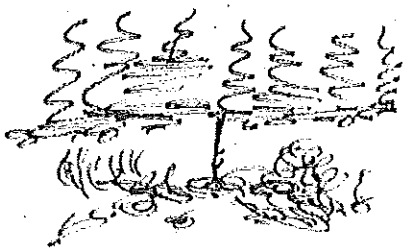

Statistical Analysis of National and Washington State Fish Consumption Data

DRAFT

September 18, 2012

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The Mountain-Whisper-Light Statistics

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EXECUTIVE SUMMARY

Purpose

This report is provided to the Washington Department of Ecology ("Ecology") through an interagency agreement with the University of Washington. Ecology requested the analysis described here to assist in responding to comments related to the statistical analysis of various surveys related to fish consumption rates for populations of fish consumers in Washington State.

From dietary survey data, this report provides fish consumption rates for these regional populations and the general U.S. population. Percentile values for each surveyed population are provided, and the data is arranged to include information about harvest location and species groups. Individual level data is used where it is available; otherwise data is directly from the original publications.

Because Washington has not had a published population-based survey for the general population, the general U.S. population is considered as a potential surrogate for the general population of Washington. The analysis in this report of the U.S. general population uses data directly from the 2003-2006 National Health and Nutrition Survey (NHANES) database and employs statistical methodology developed by the National Cancer Institute (NCI).

In this report we calculate fish consumption rates for the following populations:

- United States population
- Tulalip Tribes
- Squaxin Island Tribe
- Suquamish Tribe
- Columbia River Tribes: Nez Perce, Umatilla, Warm Springs and Yakima Tribes
- Asian and Pacific Islanders residing in King County

Methods

The data are all derived from sample surveys. The reported rates (in grams/day—g/day) are limited to fish consumers only. Consumers are defined in terms of consumption of the species group considered. Consumption rates are presented, when available, for all species (fish and shellfish combined), for non-anadromous species, for shellfish, and for finfish. These categories of species are also, when possible, broken down into consumption rates for fish obtained from all sources, as well as for fish harvested from Puget Sound, from the Columbia River, or just "harvested."

In general the mean, median and 95th percentile rates are presented for most of the populations and by categories of fish species and source of fish consumed. Other percentiles are presented for some populations.

Data on consumption rates at the level of individual respondents was available only for the U.S. population (from the NHANES database) and for the Tulalip Tribes. For other populations some of the consumption rates have been

previously calculated for consumers only from data at the individual level and reported, and those rates are included here, when available. When not simply transcribed from other reports, the rates have been computed by various methodologies starting from published aggregated rates (means and percentiles). The different surveys and their published reports required different methodologies. The varying methodologies are described briefly in the report, with details provided in the appendices. Those who are interested should be able to reproduce most of the rates presented in this report. Note, however, that in order to calculate some of the rates, access to the original, individual-level data ("raw" data) would be needed. In addition, reproduction of rates calculated by the "NCI method" would require some statistical knowledge and knowledge of the SAS programming language.

For the reader who is interested only in the numeric rates, the appendices can be skipped. The appendices are important for a fuller understanding of various issues in estimation of consumption rates.

Throughout the report the term "fish" refers to both finfish and shellfish combined, unless noted otherwise.

Results

Some key rates presented in this report appear in Table E-1. Rates are provided for the U.S. general population using two methodologies; the approach provided in the EPA Exposure Factors Handbook (EFH), and the approach provided by the NCI method. All results are presented by species groups; regional data is further segmented by source to account for local harvest.

The rates span a wide range. The median consumption rates for all species combined and from all sources vary from a low of 12.7 g/day (USA population) to a high of 132.1g/day (Suquamish Tribe.) These two populations also have the lowest and highest 95th percentile rates, respectively. Among the consumption rates for locally harvested fish the Native American Tribes have the highest consumption rates (with the highest median of 57.5g/day occurring from the Suquamish Tribe). The lowest median rate for harvested fish is 6.5 g/day for the Asian and Pacific Islanders (API), due to their low proportion of harvested fish.

Other rates are presented in tables of the results section and a number of rates are summarized in Appendix 1.

Table E-1. Fish consumption rates (g/day), consumers only, for adults (age 18+), by population, species group and source of fish consumed. Mean and selected percentiles.

Population	Species	Source	N	Mean	50%	90%	95%
USA/EFH	All	All	2,853	56	37.9	127.9	168.3
USA/EFH	Finfish	All	2,200	49.9	34.6	115.3	149.8
USA/EFH	Shellfish	All	1,113	43	25.7	100.5	146.6
		All					
USA/NCI	All fish	All	6,465	18.8	12.7	42.5	56.6
USA/NCI	Finfish	All	6,465	14	9	31.8	43.3
USA/NCI	Shellfish	All	6,465	5.4	2.4	13.2	20.5
		All					
Tulalip Tribes	All	All	73	82.2	44.5	193.4	267.6
Tulalip Tribes	Finfish	All	72	44.1	22.3	109.6	203.9
Tulalip Tribes	Shellfish	All	61	42.6	15.4	112.9	140.8
Tulalip Tribes	Non-anadromous	All	71	45.9	20.1	118.4	150.6

Population	Species	Source	N	Mean	50%	90%	95%
Tulalip Tribes	Anadromous	All	72	38.1	16.8	92.1	191.1
Tulalip Tribes	All	Puget Sound	71	59.5	29.9	138.5	237.4
Tulalip Tribes	Finfish	Puget Sound	71	31.9	13	78.4	145.8
Tulalip Tribes	Shellfish	Puget Sound	53	36.9	14.2	111.4	148.3
Tulalip Tribes	Non-anadromous	Puget Sound	59	35.5	14.8	109.2	145
Tulalip Tribes	Anadromous	Puget Sound	70	30.4	11.8	66	148.2
Squaxin Island Tribe.	Anadromous	All	117	55.1	25.3	128.2	171.1
Squaxin Island Tribe.	Shellfish	All	86	23.1	10.3	54	83.6
Squaxin Island Tribe.	Finfish	All	117	65.5	31.4	149.7	208
Squaxin Island Tribe.	All fish	All	117	83.7	44.5	205.8	280.2
Squaxin Island Tribe.	Non-anadromous	All	NA	28.7	15.2	70.5	95.9
Squaxin Island Tribe.	Anadromous	Puget Sound	NA	44.1	20.2	102.5	136.8
Squaxin Island Tribe.	Shellfish	Puget Sound	NA	14.3	6.4	33.5	51.9
Squaxin Island Tribe.	Finfish	Puget Sound	NA	45	21.6	102.8	142.9
Squaxin Island Tribe.	All fish	Puget Sound	NA	56.4	30	138.6	188.6
Squaxin Island Tribe.	Non-anadromous	Puget Sound	NA	12.3	6.5	30.3	41.2
Columbia river	All	All	464	63.2	40.5	130	194
Columbia river	Non-anadromous	All	NA	32.6	20.9	67	99.9
Columbia river	Anadromous	All	NA	30.6	19.6	63.1	94.1
Columbia river	All	Col. R.	NA	55.6	35.6	114	171
Columbia river	Non-anadromous	Col. R.	NA	28.6	18.4	58.9	87.9
Columbia river	Anadromous	Col. R.	NA	27	17.3	55.5	82.8
Suquamish Tribe	All	All	92	213.9	132.1	489.0	796.9
Suquamish Tribe	Anadromous	All	92	48.8	27.6	132.7	172.0
Suquamish Tribe	Non- anadromous	All	89-91	168.7	101.9	377.3	614.9
Suquamish Tribe	Shellfish	All	91	134.2	64.7	363.4	615.4
Suquamish Tribe	All	Puget Sound	91	165.1	57.5	396.7	766.7

Population	Species	Source	N	Mean	50%	90%	95%
Suquamish Tribe	Anadromous	Puget Sound	89-91	38.6	21.8	104.8	135.9
Suquamish Tribe	Non- anadromous	Puget Sound	89	125.6	49.1	379.8	674.1
Suquamish Tribe	Shellfish	Puget Sound	89-91	108.7	52.4	294.4	498.5
API	All	Harvested	125		6.5	25.9	58.8
API	Non-anadromous	Harvested	112		6.2	37.9	54.1
API	All	All	202		74	226.9	286.1

Notes. USA/EFH: USA rates calculated using the methods of the Exposure Factors handbook (EPA, 2011.) USA/NCI: USA rates calculated using the NCI method.

NA: not available or data needed for computation not available.

Discussion

The rates are dependent on survey and analysis methodology.

One persistent issue in defining rates for "consumers only" is the issue of who is a consumer. These definitions have varied from a definition of a consumer as a person who reported consuming fish on either of two specified survey days to a definition of everyone as a fish consumer—varying only in amount—to a definition of a consumer as a person who reports eating fish during some defined or undefined past period. These definitions do have an impact on the consumption rates; this report includes discussion on the impact of the "consumer" definition. In using the national data we have been able to screen out those who are likely to be self-reported fish non-consumers. All others are regarded as consumers. After screening out non-consumers, we applied the "NCI methodology" (Tooze, 2006), developed for determining consumption rates for episodically consumed foods, to national fish consumption data to obtain the mean and percentiles of fish consumption rates.

The consumption data for individual respondents has not been modified in any way, nor have data been deleted. There is no evidence that any individual consumption rate encountered was impossible. There may be consumption rates that might be considered outliers, but there was no basis for removing or modifying them.

The rates for the USA population may be considered as a surrogate for Washington State general population rates. This is a plausible working assumption, but it is only an assumption. The differences between the two populations should be noted. The national data used for the USA rates covers coastal as well as non-coastal states and includes states with many vs. few fishing opportunities. It may be possible in the future to use a subset of the national data to calculate rates for states that have fishing and harvesting opportunities more similar to those in Washington than the national data provide.

Acknowledgments

We would like to thank the participants in the surveys who supplied data for us to use. Surveys are time-consuming, and openness by the respondents is needed. We thank the many people who have trusted the survey process and have taken the time to share personal information about fish consumption and other aspects of their lives. We also thank the staff members whom we contacted from the Environmental Protection Agency (EPA) and the National Cancer Institute (NCI) and the statisticians and scientists who developed the "NCI method." These people all generously shared their time and experience with us. Finally, we wish to thank the many persons from diverse sectors of the public who offered comments in response to the technical support document that was issued in 2011 by WDOE (WDOE, 2011.) We reviewed all of these comments for issues that might be relevant to the statistical analysis presented in this report. We do feel that we were able to do a better job by having the opportunity to read the many comments. Any remaining errors in this report belong to the authors and not to any of the people or sources that were consulted.

INTRODUCTION AND BACKGROUND

Purpose of this Report

The purpose of this report is to provide calculations of fish consumption rates from dietary surveys conducted in Washington State and of the general U.S. population. Mean, median, 75th, 80th, 85th, 90th, and 95th percentile values for each surveyed population are provided; information about harvest location and species groups are included. This fish dietary information is to assist the Washington Department of Ecology (Ecology) in responding to comments received on the September 2011 draft of Ecology's Fish Consumption Rate Technical Support Document V.1 (publication number 11-09-050).

This report will assist Ecology in responding to the following technical issues:

- Provide information from regional specific fish dietary surveys on harvest location and species groups consumed (finfish, shellfish, anadromous, or non-anadromous) for adult fish-consuming populations in Washington.
- Using current national fish dietary information (the 2003-2006 NHANES data), provide general population fish consumption rates that statistically correct for problems with estimates derived directly from surveys of consumption on specified days .

The work in preparing this report has been commissioned by the Washington Department of Ecology (Ecology) through an interagency agreement with the University of Washington. Ecology requested this report to assist in responding to comments related to the statistical analysis of various surveys related to fish consumption rates for populations of fish consumers in Washington State.

Organization of this Report

The report follows the IMRD ("imred') pattern commonly used in scientific journals, with Introduction, Methods, Results and Discussion sections. The distinction between the methods and results sections here is not strict, because some numerical results need to be presented in the methods section to clarify the use of methods. To assist with readability methodological details have been placed in the appendices. Calculated rates are presented in the results section.

Fish Consumption Surveys

The fish consumption rates in this report are calculated from population surveys. The populations include the general United States population, specified Pacific Northwest tribal populations, and Asian and Pacific Islander populations living in King County.

Specifically, the fish consumption rates presented in this report are calculated from the surveys of the following six populations (with primary report references noted.)

- United States population (National Center for Health Statistics, 2005)
- Tulalip Tribes (Toy, 1996)
- Squaxin Island Tribe (Toy, 1996)
- Suquamish Tribe (The Suquamish Tribe, 2000)

- Columbia River Tribes: Nez Perce, Umatilla, Warm Springs and Yakima Tribes[1] (CRITFC, 1994)
- Asian and Pacific Islanders residing in King County (Sechena, 1999; Sechena, 2003)

The fish consumption rates derived from (a) regional specific fish dietary surveys and (b) general U.S. population fish consumption estimates from national surveys come from data obtained by asking questions of two different types of populations.

- The regional specific fish dietary surveys estimate fish consumption from Pacific Northwest populations that regularly consume fish. These are the tribal populations and Asian-Pacific Islanders.
- The population surveyed for the national fish consumption estimates is the entire U.S, population, and participants are sampled from many geographic areas in a manner that allows calculation of unbiased rates for the entire U.S. population.

Fish Consumption Rates Technical Support Document

A great deal of information about fish consumption surveys can be found in a draft Technical Support Document (TSD) available from the Washington Department of Ecology (Fish Consumption Rates Technical Support Document V 1.0, pub no 11-09-050, Washington Department of Ecology, 2011.)

This report does not repeat that information. The analysis in this report was prepared specifically to assist in addressing questions arising from public comments submitted on the draft TSD.

Exposure Factors Handbook

There are a number of reports of fish consumption rates. Prominent among them is the recently updated Exposure Factors Handbook (EPA, 2011). Chapter 10, *Intake of Fish & Shellfish*, of the Exposure Factors Handbook presents a number of fish consumption rates.

Particularly relevant to this the discussion in this report are Tables 10-8, 10-10, 10-12, which present consumer-only fish consumption rates derived from the National Health and Nutrition Examination Survey (NHANES). The NHANES data is used in this report to estimate U.S. national adult consumption rates.

When using data from fish consumption surveys it is not always possible to exactly match a survey and its derived consumption rates with a specific population. There is simply not a fish consumption survey covering every population of interest in Washington State or in the United States. Thus, those using fish consumption rates need to make a choice among available rates, taking into account the goodness of the match of the survey to the population of interest.

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[1]The calculated consumption rates and other statistics in the published report represent the combined Columbia River tribes.

Definition of Consumer

Fish consumption estimates can be derived either for all people (whether or not they consume fish) or for fish consumers only. It is important to define who is a fish consumer in the context of the surveyed population. Estimates of regional specific and national fish consumption cited in this report are based on different definitions of fish consumers, and fish consumption rates vary depending on how consumers are defined.

When looking at national data, this report provides information using two definitions of consumer. First, national fish consumption estimates are based on a definition of fish consumers as persons who, over an extended period of time, have a non-zero usual (average) daily intake of fish. Second, national fish consumption estimates are also provided for people who consume fish on either one or both of the two non-consecutive days surveyed.

National fish dietary information is based on the 2003-2006 National Health and Nutrition Survey (NHANES). As noted, estimates of fish consumption may vary depending on how a fish consumer is defined, and the two definitions (categories) of fish consumers both are applied to the NHANES dietary information for the U.S. population.

A third category consists of surveys that asked questions about usual consumption habits. The identified surveys of Native American Tribes in Washington and of the Asian and Pacific Islander populations in King County, Washington, included direct questions on usual fish consumption and other dietary information that provided data for calculation of estimated usual daily fish consumption.

It is important to note that for all surveys the consumption data are reported from each respondent's memory. Thus, all the surveys are subject to errors of memory and other types of survey reporting errors. Nevertheless, these data provide an informative picture of what fish people eat, both in terms of quantity and types of fish.

Populations, Samples, Statistical Models

This report includes some fish consumption rates estimated directly from data representing consumption by individuals ("individual level data"). Other rates have been estimated using published tabulations of means, medians or other percentiles of rates. Yet other rates have been estimated by fitting a model to data on fish consumption at the individual level. (See Table 1.)

As discussed later in this report, one cannot say that one method is specifically superior to the others. Each of the methods for analyzing the data has merits and limitations.

Table 1 shows which methodology was used to estimate rates for each of the different populations included in this report. For some of the populations, individual-level data were available for use in calculating rates and summary statistics; otherwise published tabulations were used.

For example, fish consumption rates for the Squaxin Island Tribe have been calculated and published (Polissar, 2006) for consumers only for fish obtained from any source (harvested, purchased, etc.). However, in order to estimate the Squaxin Island Tribe's consumption rates for fish harvested from Puget Sound, the calculations in this report used the published mean percentages of fish harvested from Puget Sound from various species groups (Toy, 1996, Table 11.)

Table 1. Source of data used for estimating means, medians or percentiles of fish consumption rates

Population	Individual level data	Published Tabulations	Modeling
United States population	X		X
Tulalip Tribes	X		
Squaxin Island Tribe		X	
Suquamish Tribe	*	X	
Columbia River Tribes		X	
Asian and Pacific Islanders		X	

*Includes some rates calculated from individual-level data

This report does not use the fish consumption rates presented in an earlier report by EPA (EPA, 2002.) That report calculated consumption rates for consumers only using a method that is quite different than the methods used to calculate any of the rates presented in this report.[2]

METHODS AND DATA

This report was prepared with consumption rates for "consumers only" as opposed to rates calculated by including both consumers and non-consumers, referred to as a "per capita" rate. The definition of a fish "consumer" can vary. Our preferred definition of consumer is one whose usual (average) daily intake over an extended period (e.g., one year) is not zero. It may be very low, but it is not zero.

This report uses that definition unless another definition is noted. Some dietary surveys explicitly include questions on how frequently fish are consumed during a specified period, such as a year, or include questions on "usual consumption."

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[2] In the EPA 2002 report, "consumer" and the rate associated with a consumer, was defined as follows (EPA 2002, section 2.2.2.):

"For the purpose of this report, "consumers only" were defined as individuals who ate fish at least once during the 2–day period...."

"If an individual was included in the set of "consumers only," the average daily consumption for that individual was determined using only data from those days when total consumption was greater than zero. For example, if fish was consumed on only one of the two days, the total consumption for the given fish–by–habitat type on that one day was considered the average daily consumption for that individual."

Based on this definition in the EPA, 2002, report, the following consumption rates would be calculated from the noted day 1, day 2 fish consumption rates (FCR.) *Example 1*, day 1 FCR = 0g/kg body weight; day 2 FCR = 2g/kg body weight; consumption rate by the EPA, 2002, method: 2g/kg-day. *Example 2*, Day 1 FCR = 2g/kg, day 2 FCR = 2g/kg; consumption rate by the EPA, 2002, method: 2g/kg-day. *Example 3*, Day 1 FCR = 0g/kg; day 2 FCR = 0g/kg; this person would be considered a non-consumer and would not be included in a "consumer-only" calculation.

The surveys of Native American Tribes whose rates are reported here use this "usual consumption" approach. Other surveys record fish consumption on specified days. Consequently, the definition of who is a consumer may depend on the survey timeframe.

The fish consumption rates for the general population, consumers only, in the most recent (2011) edition of the Exposure Factors Handbook (EPA, 2011) are based on the National Health and Nutrition Examination Survey (NHANES) two-day dietary recall survey. The definition of a fish consumer used in the Handbook is a person who consumed fish on at least one of the two days, and the consumption rate attached to that person is the average consumption for the two days.[3]

NHANES included self-reported food consumption for two specified days, plus a food frequency questionnaire (FFQ) embedded in the survey. The FFQ asked the participants how frequently they ate certain types of food over the past 12 months. If a person answered "never" to all fish consumption questions of the FFQ, the answers are probably adequate to distinguish consumers from non-consumers. (See also Appendix 2.)

Source of Fish Consumed

Knowledge of the fraction of fish consumption that comes from local harvesting is important. Some of the surveys covered in this report do have that kind of information. For the U.S. general population (and for the Washington State general population) there is not data available on the fraction of fish consumed that comes from local harvesting.

Two Types of Questionnaires on Fish Consumption

The two types of survey questionnaires that form the basis for fish consumption rates presented in this report are:

- 24-hour dietary recall, covering the specific food items, and their quantity, eaten on each of two specified days (NHANES survey). (The NHANES survey included a food frequency questionnaire, but not in a form that could be used, alone, to estimate fish consumption rates. It is useful, however in defining fish non-consumers.)
- Food frequency questionnaires—directed at long term or usual fish consumption frequencies—combined with questions on amount eaten per eating occasion (Tulalip Tribes, Squaxin Island Tribe, Suquamish Tribe, Columbia River Tribes, Asian and Pacific Islanders).

NHANES Survey

NHANES is an ongoing national sample survey of the United States population (NCHS, 2005) from which this report uses data collected during the years 2003 to 2006. This survey can be used to estimate food consumption rates for the entire United States population.

The NHANES survey was conducted in clusters of counties (or single large counties or metropolitan areas). Part of the survey was administered by questionnaire and part of it through self-reporting. Specifically, for the two days'

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[3] See Section 10.1, Introduction, Page 10-1 of the Exposure Factors Handbook (EPA, 2011.) "The general population studies in this chapter use the term consumer-only intake when referring to the quantity of fish and shellfish consumed by individuals during the survey period. These data are generated by averaging intake across only the individuals in the survey who consumed fish and shellfish."

intake portion of the survey, the first day's data was collected by interviewers directly on site (within dwellings), while the intake for the second day was collected by telephone followup. [4]

In this report the analysis of rates based on the NHANES survey is limited to persons age 18 and over. This age cut is a common definition of "adult," though it is not uniformly followed in other surveys.

EPA Dietary Analysis Methods

Our analysis of fish consumption from the NHANES database is based on important and innovative work by EPA's Office of Pesticide Programs. EPA carried out an extensive exercise of converting named food items (for example, pizza, Caesar dressing.) into standardized recipes. This enabled specifying the commodities that are components of those recipes. Thus, for each consumed food item named by survey respondents in the NHANES survey, EPA provides a corresponding recipe with known ingredients.

EPA then grouped individual ingredients into several hundred "commodity" groups, including six categories of fish or shellfish. Other examples from the EPA's long list of commodities include wheat flour, tomato puree and olive oil.[5] The EPA work enabled the survey respondents' list of food items eaten in each 24-hour recall period to be converted to quantities of fish and other food commodities.

The extensive EPA work to develop the conversion from conventionally named food items to commodities captures even small quantities of fish in a nominally non-fish dish. For example, the food "Dark-green leafy vegetable soup with meat, Oriental style," is itemized by the EPA for a 91 gram serving (a fifth of a pound) and includes 0.12 grams of fish, or 0.13% by weight.

It seems likely that such low levels of fish consumption occur due to seasoning or other incidental (perhaps even unaware) usage of fish products by the consumer. It also seems that for most "sparse-fish" consumption days the source of small quantities of fish would not be a local harvest of fish or shellfish. It is more probable that the fish ingredient might arise from a commercial product with a non-local source.

One of the goals of this report is to estimate consumption of locally harvested fish or shellfish. The trace quantities of fish consumed on some of the days or as an average for two days in the NHANES survey probably originates from non-local sources.

A listing of fish-containing food items which were consumed on days where the respondent consumed less than 1 g of fish (total) shows, predominantly, various types of cheese spread and Caesar dressing. It seems unlikely that these items are created from locally harvested fish.

These "sparse-fish" consumption items and days have been retained in the analysis, even though it is likely that they are not from local harvest. Only a small percentage of fish-consuming respondents had consumption days with less than 1g/day.

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[4] NHANES dietary documentation (2003): http://www.cdc.gov/nchs/nhanes/nhanes2003-2004/DR1IFF_C.htm

[5] The following link allows exploration of the commodities itemized for each recipe: http://fcid.foodrisk.org/recipes/

The fish consumption rates based on the NHANES data use the following six commodities:[6]

- Fish-freshwater finfish
- Fish-freshwater finfish, farm raised
- Fish-saltwater finfish, other
- Fish-saltwater finfish, tuna
- Fish-shellfish, crustacean
- Fish-shellfish, mollusk

Survey Estimates of Fish Consumption Rates

We have calculated USA adult fish consumption rates from the NHANES data using two methods.

The first method, based on standard survey statistical methodology and a particular definition of "consumer", was used by the EPA in presenting NHANES fish consumption rates in the Exposure Factors Handbook (Chapter 10, 2011). Table 10-8; 10-10 and 10-12 of that report presents estimated rates, for fish consumers only, for the entire population of the USA and also broken down by various age, gender and ethnic groups. The definition of "consumer" used for calculation of rates presented in those tables is a person who consumed fish on at least one of the two days of the NHANES survey[7]. Using that definition we calculated the consumption rates for adult consumers only (age 18 and over) with two days reported on the 24-hour dietary recall.[8] The second method employs the National Cancer Institute (NCI) methodology for episodically consumed foods.

The NHANES survey includes data on what people ate on two selected days—chosen far enough apart to assure some level of independence of consumption on these days. While this method has the merit of capturing consumption before it fades from memory, it does not accurately portray consumption of foods that are consumed episodically, such as fish. This accuracy problem can be seen from Table 2 which compares the response to a) direct questions on the frequency during the past 12 months of eating certain food items that contain fish to b) the recall of consumption on two specified days.

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[6] Source for categories of fish commodities: http://fcid.foodrisk.org/dbc/csv/

Download file: Commodity_Vocabulary.csv

[7] Personal communication: teleconference with staff of Office of Pesticide Programs, EPA, May 1, 2012

[8] Prior to carrying out these calculations, we verified that we had the correct data from NHANES and the correct computational method by calculating, comparing and reproducing exactly the fish consumption rates in the first numeric row of results in Table 10-12 of Chapter 12 of the Exposure Factors Handbook. (EPA, 2011.)

Table 2. A comparison of fish consumption reported by dietary recall on two specified days vs. fish consumption reported for the last year on a food frequency questionnaire (FFQ).

Frequency of fish consumption as reported on the FFQ	N adults	Zero fish was consumed on both days (%)	Fish was consumed on at least one day (%)	Total (%)
Never	680	88%	12%	100%
Ever	6,465	66%	34%	100%
All adults	7,145	68%	32%	100%

Notes: 1) FFQ responses on fish consumption were categorized into "never" vs. any frequency greater than "never" (i.e., ever) in the last 12 months. 2) Percentages are based on counts of adult respondents. 3) Limited to adults, age 18 and over, who responded to both the food frequency questionnaire (FFQ) and the two 24-hour recall questionnaires on the NHANES survey, 2003-2006. 4) The five relevant fish consumption questions from the FFQ are numbered FFQ0091-FFQ0095. See Appendix 2. Download full questionnaire from: riskfactor.cancer.gov/diet/FFQ.English.June0304.pdf

Table 2 shows that a large proportion (about two-thirds) of those who did report ever eating fish on the FFQ did not report fish consumption on either of the sampled recall days. This information implies that many "true" fish consumers are among those with no consumption reported on either of the two 24-hour recall days. Using the 2-day reporting to identify fish consumers and their consumption rates introduces false negatives: true consumers who did not happen to report eating fish on either of the recall days.

Also of interest is the 12% of adults who reported never eating fish on the food frequency questionnaire but who did report some fish consumption on at least one of the two recall days.[9] While it appears that there is misclassification in both directions when the FFQ and the 24-hour recall days are compared, it appears safe to exclude from our further analysis of fish consumption rates from NHANES data those adults who reported "never" in response to the five fish consumption questions on the FFQ. These five questions collectively include any possible form of fish or shellfish consumption. Exclusion of these survey participants removes a relatively small number of true fish "consumers" from our analysis dataset, but it is also likely to remove a much larger number of true non-consumers. For this reason the exclusion is likely to have a net effect of improving accuracy of the estimated fish consumption rates.

A second issue that it is important to understand when using the NHANES data is that the fish consumption reported for two recall days is not an accurate indication of usual intake amount. Consumers of fish do not eat the same quantities of fish every day. The large number of fish consumers (identified by the FFQ) who consumed fish on only one of the two days is an indication of this variation over time. And, even among those who did eat fish on two days, the amount eaten varies greatly between the days.

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[9] This small "inconsistent" group (82 adults) had average consumption rates similar to the "consistent" group (those who reported eating fish both on the food frequency questionnaire and on the 24-hour recall days.) The mean two-day fish consumption rates for the inconsistent and consistent fish consumers were 46.7 g/day and 54.1 g/day, respectively, with medians of 34.3 g/day and 37.6 g/day, respectively. These averages are based on adults with two days available for the 24-hour dietary recall and a non-missing response on the food frequency questionnaire.

Figure 1 shows a comparison of amount of fish eaten on the two days of recall for those adults who consumed fish on both days. Each point represents one survey adult.

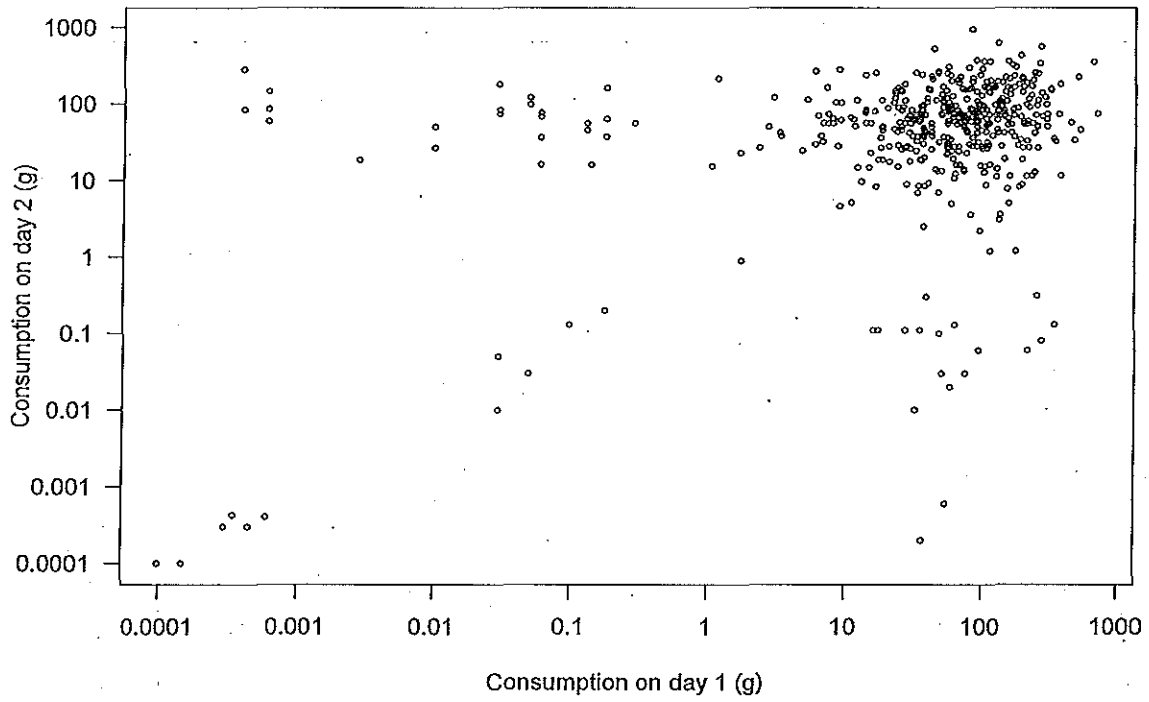

Figure 1. Scatterplot of day 1 vs. day 2 fish consumption amounts (grams) from 24-hour dietary recall

Notes: NHANES 2003-2006. Includes N = 466 adult respondents with non-zero fish consumption on both recall days and a non-missing response to the five relevant fish consumption questions on the food frequency questionnaire.

Figure 1 shows that it would not be uncommon to have a 10-fold change in fish consumption when two days are compared. For example, a number of points represent people who consumed 10 grams on one day and 100 grams on another day. (See points in the figure located above 10 grams on the day 1 horizontal axis and across from 100 grams on the day 2 vertical axis.)

Trace quantities of fish

Figure 1 also shows the adults who consumed minuscule quantities of fish on some days. Note the scattering of points that are below 1 gram on either or both days. These points may represent people who consumed fish which was present in small quantities in a nominally "non-fish" food item, such as Caesar salad dressing or cheese spread. An example is a respondent whose sole consumption of fish on one of the consumption days was 0.03 grams from Caesar salad dressing.[10]

[10] The respondent with sequence i.d. number 24231 consumed 0.03 grams of fish on day 2 from Caesar dressing.

National Cancer Institute (NCI) Methodology

Professor Janet Tooze and others have developed a methodology for estimating the usual intake of episodically consumed foods, such as fish (Tooze et. al., 2006; Dodd, et al, 2006; Kipnis et. al., 2009; Keogh, 2011). This methodology addresses the day-to-day variation in reported consumption and also addresses the occurrence of non-consumption days for those who are true consumers. The NCI method, based on the work of Tooze et al, has been used to estimate consumption of a wide variety of dietary components. The National Cancer Institute web site shows consumption rates for 39 food groups based on the NCI method applied to data from the NHANES survey, 2001-2004.[11]

The NCI method fits a model for usual intake (grams/day) of a commodity, such as fish, based on data from a survey with reported consumption on two or more days.[12] The mean and percentiles of consumption are estimated from the distribution of usual intake, which is part of the fitted model. The model assumes:

1) There is an underlying distribution of true usual intake for the population being studied. The true intake for a given person might be thought of as their average daily intake—averaged over the course of a year, often reported as grams per day. The usual intake for a person does not have the ups and downs that occur with intake for any given day; the usual intake is a single number for each person. This usual, average or "true" intake would typically vary from person to person in the population. The set of values of usual intake would typically have relatively few people at very low or very high values of intake and relatively more people in between.

The set of usual intake values for a population do not have to be a "bell-shaped curve," but the true distribution, it is assumed in the NCI methodology, can be transformed to the normal (bell curve) distribution in a fairly flexible manner, specified by the methodology. (We note that fish consumption distributions tend to be skewed toward large consumption values and can often be approximated by the lognormal distribution; this phenomenon is consistent with the "transformation-to-the-bell-shape" assumption here.)

2) There is day to day variation in how much a person consumes of a commodity—on days when they do consume. The daily consumption varies around their usual intake.

3) There is a certain probability that a person will consume on any given day, and this probability can vary from person to person. For example, there can be frequent and infrequent consumers of fish.

4) There may be a correlation between consumption rate and the frequency of consumption. For many foods, those people who consume the food more frequently also consume more of it on the actual consumption day (Tooze et. al. 2006).[13]

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[11]The consumption rates for various food groups are tabled at: http://riskfactor.cancer.gov/diet/usualintakes/pop/ The tables do include fish consumption, but not in the form needed for this project.

[12] The model requires data with two or more independent periods of observation, but the periods can be single days or any other unit of time, such as, for example, two 3-day periods.

[13] The positive correlation between frequency of consumption and consumption amount appears to be true for fish consumption among the USA adult population, as reflected in the NHANES 2003-2006

5) All survey respondents who are included in the analysis are assumed to be fish consumers. This includes the possibility that the consumption rate of some consumers may be very low—e.g., those who consumer fish only as it might appear in a condiment such as Caesar salad dressing. In using the NCI method in this report, survey respondents were excluded only if they reported on the food frequency questionnaire that they never consumed fish.

Additional notes on the NCI methodology are available in Tooze, 2006. An instructive webinar series featuring Dr. Tooze and others is available on the web.[14] The SAS statistical programming language code for carrying out the calculations using the NCI methodology is available online.[15]

Of note, the NCI methodology is used in this report only for estimation of consumption rates for the general population of the USA and not for the calculation of rates presented later in this report for the Native American Tribes and Asian and Pacific Islander (API) populations. The NCI methodology is suited uniquely to consumption information for episodically consumed foods collected for two or more specified days. In contrast, an extended food frequency questionnaire addressing usual (long-term) consumption was used in the Tribal and API surveys.

Fish Consumption Rates: Native American Tribal and Asian & Pacific Islander Surveys

The intent of all of the methodologies used in this report for the Tribal and API data analysis was to yield, when possible, consumer-only consumption rates for all species of fish and shellfish combined and for sub-groups of species, such as anadromous, non-anadromous and shellfish species. Further, for each species group, this report provides estimates of the consumption rates for fish obtained from all sources and then for fish obtained from local harvesting.

We have used varying methodology—depending on information and data available—for estimation of fish consumption rates for the Native American Tribes in Washington and for the Asian and Pacific Islander (API) Populations in King County. We describe the methodology specific to each population in the appendices.

In contrast to the NHANES data for the U.S. general population, the Tribal and API surveys queried usual or long-term consumption directly as part of the food frequency questionnaires. The NCI methodology has not been (and can

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survey. Those individuals who consumed fish on both dietary recall days had a mean of 98 g fish consumption per day. Individuals who consumed on only one day had a mean of 86g consumption on the consumption day—12 g (13%) less than the more frequent fish consumers. The rates reported in this footnote are survey-based estimates. Only individuals with two dietary recall days are included in the calculations. There were 619 two-day consumers (median, 79 g/day) and 3,587 single-day consumers (median, 57g).

[14] An excellent series of webinars, including a talk and materials by Dr. Tooze on the NCI method, are available at http://riskfactor.cancer.gov/measurementerror/ .

[15] The SAS code for implementing the NCI methodology is available at http://riskfactor.cancer.gov/diet/usualintakes/macros_single.html. It would be possible to start from the statistical theory behind the NCI method and develop programming code for its implementation in another statistical programming language instead of SAS. Considerable statistical expertise and time would be needed for such a venture.

not be) applied to Native American and API data, since there was not an assessment of consumption on two or more specified days .

In general, the Tribal and API fish consumption survey questionnaires included questions on frequency of consumption of particular species and on portion sizes consumed for the same species. Combining appropriate data on the frequency of consumption and the quantity consumed per eating occasion can yield an average consumption rate per day.

Among the consumption rates presented in this report for the Native American and API populations, only the fish consumption rates for the Tulalip Tribes were all calculated from individual-level data. For the other populations there was a need to start from previously tabulated and published survey means and percentiles. When a published tabulation had consumer-only mean and percentiles of consumption rates expressed in units of g/kg-day, we used the average body weight from the specific survey sample as a multiplier to yield means and percentiles in units of g/day. Similarly, if computations carried out for this report yielded a mean and percentiles of consumption in g/day for consumption from all sources, the report then presents consumption rates for harvested fish, when possible, by multiplying the all-sources rates by a percentage harvested value to yield a harvested consumption rate.

Treatment of Outliers

In one previous publication of rates for the Tulalip and Squaxin Island Tribes (Toy, et al, 1996) some rates for a small number of individual consumers were adjusted downward on the basis that they might be considered as outliers. In that report, the downward-adjusted rates were used in combination with rates for all other individuals for the calculation of means and percentiles. In a later publication of consumer-only rates for the Tulalips and Squaxin Island Tribes (Polissar, et al, 2006) the rates for all individuals were not adjusted in any way but were used "as is" for the calculation of means and percentiles. In the current report we follow the second approach (no adjustment.)

There are two reasons to leave the rates intact. First, even the largest consumption rates reported for these tribes and for other populations covered in the current report are plausible. They may be large, but there is no overriding reason to designate them as impossible.

The second reason that the rates have been left intact (with no adjustment for "outliers") is the potential for bias in any adjustment. Any consumption reported by an individual from memory may be reported too high, too low, close to, or right on the unknown true consumption value. Because the true value is unknown, it is impossible to designate any particular reported rate as "too high," "too low," or "accurate". If only the highest rates are adjusted downward, then the mean and the high-end percentiles calculated after such adjustments will be biased downward. Further, if individual rates are to be scrutinized, then every rate should be scrutinized. The rates that tend to attract attention, however, are the high rates. There may be other, lower rates that were reported too low relative to the unknown true rate. The rates that are buried amidst the general run of rates (say, those between the 10th and 90th percentiles) may have positive or negative errors (relative to "the truth"), but they generally do not attract attention or invite adjustment. Thus, our philosophy in this report is that, given the plausibility of all of the reported individual rates and the potential for bias in adjusting rates, the individual rates should be left intact.

Rates in other publications calculated from the tabulations in the original Tulalip Tribes and Squaxin Island report (Toy, et al, 1996) may differ from rates presented here due to the different handling of large consumption rates (potential "outliers") in this report compared to their treatment in the original report.

Surveys of Recreational and Subsistence Fishing

Fish consumption rates can also be derived from surveys of people who fish recreationally and for subsistence. These surveys, commonly called "creel surveys"[16], have been carried out at fishing and harvesting locations. The respondents in these surveys do not belong to a well-defined geographic or ethnic population, and, therefore, the consumption rates from these surveys have not been included in this report. Creel survey rates, however, may be informative in comparison to population-based rates.

Ecology's technical support document includes a substantial section (with references to the literature) on creel and recreational surveys (WDOE, 2011.) The document is scheduled to be updated in 2012.

Interpolation

In order to supply a complete set of rate percentiles we have sometimes interpolated between percentiles that were readily available. The goal was to provide the mean and the following percentiles for any given population and category of fish consumption: 50%, 75%, 80%, 85%, 90% and 95%. Some survey reports or our computations based on those reports (or computations by the NCI method) did not include percentiles of interest, such as 80% and 85%. In these cases we used bracketing known percentiles and interpolation to provide the missing percentiles.

The lognormal distribution provides a very good approximation to most fish consumption distributions (for consumers only). A plot of the log of percentiles from the lognormal distribution vs. the percentiles of the normal distribution yields a straight line. Thus, we interpolated between the logarithm of known percentiles to yield the log of the missing percentiles. The antilog of these values yielded the percentiles on the original scale (consumption in g/day.) The guide to linear interpolation was the set of percentiles from the standard normal distribution—corresponding to the relevant cumulative percentages: 50%, 75%, 80%, 85%, 90% and 95%. Thus, for example, to interpolate between the 75th and 90th percentile known fish consumption rates to derive the 80th percentile rate, the 75th, 80th and 90th percentiles from the standard normal distribution would be 0.674, 0.842, and 1.282, respectively. The interpolation procedure is equivalent to fitting a lognormal distribution to a small section of the distribution and anchoring it with the two known percentiles which bracket the missing percentile.

RESULTS

Fish Consumption Rates from the NHANES 2003-2006 Survey

This report presents fish consumption rates derived from the NHANES survey using two methodologies. First, we present consumption rates using only the data as collected (without any modeling) and standard survey estimation procedures based on the survey design. The method takes account of sampling weights, stratification and clustering. Second, we present estimates using the NCI method for handling episodically consumed foods. The method involves fitting a model to the data and obtaining estimates from the model; the method also takes account of survey design.

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[16] The name for this type of survey is derived from "creel," the wicker basket used for carrying newly caught fish.

Fish consumption rates, NHANES, 2003-2006, consumer defined only by *reported* consumption on two days

In this approach to estimating fish consumption, the rates very literally reflect the reported consumption on two specific days in the life of each respondent. As noted earlier, the NHANES survey has recorded consumption of fish-containing items and other foods during two designated reporting days for each survey respondent. The definition of consumer used in the EPA's Exposure Factors Handbook (EPA, 2011) is a person who consumed fish on either or both of the two days. The rates in Table 3 are based on that definition but they are calculated from survey respondents age 18 and over. Appendix 2 includes an analysis that is helpful in understanding the impact of that definition on estimated rates.

Table 3. Fish consumption rates (g/day) for adult consumers only, USA population, based on NHANES 2003-2006. "Consumers" defined based on two days of consumption.

Species	N	Mean	Min	50%	75%	80%	85%	90%	95%	99%	Max
All	2,853	56.0	<0.1	37.9	78.8	87.6	105.2	127.9	168.3	255.7	512.5
Finfish	2,200	49.9	<0.1	34.6	68.9	82.4	95.4	115.3	149.8	217.0	512.5
Shellfish	1,113	43.0	<0.1	25.7	54.4	63.0	75.0	100.5	146.6	249.6	384.0

Notes: 1) "Consumers" are defined as those who consumed fish on at least one of the two dietary recall days. 2) Limited to those with data for two dietary recall days. 3) The minimum and maximum rates are as recorded in the individual level data and are not products of the survey estimation procedure. 4) As input to the survey estimation procedure the fish consumption rate for an individual respondent is the mean consumption for the two reported days.[17]

Fish consumption rates based on the NCI method, NHANES, 2003-2006

The rates in Table 4 are based on application of the NCI method to data collected by dietary recall from two specified days in the NHANES 2003-2006 surveys.

As noted in the methodology section, above, this report does not include fish consumption rates based on the NHANES survey for consumption of locally harvested fish. The NHANES survey did not include questions whose responses would provide a basis for estimating the "local catch" proportion of consumed fish or, more directly, the consumption in grams per day of fish obtained from local habitats,

While this report does not provide an estimate of the consumption rate of locally harvested fish for the general adult population of Washington, a simple calculation related to fishing licenses may be of interest. The percentage of the adult population with fishing licenses might be considered informally in the discussion of consumption rates.

Using data supplied by the licensing division of the Washington Department of Fish and Wildlife (WDFW), population estimates from Washington's Office of Financial management, and (from NHANES data) the estimated fraction of the U.S. population who are fish consumers, the rate of licensing in Washington 2008 would have been an estimated 24 licenses (of persons age 15 or over) per 100 fish-consuming persons age 18 and over. If every person with a license

[17] E.g., if the two days of consumption yielded zero grams and 50 grams, respectively, the mean would be 25 grams/day. Similarly, a consumption pattern of (10 grams, 90 grams) for the two days would yield a mean of 50 grams/day.

has only one license, then this would be approximately the percentage of adults with fishing licenses. This is not an estimate of the percentage of consumed fish that are locally harvested,

Table 4. Fish consumption (g/day) estimated from NHANES 2003-2006 by the NCI method. Consumers only. Adults (age 18+). Mean and percentiles.

Species	N	Mean	Min	50%	75%	80%	85%	90%	95%	99%	Max
All fish	6,465	18.8	<0.1	12.7	24.8	28.9	34.5	42.5	56.6	90.8	941.2
Finfish	6,465	14.0	<0.1	9.0	18.1	21.2	25.5	31.8	43.3	72.7	941.2
Shellfish	6,465	5.4	<0.1	2.4	6.0	7.5	9.7	13.2	20.5	43.8	704.9

Notes: 1) Minimum and maximum values are from recorded survey data and are not estimated by the NCI method. 2) NHANES 2003-2006 data were restricted to those survey respondents with a) two days of data from the 24-hour dietary recall, b) non-missing data on the food frequency questionnaire, and c) some fish consumption reported on the food frequency questionnaire (i.e., at least one of the five fish consumption questions on the FFQ was not answered "never" for frequency of consumption.) 3) The current SAS software for the NCI method does not supply the 80th percentile values. The 80th percentile values reported here were estimated by interpolation between the NCI method's 75th and 85th percentile. Interpolation was carried out for log percentiles (followed by anti-log) with interpolation based on the standard normal deviates of 0.6745, 0.8416 and 1.0364 for the 75th, 80th and 85th percentiles, respectively.

Native American Tribes

Tulalip Tribes

Individual-level data were available by permission of the Tulalip Tribes. All reported consumption rates were derived directly from the individual level data.

Table 5. Consumption of various species groups of fish by the Tulalip Tribes, consumers only, g/day, by source of fish consumed: all sources or harvested from Puget Sound.

Species	Source	N	Mean	50%	75%	80%	85%	90%	95%	Max
All	All	73	82.2	44.5	94.2	119.6	141.5	193.4	267.6	710
Finfish	All	72	44.1	22.3	49.1	59.1	65.1	109.6	203.9	278.3
Shellfish	All	61	42.6	15.4	40.1	59.1	82.7	112.9	140.8	461.4
Non-anadromous	All	71	45.9	20.1	52.4	65.6	80.2	118.4	150.6	469.8
Anadromous	All	72	38.1	16.8	43.3	46.4	57.3	92.1	191.1	265.3
All	Puget Sound	71	59.5	29.9	75	79.4	122.6	138.5	237.4	450
Finfish	Puget Sound	71	31.9	13	33.1	42.4	55.4	78.4	145.8	236.7
Shellfish	Puget Sound	53	36.9	14.2	40.1	52.7	85.8	111.4	148.3	230.7
Non-anadromous	Puget Sound	59	35.5	14.8	38.8	48.7	67.6	109.2	145	233.8
Anadromous	Puget Sound	70	30.4	11.8	32.4	39.3	55.1	66	148.2	236.7

Squaxin Island Tribe

We used published results—not individual level data—to estimate the consumption rates for the Squaxin Island Tribe in Table 6. The calculations are described in Appendix 3. Appendix 4 includes an evaluation of the use of published fish consumption rates (as a starting point for calculations) vs. use of individual level ("raw") data.

Table 6. Consumption in g/day, Squaxin Island Tribe, consumers only, mean and percentiles, by species group and source.

Species	Source	N	Mean	50%	75%	80%	85%	90%	95%
Anadromous	All	117	55.1	25.3	65.8	79.0	97.9	128.2	171.1
Shellfish	All	86	23.1	10.3	23.9	29.9	38.8	54.0	83.6
Finfish	All	117	65.5	31.4	82.3	97.1	117.6	149.7	208.0
All fish	All	117	83.7	44.5	94.4	117.0	150.2	205.8	280.2
Non-anadromous	All	NA	28.7	15.2	32.3	40.0	51.4	70.5	95.9
Anadromous	Puget Sound	NA	44.1	20.2	52.6	63.2	78.3	102.5	136.8
Shellfish	Puget Sound	NA	14.3	6.4	14.8	18.5	24.1	33.5	51.9
Finfish	Puget Sound	NA	45.0	21.6	56.5	66.7	80.8	102.8	142.9
All fish	Puget Sound	NA	56.4	30.0	63.5	78.8	101.1	138.6	188.6
Non-anadromous	Puget Sound	NA	12.3	6.5	13.9	17.2	22.1	30.3	41.2

NA = not available or not computed

Columbia River Tribes

The 1994 report of a survey of Columbia River Tribes reports the mean and various consumption rates for all adult fish consumers (CRITFC, 1994, Table 10, pages 85-86.) The percentages presented in CRITFC Table 10 were derived from data that were statistically weighted to account for the relative sizes of the tribes. Our estimated consumption rates for the Columbia River tribes in Table 7, below, are derived from the results in CRITFC Table 10 and from other results in the report.

The CRITFC report gives percentages of consumers corresponding to each reported value of consumption (g/day.) For example, 6.5% (weighted percentage) of consumers were reported to consume 97.2 g/day. We used the specific individual consumption rates and their weighted percentages in CRITFC Table 10 to derive mean and percentiles of consumption using standard procedures for estimating the mean and percentiles from survey (weighted) data (Binder, 1991.) Other data in the CRITFC report were used to derive proportions of fish harvested from the Columbia River and other statistics needed to produce our various categories of fish consumption in Table 7 here. Details are in Appendix 3.

Table 7. Mean and percentiles of consumption rates (g/day) by species group and source, Columbia River Tribes, adult consumers only.

Species	Source	N	Mean	50%	75%	80%	85%	90%	95%	99%	Max
All	All	464	63.2	40.5	64.8	81.0	97.2	130	194	486	972
Non-anadromous	All	NA	32.6	20.9	33.4	41.7	50.1	67.0	99.9	250	NA
Anadromous	All	NA	30.6	19.6	31.4	39.3	47.1	63.1	94.1	236	NA
All	Col. R.	NA	55.6	35.6	57.0	71.3	85.5	114	171	428	NA
Non-anadromous	Col. R.	NA	28.6	18.4	29.4	36.7	44.1	58.9	87.9	220	NA
Anadromous	Col. R.	NA	27.0	17.3	27.7	34.6	41.5	55.5	82.8	207	NA

NA = not available or not computed

Suquamish Tribe

Estimates for consumption of Puget Sound-harvested seafood by fish consumers in the Suquamish Tribe in g/day are available for all fish (combined) and for all except anadromous fish in the following document: "Selected Suquamish Tribe Seafood Ingestion Rates, Consumers Only" (Polissar, 2007.) The document includes the methodology used to derive rates. Fish consumption rates in that document were calculated from data available at the individual level. Selected rates presented in that document are shown in the rows in Table 8 corresponding to 1) all species, Puget Sound source and 2) all species except anadromous, Puget Sound source.

All other rates in the table, aside from those in the two designated rows, were calculated in a different way, using methods described in Appendix 3.

Table 8. Mean and percentiles of consumption rates (g/day) by species group and source, Suquamish Tribe, adult consumers only.

Species	Source	N	mean	50%	75%	80%	85%	90%	95%	Max
All	All	92	213.9	132.1	284.2	320.6	390.4	489.0	796.9	1453.6
Anadromous	All	92	48.8	27.6	79.1	90.1	114.2	132.7	172.0	274.1
Non- anadromous*	All	89-91	168.7**	101.9	219.3	247.4	301.2	377.3	614.9	NA
Shellfish	All	91	134.2	64.7	145.1	182.1	230.8	363.4	615.4	1262.1
All	Puget Sound	91	165.1	57.5	220.7	250.4	300.9	396.7	766.7	1248.2
Anadromous	Puget Sound	89-91	38.6	21.8	62.5	71.2	90.2	104.8	135.9	NA
Non- anadromous*	Puget Sound	89	125.6	49.1	116.2	177.4	211.1	379.8	674.1	1095.5
Shellfish	Puget Sound	89-91	108.7	52.4	117.6	147.5	186.9	294.4	498.5	NA

*Includes the following species groups: pelagic, bottom-feeding, and shellfish. The rates do not include species in Group F (other finfish) and Group G (other shellfish) defined in Table T-4 of Suquamish, 2000.

NA: not available or data needed for computation were not available.

**Based on an assumed n = 90 consumers.

Asian and Pacific Islanders

Seafood consumption rates for the Asian and Pacific Islander (API) community were estimated in Sechena, 1999. Appendix M3 of the report provides mean and 50th, 75th and 90th percentiles of consumption in g/kg-day of a variety of species groups. A 2005 EPA report (Kissinger, 2005) presented a re-analysis for consumers only which took account of harvesting. That report covers the methodology underlying the rates. Excerpts from Table 5 of that report are offered in Table 9 of this report. Whereas for most species the uncooked weight of fish consumed was calculated, for some species the survey calculated cooked weights, since cooking was needed to provide better access to the edible portion of the organism[18]. The rates reported here include no adjustment for cooking effect and they may be biased downward. See Kissinger, 2005, Table 8, for a compilation of rates adjusted to remove the cooking effect.

Table 9. Fish consumption rates (g/day), adult Asian and Pacific Islanders resident in King County, selected percentiles by species group and source

Species group	Source	No. consumers	50%	75%	80%	85%	90%	95%
All	Harvested*	125	6.5	13.5	16.2	19.9	25.9	58.8
Non-anadromous	Harvested*	112	6.2	16.1	20.4	26.9	37.9	54.1
All	All	202	74.0	133.5	154.5	183.2	226.9	286.1

*Harvested from any location.

Notes. 1) Adapted from Table 5 of Kissinger, 2005. 2) 75%, 80%, 85% percentile values were computed for this report by interpolation (percentile by percentile) between the log 50th and log 90th percentile values from this table, followed by antilog. Percentiles (50%, 75%, 80%, 85%, 90%) of the standard normal distribution were the basis for interpolation.

[18] Kissinger, 2005 notes: "However consumption of the following shellfish species was recorded in terms of cooked weight: butter clams, cockles, crab, geoducks, horse clams, macoma, manila/little neck, moon snail, mussels, oysters, razor clams, and scallops. These organisms were steamed or boiled in order to facilitate removal of edible tissue from the shell."

DISCUSSION

We have presented a number of fish consumption rates that may be relevant for considerations related to regulatory purposes. The rates span a wide range, and it will be important to users of these rates to attempt to match the particular rate regimen to the appropriate population and regulatory question.

The rates are of varying quality and depend on assumptions to a varying extent. All of the rate regimens depend on the assumption that people can remember what they have eaten—either in the last 24 hours or on the general frequency of consumption of specified kinds of fish or shellfish over an extend period. Taking the rates at face value also means that we regard memory as correctly representing the actual quantity of fish eaten.

While the rates are not perfect, they are meaningful. We have not supplied standard errors or confidence intervals ("margins of error") for the rates. For a given statistic, such as the 95th percentile of fish consumption, studies with larger sample sizes will generally supply more precise values than smaller studies.

One pitfall to avoid in using these rates is to assume that the 95th percentile of consumption—a percentile that is likely to play a prominent role in discussions—is determined only by the few highest reported consumption values. For example, the Tulalip Tribes survey had 73 participants, and the 95th percentile of consumption would fall between the third and fourth largest reported consumption rates. We sometimes hear the fallacy that in a case like this the 95th percentile of consumption <u>only</u> depends on four data points. Not true. Aside from the top four rates in the Tulalip Tribes' data, there are the other 69 reported rates pushing the top four up to the top. Omitting any of the lower rates would change the 95th percentile, as would dropping any of the top four rates. All of the reported rates have weighed in on determining the 95th percentile, or any percentile, or the mean. Nevertheless, it is certainly true that the 95th percentile is not as well determined as a more central percentile, such as the median.

The following issues influence fish consumption rates or are considerations in their use.

Survey and Analysis Methodologies

The surveys and analyses of those surveys differ in their definition of a fish consumer, and the definition has a very substantial impact on the calculated consumption rates. The most inclusive definition is used in the NCI method (applied here to the USA survey data from NHANES). In the NCI methodology, (Tooze, 2006), all respondents entered into the analysis of rates are considered consumers, though the amount consumed may be from very little on up. In our report those NHANES national survey respondents who indicated that they never consume fish were excluded from the analysis, so the balance of respondents are very likely to be true fish consumers. The definition of consumer used in the Exposure Factors Handbook (EPA, 2011, Chapter 10)—with fish consumption rates based on the NHANES data—is a person who consumed fish on either of the two dietary recall days. This definition stays very close to the recorded data but is, perhaps, too literal. We have shown in Appendix 2 that using one day vs. two days of reported consumption to define a consumer has a drastic influence on the calculated consumption rates. The calculated consumption rates will be lower for surveys that a) include more days surveyed, b) define a consumer as one who consumes the specified food item on <u>any</u> of the survey days and c) calculate the consumption rate for an individual as the average of consumption rates for the individual survey days (including days with zero consumption.)

Clearly, using the literal definition of a consumer, the resulting "consumer" group included in the analysis and the rates calculated for them depend on what information the survey captures. However, the true usual consumption of each survey respondent is independent of the survey discovery mechanism. Nevertheless, it will be valuable if results

based on the literal definition of a consumer (consumption reported on at least one of the surveyed days), as used in the current Exposure Factors Handbook, continue to be presented, since there will always be some demand for rates that are not based on modeling, no matter how realistic the modeling is. For this reason in this report the rates calculated by the NCI method are presented along with the rates calculated by the method used in the Exposure Factors Handbook.

The NCI method uses a model to estimate the distribution of fish consumption rates, and the percentiles of rates are likely to be closer to the truth than with the literal definition of a consumer, which is based on consumption reported for only two designated days. The model assumptions, described earlier in this document, are realistic, including the variation in people's daily decisions about consuming vs. not consuming fish and also including variations in the amount of fish consumed on a "fish day," and other features.

Figure 2 below shows the results of a simulation study carried out by Dr. Janet Tooze, comparing the NCI method to the literal method of defining consumption.[19] In Dr. Tooze's simulation, a hypothetical "survey" with two days for reporting on diet (as in NHANES) was simulated and the distribution of consumption rates was compared between a) the true distribution of usual consumption, b) a 2-day mean of reported consumption per the respondent (all respondents—consumers with zero and with non-zero consumption), and c) the NCI method. Selection (b) is not the approach in the Exposure Factors Handbook, but the simulation is, nevertheless, useful as a comparison of "the truth" to the two methods just described—(a) and (b). Note that the NCI method well approximates the truth, and the distribution of the 2-day method is quite different from the truth; in particular, the two-day method has an excess of zero or very low consumption rates.

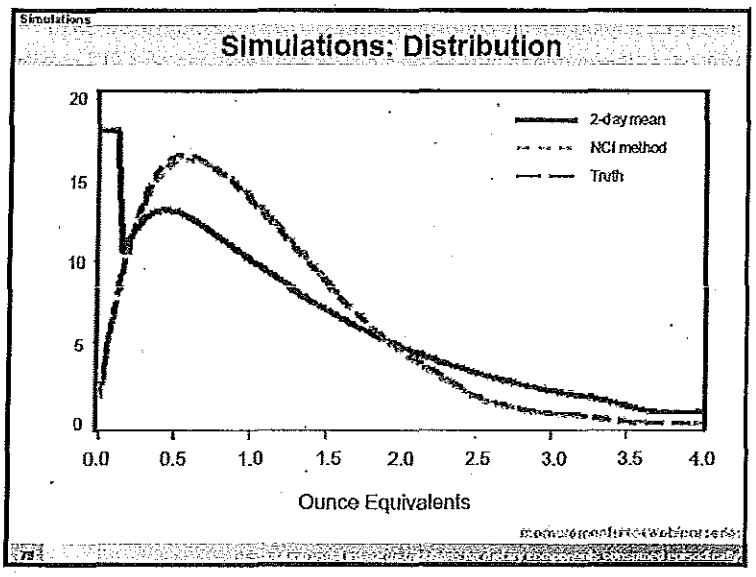

Figure 2. A simulation example of the NCI method at work. See text.

[19] The figure (used with permission) is a slide from Dr. Janet Tooze's webinar 3 at the following link: http://riskfactor.cancer.gov/measurementerror/

Outliers

This report is true to the survey data, as obtained. There is not an accepted definition of outlier that should be mechanically applied here. No recorded fish consumption values have been changed or deleted. While some of the consumption rates for individuals are large, none appear to be impossible. They may raise questions, but they are still within the realm of possibility.

We have encountered data values in other settings that appear to have arisen from a population that differs from that under study. The unusual values might be due to a key entry error, recording error or a contamination of the study by a truly aberrant person or entity. The usual procedure is to work back upstream in the data collection process and see what happened. That is not possible here, but, again, though there may have been "outliers" by formal testing rules, none of the consumption rates that we have come across appear to be impossible. In the 2003-2006 NHANES survey described earlier, the highest adult consumption rate encountered in our data analysis of over 6,400 respondents was 941 g/day, based on two days of reporting. Only two days of consumption data for such a large group of people might, indeed, turn up some unusually large values that are higher than the person's usual (average) intake. Nevertheless, this daily intake (a little over two pound per day, uncooked weight) seems possible among this large group of people.

An additional fact is that an outlier search tends to be one-sided. A large value draws attention, but perhaps some of the very small values should be examined, too, if the spirit of examination is to be unbiased. For example, a very small salmon consumption rate might appear anomalous for an individual in a Native American Tribe that values salmon culturally, socially, and as a favorite food.

Thus statistically, we have allowed the data to stand, finding no individual consumption rates so egregious as to require ejection. See also the discussion of outliers in the methods sub-section on Native American and API surveys.

Suppression

Some authors have suggested that current fish consumption rates of the Native American Tribes are suppressed compared to historical consumption rates and that this suppression affects the health of members of the Tribe. (See, for example, Donatuto & Harper, 2008.) Hopefully, studies underway will provide some insight into the historical consumption rates.

This report offers no opinion or finding on the suppression issue. However, since health outcomes are a factor in setting regulations, our recommendation is that suppression effects be considered at an appropriate time. .

Does National Data Represent Washington State?

We do not know of a representative survey that covers fish consumption among the general adult population in Washington State. We have developed consumption rates from the NHANES study data for the USA as a whole, but we do not know how similar fish consumption rates are between the USA and Washington State.

It may be possible to obtain a subset of NHANES data that covers the coastal states of the USA (vs. interior states), where fish consumption rates may be more similar to those in Washington. However, the geographic identifiers in NHANES are masked and a lengthy application and approval process is needed to obtain geographic data. Washington has about 2% of the USA population, so the NHANES sample size for the State is likely to be too small. The collection of coastal states would be more likely to have a sufficient sample size. There would be statistical

issues to address in using a subset of the NHANES geographic coverage, when the survey was designed to represent the USA and not designed to represent individual states.

Farmed and Purchased Fish

We have tried to estimate the portion of fish consumption that comes from harvest of fish by individuals. However, even purchased fish may include some product that was farmed from local waters or was harvested locally and ended up in locally sold commercial products. Similar to the suppression issue noted above, this is a topic for which we have obtained no data and, thus, have no comment on it.

Peak Exposures

The rates presented in this report are for usual consumption, consisting of consumption over a long period, such as a year. It is likely that consumption varies throughout the year as different species become more or less abundant. This report does not supply any information on "peak", seasonal or short-term fish consumption rates that may differ substantially from the long-term, average consumption rates.

Strengths and Limitations

The main strength of the fish consumption rates reported here is that they are based on individual survey respondents' direct answers to questions about fish consumption. The answers to these questions will have the strengths and limitations that accompany any answers about behaviors that are not directly observed by survey staff. However, use of rates based on the memory of those who ate the fish are likely to be far superior to rates based on speculation.

A second strength of this report is that some of the rates reported here were calculated from the original, "raw" data on fish consumption obtained from individuals. The rates for the USA (NHANES data), the Tulalip Tribes and some of the rates for the Suquamish Tribe are in that category. All other rates reported here were calculated based on published or publicly available tabulations of means and percentiles of fish consumption. Those tabulations were, themselves, calculated from the raw, individual-level data.

It is a limitation of a number of our rates that they are based on assumptions that seem reasonable or operationally acceptable but cannot be verified without access to the individual-level data. For example, some percentiles of fish consumption reported in g/kg-day have been multiplied by a mean body weight from the same survey to yield percentile rates in g/day. In that calculation there is an implicit assumption that the consumption rates in g/kg-day do not depend on the weight of a person. That is, the assumption implies that, on the average in the population, a person who weighs 50% more than someone else would eat 50% more fish (by weight) than the other person.

A second assumption commonly used here is that the fish consumption rates are not dependent on the percentage of that consumption that is harvested (from Puget Sound, from the Columbia River, or just "harvested.") That assumption comes into play, for example, when we have multiplied the mean and percentiles of consumption rates for all sources of consumption by the mean percentage of consumption harvested from Puget Sound to yield mean and percentiles of fish consumption harvested from Puget Sound. Implicit in that calculation is the assumption that, on the average in the population, light and heavy consumers of fish all derive the same percentage of their consumption from Puget Sound.

These assumptions are untested for the populations for which we did not have access to individual-level data. In general, the fewer the assumptions, the more accurate the rate is likely to be. Thus, rates in g/day calculated from individual level data are likely to be the most accurate, and rates based on assumptions about the role of body weight, percent harvested or percent non-anadromous fish consumption or on an assumption of the lognormal distribution are likely to be less accurate—the degree of accuracy depending on the quality of the assumption.

ABOUT THE AUTHORS

Nayak L. Polissar, PhD, is the owner and Principal Statistician of The Mountain-Whisper-Light Statistics. He was on the faculty of the University of Washington Department of Biostatistics for 15 years before founding The Mountain-Whisper-Light Statistics. He is author or co-author of over 200 scientific articles in peer-reviewed journals. Dr. Polissar was the lead statistician for four of the fish consumption surveys cited in this report. He is the manager of activities for this project and his contributions include methodology, writing and review.

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Aleksandr Y. Aravkin received a PhD in mathematics (optimization) and an MS in statistics from the University of Washington in 2010. Dr. Aravkin has been collaborating with The Mountain-Whisper-Light since 2007 and is currently a postdoctoral fellow at the University of British Columbia. His contributions for this project include literature review of underlying survey materials, methodology and review.

Patrick Danaher has a Master's degree in biostatistics from the University of Washington and is a PhD candidate in the same program. His involvement in the study includes methodology, calculation of fish consumption rates for the Native American and Asian and Pacific Islander surveys, review of creel/recreational fishermen surveys, writing and review.

John Kalat is a project employee of The Mountain-Whisper-Light Statistics. He worked for the SHARP Program at the State of Washington Department of Labor and Industries for 13 years, managing very large data projects, data reduction for use by researchers and methods of improving the efficiency and effectiveness of data projects. His involvement in this project includes locating and accessing appropriate data, data management of large files and review of the report.

GLOSSARY

CRITFC:	Columbia River Inter-Tribal Fish Commission
EFH:	Exposure Factors Handbook
EPA:	U.S. Environmental Protection Agency
FCR:	fish consumption rate
FFQ:	food frequency questionnaire
NHANES:	National Health and Nutrition Examination Survey
NCI:	National Cancer Institute
SHARP:	Safety & Health Assessment & Research for Prevention, State of Washington Department of Labor and Industries
TSD:	Technical Support Document.
WDFW:	Washington Department of Fish and Wildlife
WDOE:	Washington Department of Ecology

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APPENDICES

Appendix 1. Summary Table of Consumption Rates Calculated

Table A-1 presents a summary of mean and selected percentile rates from earlier tables.

Table A-1. Fish consumption rates (g/day) by population, species group and source of fish consumed.

Population	Species	Source	N	Mean	50%	75%	80%	85%	90%	95%
USA/EFH	All	All	2,853	56	37.9	78.8	87.6	105.2	127.9	168.3
USA/EFH	Finfish	All	2,200	49.9	34.6	68.9	82.4	95.4	115.3	149.8
USA/EFH	Shellfish	All	1,113	43	25.7	54.4	63	75	100.5	146.6
USA/NCI	All fish	All	6,465	18.8	12.7	24.8	28.9	34.5	42.5	56.6
USA/NCI	Finfish	All	6,465	14	9	18.1	21.2	25.5	31.8	43.3
USA/NCI	Shellfish	All	6,465	5.4	2.4	6	7.5	9.7	13.2	20.5
		All								
Tulalip Tribes	All	All	73	82.2	44.5	94.2	119.6	141.5	193.4	267.6
Tulalip Tribes	Finfish	All	72	44.1	22.3	49.1	59.1	65.1	109.6	203.9
Tulalip Tribes	Shellfish	All	61	42.6	15.4	40.1	59.1	82.7	112.9	140.8
Tulalip Tribes	Non-anadromous	All	71	45.9	20.1	52.4	65.6	80.2	118.4	150.6
Tulalip Tribes	Anadromous	All	72	38.1	16.8	43.3	46.4	57.3	92.1	191.1
Tulalip Tribes	All	Puget Sound	71	59.5	29.9	75	79.4	122.6	138.5	237.4

Population	Species	Source	N	Mean	50%	75%	80%	85%	90%	95%
Tulalip Tribes	Finfish	Puget Sound	71	31.9	13	33.1	42.4	55.4	78.4	145.8
Tulalip Tribes	Shellfish	Puget Sound	53	36.9	14.2	40.1	52.7	85.8	111.4	148.3
Tulalip Tribes	Non-anadromous	Puget Sound	59	35.5	14.8	38.8	48.7	67.6	109.2	145
Tulalip Tribes	Anadromous	Puget Sound	70	30.4	11.8	32.4	39.3	55.1	66	148.2
Squaxin Island Tribe	Anadromous	All	117	55.1	25.3	65.8	79	97.9	128.2	171.1
Squaxin Island Tribe	Shellfish	All	86	23.1	10.3	23.9	29.9	38.8	54	83.6
Squaxin Island Tribe	Finfish	All	117	65.5	31.4	82.3	97.1	117.6	149.7	208
Squaxin Island Tribe	All fish	All	117	83.7	44.5	94.4	117	150.2	205.8	280.2
Squaxin Island Tribe	Non-anadromous	All	NA	28.7	15.2	32.3	40	51.4	70.5	95.9
Squaxin Island Tribe	Anadromous	Puget Sound	NA	44.1	20.2	52.6	63.2	78.3	102.5	136.8
Squaxin Island Tribe.	Shellfish	Puget Sound	NA	14.3	6.4	14.8	18.5	24.1	33.5	51.9
Squaxin Island Tribe	Finfish	Puget Sound	NA	45	21.6	56.5	66.7	80.8	102.8	142.9
Squaxin Island Tribe	All fish	Puget Sound	NA	56.4	30	63.5	78.8	101.1	138.6	188.6
Squaxin Island Tribe	Non-anadromous	Puget Sound	NA	12.3	6.5	13.9	17.2	22.1	30.3	41.2
Columbia river	All	All	464	63.2	40.5	64.8	81	97.2	130	194
Columbia river	Non-anadromous	All	NA	32.6	20.9	33.4	41.7	50.1	67	99.9
Columbia river	Anadromous	All	NA	30.6	19.6	31.4	39.3	47.1	63.1	94.1
Columbia river	All	Col. R.	NA	55.6	35.6	57	71.3	85.5	114	171
Columbia river	Non-anadromous	Col. R.	NA	28.6	18.4	29.4	36.7	44.1	58.9	87.9

Population	Species	Source	N	Mean	50%	75%	80%	85%	90%	95%
Columbia river	Anadromous	Col. R.	NA	27	17.3	27.7	34.6	41.5	55.5	82.8
Suquamish Tribe	All	All	92	213.9	132.1	284.2	320.6	390.4	489.0	796.9
Suquamish Tribe	Anadromous	All	92	48.8	27.6	79.1	90.1	114.2	132.7	172.0
Suquamish Tribe	Non- anadromous	All	89-91	168.7**	101.9	219.3	247.4	301.2	377.3	614.9
Suquamish Tribe	Shellfish	All	91	134.2	64.7	145.1	182.1	230.8	363.4	615.4
Suquamish Tribe	All	Puget Sound	91	165.1	57.5	220.7	250.4	300.9	396.7	766.7
Suquamish Tribe	Anadromous	Puget Sound	89-91	38.6	21.8	62.5	71.2	90.2	104.8	135.9
Suquamish Tribe	Non- anadromous	Puget Sound	89	125.6	49.1	116.2	177.4	211.1	379.8	674.1
Suquamish Tribe	Shellfish	Puget Sound	89-91	108.7	52.4	117.6	147.5	186.9	294.4	498.5
API	All	Harvested	125		6.5	13.5	16.2	19.9	25.9	58.8
API	Non-anadromous	Harvested	112		6.2	16.1	20.4	26.9	37.9	54.1
API	All	All	202		74	133.5	154.5	183.2	226.9	286.1

Notes. USA/EFH: USA rates calculated using the methods of the Exposure Factors handbook (EPA, 2011.) USA/NCI: USA rates calculated using the NCI method.

Appendix 2. Notes on the NCI Method and NHANES Data

Use of the NHANES FFQ to define never-consumers of fish

The NHANES food frequency questions used to screen for never-consumers of fish are shown below (downloaded from: *riskfactor.cancer.gov/diet/FFQ.English.June0304.pdf*). In order to be considered as a never-consumer, we required a "never" answer to questions #91, #93-95, **and**, also, either (a) or (b) to be true: [(a) a "never" answer to #92 and no answer—blank—to #92a]; [(b) an "almost never or never" answer to #92a].

91. How often did you eat **smoked fish** or **seafood** (such as smoked salmon, lox, or others)?

○ NEVER

○ 1–6 times per year	○ 2 times per week
○ 7–11 times per year	○ 3–4 times per week
○ 1 time per month	○ 5–6 times per week
○ 2–3 times per month	○ 1 time per day
○ 1 time per week	○ 2 or more times per day

92. How often did you eat **sushi**?

○ NEVER (GO TO QUESTION 93)

○ 1–6 times per year	○ 2 times per week
○ 7–11 times per year	○ 3–4 times per week
○ 1 time per month	○ 5–6 times per week
○ 2–3 times per month	○ 1 time per day
○ 1 time per week	○ 2 or more times per day

Question 93 appears on the next page.

Over the past 12 months...

92a. How often did the **sushi** you ate contain **raw fish** or **seafood** (including shellfish)?

○ Almost never or never
○ About 1/4 of the time
○ About 1/2 of the time
○ About 3/4 of the time
○ Almost always or always

93. How often did you eat **raw oysters, raw clams,** or **other raw fish** (not including raw fish in sushi)?

○ NEVER

○ 1–6 times per year	○ 2 times per week
○ 7–11 times per year	○ 3–4 times per week
○ 1 time per month	○ 5–6 times per week
○ 2–3 times per month	○ 1 time per day
○ 1 time per week	○ 2 or more times per day

94. How often did you eat **fish sticks or fried fish** (including fried seafood or shellfish)?

○ NEVER

○ 1–6 times per year
○ 7–11 times per year
○ 1 time per month
○ 2–3 times per month
○ 1 time per week
○ 2 times per week
○ 3–4 times per week
○ 5–6 times per week
○ 1 time per day
○ 2 or more times per day

95. How often did you eat **all other fish or seafood** (including shellfish) that was **NOT FRIED, SMOKED,** or **RAW** ?

○ NEVER

○ 1–6 times per year
○ 7–11 times per year
○ 1 time per month
○ 2–3 times per month
○ 1 time per week
○ 2 times per week
○ 3–4 times per week
○ 5–6 times per week
○ 1 time per day
○ 2 or more times per day

Comment on "consumer only" definition used with NHANES data.

Table A-2 shows consumption rates when a "consumer" is defined as a) one who consumes fish on **either** of the two dietary recall days of the NHANES survey and the consumption rate is the average of consumption on the two days (first numeric row of the table); b) one who consumes fish on day 1 of the 2 days of dietary recall; and, c) one who consumes fish on day 2 of the 2 days of dietary recall. The rates in the table are based on a standard survey estimation procedure using the statistical weights and the survey design. The first three numeric rows do not use the NCI method. The last numeric row—based on the NCI method—is included for comparison.

Note that the consumption rate rises considerably when consumers detected on only one day of consumption are included (second and third numeric rows) compared to the average for two days (first numeric row.) The literal definition of consumer tends to underestimate the number of consumers and overestimate consumption rates for "consumers", a bias that will be smaller for surveys with more days of consumption reporting and when consumers are defined as those who consume fish on any of the days. The NCI method does draw on all of the data collected on the two dietary recall days, including the occurrence of zero consumption on either or both days.

Table A-2. Fish consumption rates (g/day) for adult consumers only, USA population, based on NHANES 2003-2006, all fish and shellfish species combined, using survey estimation

Consumption on:	N	Mean	Min	1%	5%	10 %	25%	50%	75%	90%	95%	99%	Max
Either day*	2,853	56.0	<0.1	<0.1	0.1	3.7	17.5	37.9	78.8	127.9	168.3	255.7	512.5
Day 1	1,685	93.9	<0.1	<0.1	0.1	5.4	28.9	63.6	128.4	212.7	266.2	477.4	957.2
Day 2	1,651	94.8	<0.1	<0.1	0.1	5.8	29.6	66.5	133.1	218.7	279.6	446.9	941.2
Comparison: NCI method**	6,465	18.8	0.0	0.9	2.0	3.0	6.2	12.7	24.8	42.5	56.6	90.8	941.2

Notes: 1) "Consumers" are defined as those who consumed fish on at least one of the two dietary recall days (first numeric row), on Day 1 (second numeric row) or Day 2 (third numeric row), respectively. 2) Limited to those with data for two dietary recall days. 3) The minimum and maximum rates are as reported in the individual level data and are not products of the survey estimation procedure.

*Fish consumption on either dietary recall day or both days. The rates for these "consumers" is the mean of fish consumption for the two survey days.

**Calculated using the NCI method. See Table 4 and accompanying description for methodology.

Appendix 3. Methodological Notes, Tribal and API Calculations

This appendix contains descriptions of the methodology used to derive fish consumption rates for the Native American tribes and the Asian and Pacific Islander populations.

Tulalip Tribes

All statistics of fish consumption rates were calculated from individual-level data. We used two datasets: 1) "Tulalip-Part-Site.sav" (an SPSS file), which contained the data on the percent of each species group harvested from Puget Sound. 2) "adultoriginal.dta", which contained consumption rates in g/kg-day and weights in kg. The "outliers" which were modified for analysis in the original publication (Toy, 1996) are not modified here. They were used "as is."

In order to calculate an individual's consumption of fish in a species group X (e.g., "all fish") in g/day, we performed the following procedure:

Define:

Rate_grpX: gkgday:	An individual's consumption rate (g/kg-day) of fish in species group X.
BW:	The individual's body weight in kg.
Percent_PS_grpX:	The percent of the individual's consumption of species group X that was harvested in Puget Sound. The percent is used as a decimal proportion during calculations.

We then calculate consumption in g/day as:

Rate_grpX_gday = Rate_grpX_gkgday * BW

Finally, we calculate consumption of Puget Sound-harvested fish in g/day as:

Rate_grpX gday_PS = Rate_grpX_gkgday * BW * Percent_PS_grpX

In order to calculate an individual's Puget Sound-harvested consumption rate for aggregate species groups, such as finfish or all fish, we add together their Puget Sound-harvested consumption rates for the appropriate individual species groups. The percentiles of fish consumption rates for a species group or the aggregate of species groups are then calculated from the corresponding distribution of consumption rates for individual adult survey respondents.

Squaxin Island Tribe

The following table, (as detailed in the last column), describes the methodology used to derive the mean and percentiles of fish consumption for the Squaxin Island Tribe as presented in Table 6 of this report. The first few columns of Table 6 are provided here in order to facilitate alignment of this methodology table with Table 8.

After deriving the 50th, 75th, 90th and 95th percentiles by the method described in the table, the 80th and 85th percentiles were derived by interpolation. See the "interpolation" sub-section in the methods section.

Methodology guide to Table 6. Consumption in g/day, Squaxin Island Tribe, consumers only, mean and percentiles, by species group and source.

Species	Source	N	Mean	50%	Methods
Anadromous	All	117	55.1	25.3	Rates from Polissar et al, 2006, Table A1.S, multiplied by Squaxin Island Tribe mean body weight (males and females combined), 82.0 kg, to yield rates in g/day. Body weight from Table 2 of Toy et al, 1996.
Shellfish	All	86	23.1	10.3	Rates from Polissar et al, 2006, Table A1.S, multiplied by Squaxin Island Tribe mean body weight (males and females combined), 82.0 kg, to yield rates in g/day. Body weight from Table 2 of Toy et al, 1996.
Finfish	All	117	65.5	31.4	Rates from Polissar et al, 2006, Table A1.S, multiplied by Squaxin Island Tribe mean body weight (males and females combined), 82.0 kg, to yield rates in g/day. Body weight from Table 2 of Toy et al, 1996.
All fish	All	117	83.7	44.5	Rates from Polissar et al, 2006, Table A1.S, multiplied by Squaxin Island Tribe mean body weight (males and females combined), 82.0 kg, to yield rates in g/day. Body weights from Table 2 of Toy et al, 1996.
Non-anadromous	All	NA	28.7	15.2	Rates for all fish, all sources, multiplied by 0.342, the proportion of total mass consumed that is from non-anadromous species.
Anadromous	Puget Sound	NA	44.1	20.2	Corresponding species group rates in upper part of this table, all sources, were multiplied by mean percentage (expressed as a proportion) of consumed fish from this species group which were harvested from Puget Sound.
Shellfish	Puget Sound	NA	14.3	6.4	Corresponding species group rates in upper part of this table, all sources, were multiplied by mean percentage (expressed as a proportion) of consumed fish from this species group which were harvested from Puget Sound.
Finfish	Puget Sound	NA	45.0	21.6	Corresponding rates for finfish, all sources, multiplied by 68.7%, the percentage of finfish total mass consumed that is harvested from Puget Sound.
All fish	Puget Sound	NA	56.4	30.0	Corresponding rates for all fish, all sources, above, multiplied by 67.3%, the percentage of all fish (total mass consumed) that is harvested from Puget Sound.
Non-anadromous	Puget Sound	NA	12.3	6.5	Corresponding rates for non-anadromous species, all sources, above, multiplied by 43.0%, the percentage of non-anadromous mass consumed that is harvested from Puget Sound.

Notes. 1) Mean percentages of fish harvested from Puget Sound from Toy et al, 1996, Table 11: Anadromous, 80%; pelagic, 23%; bottom fish, 13%; shellfish, 62%. 2) The following consumption rate statistics, quoted in the table above, can be calculated from the combination of Polissar et al, 2006, Table A1.S, and Toy et al, Table 11: non-anadromous fish are 34.2% of the total mass of fish consumed from all sources; among all fish consumption harvested from Puget Sound, finfish contribute 68.7% of the mass; among all fish species consumed, 67.3% of the mass is harvested from

Puget Sound; among non-anadromous species, 43.0% of the mass consumed is harvested from Puget Sound. These statistics were calculated using the methodology shown below. For example, the percentage of finfish consumption that is harvested from Puget Sound is 65.45/95.30 = 68.7% = 0.687; the values of 65.45 and 95.30 used in this calculation are from the last row of the table below.

(1) Species	(2) N consumers*	(3) Mean consumption rate, g/kg-day*	(4) = (2)*(3) Mass consumed, g/kg- day**	(5) % Harvested from Puget Sound***	(6) = (4)*(5, as proportion) Mass consumed from Puget Sound, g/kg-day**
Anadromous fish	117	0.672	78.62	80%	62.90
Pelagic fish	62	0.099	6.14	23%	1.41
Bottom fish	94	0.093	8.74	13%	1.14
Shellfish	86	0.282	24.25	62%	15.04
Other fish	39	0.046	1.79	0%	0.00
Total			119.55		80.48
Non-anadromous			40.93		17.58
Finfish			95.30		65.45

*From Polissar et al, 2006, Table A1.S. **These are estimates of the mass consumed, g/kg-day, by the sampled survey respondents all together. It is not a population estimate. ***From Toy et al, 1996, Table 11.

Suquamish Tribe

The following table, last column, describes the methodology used to derive the mean and percentiles of fish consumption for the Suquamish Tribe as presented in Table 8 of this report. The first few columns of Table 8 are provided here in order to facilitate alignment of this methodology table with Table 8.

Methodology guide to Table 8: Mean and percentiles of consumption rates (g/day) by species group and source, Suquamish Tribe, adult consumers only.

Species	Source	N	mean	50%	Methods
All	All	92	213.9	132.1	Mean of 79.0 kg body weight (Suquamish, 2000, Table T-2) multiplied by percentile rates from Liao, 2002, to yield rates in g/day.
Anadromous	All	92	48.8	27.6	Mean of 79.0 kg body weight (Suquamish, 2000, Table T-2) multiplied by percentile rates from Liao, 2002, to yield rates in g/day.
Non-anadromous*	All	89-91	168.7**	101.9	Based on Suquamish Tribe (2000) Table C-2 and on All/All rates in Table 8. Mean based on: a) an assumed n = 90 non-anadromous/all-sources consumers; b) total g/day consumed by survey respondents for all non-anadromous species combined, all sources, calculated from the table just below this one; and, c) mean = (total consumed g/day)/90. Percentiles estimated as All/all category percentiles in Table 8 multiplied by the ratio of two total consumption amounts: [total mass consumed by survey respondents per day (g/day), non-anadromous/all category] / [total mass consumed by survey respondents per day (g/day), all/all category]. The ratio is 0.7716. The range for "N" is based on the minimum for other rows with known N and the maximum for other rows with known N, excluding the all-species/all-sources row and the anadromous/all row.
Shellfish	All	91	134.2	64.7	Percentile rates from Liao, 2002 and mean from Suquamish Tribe, 2000, Table C-2, multiplied by mean of 79.0 kg body weight (Suquamish, 2000, Table T-2) to yield percentile rates in g/day.
All	Puget Sound	91	165.1	57.5	Transcribed from Polissar, 2007; calculations were based on individual-level data.
Anadromous	Puget Sound	89-91	38.6	21.8	Anadromous/all rates in Table 8 multiplied by mean percentage of anadromous fish consumption harvested from Puget Sound (79%/0.79 from Suquamish 2000, Table T-18.) The range for "N" is based on the minimum for other rows with known N and the maximum for

Species	Source	N	mean	50%	Methods
					other rows with known N, excluding the all-species/all-sources row and the anadromous/all row.
Non-anadromous*	Puget Sound	89	125.6	49.1	From Polissar, 2007, individual level data
Shellfish	Puget Sound	89-91	108.7	52.4	Mean and percentiles calculated by multiplying shellfish/all rates in Table 8 by mean percentage of shellfish harvested from Puget Sound (81%/0.81, from Suquamish Tribe, 2000, Table T-18.) The range for "N" is based on the minimum for other rows with known N and the maximum for other rows with known N, excluding the all-species/all-sources row and the anadromous/all row.

*Includes the following species groups: pelagic, bottom-feeding, and shellfish. The rates do not include species in Group F (other finfish) and Group G (other shellfish) defined in Table T-4 of Suquamish, 2000. **Based on an assumed n = 90 consumers.

The following table includes values used to calculate the mean rate for the category non-anadromous/all sources. It was also used to calculate the ratio:

[total mass consumed by survey respondents per day (g/day), non-anadromous/all category] / [total mass consumed by survey respondents per day (g/day), all/all category].

The ratio, 0.7716, was used as a multiplier to derive the percentiles for the non-anadromous/all category.

Suquamish Tribe: consumers only, consumption from all sources.

Species	n	Mean (g/day)	Mass consumed, g/day, all survey respondents
Group A*	92	48.8	4491.624
Group B	49	7.5	367.745
Group C	87	11.4	989.712
Group D	76	9.3	708.472
Group E	91	130.1	11840.283
Group F	85	10.6	899.81
Group G	42	8.9	374.934
All Finfish	92	81.1	7456.968
All Shellfish	91	134.2	12214.111
All Seafood	92	213.9	19674.476
Total, non-anadromous			15180.956
mean, non-anadromous	90		168.7

*Group A: anadromous.

Columbia River Tribes

From manual measurements on Figure 7 of the CRITFC report (CRITFC, 1994) the mean intake of anadromous fish among all consumers and non-consumers of anadromous fish was estimated to be 28.5 g/day. We convert this quantity to mean intake amongst consumers of fish by dividing this number by 0.93, the estimated percent of tribe members that consume seafood. (See page 69 of the CRITFC report.) Table 10 of the same publication reports that the mean intake of all fish by consumers of fish is 63.2g/day. Thus, we can conclude that approximately 48.5% of all seafood consumed by the tribes surveyed is anadromous fish. We use this quantity to estimate mean and percentile consumption rates of anadromous or non-anadromous fish by multiplying the "all-fish" mean and percentiles of consumption by 0.485 and 0.515, respectively.

Finally, the CRITFC report (page 45) offers an estimate that 88% of fish consumed by the tribes surveyed is harvested from the Columbia River. To estimate mean and percentile intakes of fish harvested in the Columbia River, we multiply our means and percentiles of consumption for fish from all sources by 0.88.

Asian and Pacific Islanders

Seafood consumption rates for the API community were estimated in the 1999 EPA report "Asian & Pacific Islander Seafood Consumption Study in King County, WA." Appendix M3 of the report provides mean and 50th, 75th and 90th percentiles of consumption in g/kg-day of a variety of species groups.

Additional analysis of the API consumption rates were carried by EPA (yielding rates in grams per day) and are reported in Kissinger, 2005. The methodology is described in that report. Table 5 of that report is the basis for 50th, 90th and 95th percentile values quoted in this report. The additional 75%, 80%, 85% percentile values were computed for this report by a) interpolation between the 50th and 90th percentile values from Kissinger, 2005, Table 5, which were expressed as logarithms for the purpose of interpolation; then, b) the derived percentiles in logarithmic format were transformed back to the original scale (g/day) by taking the antilog. Percentiles (50%, 75%, 80%, 85%, 90%) of the standard normal distribution were the basis for interpolation

Appendix 4. Proportionality Assumption vs. Individual ("Raw") Data

In various places in this report we have presented means and percentiles of consumption rates derived by using a simple proportionality assumption. In this appendix we carry out a brief assessment of the validity of that approach

For the Squaxin Island Tribe, mentioned as an example here, individual level data were not available for use in this report. Therefore we have taken consumer-only shellfish consumption rates (mean and percentiles from Polissar, 2006) and multiplied them by the Squaxin Island Tribe's mean body weight (from the survey) to yield the estimated percentiles and mean of shellfish consumption rates in g/day. We have then multiplied these percentiles and mean by the tribe's mean proportion of shellfish harvested from Puget Sound[20] to yield percentiles and mean consumption of shellfish harvested from Puget Sound. This procedure seems reasonable, but how well does it work?

In order to assess the accuracy of these, simple, proportionality adjustments, we used consumption rates from the Tulalip Tribes, for which data were available at the individual level. The data could also be handled as if certain data were available only in published form as means, as was the case for the Squaxin Island Tribe and for some other populations covered in this report.

Using the Tulalip Tribes' individual level data, in this appendix we have calculated the mean and percentiles of consumption (g/day) for fish harvested from Puget Sound. We compare the results starting from two different types of data: a) consumers' individual level consumption rates of g/kg-day, individual body weight (kg) and individual stated percent harvested from Puget Sound; and, b) starting from consumer-only published percentiles and mean of consumption expressed in g/kg-day (from Polissar, 2006) and adjusting it to g/day harvested from Puget Sound using all-tribe group means for body weight and all-tribe group means for percent harvested from Puget Sound.[21] We test the validity of the group "means" approach by applying it to the Tulalip Tribes' published consumer-only consumption rates in g/kg-day, and then compare the resulting mean and percentiles to the corresponding mean and percentiles calculated by fully using the individual level data.

Table A-3 shows the summary statistics that result from using the full Tulalip individual-level data vs. the summary statistics that result from using the "means" estimation method described above, starting from the consumer-only percentiles of fish consumption in g/kg/day from Polissar, 2006.

Table A-3. The Tulalip Tribes, mean, median and percentiles of fish consumption (g/day) harvested from Puget Sound, all species, calculated from individual level data and calculated by using group means for body weight and for percent harvested from Puget Sound.

Method	mean	50%	75%	80%	85%	90%	95%
Using individual-level data	59.5	29.9	75	79.4	122.6	138.5	237.4
Using group means	48.8	29.3	53.7	68.3	92.7	117.1	126.9

[20] Each adult survey respondent reported their own estimate of their percentage of consumed shellfish which was harvested from Puget Sound.

[21] The Tulalip Tribes' mean percent harvested from Puget Sound for all fish was calculated in the same way as the corresponding statistic for the Squaxin island Tribe. See Appendix 3, section on the Squaxin Island Tribe, for details and formulas.

Note that the agreement between the two methods is fair to good for the mean, median and for the 75th to the 90th percentile, but the agreement is poor for the 95th percentile. However, the agreement or lack of agreement between rates calculated by the two methods should be considered along with the precision of the rates. If the rates are inherently imprecise, then substantial disagreement may be expected, aside from any methodologic cause of differences. If the rates are precise, then methodology is likely a full or partial cause of the differences. With just the information in Table A-3, it is impossible to say whether the differences in rates calculated by the two methods are likely due to chance or more likely due to the different methodologies.