tilapia	78.08	1.70	Raw
	71.59	2.65	Cooked, dry heat
Tilefish	78.90	2.31	Raw
	70.24	4.69	Cooked, dry heat
Trout, Mixed Species	71.42	6.61	Raw
	63.36	8.47	Cooked, dry heat
Trout, Rainbow, Farmed	72.73	5.40	Raw
	67.53	7.20	Cooked, dry heat
Trout, Rainbow, Wild	71.87	3.46	Raw
	70.50	5.82	Cooked, dry heat
Tuna, Fresh, Bluefin	68.09	4.90	Raw
	59.09	6.28	Cooked, dry heat
Tuna, Fresh, Skipjack	70.58	1.01	Raw
	62.28	1.29	Cooked, dry heat
Tuna, Fresh, Yellowfin	70.99	0.95	Raw
	62.81	1.22	Cooked, dry heat
Tuna, Light	59.83	8.21	Canned in oil, drained solids
	74.51	0.82	Canned in water, drained solids
Tuna, White	64.02	8.08	Canned in oil, drained solids
	73.19	2.97	Canned in water, drained solids

Table 10-29. Mean Percent Moisture and Total Fat Content for Selected Species (Continued)

Species	Moisture Content (%)	Total Fat Content (%)	Comments
Turbot, European	76.95	2.95	Raw
	70.45	3.78	Cooked, dry heat
Whitefish, mixed species	72.77	5.86	Raw
	65.09	7.51	Cooked, dry heat
	70.83	0.93	Smoked
Whiting, mixed species	80.27	1.31	Raw
	74.71	1.69	Cooked, dry heat
Wolffish, Atlantic	79.90	2.39	Raw
	74.23	3.06	Cooked, dry heat
Yellowtail, mixed species	74.52	5.24	Raw
	67.33	6.72	Cooked, dry heat
		SHELLFISH	
Abalone	74.56	0.76	Raw
	60.10	6.78	Coofed, fried
Clam	81.82	0.97	Raw
	63.64	1.95	Canned, drained solids
	97.70	0.02	Canned, liquid
	61.55	11.15	Cooked, breaded and fried
	63.64	1.95	Cooked, moist heat
Crab, Alaska King	79.57	0.60	Raw
	77.55	1.54	Cooked, moist heat
	74.66	0.46	Imitation, made from surimi
Crab, Blue	79.02	1.08	Raw
	79.16	1.23	Canned
	77.43	1.77	Cooked, moist heat
	71.00	7.52	Crab cakes
Crab, Dungeness	79.18	0.97	Raw
	73.31	1.24	Cooked, moist heat
Crab, Queen	80.58	1.18	Raw
	75.10	1.51	Cooked, moist heat
Crayfish, Farmed	84.05	0.97	Raw
	80.80	1.30	Cooked, moist heat
Crayfish, Wild	82.24	0.95	Raw
	79.37	1.20	Cooked, moist heat
Cuttlefish	80.56	0.70	Raw
	61.12	1.40	Cooked, moist heat
Lobster, Northern	76.76	0.90	Raw
	76.03	0.59	Cooked, moist heat
Lobster, Spiny	74.07	1.51	Raw
	66.76	1.94	Cooked, moist heat
Mussel, Blue	80.58	2.24	Raw
	61.15	4.48	Cooked, moist heat
Octopus	80.25	1.04	Raw
	60.50	2.08	Cooked, moist heat
Oyster, Eastern	86.20	1.55	Raw, farmed
	85.16	2.46	Raw, wild
	85.14	2.47	Canned
	64.72	12.58	Cooked, breaded and fried
	81.95	2.12	Cooked, farmed, dry heat
	83.30	1.90	Cooked, wild, dry heat
	70.32	4.91	Cooked, wild, moist heat

Table 10-29. Mean Percent Moisture and Total Fat Content for Selected Species (Continued)

Species	Moisture Content (%)	Total Fat Content (%)	Comments
Oyster, Pacific	82.06	2.30	Raw
	64.12	4.60	Cooked, moist heat
Scallop, mixed species	78.57	0.76	Raw
	58.44	10.94	Cooked, breaded and fried
	73.10	1.40	Steamed
Shrimp	75.86	1.73	Raw
	75.85	1.36	Canned
	52.86	12.28	Cooked, breaded and fried
	77.28	1.08	Cooked, moist heat
Squid	78.55	1.38	Raw
	64.54	7.48	Cooked, fried

Source: USDA, 2007.