DEQ Water Quality Division - Standards and Assessments

State of Oregon
Department of Environmental Quality

Human Health Focus Group Report
Oregon Fish and Shellfish Consumption Rate Project

June 2008

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1. INTRODUCTION

Oregon has over 110,000 miles of rivers and streams, more than 6,000 lakes and ponds, and 362 miles of coastal waters (ODEQ 2000). These waters support fish and shellfish species that are consumed by a broad range of Oregonians. Potentially toxic chemicals are found in some Oregon waters (ODEQ 2008). Over time, fish and shellfish may accumulate these pollutants, resulting in a potential risk to the health of people who consume them. The magnitude of health risks depends on the amount of fish or shellfish consumed, the level of contamination in the fish and shellfish, and a person's susceptibility to a particular contaminant. The Oregon Department of Human Services (ODHS) has issued numerous fish advisories throughout the state's rivers and reservoirs (ODHS 2007) to protect the health of people who may consume contaminated fish.

For purposes of its regulatory programs, the Oregon Department of Environmental Quality (ODEQ) is responsible for establishing the level of human health protection for Oregonians who consume fish and shellfish from state water bodies. In order to provide adequate protection for Oregonians, ODEQ needs to accurately assess how much fish Oregonians consume and adopt an appropriate fish consumption rate. This fish consumption rate is used with other factors such as chemical toxicity to develop human health-based water quality criteria. These criteria are codified into Oregon law as human health water quality standards (OAR 340-41). These human health water quality standards are used in ODEQ's regulatory programs to establish water quality permit limits, etc.

The purpose of this report is to document the discussion and conclusions of the Human Health Focus Group. The Human Health Focus Group includes Pacific Northwest scientists who were convened to advise the Oregon Fish and Shellfish Consumption Rate Project on technical issues surrounding the selection of fish consumption rates in Oregon. The Fish Consumption Rate Project is a collaborative effort of ODEQ, the U.S. Environmental Protection Agency (EPA), and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). The purpose of this collaborative effort is to revise ODEQ's current fish consumption rate of 17.5 grams per day (g/day). In addition to the three cooperating agencies the Fish Consumption Rate Project includes a Core Team of about 40 individuals and organizations that are either directly affected by or interested in the outcome of this project.

The Human Health Focus Group members are regional experts with experience in the areas of toxicology, risk assessment, public health, biostatistics, and/or epidemiology. The members of the Human Health Focus Group were selected from nominations received from the Fish Consumption Rate Project's Core Team as well as ODEQ, EPA, and CTUIR. A total of 26 nominations were received and the six members were selected by ODEQ, EPA, and the CTUIR.

1.1 MEMBERS OF THE HUMAN HEALTH FOCUS GROUP

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1.2 OBJECTIVES FOR THE HUMAN HEALTH FOCUS GROUP

In their advisory role to the Fish Consumption Rate Project, the Human Health Focus Group was asked to address the following three questions:

1) Considering the available local, regional and national information on fish consumption, what is the scientific evidence Oregon should rely on when selecting a fish consumption rate to use in setting water quality criteria?
2) How should salmon be considered in selecting a fish consumption rate and/or setting criteria?
3) To what extent are populations who consume more than the current fish consumption rate of 17.5 g/day at a greater risk for adverse health impacts?

The Human Health Focus Group was asked to review the available scientific evidence that would inform the Fish Consumption Rate Project. The scientific evidence was gathered from existing literature and the expertise of the Human Health Focus Group. Many different fish consumption rate studies are available in the literature. The Human Health Focus Group chose a subset of relevant studies to assess more comprehensively as well as provide a manageable summary of information.

The Human Health Focus Group was asked to provide a range of fish consumption rates that the group deems to be credible and representative of various Oregon fish-consuming populations. The Oregon Environmental Quality Commission, ODEQ's governing body, is responsible for choosing a fish consumption rate(s), or alternatively, a range of consumption rates. This risk management decision will specifically consider the people that will be protected by the human health-based water quality criteria (e.g. the general population, tribal populations, children and other sensitive populations), and what percentage of those populations to protect. The Environmental Quality Commission will be responsible for considering whether to include Pacific salmon in the rate, if there should be a single statewide fish consumption rate or various rates for different regions, and how revised human health criteria will be implemented. Overall, the Fish Consumption Rate Project encompasses a complicated mix of science and policy considerations.

The discussion and conclusions presented in this report were generated in one year (May 2007 – May 2008), a relatively short time considering the scope of the questions addressed. This report should be used in conjunction with the wide range of literature on fish consumption data that already exists. Some of this literature can be found in the report's cited references (Chapter VIII), and in the attached bibliography of related literature sources (Chapter IX). This report is not a comprehensive review of all fish consumption surveys. It is a focused review of the fish consumption surveys most relevant to fish consumers in Oregon, a review which was subject to the time constraints of the overall Fish Consumption Rate Project schedule. EPA ambient water quality criteria guidance (USEPA 2000a) recommends that "states use regional or local consumption studies and consumption rates to adequately protect the most highly exposed population when developing state water quality criteria". Other relevant national and world studies on fish consumption patterns were also reviewed by the Human Health Focus Group members during this process, but time constraints prevented in-depth analysis of all of these studies. Additionally, this report represents a brief review and recommendations for how Pacific salmon should be considered in selecting a fish consumption rate, but does not provide a comprehensive review of the life histories or potential sources of contamination for Pacific salmon.

This report is a summary of the Human Health Focus Group discussions, recommendations, and conclusions for each of the three questions posed by ODEQ, EPA, and CTUIR. There are seven chapters in this report. The historical and regulatory background regarding selection of a fish consumption rate(s) for human health-based water quality criteria in Oregon are described in Chapter 2. The results and discussion of the Human Health Focus Group's review of fish consumption surveys relevant to Oregon are presented in Chapter 3. The Human Health Focus Group's discussion of the inclusion of Pacific salmon in the fish consumption rate is given in Chapter 4. The rationale and recommendations of the Human Health Focus Group for fish consumption rate(s) for Oregon are described in Chapter 5. A brief description of human health risk assessment and its application to human health-based water quality criteria is presented in Chapter 6. Finally, the conclusions and recommendations of the Human Health Focus Group for the Fish Consumption Rate Project are presented in Chapter 7.

Detailed Human Health Focus Group meeting minutes and information on the Human Health Focus Group meeting schedule can be obtained from ODEQ or online at (http://www.deq.state.or.us/wq/standards/fishfocus.htm)

2. BACKGROUND

Water quality standards are the foundation of ODEQ's water quality program and influence a variety of other programs within ODEQ. Standards are established to protect the designated uses of Oregon waters, such as fishing, swimming, irrigation, drinking water, and industrial use. Water quality standards consist of three basic elements: 1) designated uses; 2) numeric and narrative water quality criteria; and 3) an anti-degradation policy. In order to restore and maintain the chemical, physical and biological integrity of Oregon waters, ODEQ works with a wide range of public and private entities to administer the regulatory programs of the Clean Water Act (CWA) that are based on water quality standards.

Water quality criteria can be both numeric and narrative and are derived for the protection of aquatic life and human health. Both aquatic life and human health criteria are used to assess water quality monitoring data and identify impaired waters, establish waste load allocations for Total Maximum Daily Loads (TMDLs), evaluate projects seeking a CWA Section 401 water quality certification, control non-point source pollution, establish cleanup targets at hazardous waste sites, and establish permit limits through the National Pollution Discharge Elimination System water quality permits. Any change in water quality criteria would affect all ODEQ programs using those criteria.

The Fish Consumption Rate Project is focused on reviewing and revising the fish consumption rate, which is one variable used to calculate human health-based water quality criteria. These criteria are intended to protect the quality of state waters so that fish and shellfish can be consumed by all Oregonians without unacceptable risk to human health. All of Oregon's waters (except the Bull Run River[1]) are designated for fishing, which makes the importance of protecting those waters relevant to all Oregonians.

Oregon's water quality standards (beneficial uses and criteria) are adopted by the Oregon Environmental Quality Commission through an administrative rule development process. The Fish Consumption Rate Project will provide fish consumption rates that will be used to establish water quality criteria for protection of human health. The application of human health-based water quality criteria in the CWA regulatory programs mentioned previously occurs in all waters of the state. According to Oregon Administrative Rule (OAR) 340-041-0001, *"Waters of the State" means lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of the State of Oregon, and all other bodies of surface or underground waters, natural or artificial, inland or coastal, fresh or salt, public or private (except those private waters that do not combine or effect a junction with natural surface or underground waters) that are located wholly or partially within or bordering the state or within its jurisdiction.*

> EPA's nationally recommended fish consumption rates are based on data from United States Department of Agriculture's (USDA) 1994-1996, 1998 Continuing Survey of Food Intake by Individuals (CSFII) and reported in USEPA 2002b.

Implementing and enforcing human health-based water quality criteria in waters of the state will only have an effect on those fish and shellfish species residing in and exposed to those waters. Thus, the selection of a fish consumption rate to be used in Oregon human health-based water quality criteria may only include those fish and shellfish species directly influenced by waters of the state. The territorial limits of Oregon extend three nautical miles from shore into the Pacific Ocean.

Oregon's current numeric human health criteria are based on EPA's 2002 recommended CWA Section 304(a) water quality criteria (USEPA 2002a). EPA derived these criteria by considering

[1] The Bull Run River is located inside a watershed that is closed to public access and is therefore not accessible for fishing.

the known toxicity of the regulated chemicals and the likely exposure people have to these chemicals. These criteria are based on a specific set of variables for estimating exposure including fish consumption rate and human body weight. EPA's current recommended CWA Section 304(a) human health-based water quality criteria are calculated using the national fish consumption rate of 17.5 g/day (USEPA 2000a). This nationally recommended rate is roughly equivalent to two, eight-ounce fish meals per month. This rate represents the 90th percentile of all people (fish consumers and non-consumers) who were interviewed from across United States.

ODEQ is considering which fish consumption rates are most appropriate to use in calculating water quality criteria that are protective of human health. These criteria will apply to Oregon waters and will be implemented through CWA regulatory programs such as National Pollution Discharge Elimination System water quality permits, water quality assessments, and Total Maximum Daily Loads. ODEQ is considering raising the fish consumption rate in part because a local study shows that the Columbia River Tribes (CRITFC 1994) eat substantially more fish than the current EPA default rate of 17.5 g/day (USEPA 2000a). EPA, in an August 15, 2005 letter to the Environmental Quality Commission (ODEQ's rulemaking body), suggested that, "Current information indicates that a fish consumption rate in the range of 105 to 113 g/day may be appropriate for some waters in Oregon, Washington, and Idaho including a number of reaches of the Columbia River (based on studies prepared by EPA and the Columbia River Inter-Tribal Fish Commission)" (Kreizenbeck 2005). Other studies identified in this report demonstrate the existence of other high-volume fish consumers in Oregon, in the United States generally and in the world. An increase in the fish consumption rate in Oregon would result in more stringent human health-based water quality criteria.

Until 2003, Oregon's water quality standards were based on a fish consumption rate of 6.5 g/day, consistent with EPA's default fish consumption rate (USEPA 2000a). EPA increased its recommended rates to a nationally-based per capita default level of 17.5 g/day while urging states to rely on local consumption data wherever possible (USEPA 2000a).

From 1999 to 2003, two separate teams reviewed Oregon's water quality standards and considered potential revisions: the ODEQ's Technical Advisory Committee (TAC) and the Policy Advisory Committee (PAC). When reviewing the appropriate fish consumption rates to calculate the human health-based criteria, the TAC proposed a tiered approach for the Oregon criteria:

1) EPA's (USEPA 2000a) default fish consumption rate (17.5 g/day) for low intensity fish consumption,
2) EPA's (USEPA 2000a) recommended subsistence fish consumption rate (142.4 g/day), for medium intensity fish consumption
3) The ninety-ninth percentile of the Columbia River Basin Tribal fish consumption rates (389 g/day, from CRITFC 1994) for high intensity fish consumption.

The PAC, upon reviewing the TAC's recommendations, had concerns about how this tiered system would be implemented, and could not come to consensus on what the appropriate fish consumption rate should be for calculating the human health-based water quality criteria.

Subsequently, ODEQ recommended to the Environmental Quality Commission that it adopt EPA's 2002 recommended CWA Section 304(a) water quality criteria for toxic pollutants, including the human health criteria (USEPA 2002a), with a few exceptions. The Environmental Quality Commission adopted these criteria, and the revised water quality criteria were submitted to the EPA on July 8, 2004 for its review and approval.

The CWA directs EPA to review and either approve or disapprove water quality standards submitted by states and authorized tribes (40CFR Part 131.5). EPA has not yet taken any action on Oregon's revised human health-based water quality criteria that were submitted on July 8, 2004, but has recommended that Oregon consider adopting a rate of 105-113 g/day for some waters in Oregon in order to be more protective of people who eat fish (Kreizenbeck 2005).

3. EVALUATION OF FISH CONSUMPTION SURVEYS

3.1 FISH CONSUMPTION SURVEYS REVIEWED

The purpose of the Human Health Focus Group review of fish consumption surveys was to establish a body of literature that documents the range of fish consumption rates practiced by fish consuming groups in the Pacific Northwest; and from which Oregon can choose a fish consumption rate.

With the help of ODEQ and EPA, the Human Health Focus Group compiled a list of national and international surveys for review. National and international studies (Table 1, located at the end of this document) demonstrate that there are a wide range of populations with diverse cultures, traditions, and practices that result in a very broad range of fish consumption patterns. This variability can be expected in any population of statewide scale and in some cases, similar variability can be seen in much smaller populations.

3.1.1 SELECTION OF RELEVANT FISH CONSUMPTION SURVEYS

Current EPA (USEPA 2000a) ambient water quality criteria guidance for adopting state fish consumption rates recommends the use of local and regional fish consumption data first, the use of national studies second, and recommends reliance on EPA default rates only if no specific regional data are available.

The Human Health Focus Group established an informal set of procedures for determining which surveys were the most relevant for Oregon and the most useful for estimating fish consumption rates. These procedures included but were not limited to the following considerations:

1) Survey design,
2) Survey questionnaire,
3) Population surveyed,
4) Statistical analysis, and
5) Type of fish and shellfish consumed

Of the national and international studies listed in Table 1, eight regional surveys and one national fish consumption survey reviewed by the Human Health Focus Group were found to be relevant for developing fish consumption rate(s) for Oregon Water Quality Criteria. With this guidance and Oregon's population in mind, nine fish consumption surveys (Table 1) were chosen for detailed review. A survey was determined relevant if the people surveyed were from Oregon or their fish consumption patterns are what one might expect from the people of Oregon.

The nine relevant surveys are:

- A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin (CRITFC 1994)
- Fish Consumption, Nutrition, and Potential Exposure to Contaminants Among Columbia River Basin Tribes. – A Masters thesis by Neil A. Sun Rhodes, Oregon Heath Sciences University (Rhodes 2006)
- Columbia Slough and Sauvie Island Fish Consumption Survey, Technical Memorandum on the Results of the 1995 Fish Consumption and Recreational Use Surveys, Amendment No. 1 (Adolfson Associates 1996)
- A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region (Toy *et al.* 1996)
- Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region (Suquamish 2000)
- Asian and Pacific Islander Seafood Consumption Study (Sechena *et al.* 1999)
- Lake Whatcom Residential and Angler Fish Consumption Survey (WDOH 2001)
- Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt (WDOH 1997)
- Estimated Per Capita Fish Consumption in the United States (USEPA 2002b)

3.1.2 SELECTION OF SURVEYS MOST USEFUL FOR RECOMMENDING FISH CONSUMPTION RATES

In this review, a survey was determined useful if the quantitative results can be relied upon as good estimates of fish consumption rates for the population surveyed. Of the nine fish consumption surveys considered to be relevant by the Human Health Focus Group, the following five surveys were determined to have the most useful data for estimating quantitative fish consumption rates:

- A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin (CRITFC 1994)
- A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region (Toy *et al.* 1996)
- Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region (Suquamish 2000)
- Asian and Pacific Islander Seafood Consumption Study (Sechena *et al.* 1999)
- Estimated Per Capita Fish Consumption in the United States (USEPA 2002b)

Four of the original nine studies were eliminated for further consideration for various reasons. The Lake Whatcom, Lake Roosevelt, Sauvie Island and the Columbia Slough are good studies, but the reported values in each of these studies were not adequate for calculating accurate fish consumption rates. The re-evaluation of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribal (CRITFC 1994) data by Rhodes did not provide any new quantitative data that would change the results of the original survey of the Columbia River Basin Tribes (CRITFC 1994).

3.1.3 RESULTS OF REVIEW OF NINE SURVEYS

The result of the Human Health Focus Group's evaluation of the nine surveys is provided in the following section.

A FISH CONSUMPTION SURVEY OF THE UMATILLA, NEZ PERCE, YAKAMA, AND WARM SPRINGS TRIBES OF THE COLUMBIA RIVER BASIN (CRITFC 1994)

Relevance

The survey of Columbia River Basin Tribes (CRITFC 1994) is regarded as the study most relevant to Oregon fish consumers. The Confederated Tribes of the Umatilla Indian Reservation and the Warm Springs Tribe, two of the four tribes surveyed, are both located in Oregon, which makes the survey a direct measure of an Oregon population. The Yakama Tribe (Washington) and Nez Perce Tribe (Idaho) both fish in parts of the Columbia River Basin in Oregon

The survey reported that 97 percent of the people interviewed eat fish. Other surveys reviewed by the Human Health Focus Group demonstrated that Asian and Pacific Islanders and Eastern European communities also consume fish at levels similar to Oregon Tribes.

The fish species consumed by Columbia Basin Tribes (CRITFC 1994), either spend their entire life in Oregon waters or part of their life in Oregon waters (Appendix A-1). The fish reported as consumed in this survey include trout, northern pike-minnow, sturgeon, suckers, walleye, and whitefish. The study also reported consumption of Pacific salmon, steelhead, lamprey, shad, smelt, and sturgeon. This is significant because all of these fish are affected by the quality of Oregon waters for all or part of their life cycle. Furthermore, 88 percent of the fish consumed by the Columbia Basin River Tribes originated from the Columbia River Basin (CRITFC 1994).

No consumption of any shellfish or open ocean finfish species was reported. The questionnaire used in the interviews did not include specific questions about marine species or shellfish. Since these questions were not asked in the interview, it is not clear how this may have affected the fish consumption rates reported by the Columbia River Tribes. Since the people of Oregon are likely to eat coastal marine seafood, the Columbia River Tribal data may not be relevant with respect to the marine and shellfish consumption patterns of Oregonians.

In summary, with the exception of the marine fish and shellfish component, the survey of Columbia River Basin Tribes (CRITFC 1994) is relevant to Oregon fish consumers because it offers a reliable and direct measurement of fish consumption by an Oregon population.

Utility

The fish consumption data reported in this survey are useful for the purposes of establishing water quality criteria for Oregon. This study was peer-reviewed and represented a random selection of 513 adult survey participants ages 18 and older from four Columbia River Basin Tribes (CRITFC 1994). Survey participants also provided information for 204 children ages five and younger from adult participant's households. The adult participants were interviewed by trained tribal representatives and asked to report 24-hour recall, weekly, monthly, seasonal, and 20-year average fish intake. The weekly estimates of fish consumption and data on serving size were used to determine the grams per day of fish consumed by each respondent. The survey's overall average and distributed rate of consumption were calculated from the individual rates. The survey did not include body weights for individual participants. This did not affect the overall usefulness of these data, since most consumption patterns are based on a measurement of grams per person per day. However, the accuracy of this measurement for individuals is reduced.

Although the raw data were not available for re-analysis, there was good documentation of the summary statistics conducted. The highest fish consumption rates were not categorized using any statistical methods, but rather considered "unreasonably high" and not included in the statistical analysis.

FISH CONSUMPTION, NUTRITION, AND POTENTIAL EXPOSURE TO CONTAMINANTS AMONG COLUMBIA RIVER BASIN TRIBES (RHODES 2006)

Relevance

This study is a re-evaluation of the original survey of the Columbia River Basin Tribes by CRITFC (1994). Thus it is relevant for developing a fish consumption rate for Oregon. There are no changes (no corrections) in the rate of consumption for the Columbia River Basin Tribes.

Utility

This report provides additional multivariate analysis on the correlation between fish consumption rates and factors including breast feeding after most recent births, percent of fish obtained non-commercially for women who recently gave birth, living off the reservation, and fish consumption rates for children and the elderly. This re-evaluation resulted in no changes or corrections to the consumption rates presented in the original Columbia River Basin Tribal survey (CRITFC 1994). Therefore, the data reported in this survey, were not included in the Human Health Focus Group's deliberations.

COLUMBIA SLOUGH AND SAUVIE ISLAND FISH CONSUMPTION SURVEY, TECHNICAL MEMORANDUM ON THE RESULTS OF THE 1995 FISH CONSUMPTION AND RECREATIONAL USE SURVEYS, AMENDMENT NO. 1 (ADOLFSON ASSOCIATES 1996)

Relevance

This study is regarded as being relevant to fish consumers in Oregon as it provides a description of the race, ethnicity, age and gender of the people fishing and the types of fish species caught and consumed in the Portland, Oregon metropolitan area. The study also provides information on various methods of fish preparation by local populations, other fishing frequencies and local fishing locations.

Utility

The data reported in this creel survey are not useful for quantitative assessment of fish consumption rates but provide regional information of subsistence fishers in the Portland metropolitan area. This study was conducted primarily on land and one day on water for 20 randomly selected days over a one month period. Both the days and times selected to conduct the survey utilized a stratified random sampling methodology. The survey team was trained and multi-lingual. A total of 91 interviews were conducted in the Columbia Slough and 55 interviews on Sauvie Island. The species, weight and length of the fish caught on the day of the interview was reported in addition the number of people consuming the catch. This survey has significant limitations for calculating individual fish consumption rates.

The quantitative fish consumption rates were limited by the inconsistencies in how individuals reported their fish consumption. The survey interviewers noted that individuals had difficulties in reporting the quantity of fish they consumed. Additionally, only fish weighed by the surveyors were counted in consumption estimates and of those fish, only 30 percent of the total weight of fish was regarded as edible despite the preparation method reported by the individual. Finally, if the participant reported that other people in the household ate fish, the individual consumption was simply divided by the number of people and individual portion size was disregarded. Overall, there was not sufficient information to calculate reliable fish consumption estimates.

A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region (Toy et al. 1996)

Relevance

The Tulalip and Squaxin Island Tribes survey is regarded as being relevant to Oregon fish-consuming populations; although some of the fish and shellfish they consumed may not be found in Oregon waters (Appendix A-2). Oregon does not have a marine body of water comparable to the size and complexity of Puget Sound, which is the fishing ground for the Tulalip and Squaxin Island Tribes. Places in Oregon such as Coos, Tillamook, and Nehalem Bays may provide a proportionally smaller habitat for comparable finfish and shellfish species that are found in Puget Sound. The life histories or habitat classifications of finfish or shellfish species were not included in the report, although they did identify those species that are found in Puget Sound.

Toy *et al.* (1996) states, "if the fish consumption rates in this report are to be used to represent fish consumption in other tribal populations, information should be collected about their species consumption, preparation methods and other relevant factors". The origin of fish consumed in the Tulalip and Squaxin Island Tribes survey was divided into five categories: a) those caught in Puget Sound, b) those caught outside Puget Sound, c) those eaten in restaurants, d) those purchased from grocery stores, and e) other. Anadromous fish (e.g. Pacific salmon) were the most heavily consumed fish group, of which 72-80 percent was caught in Puget Sound. Seventy-five percent of the shellfish consumed came from Puget Sound. Less than 50 percent of the open ocean fish (e.g. cod, Pollock) consumed by The Tulalip and Squaxin Island Tribes were collected from the Puget Sound.

The rates in this report are specifically relevant to Oregon fish-consuming populations, especially the coastal communities. Since the results are comparable to the fish consumption rates of members of the Columbia River Basin Tribes (CRITFC 1994), it demonstrates a simple relationship between tribal fish-consuming populations in the Pacific Northwest: people eat what's available to them and what's culturally preferred. Additionally, there are patterns of high consumption rates in Pacific Northwest Tribes regardless of species consumed or origin of the fish.

<u>Utility</u>

The fish consumption data reported in this survey are useful for the purposes of establishing water quality criteria for Oregon. This study represented a random selection of 190 adult survey participants from the Tulalip and Squaxin Island Tribes in Washington State. Additionally, survey participants provided information on 69 children of age six years and younger. The participants were interviewed by trained tribal representatives and asked to report on the number of fish meals eaten per day, per week, per month or per year over a one-year period and the portion size of each meal. Individual consumption rates were calculated using the portion size reported and the frequency of consumption, which depended upon how the participant reported it (daily, weekly, monthly, yearly). Any participant that did not eat any fish at all (non-consumer) was not included in the survey or data analysis since the survey objective was to ascertain the consumption rates of people who did eat fish.

The participants also reported their own body weight, which allowed for the calculation of consumption rates in grams per kilogram per day (g/kg/day). Including human body weights enhances the accuracy of estimating risk to any given individual. This study presented varied and useful analyses and summary statistics. There were a number of large consumption rates reported for this study. These high rates were considered outliers (an observation that is numerically distant from the rest of the data). The outliers were re-coded "…to the largest reported consumption rate within three standard deviations of the arithmetic mean" (Toy *et al.* 1996). Toy *et al.* 1996 acknowledged that, when calculating central tendencies, there is the potential that excluding outliers in such a manner may add bias in studies specially designed to examine variation and range of fish consumption and such biases would underestimate true fish consumption.

FISH CONSUMPTION SURVEY OF THE SUQUAMISH INDIAN TRIBE OF THE PORT MADISON INDIAN RESERVATION, PUGET SOUND REGION (SUQUAMISH 2000)

<u>Relevance</u>

The Suquamish Tribe survey is regarded as being relevant to Oregon fish-consuming populations. The type of fish caught in Puget Sound varies from those found in Oregon waters (Appendix A-3). While there is not a one hundred percent correlation between Puget Sound and Oregon waters this limitation does not affect the relevance of this study to Oregon populations.

The origin of fish consumed was divided into five categories: a) those caught in Puget Sound, b) those caught outside Puget Sound, c) those eaten in restaurants, d) those purchased from grocery stores, and e) other. The most heavily consumed fish groups in this survey were Pacific salmon (including steelhead) and shellfish. For both of these groups, 80-90 percent of the fish or shellfish consumed was harvested, of which the vast majority was harvested in Puget Sound. All other fish groups exhibited much lower harvest rates (less than 50 percent) and had higher percentages of restaurant or grocery origin. These data show that for certain groups of fish (Pacific salmon and shellfish) the local (Puget Sound) harvest comprises the vast majority of fish consumed.

This study of the Suquamish Tribe follows the same methodology within the same basin (Puget Sound) as the study of the Tulalip and Squaxin Island Tribes. Thus, the rates in this report are specifically relevant to Oregon fish-consuming populations, especially the coastal communities.

Utility

The fish consumption data reported in this survey are useful for the purposes of establishing water quality criteria for Oregon. This study represents a random selection of 92 adult survey participants from the Suquamish Tribe. Additionally, survey participants provided information on 31 children ages six years and younger. The participants were interviewed by trained tribal representatives and asked to report on the number of fish meals eaten per day, per week, per month or per year over a one-year period and the portion size of each meal. Individual consumption rates were calculated using the portion size reported and the frequency of consumption, which depended on how the participant reported it (daily, weekly, monthly, yearly). All 92 survey respondents reported eating some type of fish which meant there were no "non-consumers" among the respondents. The participants also reported respondent body weight, which allowed for the calculation of consumption rates in g/kg/day. Including body weight enhances the accuracy of estimating risk to any given individual or population. Good summary statistics were presented in the report with useful and varied analyses of the data. The analysis did not exclude any data.

The Suquamish staff chose to include high consumption rates because they were familiar with the individuals eating those large quantities and that the consumption rates reported were likely to reflect real consumption (Suquamish 2000). With no adjustments made for the high consumption rates, it was noted that the reported means may be highly influenced by the consumption of just a few individuals.

ASIAN AND PACIFIC ISLANDER SEAFOOD CONSUMPTION STUDY (SECHENA ET AL. 1999)

Relevance

The Asian and Pacific Islander survey is regarded as being relevant to Oregon fish-consuming populations (with some limitations), as there were a significant number of marine finfish and shellfish species consumed by people interviewed in this study that may or may not be found in certain Oregon waters (see Appendix A-4).

The origin of fish consumed was divided into four categories: a) those harvested in King County, b) those caught outside King County, c) those eaten in restaurants, and d) those purchased from grocery stores or street vendors. The most heavily consumed fish group in this survey was shellfish. For all fish groups, 79-97 percent of the seafood consumed came from either groceries/street vendors or restaurants. Seafood known to be harvested locally comprised from three percent to twenty-one percent of their diet. These data show that the vast majority of fish and shellfish consumed by Asian and Pacific Islanders is obtained through groceries/street vendors and restaurants.

The rates in this report are potentially relevant to Oregon fish-consuming populations such as the Asian and Pacific Islander communities in Oregon. The vast majority of seafood consumed was purchased, but it is not known what proportion of purchased fish was locally caught. Despite this limitation, the study is still relevant to the Asian and Pacific Islanders of Oregon as an indicator of their fish consumption patterns.

Utility

The data on fish consumption rates reported in this survey are useful for the purposes of establishing water quality criteria for Oregon. This study represented a selection of 202 adult survey participants from 10 different ethnic communities that comprise the Asian and Pacific Islander community of King County, Washington. The participants were interviewed by trained representatives from each of the ethnic communities represented and asked to report on the number of annual servings and the portion size of the servings. Individual consumption rates were calculated using the portion size reported multiplied by the number of annual servings and then divided by 365 days times the respondent's body weight. Any participant that did not eat any fish was not included in the survey or data analysis since the survey objective was to ascertain the consumption rates of people who did eat fish.

The participants also reported their own body weights, which allowed for the calculation of consumption rates in g/kg/day. Including human body weights enhances the accuracy of estimating risk to any given individual or population.

Summary statistics were presented in the report with useful and varied analyses of the data. The authors (Sechena *et al*. 1999) reported that there were an usually large number of high fish consumption rates. The values that were identified as outliers were those observed values greater than three standard deviations above the mean. These outliers were then given a smaller value equal to the mean plus three standard deviations.

CONSUMPTION PATTERNS OF ANGLERS WHO FREQUENTLY FISH LAKE ROOSEVELT (WDOH 1997)

Relevance

This survey is regarded as being relevant to Oregon fish consumers. The populations surveyed in this study are likely to exist on a comparable lake in Oregon. The species reported in the survey included kokanee, rainbow trout, walleye and bass. Some or all of these species are likely to be found in Oregon lakes as well. Survey participates were primarily vacationing boat anglers returning from fishing trips. No tribal members were surveyed.

Utility

The data reported in this survey are not useful for quantitative assessment of fish consumption rates. This survey was conducted to determine the consumption patterns of anglers who repeatedly fish in Lake Roosevelt. Creel and fish consumption surveys were conducted at boat launches with people returning from their fishing trips at randomly selected locations. The survey was pilot tested and administered by creel clerks over a four to five month period during 1994 and 1995. The survey protocol was slightly altered from one year to the next to collect more accurate and meaningful consumption data. A total of 448 interviews were conducted. Anglers who did not consume fish (total of 57) were not included in the data analysis. Data collected showed that 84 percent of all respondents were members of two adult households.

The fish consumption rates derived from this survey were not useful because of inconsistencies in how the consumption information was reported. Although the frequency of consumption was obtained, there were difficulties in obtaining the portion size consumed at each meal, which led to further difficulties in calculating individual consumption rates. Therefore, actual consumption rates were not reported, but frequency of consumption and number of fillets eaten per meal was reported.

LAKE WHATCOM RESIDENTIAL AND ANGLER FISH CONSUMPTION SURVEY (WDOH 2001)

Relevance

This survey is regarded as being relevant to Oregon fish consumers as populations similar to those surveyed in this study are likely to exist on a comparable lake in Oregon. The species reported in the survey included smallmouth bass, yellow perch, kokanee, cutthroat trout, and signal crayfish. Some or all of these species are likely to be found in Oregon lakes as well. The source of the fish consumed was Lake Whatcom. There was no indication through the survey protocol if those interviewed consumed harvested fish from any other lake, river, or bay. There was, however, a question about the consumption of canned tuna fish since the study was driven originally by concerns of mercury exposure. Nineteen of the 242 respondents consumed tuna an average of 4.2 times over the previous four weeks. This fact may indicate that these respondents are frequent “fish eaters” and may supplement their diets with fish from other sources such as restaurants or grocers stores.

Utility

This study was designed to collect fish consumption information from residents who live on or near the lake or in developments with direct access to the lake, boat anglers accessing the lake at public boat launch facilities, and shore anglers. Although, the data reported in this survey are not useful for quantitative assessment of fish consumption rates, the study provides some information on types of fish collected and eaten, even in the presence of fish advisories. Only average meal sizes were calculated, and an accurate frequency of meals per week or month was not clearly presented. Due to elevated mercury levels in some fish species reported in a screening survey from Lake Whatcom, Washington, fishing was already influenced by perceived contamination as reported in local media. This study also gathered information regarding the respondents’ perceptions and likely reactions to a fish consumption advisory. There were trained interviewers who went door-to-door at randomly selected residencies and approached anglers during specified times on the boat launches and the shore. There interviewees included residents (194), boat anglers (38), and shore anglers (10).

The participants were asked to report on how many times over the previous four weeks they had eaten fish from Lake Whatcom, how many fish were eaten per meal, and how many months per year they consumed Lake Whatcom fish. They were also asked to report typical meal size based on a picture of a Pacific salmon fillet. Fish consumption rates were calculated using the number of reported fish eaten per meal multiplied by the average fillet weight of that species, which was obtained from a previous Lake Whatcom fish sampling effort.

The fish consumption rates from this survey were not useful because of inconsistencies on how the interviewees reported their fish consumption. The four-week recall diet limited the ability to fully quantify fish consumption due to the low number of people that consumed fish during that period. Although some limitations exist for the data, they do provide an indication of the amount of fish consumed exclusively from Lake Whatcom, Washington following the media coverage of potential contamination issues.

ESTIMATED PER CAPITA FISH CONSUMPTION IN THE UNITED STATES (USEPA 2002B

Relevance

This large national study is relevant to Oregon and provides context upon which specific, regional data can be based. The methodology used to conduct the survey and analyze the data is useful for analyzing fish consumption trends of the U.S. population via per-capita consumption rates. The study does not report state-specific fish consumer survey results from Oregon alone but was designed as a national study.

There was a wide variety of fish consumed in this survey, some of which may be found in Oregon waters.

Utility

The EPA national estimates of fish consumption (USEPA 2002b) are considered useful for the purposes of establishing water quality criteria for Oregon. The EPA national estimates (USEPA 2002b) were based on combined data from the USDA 1994-1996 and 1998 Continuing Survey of Food Intakes by Individuals (CSFII). The survey of 20,607 people (adults and children) was well designed to be statistically representative of the overall per-capita consumption rates of the U.S. population. The 24-hour dietary recall was administered by an interviewer and was conducted on two non-consecutive days. Data collection from these surveys spanned a period of four years. For this national survey individuals were interviewed in-person on their food intake on two non-consecutive days. Advantages of the survey methodology are that is that it is statistically representative of all 50 states, it has a good design for per-capita consumption estimates, the interviewer administration enhances its accuracy, and it was administered on non-consecutive days, which avoids correlated consumption data.

Because of the extraordinarily large survey population and the fact that individuals were chosen to statistically represent overall US populations this data set provides a valuable context for Pacific Northwest surveys.

Short-term data collection (two day - 24 hour recall) may not be representative of long-term consumption rates that have been averaged over time. However, since large numbers (20,607) of individuals were included in the EPA estimated per capita survey (USEPA 2002b and the survey includes more than one time period and season, there is a greater likelihood of capturing the distribution of consumption rates when compared to smaller surveys.

Since the goal of the USDA CSFII surveys was to represent the diet of all people (per capita) in the United States, the data included people who eat fish (consumers) and those who don’t eat fish (non-consumers). Including non-consumer data in a fish consumption rate can result in misleadingly low fish consumption rates. In addition to reporting the per capita fish consumption rates, EPA (2002) considered it appropriate to report the data for consumers only as well as the combined consumer and non-consumer data.

The Human Health Focus Group agreed that exposure assessments and the evaluation of potential risks to fish consumers must consider the consumption rates appropriate for actual consumers. Thus, EPA (USEPA 2002b) "consumer-only" data were examined for their usefulness. The statistical certainty of the USDA CSII Study was quite high because of the large number of participants (20,607). This certainty is reduced when "consumer-only" data for only adults are extracted because of the decrease in the number of people from 20,607 to 2,585. However, the Human Health Focus Group considered these rates to be useful for Oregon with the acknowledgement of decrease in statistical certainty.

3.1.4 General Discussion of Fish Consumption Survey Methodologies

The survey methodologies in the studies reviewed by the Human Health Focus Group include interview questionnaire (CRITFC 1994, Toy *et al.* 1996, Suquamish 2000, Sechena *et al.* 1999, dietary recall (USEPA 2002b) and creel surveys (Adolfson 1996, WDOH 1997, WDOH 2001). Each of these methodologies has individual advantages and disadvantages.

Fish consumption surveys are designed to estimate the fish consumption patterns of a target population. A number of potential biases can influence survey results. Response rates, literacy, and language barriers may affect the quality of data collected in surveys. Other sources of bias in a survey include interviewer bias, differential effort by interviewers or respondents, cultural differences in interpretation, recall bias or memory problems, and over- or under-reporting (OEHHA 2001). Finally, different methods of data analysis can yield very different estimates of consumption from the same dataset.

The four personal interview surveys reviewed by the Human Health Focus Group utilized local interviewers to conduct the interviews for their own groups, to ensure that the people being interviewed felt comfortable answering the survey questions. This approach helps enhance the trust of the interviewee and the effectiveness of communication during the interview. Personal interviews are often pilot-tested to enhance the relevance of the questionnaire.

Personnel interview surveys may suffer from recall bias as individuals lose accuracy as time from an activity increases. This becomes a challenging issue when individuals are asked to recall consumption rates over prior twelve months. An individual may remember that they ate fish a certain number of times but they may not remember the exact amount in each instance.

The Human Health Focus Group reviewed three creel surveys for this report. Creel surveys are field interviews of anglers at the site they are fishing. Many creel surveys include inspection of the angler's catch, which can increase survey accuracy. Creel survey results are limited by the locations, seasons, dates, and times of the interview. Language and literacy may present difficulties during an interview (USEPA 1998). Since interviews are based upon when the interviewer chooses to visit the angling site, interviewees are not prepared for the interview and may be less likely to participate. The interviewee also may not trust the stranger conducting the interview.

The Human Health Focus Group reviewed only one dietary recall survey for this report. Short-term data collection (two day - 24 hour recall) is a well accepted methodology for dietary studies because individuals more accurately recall recent events, such as the food they consumed within the last day). Recall surveys that are administered by a trained interviewer allow for consistency between participants and reduce the errors in reporting that are possible in self reported surveys. Correlated consumption data can occur if a participant cooks and eats fish on one day and then eats that same fish as leftovers the next day. This can be avoided by conducting the survey on non-consecutive days.

Although estimates of consumption from dietary recalls may be reported as g/day, the values may not be representative of long-term consumption rates that have been averaged over time and presented as a daily rate. Other fish consumption study methodologies consider fish consumption over a much longer period of time and are therefore more likely to more closely represent the fish consumption patterns of the population studied.

3.2 CONSUMERS-ONLY DATA

Fish consumption surveys typically include people who eat fish and people who don't eat fish. People who don't eat fish are termed "non-consumers". Those that do eat fish are considered "consumers". The proportion of non-consumers included in the survey will vary depending on the population being interviewed. For instance, of the 500 respondents in *A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin* (CRITFC 1994), 93 percent were fish consumers. It is common among the tribal populations reviewed in this report to have a high percentage of fish consumers in their population. In contrast, EPA (USEPA 2002b) evaluated national data from approximately 20,000 individuals (3 years and older). Approximately 28 percent were fish consumers.

In EPA's *Estimated Per Capita Fish Consumption in the United States* (USEPA 2002b), fish consumption data were collected using a non-consecutive two-day dietary recall. Anyone who didn't eat fish on either of the two recall days was considered a non-consumer. This methodology has the potential to underestimate the number of consumers in a population. Furthermore, anyone who did eat fish on either of the two days would be considered a consumer. The data for an individual consumer were then assumed to be that person's rate of consumption for every day of the year. In this case, a reported value for short-term consumption on two survey days was used to estimate long-term or "usual" intake of fish and shellfish.

Oregon's current fish consumption rate of 17.5 g/day was determined on a per-capita basis for the entire U.S. population (USEPA 2002b) including fish consumers and non-consumers. All non-consumers are recorded as having a consumption rate of zero g/day. When averaging in the zero consumption rates of the non-consumers with the actual rates of the consumers, the resulting rates represent the averages across an entire population, and do not represent the actual fish consumption rate for people who eat fish.

Oregon's human health-based water quality criteria are developed to specifically protect individuals who consume fish, which would make the consumer-only rates most representative of a fish-consuming population. Oregon should base its regulatory consumption rate on data specifically derived from consumers of fish.

3.3 SUPPRESSED RATES

The Human Health Focus Group also discussed some of the factors that may contribute to the suppression of fish consumption rates. Current reported fish consumption rates may be depressed compared to historic rates due to several factors: 1) significant reductions in fish populations, 2) the belief that fish that reside in polluted waters will bio-concentrate pollutants, 3) contaminated fish, and 4) the intended impact of local fish advisories or the unintended consequences of national fish advisories of commercial fish species that are not applicable to local waters

The Human Health Focus Group also noted that three of the five studies presented in Table 3 (in Section 5.2) excluded or discounted high fish consumers by identifying statistical outliers. This would have the effect of underestimating the true range in fish consumption rates. If the rates are already suppressed the elimination of the highest values may be reporting an artificially low fish consumption rate.

3.4 FISH SPECIES CONSUMED

There are a variety of fish and shellfish species represented in the studies reviewed. Fish and shellfish species can be classified as marine, estuarine, or freshwater based upon the habitat in which they are born/hatched, reproduce, grow, and die. Some species of fish or shellfish can spend portions of their life in multiple aquatic environments. Pacific salmon hatch in freshwater, migrate to the ocean and then return to freshwater to spawn and die. Other migratory species commonly consumed in Oregon include sturgeon, lamprey, smelt, and shad. Note that the white sturgeon is landlocked because of dams on the Columbia River.

The seafood species consumed by recreational and subsistence fishers are dependent upon where these people live and fish. The availability of fish and shellfish is a major factor influencing the types of seafood consumed by populations who harvest for consumption purposes. For example, tribal members interviewed in the survey of Columbia River Basin Tribes (CRITFC 1994) reported eating resident trout, northern pike-minnow, sturgeon, suckers, walleye, and whitefish. They also consumed Pacific salmon, lamprey, shad, smelt, and sturgeon. They did not report eating any shellfish or open ocean finfish species. This may be influenced by the fact that the Columbia River Basin Tribes (CRITFC 1994) questionnaire did not include questions about consumption of specific marine fish or shellfish species.

In contrast, the Puget Sound Tribes (Tulalip and Squaxin Island) reported eating a variety of marine and migratory fish species (e.g. cod, sole, Pacific salmon) and shellfish (e.g. clams) (See Appendix A-2). All of these tribes were consuming fish and shellfish that were available to them in their given harvest locations. Although direct comparisons of the fish and shellfish species consumed between the Columbia River Tribes and the Puget Sound Tribes are difficult, an overall comparison of consumption patterns among tribal fishers is relevant.

The surveys reviewed by the Human Health Focus Group (Table 1, located at the end of this document) suggest that fish consumers generally eat a variety of species that are most readily available geographically and seasonally. Additionally, the ranges of consumption rates among fish consumers tend to be comparable regardless of the species that are available at a given location. Thus, it is reasonable to assume that persons who eat fish will change or substitute species based on availability, cost and accessibility.

4. PACIFIC SALMON IN THE FISH CONSUMPTION RATE

EPA's national default fish consumption rates are derived for specific fish habitats (freshwater, estuarine, marine 65 FR 66469, 2000a). The choice of a fish consumption rate to use in calculating water quality criteria can be influenced by what types of fish and shellfish are included in the rate.

Human health water quality criteria are applied to "waters of the state" (as previously defined) and are used to maintain and improve water quality through numerous CWA regulatory programs administered by ODEQ. Implementing and enforcing human health criteria in waters of the state will only affect those fish and shellfish species residing in and exposed to those waters. Since water quality criteria are only protective of Oregon waters, it is important to understand which fish and shellfish species are found in Oregon waters. This is not a simple task since Oregon waters technically extend three nautical miles off the Oregon coast. There are a wide variety of fish and shellfish that live within that nautical boundary for all or part of their life cycle. Complicating matters even further is the presence of migratory fish (e.g., Pacific salmon), which spend part of their life cycle in the freshwaters of Oregon and part of their life cycle in deep ocean waters that are outside Oregon's jurisdiction.

4.1 EPA CLASSIFICATION OF PACIFIC SALMON

For some species their life history involves multiple habitats (e.g. anadromous). EPA designated their habitat as fresh water/estuarine and marine on a case-by-case basis (Table 2 excerpt from USEPA 2002b). EPA classified the habitat of salmon based on commercial-landings data provided by the National Marine Fisheries Service for the period of 1989-1991 (65 FR 66469, 2000b). All landings of Pacific salmon, including Chum, Coho, King, Pink, or Sockeye were assigned to marine habitat. All landlocked Great Lakes salmon and farmed salmon received the classification of freshwater.

Migratory
Fish that move between multiple habitats (freshwater, estuarine, and marine).
Anadromous
Migratory fish that spend most of their lives in the sea and migrate to fresh water to breed (Myers, 1949 as reported in Bond, 1979)

As the landings of Pacific salmon were reported from the marine environment, Pacific salmon were classified as marine (USEPA 2002b) and excluded from the national default fish consumption rates for calculating water quality standards. However, states and authorized tribes can make alternative assumptions to specifically account for the dietary preferences of the specific population (Oregon) of concern.

TABLE 2 EPA HABITAT APPORTIONMENTS (EXCERPT FROM TABLE 2-1 HABITAT APPORTIONMENTS, EPA 2002B)

		USDA CSFII food survey database	
Species	**Habitat**	**1994-1996**	**1998**
Flatfish	Estuarine (Flounder)	90	84
	Marine (Halibut)	10	16
Clams	Estuarine (softshell)	2	3
	Marine (Ocean Quahog, Quahog, Atlantic Surf, and remaining hardshell species)	98	97
Crab	Estuarine (Blue, Soft, Hard, Peeler, Dungeness)	66	47
	Marine (King, Snow, Jonah, and Other	34	53
Scallop	Estuarine (Bay)	0.6	0.7
	Marine (Calico and Sea)	99	99
Salmon	Freshwater (Great Lakes)	0.06	0.05
	Estuarine (Aquaculture)_	3	5
	Marine (Pacific)	97	95

4.2 PACIFIC SALMON IN OREGON WATERS

Pacific salmon and other migratory species present a rather complicated life history for establishing habitat preferences. Pacific salmon reside and pass through waters of the state. They are spawned and develop in waters of the state, and, after spending time in the ocean, return to Oregon freshwaters to spawn and die. Additionally, local data reviewed by the Human Health Focus Group (CRITFC 1994) indicate that Pacific salmon are caught in waters of the state in addition to the deep marine water landing data that EPA relied upon to classify Pacific salmon.

Different Pacific salmon species have different life histories, and therefore use fresh and estuarine waters for different lengths of time, and at different intensities. For example, Fall Chinook may be more at risk for uptake of toxic contaminants because of their greater use of shallow-water habitats in the estuary, where toxic sediments are most likely to accumulate (Fresh 2005). Spring Chinook enter fresh waters early in the year and do not spawn until late fall or early winter. These varying life histories also affect the exposure patterns in the marine portion of the Pacific salmon life history, where some stocks may spend more time in coastal waters within the regulatory boundaries of Oregon's water quality standards.

The source of the pollutants found in Pacific salmon tissue is not well understood. The Human Health Focus Group did not conduct a comprehensive review of the life histories or potential sources of contamination for Pacific salmon. Johnson *et al.* (2007a, b) studied the tissue residue levels of chemicals in juvenile Chinook salmon in the Columbia River. They detected the following fish tissue chemical residues: PCBs, DDT, and, to a small extent, aromatic hydrocarbons, chlordanes, aldrin, dieldrin and mirex. These data demonstrate exposure to toxic chemicals occurs during the freshwater portion of the Pacific salmon life cycle.

4.3 RELATIVE SOURCE CONTRIBUTION

If Pacific salmon are not included in the fish consumption rate, utilizing the concept of Relative Source Contribution (RSC) is another way to account for some of the potential risk from consuming Pacific salmon in addition to all other marine fish and shellfish. The purpose of the RSC concept is to account for all other sources of exposure other than those associated with consumption of freshwater and estuarine finfish and shellfish, such as skin absorption, inhalation, drinking water, marine fish, other foods, and occupational exposures.

EPA applies the concept of RSC to chemicals with a reference dose to account for exposure through consumption of marine fish, Pacific salmon and other non-fish sources. The RSC value is not applied to carcinogens. EPA's ambient water quality criteria guidance (USEPA 2000a) states that the concept of the RSC does not apply to carcinogens because regulatory agencies are only responsible for assessing incremental risk from exposure to contaminants in fish tissue and water and no other exposures. In addition EPA states that:

> "...health-based criteria values for one medium [water] based on linear low-dose extrapolation [cancer] typically vary from values for other media in terms of the concentration value, and often the associated risk level. …Therefore, the RSC concept could not … apply unless all risk assessments for a particular carcinogen … resulted in the same concentration value and same risk level; that is, an apportionment would need to be based on a single risk value and level." (USEPA 2000a)

The RSC value is applied to chemicals with a reference dose to ensure that exposure to these chemicals, when combined with all other sources will not exceed the reference dose (65 FR 66473, 2000). Details of how the RSC values are incorporated into the equation to calculate human health-based water quality criteria can be found in EPA's *Methodology for Deriving Ambient Water Quality Criteria for the Protection for Human Health* (USEPA 2000a).

The RSC value could be applied to the 47 chemicals with a references dose within the current list of priority pollutants. Oregon currently applies the RSC values developed by EPA to human health-based water quality criteria for the following pollutants (more details are available in Appendix B):

- Antimony
- Methylmercury
- Thallium
- Cyanide
- Chlorobenzene
- 1,1, Dichloroethylene
- Ethylbenzene
- Toluene
- 1,2 Trans Dichloroethylene
- 1,2 Dichlorobenzene
- 1,4 Dichlorobenzene
- Hexachlorocyclo-pentadiene
- 1,2,4 Trichlorobenzene
- Gamma-BHC
- Endrin

The concept of the RSC is not applied to the other 32 toxicity reference dose-based criteria. This does not necessarily mean that other reference dose-based criteria do not have other routes of exposure. It simply means that there may not be enough data for EPA to establish RSC values for these other 32 chemicals.

At this time the only pollutant whose exposure pathway is known to be primarily from marine fish and Pacific salmon is methylmercury. The primary source of methylmercury is through consumption of marine fish. Oregon's current criterion for methylmercury incorporates an RSC value of 2.7×10^{-5} milligrams per kilogram (mg/kg) of body weight per day that accounts for the consumption of marine fish shellfish and salmon (Appendices B and C). All other water quality criteria for which RSC values have not been developed do not encompass protection of humans through exposure via consumption of marine fish or Pacific salmon.

EPA provides guidance for calculating RSC values outside of its own default values (Appendix D). This process requires robust datasets on sources of exposure for individual chemicals. Data on other sources of exposure do not exist for Oregon. It would be difficult for ODEQ to develop Oregon-specific RSC values without assistance from EPA.

If Oregon-specific RSC values cannot be derived, then states and tribes have the option to rely upon the EPA default RSC value of 20 percent (of the reference dose). In this approach states and tribes could apply an RSC value of 20 percent to the remaining 32 chemicals that have a reference dose. Since there are no data to evaluate whether the 20 percent default option for the remaining criteria satisfactorily accounts for exposure through Pacific salmon consumption and all other non-fish exposures, the Human Health Focus Group cannot evaluate the use of the RSC concept on its technical merits. Therefore, the use of a default RSC value of 20 percent remains a policy decision.

Double Counting

To prevent double counting, exposures considered through the relative source contribution factor should not be included in the fish consumption rate.

4.4 INCLUDING PACIFIC SALMON IN THE FISH CONSUMPTION RATE

Since Pacific salmon are a known part of the diet for fish-consuming populations in Oregon, the human health-based water quality criteria should account for the potential risk incurred from consuming Pacific salmon. The surveys reviewed by the Human Health Focus Group not only reveal that Pacific salmon is being eaten, but also indicate with varying degrees of accuracy how much Pacific salmon is being consumed. Knowing the amount of consumed Pacific salmon allows for measurable and scientifically defensible inclusion of Pacific salmon in the fish consumption rate. Including Pacific salmon in the fish consumption rate can provide more scientific certainty that Pacific salmon consumption is being accurately accounted for when calculating risk-based water quality criteria.

The alternative to including Pacific salmon in the fish consumption rate is using the concept of the RSC to account for Pacific salmon exposure. The concept of the RSC falls short of full protection because of insufficient data to calculate accurate RSC values, and the RSC process does not account for carcinogenic risk. However, there are reliable data available from studies on the consumption of Pacific salmon. Therefore, it is more accurate to account for the total human health risk by including Pacific salmon directly in the fish consumption rate rather than trying to address it through an estimated RSC value.

4.5 INCLUDING MARINE FISH IN THE FISH CONSUMPTION RATE

During discussions about inclusion of Pacific salmon in the fish consumption rate, the Human Health Focus Group also discussed the possibility of including all marine fish in the fish consumption rate. If a deep ocean fish such as tuna is consumed by an Oregonian, there is a potential that the fish may contain contaminants that would add to the health risk of the consumer. So, regardless of the source of the fish, fish consumers face potential risks. Although this is true, Oregon's fish consumption rate and its associated human health-based water quality criteria can only be applied to waters within the regulatory jurisdiction of the State of Oregon (OAR 340-041-0001(1)). The jurisdiction in marine waters is confined to Oregon's waters of the state, which extend three nautical miles into the Pacific Ocean from the Oregon coast.

5. SELECTING FISH CONSUMPTION RATES

5.1 PROCESS FOR SELECTING FISH CONSUMPTION RATES

A variety of quantitative fish consumption estimates were selected from the five surveys considered relevant and useful by the Human Health Focus Group:

- A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin (CRITFC 1994)
- A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region (Toy *et al.* 1996)
- Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region (Suquamish 2000)
- Asian and Pacific Islander Seafood Consumption Study (Sechena *et al.* 1999)
- Estimated Per Capita Fish Consumption in the United States (USEPA 2002b).

The following process was used by the Human Health Focus Group to refine the recommended fish consumption rates:

1) Eliminate fish consumption rates that include non-fish-consuming populations
2) Include all fish consumption estimates regardless of the source of the fish (harvested or purchased)
3) Include fish consumption estimates for all types of seafood (fish and shellfish species) from marine, freshwater, and estuarine habitats.

1) Eliminate fish consumption rates that include people who don't eat fish.
Oregon's human health-based water quality criteria are developed to specifically protect individuals who eat fish. Therefore it seems most appropriate to select those fish consumption estimates for people who eat fish and exclude estimates that include people who don't eat fish. The inclusion of the non-fish consuming population lowers the consumption rate and thus reduces the level of protection for the people who do eat fish.

2) *Include all fish consumption estimates regardless of the source of the fish (harvested or purchased).*

In some surveys, the respondents report on the source of the fish they consume. Sources of fish and shellfish can include self-harvested, or purchased from stores or restaurants. The fish and shellfish that are purchased may be locally caught. The Human Health Focus Group decided that it is more important to capture the fish consumption rate for all fish consumed rather than excluding those estimates for fish that was purchased.

3) *Include fish consumption estimates for all types of seafood (fish and shellfish species) from marine, freshwater, and estuarine habitats***.**

Deep ocean fish that are found beyond three nautical miles off the Oregon coast (tuna, shark, halibut, etc) are not included in the current fish consumption rate in Oregon. ODEQ was not able to provide a list of the exact species that would be considered near-shore marine fish that live within three nautical miles of the coast. Therefore these particular species could not be isolated from the deep ocean fish in the surveys.

In addition to marine species, EPA's national guidance recommends that Pacific salmon and other migratory species be excluded from the fish consumption rates for water quality criteria.

Exposure to chemicals in marine fish and migratory fish including Pacific salmon is accounted for through the concept of the RSC. Thus, people who eat these fish may be protected through an indirect measure of exposure. However, there is only one chemical (methylmercury) where marine species (Pacific salmon and other migratory species), are accounted for using the concept of RSC. Due to EPA's policy regarding the lack of data that prevents the application of the concept of RSC across all other chemicals and endpoints such as carcinogenesis, the Human Health Focus Group chose not to recommend use of the RSC approach.

Oregonians eat a variety of fish species that may be harvested from fresh water, estuarine, or marine habitats. All types of fish and shellfish are included in the fish consumption rates recommended by the Human Health Focus Group. In particular, Pacific salmon is a major component of fish consumption in Oregon. Including Pacific salmon and other migratory species in the fish consumption rate can provide more scientific certainty that these species are accurately accounted for when calculating water quality criteria.

The alternative to including salmon in the fish consumption rate, as explained in the report, is using the concept of the RSC to account for salmon exposure. This will fall short of full protection because sufficient data are not available to calculate accurate RSC values, and the RSC process does not account for carcinogenic risk. Therefore, it is more accurate to account for the total human health risk by including salmon directly in the fish consumption rate itself.

5.2 RECOMMENDED FISH CONSUMPTION RATES

The final fish consumption rates identified by the Human Health Focus Group are presented in Table 3. The range of fish consumption rates presented in Table 3 provides a scientific basis for choosing a fish consumption rate and establishing water quality criteria that are protective of Oregonians that eat fish. A range of statistical values from each of the five studies: the mean, the median, and the 75th, 90th, 95th, and 99th percentiles are listed in Table 3. Note that there are six surveys reported in five studies. The Toy *et al.* report includes surveys of two tribes (Squaxin Island Tribe and Tulalip Tribes).

TABLE 3. ADULT FISH CONSUMPTION RATES (GRAMS PER DAY) RECOMMENDED BY THE HUMAN HEALTH FOCUS GROUP FOR OREGON HUMAN HEALTH-BASED WATER QUALITY CRITERIA.

Group	Species included in consumption rate evaluation	N	Statistic					
			Mean	Median	Percentile			
					75th	90th	95th	99th
Tulalip Tribe	Anadromous and estuarine finfish and shellfish	73	72	45	85	186	244	312
Suquamish Tribe	Anadromous and estuarine finfish and shellfish	284	214	132	NA	489	NA	NA
Squaxin Island Tribe	Anadromous and estuarine finfish and shellfish	117	73	43	NA	193	247	NA
Columbia River Tribes	Freshwater and anadromous finfish	512	63	40	60	113	176	389
Asians & Pacific Islanders	Anadromous and estuarine finfish and shellfish	202	117	78	139	236	306	NA
U.S. General Population	Freshwater, anadromous, estuarine, and marine finfish and shellfish	2585	127	99	NA	248	334	519

N = Number of adults in survey
NA= Statistical value not available.
Adults are 18 years or older for all surveys except Suquamish; Suquamish adults were 16 years or older
All values reported in this table are described in Table 1 (located at the end of this document)
Tulalip Tribes and Squaxin Island Tribe from Toy *et al.* 1996.
Suquamish Tribe from Suquamish. 2000.
Columbia River Treaty Tribes from CRITFC. 1994.
The Columbia River Tribes did not report marine fish consumption;
The 75, 90, 95 and, 99th percentiles are interpolated from percentiles reported in CRITFC 1994
Asian Pacific Islanders from Sechena *et al.* 1999.
US General Population from US EPA. 2002b.

The Human Health Focus Group only included fish consumption rates (Table 3) for adults in their recommended list of fish consumption rates. When fish consumption rates from these surveys are reported as grams per person per day, the consumption for children is lower than that of the adults and thus when expressed as an exposure value of grams per day, the adult levels may be protective of children. At this time the USEPA recommended water quality criteria are derived for adults with an average body weight of 70 kg (USEPA 2000a). With respect to exposure, children are particularly vulnerable compared to adults due to their lower body weight, differing metabolism, and behaviors. Thus it may be appropriate for the State of Oregon to develop water quality criteria for children.

Table 3 does not include the fish consumption rate of 17.5 g/day which is the basis for current Oregon water quality criteria. This number is considerably lower than the estimates recommended by the Human Health Focus Group because it was calculated in part by including people who don't eat fish and excluding Pacific salmon as well as other migratory and marine species. It is not an accurate estimate of long-term fish consumption rates for people who eat fish. For example, the fish consumption rate of 248 g/day for the general population (USEPA 2002b) shown in Table 3 is more than 14 times greater than the current EPA default fish consumption rate (17.5 g/day) and more than double the 90th percentile (113 g/day) fish consumption rate for the Columbia River Basin Tribes (CRITFC 1994). For the U.S. general population, the mean seafood consumption rate for adults who consume fish is 127 g/day (+/- 6 g/day), while five percent of the adult population consumes 334 grams per day or more (+/- 15 g/day). These fish consumption rates are based on a sample of 2,634 adult consumers 18 years and older (USEPA 2002b, Section 5.2.1.1.Table 4.).

All the fish consumption rates in Table 3 are higher than the current 17.5 g/day fish consumption rate used in the current Oregon water quality criteria. The reason for this is that the Human Health Focus Group included only fish consumption rates for people who eat fish; and included all marine and migratory species described in the regional studies. The 90th and 95th percentile consumption rates for US fish consumers shown in Table 3 are consistent with, and are in fact greater than, the corresponding consumption levels documented in the Pacific Northwest regional studies identified by the Human Health Focus Group.

The Human Health Focus Group recommends selecting an Oregon fish consumption rate from a range of values that includes only those data for fish consumers (since this is about people who eat fish) and all types of fish (fresh water, estuarine, marine, and migratory finfish and shellfish). The national survey fish consumption survey (USEPA 2002b), is important to Oregon because the fish consumption rates from the national survey reflect the general U.S. population. Since there is no similar state-wide survey of all fish-consuming populations in Oregon, the national survey remains a relevant contextual piece of information for determining a change in the Oregon fish consumption rate.

The Human Health Focus Group discussed how recommendations for a fish consumption rate should be presented for use by Oregon. Scientists frequently present their scientific results in two ways, one to represent uncertainty and one to represent variability. Scientists present uncertainty information as 95 percent confidence levels around the mean which is based on a standard error calculation.

For the types of issues the Human Health Focus Group considered in this report, variability in fish consumption rates, scientists usually present the 95th percentile which represents the variability of the population at two standard deviations from the mean (Kavloch *et al.* 1995). The majority of scientists on the Human Health Focus Group referred to this value when they discussed approaches for communicating how the fish consumption values could range for the Oregonian populations. One member used the 90th percentile as the point of reference. Both values are presented in Table 3.

Although the survey (cited here) of Japanese and Korean communities was not reviewed by the Human Health Focus Group because the results were not yet published, the results of the survey add to the conclusions made by the Human Health Focus Group about relevant fish consumption rates to recommend for the Oregon population.

> *Mercury Exposure from Fish Consumption within the Japanese and Korean Communities*. Ami Tsuchiya, Thomas A. Hinners, Thomas M. Burbacher, Elaine M. Faustman, Koenraad Mariën. Journal of Toxicology and Environmental Health 2008 (in press).
>
> *Fish intake guidelines: Incorporating n-3 fatty acid intake and contaminant exposure in the Korean and Japanese communities*. Ami Tsuchiya, Joan Hardy, Thomas M. Burbacher, Elaine M. Faustman, Koenraad Mariën. American Journal of Clinical Nutrition. 2008 (in press).

The survey, conducted by scientists at the Washington State Department of Health and University of Washington, assessed fish consumption in woman in Asian populations, Japanese and Korean, living in Western Washington. The results indicate fish consumption rates higher than the national average. The mean fish consumption rates for the Japanese and Korean populations (73 and 82 grams/day, respectively) fall within the range of mean rates of the surveys assessed by the Human Health Focus Group (shown in Table 3). The 95th percentile of the rates was 188 grams/day for the Japanese population and 230 grams/day for the Korean population. Both of these values also fall within the range of 95th percentiles of surveys assessed by the Human Health Focus Group (shown in Table 3) and thus provide additional support for Pacific Northwest fish consumption values of relevance for Oregon populations.

5.3 OREGON POPULATION-BASED FISH CONSUMPTION RATES

It is important to consider the number of Oregonians who are high consumers of seafood based upon the fish consumption rates shown in Table 3 of this report. In order to do this we have used estimates of the population based upon the 2003 Oregon Population Report of the Population Research Center at Portland State University. In these calculations, we assume that the Oregon population's dietary patterns are similar to the general U.S. population reported in Table 3. The data for the U.S. general population in Table 3 of this report, which comes from Section 5.2.1.1, Table 4, in USEPA Estimated Per Capita Fish Consumption in the United States August 2002b, is for adult consumers of seafood 18 years of age or older (n=2,634). Here, seafood is defined as finfish and shellfish from fresh, estuarine, and marine environments. The population of Oregon in 2003 was 2,655,700 adults, 18 years and older (see Table 9 of 2003 Oregon Population Report).

In the US EPA 2002 survey used to generate the general population fish consumption rates in Table 1 (located at the end of this document), 28 percent of the population interviewed were consumers (see Section 5.1.1.1 Figure 4 in USEPA Estimated Per Capita Fish Consumption in the United States August 2002b). In the study, participants were asked to recall their seafood consumption on two non-consecutive days and consumers were participants who ate seafood on at least one of the two days. Assuming the Oregon population is similar to the U.S. general population's diet, we estimate that there are:

2,665,700 X 28% = 746,400 adult Oregonians consuming fish.

If we consider high consumers of fish as being those at the 90th percentile and above (consuming at or above 248 grams of fish per day in Table 3 of this report) this would include:

746,400 X 10% = 74,640 adult Oregonians who are high consumers.

248 grams per day is equivalent to consuming 8.6 oz. of seafood per day, which is a plausible daily intake fish consumption rate for high consumers. This calculation only considers adult consumers and does not consider children who consume fish.

In 2003, the population of Oregonians under the age of 14 years old was 722,885. Applying the same calculation as that used for adults, children with a fish consumption rate of 191 grams of fish per day (USEPA 2002b, Section 5.2.1.1.Table 4)), would result in:

772,885 x 28% x 10%= 21,640 young Oregonians (under 15 years old) who are high consumers.

6. HUMAN HEALTH RISK AND WATER QUALITY CRITERIA

6.1 HUMAN HEALTH RISK

Risk assessment is the determination of the likelihood of adverse human health effects due to exposure to toxic chemicals. This determination is made by combining estimates of exposure through ingestion, inhalation, or skin absorption of a chemical with an estimate of toxic effects of that chemical. Exposure includes measures of duration and frequency of contact as well as body weight. Quantitative and qualitative estimates of exposure and toxicity are combined to estimate risk.

> The lifetime probability of developing cancer for the American male is 1 in 2; for the American female it is 1 in 3 based on data from 2002-2004 (American Cancer Society 2008).

Toxicology provides information on the nature of the adverse effects that can be caused by the pollutant under consideration and the doses that cause the effect. Adverse health effects can range from immunological diseases to birth defects or cancer. The type of health effect caused by exposure to toxic chemicals has historically been divided into two categories based on the biological endpoints observed: 1) cancer and 2) non-cancer effects (e.g. neurological, cardiovascular, reproductive, developmental and immunological effects and blood and metabolic disorders). Toxicity information is usually obtained from animal experiments. Such studies can provide important dose-response information for identifying a reference dose for individual chemicals. The level of effect relates directly to the amount and duration of exposure. Studies of human populations can provide important information about sensitivity and variability of humans and can also provide information about exposure and the absorption, distribution, metabolism and excretion of chemicals in humans.

Non-cancer chemicals affect the function of various organ systems. The measure of effect for these chemicals is the reference dose. The reference dose is defined as an estimate of a daily oral exposure to a chemical by humans, including sensitive subpopulations, which are likely to be without an appreciable risk of causing adverse effects over a lifetime. Exposure below the reference dose is considered to be without statistically or biologically significant adverse effects. Once the reference dose is exceeded an individual is at increased risk of adverse health effects.

For most cancer-causing chemicals there is no toxicity threshold or reference dose. Because carcinogenic chemicals are thought to initiate the cancer process at almost any concentration, a dose-response parameter referred to as the cancer slope factor is used for chemicals that display toxic behavior such that the carcinogenic risk increases linearly as the chemical dose increases. The cancer slope factor is a measure of chemical potency.

Risk estimates for carcinogens are expressed as the incremental probability of developing cancer (e.g., an additional one in one million chance of developing cancer) over a lifetime of exposure to potential carcinogens. Risk estimates for non-cancer causing chemicals are expressed as a hazard index or the ratio of the dose to the individual or population divided by a reference dose.

EPA records the most current scientific judgment on chemical toxicity in the Risk Integrated Information System (IRIS). IRIS is an electronic online data base maintained by EPA that provides chemical-specific risk information on the relationship between chemical exposures and estimated human health effects. The IRIS chemical files contain information on factors that are used in estimating risk or developing water quality such as oral Reference Doses (RfDs) and inhalation Reference Concentrations (RfCs) for chronic noncarcinogenic health effects; oral and inhalation cancer slope factors (CSF) and unit risks for chronic exposures to carcinogens; Drinking Water Health Advisories (HAs); EPA regulatory action summaries; and, supplementary data on acute health hazards and physical/chemical properties. More information on individual pollutants can be found online at: http://www.epa.gov/iriswebp/iris/index.html.

6.2 HUMAN HEALTH WATER QUALITY CRITERIA

A human health water quality criterion is the highest concentration of a pollutant in water that is not expected to pose a significant risk to human health. Human consumption of contaminated aquatic life is of primary concern because the presence of even extremely low ambient concentrations of bioaccumulative pollutants in surface waters can result in chemical residue concentrations in fish tissue that may pose a human health risk.

> EPA's recommended procedures for developing human health criteria are provided in the revised *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (USEPA 2000a)*.

ODEQ has numeric human health-based water quality criteria for 130 toxic pollutants. Human health-based water quality criteria regulatory limits are derived for: 1) cancer and 2) non-cancer effects. In the case of carcinogens:

> "the [ambient water quality criterion] represents the water concentration that would be expected to increase an individual's lifetime risk of carcinogenicity from exposure to the particular pollutant by no more than one chance in one

million, regardless of the additional lifetime cancer risk due to exposure, if any, to that particular substance from other sources." (USEPA 2000a)

The acceptable level of cancer risk is usually expressed as an incremental cancer risk or an additional cancer risk.

The mathematical estimation of risk is different for carcinogenic and non-carcinogenic biological endpoints (Equations 1 and 2). When developing water quality criteria, the regulatory agency establishes the acceptable risk level and then determines the concentration in water and fish tissue that will not exceed the acceptable risk levels.

Exposure scenarios for the derivation of human health-based water quality criteria address two types of exposure: 1) combining ingestion of fish and surface water, and 2) ingestion of fish alone. Exposure factors include: bioconcentration, body weight, drinking water ingestion rate, and fish ingestion rates. Other exposure route information (skin absorption, other dietary sources, inhalation, etc) should be considered and incorporated into human exposure evaluations as the RSC values.

EPA generally assigns a mix of central tendency values (e.g., average for the population) and high end values (e.g., 90th or 95^{th} percentiles) for exposure factors such as ingestion rates and body weight. For the purposes of developing water quality criteria EPA uses an average adult body weight of 70 kg. The water quality criteria equations (Equations 1 and 2) for chemical exposure are defined as body weight divided by the drinking water intake rate added to the fish ingestion rate, multiplied by the bioconcentration of the chemical from water into fish tissue.

For carcinogens, the water quality criteria are calculated by dividing the acceptable risk level by the rate of tumor production (cancer slope factor). This estimate of toxicity is then multiplied by the chemical exposure to estimate risk (Equation 1). The regulatory agency or other decision makers prescribe the acceptable risk level. ODEQ established an acceptable cancer risk level of an additional one in one million chance of developing cancer.

The bioconcentration factor (BCF accounts for the uptake by fish or shellfish of a pollutant from the surrounding water. Units of liters/kg (L/kg)

The following description of the estimation of the water quality criteria for dioxin and DDT illustrates the relationship of toxicity, the fish consumption rate, and the bioconcentration factor with the ambient water quality criterion. Dioxin (cancer slope factor 156,000 per mg/kg-day) is much more potent than DDT (cancer slope factor 0.34 per mg/kg-day). DDT has a higher bioconcentration factor (53,600 L/kg) than dioxin (5,000 L/kg). Using the current ODEQ fish consumption rate of 17.5 grams per day the water quality criterion for dioxin will be 0.00000000513 µg/L; DDT will be 0.000219 µg/L. Even though the uptake of DDT into fish tissue is greater than the uptake of dioxin the high toxicity of dioxin results in a lower ambient water quality criterion.

If the fish consumption rate were increased by ten-fold to 175 grams per day the water quality criterion for dioxin would be 0.000000000513 µg/L; 0.0000219 µg/L for DDT. Thus, if someone eats ten times more fish than the current ODEQ rate of 17.5 grams/day they would exceed the Oregon acceptable cancer risk level of an additional one in one million chance of developing cancer. Their risk of developing cancer from exposure to dioxin or DDT would be one in one hundred thousand.

<u>Equation 1</u> ***Cancer***

$$\text{AWQC} \quad = \quad \text{Risk/CSF} \; \bullet \left[\frac{\text{BW}}{\text{DI} + [\text{FCR} \bullet \text{BCF}]} \right]$$

<u>Equation 1</u> ***Cancer Dioxin***

$$0.00000000513\ \mu\text{g/L} \quad = \quad 156{,}000/\text{mg/kg/day} \; \bullet \left[\frac{70\ \text{kg}}{2\ \text{L/day} + [17.5\ \text{g/day} \bullet 5{,}000\ \text{L/kg}]} \right]$$

<u>Equation 1</u> ***Cancer DDT***

$$0.000219\ \mu\text{g/L} \quad = \quad 0.34/\text{mg/kg/day} \; \bullet \left[\frac{70\ \text{kg}}{2\ \text{L/day} + [17.5\ \text{g/day} \bullet 53{,}600\ \text{L/kg}]} \right]$$

AWQC = Ambient Water Quality Criteria (µg/L)
BW = Body Weight (kg)
DI = Drinking Water Intake (L/day)
FCR = Fish Consumption Rate (kg/day)
BCF = Bioconcentration Factor of chemical from water to fish tissue (L/kg)
Risk = Acceptable Cancer Risk Level (Oregon = an additional one in one million chance of developing cancer)
CSF = Cancer Slope Factor

For chemicals with a reference dose, the water quality criteria are calculated by multiplying the reference dose times the chemical exposure (Equation 2). The RSC is either subtracted from the reference dose if the concentration of the chemical in other media is known (methylmercury Appendix C) or a percentage of the exposure is attributed to freshwater and estuarine fish and shellfish consumption (20 percent). The effect of toxicity, the fish consumption rate, the bioconcentration factor, and the RSC on the determination of water quality criteria for chemicals with a reference dose is illustrated by the following examples for endrin and pyrene.

The reference dose for the pesticide endrin is 0.0003 mg/kg/day. In addition only a fraction (20 percent) of the exposure to endrin is attributed to freshwater and estuarine fish and shellfish. The primary source of endrin is from its presence in air, water, sediment, soil, fish, and other aquatic organisms (Appendix C). The bioconcentration factor for endrin is 3,970 L/kg. The reference dose for pyrene is 0.03 mg/kg/day. The bioconcentration factor for pyrene is 30 L/kg. With the current ODEQ fish consumption rate of 17.5 grams per day, the water quality criterion for endrin is 0.0605 µg/L; the water quality criterion for pyrene is 4,000 µg/L. Endrin's higher toxicity and bioconcentration factor result in a lower water quality criterion for endrin than pyrene. If the fish consumption rate were increased 10 times to 175 grams per day the water quality criterion for endrin would be 0.00605 µg/L; for pyrene it would be 400 µg/L. The people who eat ten times more fish than the current fish consumption rate would exceed the reference dose by ten.

ODEQ established the level of protection from exposure to chemicals with a reference dose as equal to or less than the reference dose for a specific chemical. The reference dose for endrin is based on adverse effects to the liver; for pyrene its adverse health effects to the kidney. Thus people who eat more than 17.5 grams per day would be at risk to adverse effects to their kidney or liver.

Equation 2 ***Non - Cancer***

$$\text{AWQC} = \text{RFD} \bullet \text{RSC} \bullet \left(\frac{\text{BW}}{\text{DI} + [\text{FCR} \bullet \text{BCF}]} \right)$$

Equation 2 ***Non - Cancer Endrin***

$$0.0605\ \mu\text{g/L} = 0.0003\ \text{mg/kg/day} \bullet 0.2 \bullet \left(\frac{70\ \text{kg}}{2\text{L/day} + [17.5\ \text{g/day} \bullet 3{,}970\ \text{L/kg}]} \right)$$

Equation 2 ***Non - Cancer Pyrene***

$$4000\ \mu\text{g/L} = 0.03\ \text{mg/kg/day} \bullet \left(\frac{70\ \text{kg}}{2\text{L/day} + [17.5\ \text{g/day} \bullet 30\ \text{L/kg}]} \right)$$

AWQC = Ambient Water Quality Criteria (µg/L)
BW = Body Weight (kg)
DI = Drinking Water Intake (L/day)
FCR = Fish Consumption Rate (kg/day)
BCF = Bioconcentration Factor of chemical from water to fish tissue (L/kg)
RFD = Reference Dose (mg/kg/day)
RSC = Relative Source Contribution

6.3 SENSITIVE POPULATIONS AND TOXICITY

The Human Health Focus Group discussed populations that may be more susceptible to environmental toxicants due to special exposure circumstances or sensitivity to the toxicity of certain pollutants. Of importance is early *in utero* and post-natal exposure of infants and children, and the elderly. There are critical periods of fetal development and the effects of prenatal chemical exposures will differ depending on the dose and the timing of the exposure (Needham *et al.* 2008). These populations include fetuses, children, and the elderly. With respect to exposure, children are particularly vulnerable as compared to adults due to their lower body weight, differing metabolism, and behaviors.

The human health-based water quality criteria are calculated using a default adult male body weight of 70 kilograms. For chemical exposure you need to know not only the amount and rate of chemical intake but also body weight. Chemical exposure is expressed relative to body weight and is calculated from the concentration of chemical in fish tissue and the frequency and duration of fish consumption. In the case of adult males (18-74 years of age), mean body weight is 78 kg (172 lbs), with 5th and 95th percentile weights of 59kg (130 lbs) to 103 kg (227 lbs), respectively. Mean adult female body weight for the same age range is 65 kg (143 lbs), with 5th and 95th percentiles of 48 kg (106 lbs) and 93 kg (205 lbs), respectively (USEPA 1997).

The variation of weight between children and adults is significant, considering that newborns typically weigh 4 kg (8 lbs) while adults can reach weights of 113 kg (250 lbs). Thus, risk estimates for children versus adults can vary considerably. In the current water quality criteria guidance EPA recommends using an average adult body weight of 70 kg (154 lbs) as a default body weight value in the water quality criteria calculations. While use of water quality criteria based on the adult default weight provides adequate protection for adults, it may not provide adequate protection for children.

As discussed in USEPA 2000a, the EPA encourages states and authorized tribes to use alternative body weight assumptions for population groups other than the general population and to use local or regional data for its calculations. In the case of children, EPA's water quality guidance (USEPA 2000a) recommends using 30 kg (66 lbs)as a default children's body weight to provide additional protection for children when chemicals of concern indicate that health effects (i.e developmental neurotoxicity, immunotoxicity, etc.) may be of particulate concern for these early ages. As this would potentially be the case for chemicals to be considered under Oregon's water quality standards, we have included Table 4 which lists fish consumption per body weight per children.

In the surveys reviewed for this report, the consumption rate for children was quite variable. In all cases the consumption rate for children was less than that for adults on a gram-per-day basis (Table 1, located at the end of this document). However, when the rates were computed with individual body weight, the children's levels included levels greater than the adults (Table 4). Note that in Tables 4 a, b, c and d, the grams of fish consumed per kg body weight per day for children at ages 6 and under all had 90th or 95th percentile values approximately 2-fold higher than those listed for the adult 90th and 95th percentile values except for the Tulalip and Squaxin Island tribes. Thus, these figures suggest the need to consider greater fish consumption rates than adult rates to ensure full protection of children specific exposure factors.

The term "children" in this document refers to birth through adolescence (16-18 years).

The potential for toxicity and adverse health outcomes varies with life stage and/or health status. Toxicity values should incorporate consideration of developmental life stages that might be particularly vulnerable. The information is then incorporated into a risk assessment. For humans, early life stages (e.g. fetus, infant) may be vulnerable to toxic chemical effects due to immature or developing metabolic and organ systems. Effects that are reversible in adults may not be reversible during the developmental stage. The concern for women of child bearing age is risk to offspring during development. There is also concern for the elderly who may be more susceptible than younger adults because of their reduced capacity for recovery due to illness, age, or ability to eliminate or metabolize chemicals. There are also people whose existing health condition (e.g. immune suppression, asthma) may exacerbate the harmful affects of toxic chemicals.

In many cases, the toxicity of chemicals is derived from laboratory studies of animals. Depending on the pollutant of interest, some of these studies consider sensitive populations, and other studies may not. Many of the toxicity values are in fact based on doses for adults so there is no direct correlation between toxicity and life stage. EPA's Integrated Risk Information System database provides information on how the toxicity of each pollutant was derived.

TABLE 4. FISH CONSUMPTION RATES (PER BODY WEIGHT) FOR CHILDREN					
Table 4a. All fish g/kg-body weight/day (excerpt from Section 4.1.1.2, Table 3 and Table 5 USEPA 2002b)					
Consumers and non consumers					
Age (years)	**N**	**Mean**	**Median**	**90%**	**95%**
3 to 5	4112	0.29		1.10	2.00
6 to 10	1553	0.21		0.78	1.40
11 to 15	975	0.16		0.57	1.10
15 to 44	4644	0.19		0.71	1.10
>44	5333	0.24		0.84	1.30
Table 4b. All fish g/kg- body weight/day (excerpt from Tables T-3 and T-14 Suquamish 2000)					
Children's rate varied from zero consumption of certain shellfish to 100% consumption for salmon					
Age (years)	**N**	**Mean**	**Median**	**90%**	**95%**
0 to 6	31	1.5		3.4	
16 to >55	92	2.7		6.2	
TABLE 4. FISH CONSUMPTION RATES (PER BODY WEIGHT) FOR CHILDREN (CONTINUED)					
Table 4c.All fish g/kg-body weight/ day (excerpt from Table 3 and Table 8, Toy *et al.* 1996)					
Non-consumers for children was 29% for Tulalip Tribes and 25% for Squaxin Island Tribe					
Tulalip Tribes					
Age (years)	**N**	**Mean**	**Median**	**90%**	**95%**

0 to 5	21		0.08	0.74	
18 to >65	73	0.89	0.55		2.88
Squaxin Island Tribe					
Age (years)	**N**	**Mean**	**Median**	**90%**	**95%**
0 to 5	48		0.51	2.06	
18 to >65	117	0.89	0.52		3.01

Table 4d. All fish mg/kg-body weight/day (excerpt from Section 5.2.1.2., Table 3 and Table 5 (USEPA 2002b)

Consumers only					
Age (years)	**N**	**Mean**	**Median**	**90%**	**95%**
3 to 5	779	4.20	3.60	8.00	10.00
6 to 10	250	3.20	2.50	6.50	8.70
11 to 15	164	2.20	1.60	4.40	6.20
15 to 44	1102	1.80	1.40	3.50	4.80
>44	1567	1.70	1.40	3.40	4.30
N=Number of people in survey					

NOTE: As with all studies, when measured body weight values are not available for individual study/survey participants, caution must be taken as evaluations of retrospectively added default body weight values can be shown to have potential to both over as well as under estimate relative exposures (Marien *et al.* 2005).

6.4 CHEMICAL INTERACTIONS

Exposure to mixtures of chemicals poses a special circumstance for toxicologists. Individual chemicals may interact in a variety of ways. The impact of multiple chemicals on toxicological response can be additive (e.g., toxicity by the same mode of action), less-than-additive (e.g., zinc inhibits cadmium toxicity by reducing the amount of cadmium absorbed), or greater-than additive (e.g., enhanced carcinogenicity for asbestos and tobacco smoke) (USEPA, 2000b). Chemical interactions may also include antagonistic interactions as well as no influence (USEPA 2000b).

Human health-based water quality criteria are calculated for individual chemicals. The calculated risk of any single chemical does not take into account the interaction of chemical mixtures that may occur when people are exposed to multiple chemicals simultaneously. Thus, human health-based water quality criteria do not take potential exposure to multiple chemicals into account.

The number of complex mixtures that may be found in the environment and concomitantly in fish tissue is difficult to predict. Thus, development of an interactive scheme for all possible chemical combinations is impossible. While the Human Health Focus Group recognizes this limitation, the lack of accounting for chemical interactions is a shortfall in the overall protectiveness of the human health-based water quality criteria. The Human Health Focus Group recommends that there be an accounting for this interaction when criteria are used to establish limits for specific regulatory actions (e.g. Total Maximum Daily Loads, water quality permits, hazardous waste cleanup) where the chemical regime is known.

In addition to concerns with potential exposure regarding the unknown interaction of multiple pollutants in fish tissue that is ingested there are the potential benefits that may occur through the concurrent ingestion of nutrients present in certain fish tissue, such as omega-3-fatty acids (e.g. docosahexaenoic acid and eicosapentaenoic acid) (Oken *et al.* 2005).

7. CONCLUSIONS

The following conclusions are based on the review of the fish consumption surveys discussed in this report as well as the expertise of the Human Health Focus Group.

The Human Health Focus Group was asked to respond to three questions posed by ODEQ, The Confederated Tribes of the Umatilla Reservation and EPA as part of the Fish Consumption Rate Project. The three questions were:

1) Considering the available local, regional and national information on fish consumption, what is the scientific evidence Oregon should rely on when selecting a fish consumption rate to use in setting water quality criteria?
2) How should Pacific salmon be considered in selecting a fish consumption rate and/or setting criteria?
3) To what extent are populations who consume more than the current fish consumption rate of 17.5 g/day at a greater risk for adverse health impacts?

1) Considering the available local, regional and national information on fish consumption, what is the scientific evidence Oregon should rely on when selecting a fish consumption rate to use in setting water quality criteria?

The Human Health Focus Group was able to identify multiple regionally relevant studies of high quality for selecting a fish consumption rate. Indeed, these studies cover not only the Pacific Northwest but the United States and the globe. Each of these studies provides a fresh view of the amount of fish that people consume over their lifetime. The national and international studies, provided as additional references, confirm the view that the level of fish consumption is quite similar across different cultures and countries. The specific types of fish consumed varies across populations.

The Human Health Focus Group reduced its list of nine relevant studies to five that are most useful for recommending fish consumption rate(s) to ODEQ, EPA, and CTUIR. Within these studies there is definitely enough information to provide the State of Oregon with reliable estimates of risk. While these surveys were not specifically done for the people of Oregon, they provide a relevant and reliable range of rates that may be considered by the state.

The Human Health Focus Group also agreed that:

- The current fish consumption rates may be suppressed due to pollution and/or decreased fish abundance
- The current rate of 17.5 grams per day does not reflect Oregon or US population fish consumption rates
- The fish consumption rate should include fish consumers only

- All types of fish should be included in the fish consumption rate regardless of whether they were bought or locally harvested
- An upper-bound fish consumption rate(s) (90 percent or 95 percent, Table 3) should be adopted by ODEQ for Oregon fish consumers

2) How should Pacific salmon be considered in selecting a fish consumption rate and/or setting criteria?

The Human Health Focus Group unanimously agreed Pacific salmon should be included in the fish consumption rate. They generally are the primary choice of fish for most fish consumers in the Pacific Northwest.

The RSC factor is not sufficiently defined to allow accounting for contaminant exposure through consumption of Pacific salmon or marine species. All members of the Human Health Focus Group agreed that data available in the surveys reviewed by the Human Health Focus Group did not distinguish between near shore marine species and deep ocean species. Therefore, the recommended fish consumption rate should include all types of marine species since the open ocean and near shore species typically found in Oregon could not be differentiated in the studies reviewed.

3) To what extent are populations who consume more than the current fish consumption rate of 17.5 grams per day (g/day) at a greater risk for health impacts?

The Human Health Focus Group finds that the current fish consumption rate would leave a proportion of the population of Oregon without protection. People who eat more than 17.5 grams per day are at an increased risk of heart, kidney or liver disease, neurological and developmental effects, cancer, and other health effects. This is a particular concern for vulnerable populations based on age, gender, or health status. The level of concern increases with higher fish consumption rates and for children since the relative consumption per body weight may be greater than these body weight-based values in adults.

In summary, people who eat more than 17.5 g/day of fish and shellfish will exceed the reference dose, or the level which is considered acceptable by EPA and at which there are no expected adverse health effects. The extent and specificity of that risk is dependent upon the toxicity of the individual chemical and cannot be easily quantified without specific pollutant considerations. People consuming more than 17.5 g/day of fish will also exceed the Oregon acceptable cancer risk level of an additional one in one million chance of developing cancer established by the ODEQ.

TABLE 1. COMPARISON OF FISH CONSUMPTION RATES
NOTE: THE COLUMN SEAFOOD SOURCE REFERS TO WHETHER FISH WERE HARVESTED LOCALLY OR PURCHASED.
THE COLUMN SEAFOOD SPECIES REFERS TO ALL TYPES OF FISH FROM A VARIETY OF HABITATS.

line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day)						Reference
								Percentile				
						Mean	Median	75th	90th	95th	99th	
Surveys reviewed by the HHFG												
1	Tulalip Tribes[a]	Children (0-5 years old)	Consumer only	All	Anadromous & resident finfish & shellfish	3.6	1.2	4.5	11.2			Toy et al 1996
2	Squaxin Island Tribe[v]	Children (0-5 years old)	Consumer only	All	Anadromous & resident finfish & shellfish	12.5	7.7	18.2	31.3			Toy et al 1996
3	Suquamish Tribe[u]	Children (9 months to 6 years old)	Consumer only	All	Anadromous & resident finfish & shellfish	24	12		57			Toy et al. 1996
4	Columbia River Tribes[p]	Children (0-5 years old)	Consumer only	All	Anadromous & resident fish	19.6		~22	~40	~68	~129	CRITFC 1994
5	Columbia River Tribes - Reevaluation of data[aa]	Children (0-5 years old)	Consumer only	All	Anadromous & resident fish	26.7	16.2		64.8	81	162	CRITFC 1994

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day) Mean	Median	Percentile 75th	90th	95th	99th	Reference
6	U.S. General Population[q]	Children (3-5 years old)	Consumer + Non-consumer	All	Resident finfish & shellfish from fresh and estuarine environments	2.19		NA	0.05	12.2	52.46	USEPA 2002
7	U.S. General Population[q]	Children (3-5 years old)	Consumer + Non-consumer	All	Anadromous & resident finfish & shellfish from fresh, estuarine, and marine environments	7.7		NA	32.56	51	100	USEPA 2002
8	U.S. General Population[r]	Children (3-5 years old)	Consumer only	All	Anadromous & resident finfish & shellfish from fresh, estuarine, and marine environments	74	64	NA	149	184	363	USEPA 2002
9	U.S. General Population[r]	Children (3-5 years old)	Consumer only	All	Resident finfish & shellfish from fresh and estuarine environments	40	23	NA	95	129	205	USEPA 2002
10	Lake Whatcom (WA) Fisherman[x]	Children	Consumer only	Lake Whatcom (WA)	Resident fish		3.6					WDOH 1997

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day) Mean	Median	Percentile 75th	90th	95th	99th	Reference
11	Columbia River Tribes[o]	Women who have breastfed (36% of survey respondents)	Consumer only	All	Anadromous & resident fish	59.1		~58.5	~112	~174	~278	CRITFC 1994
12	U.S. General Population[s]	Women (15-44 years old)	Consumer only	All	Anadromous & resident finfish & shellfish from fresh, estuarine, and marine environments	108	77	NA	221	315	494	USEPA 2002
13	U.S. General Population[t]	Women (15-44 years old)	Consumer only	All	Resident finfish & shellfish from fresh and estuarine environments	75	36	NA	172	273	502	USEPA 2002
14	Tulalip Tribes[a]	Adults	Consumer only	All	Anadromous & resident finfish & shellfish	72	45	85	186	244	312	Toy et al 1996
15	Tulalip Tribes[a]	Adults	Consumer only	Harvested anywhere	Anadromous & resident finfish & shellfish	63	37	80	159	236	311	Toy et al 1996
16	Tulalip Tribes[a]	Adults	Consumer only	Harvested from Puget Sound	Anadromous & resident finfish & shellfish	54	30	74	139	194	273	Toy et al 1996

TABLE 1. COMPARISON OF FISH CONSUMPTION RATES

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day)						Reference
						Mean	Median	Percentile				
								75th	90th	95th	99th	
17	Tulalip Tribes[a]	Adults	Consumer only	All	Resident finfish & shellfish	36	18	41	116	132	168	Toy et al 1996
18	Tulalip Tribes[a]	Adults	Consumer only	Harvested anywhere	Resident finfish & shellfish	32	14	40	103	116	157	Toy et al 1996
19	Tulalip Tribes[a]	Adults	Consumer only	Harvested from Puget Sound	Resident finfish & shellfish	31	14	39	90	113	157	Toy et al 1996
20	Squaxin Island Tribe[v]	Adult males	Consumer only	All	All Fish and shellfish	73	NA	NA	165	249	NA	Toy et al 1996
2	Squaxin Island Tribe[v]	Adult females	Consumer only	All	All Fish and shellfish	70	NA	NA	220	274	NA	Toy et al 1996
22	Suquamish Island Tribe[b]	Adults (16 or older)	Consumer only	All	Anadromous & resident finfish & shellfish	214	132		489	NA	NA	Suquamish 2000
23	Suquamish Tribe[c]	Adults (16 or older)	Consumer only	Harvested from Puget Sound	Anadromous & resident finfish & shellfish	165	58	221	397	767	NA	Suquamish 2000
24	Suquamish Tribe[c]	Adults (16 or older)	Consumer only	Harvested from Puget Sound	Resident finfish & shellfish	126	49	116	380	674	NA	Suquamish 2000

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day)						Reference
						Mean	Median	Percentile				
								75th	90th	95th	99th	
25	Columbia River Tribes[d]	Adults	Consumer only	All	Anadromous & resident fish	63	40	60[e]	113[f]	176[g]	389	CRITFC 1994
26	Columbia River Tribes[m]	Adults	Consumer + Non-consumer	All	Anadromous & resident fish	58.7	~40	~57	~113	170	389	CRITFC 1994
27	Columbia River Tribes[n]	Adults	Consumer only	All	Resident fish	~43		~41	~82	~124	~284	CRITFC 1994
28	Asians & Pacific Islanders[h]	Adults	Consumer only	All	Anadromous & resident finfish & shellfish	117	78	139	236	306	NA	Sechena et al 1999
29	Asians & Pacific Islanders[h]	Adults	Consumer only	Harvested anywhere	Anadromous & resident finfish & shellfish	16	7	16	49	76	NA	Sechena et al 1999
30	Asians & Pacific Islanders[h]	Adults	Consumer only	Harvested from King County	Anadromous & resident finfish & shellfish	14	6	15	26	57	NA	Sechena et al 1999

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day)						Reference
								Percentile				
						Mean	Median	75th	90th	95th	99th	
31	Asians & Pacific Islanders[h]	Adults	Consumer only	Harvested anywhere	Resident finfish & shellfish	16	7	18	54	72	NA	Sechena et al 1999
32	Asians & Pacific Islanders[h]	Adults	Consumer only	Harvested from King County	Resident finfish & shellfish	14	7	16	33	57	NA	Sechena et al 1999
33	U.S. General Population[i]	Adults (18 or older)	Consumer + Non-consumer	All	Resident freshwater/estuarine finfish & shellfish[j]	8	0	NA	17	50	143	USEPA 2002
34	U.S. General Population[k]	Adults (18 or older)	Consumer + Non-consumer	All	Anadromous & resident finfish & shellfish from fresh, estuarine, and marine environments	20	0	NA	75	111	216	USEPA 2002
35	U.S. General Population[l]	Adults (18 or older)	Consumer only	All	Anadromous & resident finfish & shellfish from fresh, estuarine, and marine environments	127	99	NA	248	334	519	USEPA 2002
36	U.S. General Population[l]	Adults (18 or older)	Consumer only	All	Resident finfish & shellfish from fresh and estuarine environments	81	47	NA	199	278	505	USEPA 2002

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day)						Reference
						Mean	Median	Percentile				
								75th	90th	95th	99th	
37	Columbia Slough Fisherman[w]	Adults	Consumer only	Columbia Slough	Resident finfish & shellfish from fresh and estuarine environments		24	36				Adolfson Associates 1996
38	Sauvie Island Fisherman[w]	Adults	Consumer only	Sauvie Island	Anadromous & resident finfish & shellfish from fresh and estuarine environments		4	6				Adolfson Associates 1996
39	Lake Whatcom (WA) Fisherman[x]	Adults	Consumer only	Lake Whatcom (WA)	Resident fish	6						WDOH 1997
40	Lake Roosevelt (WA) Fisherman[y]	Adults	Consumer only	Lake Roosevelt (WA)	Resident fish	42					90[z]	WDOH 1997
Angler surveys in the U.S. - useful references - surveys not reviewed by the HHFG												
41	Michigan licensed anglers	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	27		35	73	102		West, 93

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day)						Reference
						Mean	Median	Percentile				
								75th	90th	95th	99th	
42	Michigan licensed anglers	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	17		20	61	82	489	West, 93
43	S. Carolina	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	48						[ab]jurer et al 1999
44	Michigan	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	27						Chan et al 1999 Having et al 1992 reported in Chan et al 1999
45	Great Lakes	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	21						Chan et al 199 Health Canada 1995 reported in Chan et al 1999
46	Santa Monica Bay (CA) Seafood consumers	anglers who ate fish from Santa Monica Bay	consumer only	harvested locally	All self caught species	50	21		107			SCCWRP and MBC (1994)
Native American - useful references												
47	Lakes Huron, Michigan, Superior	Adults	subsistence-recall	harvested locally	fresh water fish	62						[ac]Dellinger 2004

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						Mean	Median	Percentile				
								75th	90th	95th	99th	
48	Lake superior	Adults	subsistence-recall	harvested locally	fresh water fish	60						[ad]Dellinger 2004
49	Inland Lakes	Adults	subsistence-recall	harvested locally	fresh water fish	46						[ad]Dellinger 2004
50	Menominee	Adults	subsistence-recall	harvested locally	fresh water fish	34						[ad]Dellinger 2004
51	Other Res	Adults	subsistence-recall	harvested locally	fresh water fish	87						[ad]Dellinger 2004
52	All tribes	Adults	subsistence-recall	harvested locally	fresh water fish	60						[ad]Dellinger 2004
53	Lakes Huron, Michigan, Superior	Adults	subsistence-actual	harvested locally	fresh water fish	4						[ad]Dellinger 2004
54	Lake superior	Adults	subsistence-actual	harvested locally	fresh water fish	11						[ad]Dellinger 2004
55	Inland Lakes	Adults	subsistence-actual	harvested locally	fresh water fish	8						[ad]Dellinger 2004
56	Menominee	Adults	subsistence-actual	harvested locally	fresh water fish	34						[ad]Dellinger 2004

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day)						Reference
						Mean	Median	Percentile				
								75th	90th	95th	99th	
57	Other Res	Adults	subsistence-actual	harvested locally	fresh water fish	8						[ad]Dellinger 2004
58	All tribes	Adults	subsistence-actual	harvested locally	fresh water fish	8						[ad]Dellinger 2004
59	Mohawk, Montreal	Adults	consumers	harvested locally	fresh water fish	33						[ae]Chan et al, 1999
60	Mohawk, Montreal	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	23						[ae]Chan et al, 1999
61	Akwasasne	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	25						Chan et al 1999 Forti et al 1995 reported in Chan et al 1999
62	Wisconsin Chippewa	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	26						Chan et al Peterson et al 1994 reported in Chan et al 1999
63	Ojibwa	Adults	Consumer + Non-consumer	harvested locally	fresh water fish	23						Burger et al 1999; Dellinger et al 1997 reported in Burger et al 1999

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line #	Group	Subgroup = gender or age	Fish Consumer only / fish Consumer + Non Consumer	Seafood Source	Seafood Species included in consumption rate evaluation	Statistic (grams/day)						Reference
						Mean	Median	Percentile				
								75th	90th	95th	99th	
64	Canadian First Nation	All ages	consumers	harvested locally	salmon only	28						[am]Mos et al, 2004
65	Canadian First Nation	All ages	consumers	harvested locally	salmon only	48						[af]Mos et al, 2004
66	Canadian First Nation	All ages	consumers	harvested locally	all marine species including salmon	44						[af]Mos et al, 2004
World												
67	Japan	Adults	Consumer + Non-consumer	All	fresh water and marine fish & shellfish	96						[ag]Nakagawa et al, 1997 (1976 data from Kitamura et al 1976)
68	Japan	Adults	Consumer + Non-consumer	All	fresh water and marine fish & shellfish	163						[ag]Nakagawa et al, 1997
69	Hong Kong	Adults	Consumer + Non-consumer	All	fresh water and marine fish & shellfish	52						[ah]Dickman and Leung, 1998

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70	Hong Kong	Adults	Consumer + Non-consumer	All	fresh water and marine fish & shellfish	164						[ah]Dickman and Leung, 1998 extracted from Euromonitor 1997

Footnotes:
[a] Values computed from Toy et al. 1996 study data (Kissinger 2003).
[b] Values g/kg/day for “all seafood” taken from Table T-3 of the Suquamish Survey (Suquamish 2000) and converted to g/day by multiplying by the average body weight for men and women of 79 kg
[c] Values computed by ShiQuan Liao and Nayak Polissar of the Mountain Whisper Light Statistical Consulting company for the Suquamish Tribe (Liao and Polissar 2007)
[d] Values compiled from Table 10 “Number of Grams per Day Consumed by Adult Fish Consumers” of the Columbia River Intertribal Fish Commission Study (CRITFC 1994)
[a] A value of 60 g/day was derived by linearly interpolating between the consumption rate/cumulative percentiles bracketing the 75th percentile (48.6 g/day, 65.1%) and (64.8 g/day, 79.1%)
[f] A value of 113 g/day was derived by linearly interpolating between the consumption rate/cumulative percentiles bracketing the 90th percentile (97.2 g/day, 88.5%) and (130 g/day, 91.6%)
[g] A value of 176 g/day was derived by linearly interpolating between the consumption rate/cumulative percentiles bracketing the 95th percentile (170 g/day, 94.4%) and (194 g/day, 97%)
[h] Values computed from 1999 EPA Asian Pacific Islander seafood consumption survey data (Kissinger 2005). Kissinger (2005) converted mixed cooked and raw wet weight consumption rate information from the 1999 publication into a wet weight consumption rate.
[i] Values taken from EPA 2002 Section 5.1.1.1, Table 4: Uncooked fish consumption estimates, U.S. Population – Finfish and Shellfish, Individuals Age 18 and Older. Values from the “freshwater/estuarine” section of the table are used.
[j] Pacific salmon were assigned to consumption of marine species rather than estuarine species (SEE Section 2.1.1 of EPA 2002 for an explanation).
[k] Values taken from EPA 2002 Section 5.1.1.1, Table 4: Uncooked fish consumption estimates, U.S. Population – Finfish and Shellfish, Individuals Age 18 and Older. Values from the “all fish” section of the table are used.
[l] Values taken from EPA 2002 Section 5.2.1.1, Table 4: Uncooked fish consumption estimates, U.S. Population – Finfish and Shellfish, Individuals Age 18 and Older. Values from the “all fish” section of the table are used.
[m] Values compiled from Table 7 “Number of Grams per Day of Fish Consumed by Adult Respondents (Fish consumers and non-fish consumers) combined - Throughout the year” of the Columbia River Intertribal Fish Commission Study (CRITFC 1994)
[n] Values compiled from Tables 10, 18 and 19 from CRITFC 1994. The average consumption rate for Pacific Northwest Salmon was estimated to be 20 grams/day. That was subtracted from the average for all fish for consumers only to result in 43 grams/day as the average fish consumption for adult consumers only for resident fish. The ratio of .73% (all fish/resident) was then applied to the other percentiles. All values are estimates.
[o] The mean values were taken from Table 16 and all other percentiles were estimated from Table 15 in CRITFC 1994. All calculated values are estimates.
[p] The mean values were taken from Table 24 and all other percentiles were estimated from Table 24 in CRITFC 1994. All calculated values are estimates.

[q] All values taken from EPA 2002 Section 5.1.1.1, Table 5
[r] All values taken from EPA 2002 Section 5.2.1.1, Table 5
[s] All values taken from EPA 2002 Section 5.2.1.1, Table 3
[t] All values taken from EPA 2002 Section 5.2.1.1, Table 1
[u] All values calculated using 16.8 as the average body weight of children and applying that body weight to values in Table T-14 in Suquamish 2000
[v] All values were calculated using an average child BW of 15.2 kg (from Table A1) and the consumption rates Toy et al., 1996, Table A9
[v] All values were calculated using an average adult female BW of 76 kg and adult male body weight of 86 kg (from Table A1) and the consumption rates Toy et al., 1996, Table A4
[w] All values taken from Adolphson 1996, Table 4, page 20. Values were converted to grams/day from kg/person/year.
[x] All values taken from Dave McBride's summary of the Lake Whatcom 2001 study. Adult average consumption of 225 g/meal was used along with a median children rate of 131 g/meal. 10 meals were assumed per year
[y] All values taken from Dave McBride's summary of the Lake Roosevelt 1997 study.
[z] All values taken from Dave McBride's summary of the Lake Roosevelt 1997 study. 90g/day was labeled as "high end consumers" and placed in the 99th percentile column for that reason.
[aa] All values taken from Rhodes 2006, Table 32.
[ab] Burger et al 1999; interview of Savannah R fisherman; n=258; mean serving size 376 g; mean fish/month 1.46 kg; mean fish per year 17.6 kg; mean age 43; 48 g/day
[ac] Chan et al 1999 questionnaire of consumption over the past 12 months; n= 42, average age 39 years; 474 to 766 grams per meal
[ad] Dellinger, 2004 questionnaire fish consumption for 12 months; estimated grams per meal = 280 grams, GLIFWC 2003 summarized in Dellinger 2003 147 tribal members from 1999 to 2002

Lake Huron Michigan, Superior male & female adults (n=271 age 40)
Lake Superior male & female adults (n= 346; 41 years)
Inland Lakes male & female adults (n=63; age=40)
Menominee male & female adults (n=66; age=39)
Other Res male & female adults (n=76; age=43)
All tribes male & female adults (n=822; age=41)

[ae] Moss et al 2004, interview of 4 Sencoten villages during summer of 2001; n=76 ages 13-75; individuals selected at random; focused on marine species; estimate monthly or yearly number of meals;
estimate grams per day (1 portion = 180 grams); 36 meals of salmon per year= 10.3 kg per person per year; 86 meals of all marine food per person per year;
Note adults over 40 years consume more fish than youth or young adults (13-40 years)
44 g/day 86 meals x 186 grams/meal divided by 365
28 g/day 10.3 kg x 100 g/kg divided by 365
48 g/day 17.5 kg x 100 g/kg divided by 365

[af] Nagakawa et al 1997 study of mercury in fish; fish rates are mean consumption of eatable fish per capita per day. Methodology for consumption survey was not reported.
1976 data are extracted from Kitamura, s. Kondo, m. Takizawa, t. Fuji, m. Mercury Kodansha Japan 267-273 1976

[ag] Dickman and Leung 1998; study of mercury and PCBs in fish tissue; Hong Kong Asians consume fish 3 to 4 times per week; Hong Kong average person 4 or more times per week average 60 kg per year; Finland and Europe fish consumption is lower; assuming 1/2 of what is imported is consumed = 18.9 kg fresh fish per person or 52 grams per day.
164 g/day 60 kg/year extracted from Consumer Asia Euromonitor plc 60-61 Britton St. London ECIM 5NA 1997
52 g/day 234500 tonnes of fish imported 1/2 consumed = 117245 tonnes by 6.2 million people 18.9 kg fresh fish per person or 52 grams per day

[ah] Values computed using a weighted average of body weight for males and females from Table A1, which was calculated as 82kg. Body weight was multiplied by "total fish" values in Table A2 to obtain final values listed.

8. REFERENCES

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10. GLOSSARY OF ACRONYMS AND UNITS OF MEASURE

10.1 ACRONYMS

AWQC	Ambient Water Quality Criteria.
BCF	Bioconcentration factor (generally expressed in liters per kilogram)
BW	Body weight (generally expressed in kilograms)
CRITFC	Columbia River Inter-Tribal Fish Commission, including the Warm Springs, Yakama, Umatilla, and Nez Perce Tribes
CROET	Center for Research on Occupational and Environmental Toxicology (CROET), Oregon Health & Science University
CSFII	Continuing Survey of Food Intakes by Individuals. A survey conducted by the United States Department of Agriculture (USDA) 1994-1996 and 1998
CTUIR	Confederated Tribes of the Umatilla Indian Reservation, including the Cayuse, Umatilla and Walla Walla Tribes
CWA	Clean Water Act.
DABT	Diplomat of the American Board of Toxicology
DEQ	Oregon Department of Environmental Quality
DHS	Oregon Department of Human Services
DI	Drinking water intake (generally expressed in liters per day)
EPA	United States Environmental Protection Agency
EQC	Environmental Quality Commission
FCR Project	Oregon Fish and Shellfish Consumption Rate Project
FCR	Fish Consumption Rate
HHFG	Human Health Focus Group
HQ	Hazard Quotient

NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System program
OAR	Oregon Administrative Rules
OEHHA	Office of Environmental Health Hazard Assessment; a division of the California Environmental Protection Agency
PAC	Policy Advisory Committee
PCB	Polychlorinated biphenyl
RfD	Reference dose
RSC	Relative Source Contribution
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
URL	Uniform Resource Locator, the global address of documents and other resources on the World Wide Web
USDA	United States Department of Agriculture
WQC	Water quality criteria.
WQS	Water quality standards
WSDOH	Washington State Department of Health.

10.2 UNITS OF MEASURE

g/day	grams per day
g/kg/day	grams per kilogram per day
kg	kilogram
kg/day	kilogram per day
L/day	liter per day
L/kg	liter per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day

APPENDIX A: FISH SPECIES IDENTIFIED AS CONSUMED IN SELECT SURVEYS

APPENDIX A – 1. SPECIES GROUPS LISTED IN A FISH CONSUMPTION SURVEY OF THE UMATILLA, NEZ PERCE, YAKAMA, AND WARM SPRINGS TRIBES OF THE COLUMBIA RIVER BASIN (CRITFC, 1994)

Anadromous	Resident
Salmon	Trout
Steelhead	Whitefish
Lamprey	Sturgeon
Smelt	Walleye
Shad	Squawfish
	Sucker

APPENDIX A – 2. SPECIES GROUPS LISTED IN A FISH CONSUMPTION SURVEY OF THE TULALIP AND SQUAXIN ISLAND TRIBES OF THE PUGET SOUND REGION (TOY ET AL. 1996)

Group A	Group B	Group C	Group D	Group E	Group F
Anadromous	**Pelagic**	**Bottom**	**Shellfish**	**Other**	**Other 2**
Chinook salmon	Cod	Halibut	Clams (Manila/Littleneck)	Canned Tuna	Trout
Pink salmon	Pollock	Sole/Flounder	Horse clam		
Sockeye salmon	Sablefish	Sturgeon	Butter clam		
Coho salmon	Rockfish	Skate	Cockles		
Chum salmon	Greenling	Eel	Mussels		
unidentified salmon	Herring	Grunters	Oysters		
Steelhead	Spiny		Shrimp		
Smelt	Dogfish		Dungeness Crab		
	Perch		Red Rock Crab		
	Mackeral		Moon Snail		
	Shark		Scallops		
			Squid		
			Sea Urchin		
			Sea Cucumber		
			Sea Urchin		
			Geoduck		
			Limpets		
			Lobster		
			Bullhead		
			Manta Ray		
			Razor clam		
			Chitons		
			Octopus		
			Abalone		
			Chitons		
			Barnacles		
			Crayfish		

Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region (Suquamish, 2000)

APPENDIX A-3. SPECIES GROUPS LISTED IN FISH CONSUMPTION SURVEY OF THE SUQUAMISH TRIBES OF THE PORT MADISON INDIAN RESERVATION, PUGET SOUND REGION (SUQUAMISH, 2000)

Group A	Group B	Group C	Group D	Group E	Group F	Group G
King salmon	Smelt	Cod	Halibut	Manila/Littleneck clams	Cabezon	Abalone
Sockeye salmon	Herring	Perch	Sole/Flounder	Horse clams	Blue Back (sockeye)	Lobster
Coho salmon		Pollock	Rockfish	Butter clams	Trout/cutthroat	Octopus
Chum salmon		Sturgeon		Geoduck	Tuna (fresh/canned)	Limpets
Pink salmon		Sable fish		Cockles	Groupers	Miscellaneous
unidentified salmon		Spiny dogfish		Oysters	Sardine	
Steelhead		Greenling		Mussels	Grunter	
Salmon (gatherings)		Bull Cod		Moon snails	Mackerel	
				Shrimp	Shark	
				Dungeness crab		
				Red rock crab		
				Scallops		
				Squid		
				Sea urchin		
				Sea cucumber		
				Oysters (gatherings)		
				Clams (gatherings)		
				Crab (gatherings)		
				Clams (razor, unspecified)		
				Crab (king/snow)		

APPENDIX A-4 SPECIES GROUPS IN ASIAN AND PACIFIC ISLANDER SEAFOOD CONSUMPTION STUDY (SECHENA ET AL. 1999).

Anadromous Fish	%	Pelagic Fish	%	Freshwater Fish	%	Bottom Fish	%	Shellfish	%	Seaweed /Kelp	%
Salmon	93	tuna	86	catfish	58	halibut	65	shrimp	98	seaweed	57
Trout	61	cod	66	tilapia	45	sole/flounder	42	crab	96	kelp	29
Smelt	45	mackerel	62	perch	39	sturgeon	13	squid	82		
Salmon eggs	27	snapper	50	bass	28	suckers	4	oysters	71		
		rockfish	34	carp	22			manila/ littleneck clams	72		
		herring	21	crappie	17			lobster	65		
		dogfish	7					mussel	62		
		snowfish	6					scallops	57		
								butter clams	39		
								geoduck	34		
								cockles	21		
								abalone	15		
								razor clams	16		
								sea cucumber	51		
								sea urchin	14		
								horse clams	13		
								macoma clams	9		
								moonsnail	4		

APPENDIX B: RELATIVE SOURCE CONTRIBUTION FACTOR FOR METHYLMERCURY

Excerpt from EPA Criterion document for Methylmercury Table 5-14, Average Mercury Concentrations in Marine Fish and Shellfish Species (EPA 2001).

Species	Concentration [a] (µg Hg/g Wet Wt.)	Species	Concentration [a] (µg Hg/g Wet Wt.)
Finfish			
Anchovy	0.047	Pompano*	0.104
Barracuda, Pacific	0.177	Porgy*	0.522[b]
Cod*	0.121	Ray	0.176
Croaker, Atlantic	0.125	***Salmon****	***0.035***
Eel, American	0.213	Sardines*	0.1
Flounder*,[e]	0.092	Sea Bass*	0.135
Haddock*	0.089	Shark*	1.327
Hake	0.145	Skate	0.176
Halibut*	0.25	Smelt, Rainbow*	0.1
Herring	0.013	Snapper*	0.25
Kingfish	0.10	Sturgeon	0.235
Mackerel*	0.081	Swordfish*	0.95[c]
Mullet	0.009	Tuna*	0.206
Ocean Perch*	0.116	Whiting (silver hake)*	0.041
Pollock*	0.15	Whitefish*	0.054[d]
Shellfish			
Abalone	0.016	Oysters	0.023
Clam*	0.023	Scallop*	0.042
Crab*	0.117	Shrimp	0.047
Lobster*	0.232	Other shellfish*	0.012b
Molluscan Cephalopods			
Octopus*	0.029	Squid*	0.026

Source: U.S. EPA (1997c).
*Denotes species used in calculation of methylmercury intake from marine fish for one or more populations of concern, based on existence of data for consumption in the CSFII (U.S. EPA, 2000b).
[a] Mercury concentrations are from NMFS (1978) as reported in U.S. EPA (1997d) unless otherwise noted, measured as ug of total mercury per gram wet weight of fish tissue.
[b] Mercury concentration data are from Stern et al. (1996) as cited in U.S. EPA (1997c).
[c] Mercury concentration data are from U.S. FDA Compliance Testing as cited in U.S. EPA (1997c).
[d] Mercury concentration data are from U.S. FDA (1978) as cited in U.S. EPA (1997c).
[e] Mercury data for flounder were used as an estimate of mercury concentration in marine flatfish in marine intake calculations.

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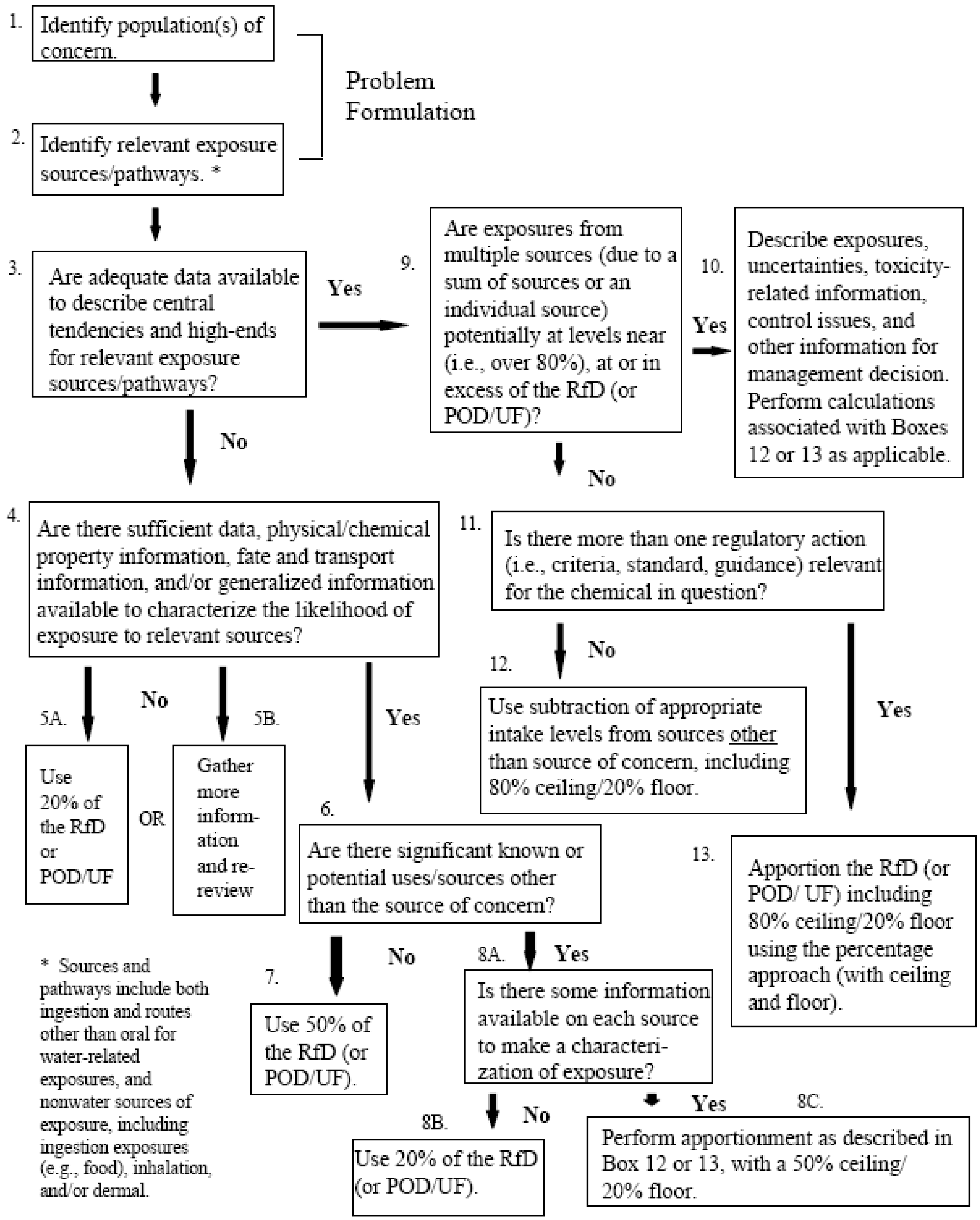
APPENDIX C: BASIS FOR RELATIVE SOURCE CONTRIBUTION VARIABLES

Compound	EPA's Recommended RSC[1, 2]	Sources of Exposure	Citation
Antimony	40%	Drinking Water Contribution= 40% Diet Contribution=50%, Inhalation Contribution=10%	Drinking Water: National Primary Drinking Water Regulations (7/17/1992) 57 FR 31784
Methylmercury	2.7×10^{-5} mg/kg BW/day (subtracted from RfD)	Accounts for marine fish consumption	EPA Methylmercury Criterion Document (1/2001) EPA 823-R-01-001
Thallium	20%		
Cyanide	20%	Available data on dietary exposure are inadequate, so apply the default value of 20% RSC.	Drinking Water: National Primary Drinking Water Regulations (7/17/1992) 57 FR 31784
Chlorobenzene	20%		
1,1 Dichloroethylene	20%	Detected in several sources (i.e. air, and wells contaminated with other solvents).	EPA Health Advisory for 1,1-Dichloroethylene of Office of Drinking Water (3/31/1987)
Ethylbenzene	20%	Primary source of exposure is from the air, although contaminants in drinking water can be quite high for wells near leaking gasoline storage tanks and drinking waters taken from surface waters.	Technical Fact Sheet on Ethylbenzene for the National Primary Drinking Water Regulations. http://www.epa.gov/safewater/dwh/t-voc/ethylben.html
Toluene	20%	Based on available data, the major source of toluene exposure is from air; occurs in low levels in drinking water, food and air. Where actual exposure data are not available, 20% RSC is assumed.	EPA Health Advisory for Toluene of Office of Drinking Water (3/31/1987)
1,2 Transdichloroethylene	20%		
1,2 Dichlorobenzene	20%	Detected in multiple sources (i.e. ground water, surface water, air), however there are insufficient data to determine where the major route of environmental exposure.	EPA Health Advisory for Ortho-, Meta-, and Para-Dichlorobenzenes of Office of Drinking Water (3/31/1987)

Compound	EPA's Recommended RSC[1, 2]	Sources of Exposure	Citation
1,4 Dichlorobenzene	20%	Detected in multiple sources (i.e. ground water, surface water, air), however there are insufficient data to determine where the major route of environmental exposure.	EPA Health Advisory for Ortho-, Meta-, and Para-Dichlorobenzenes of Office of Drinking Water (3/31/1987)
Heachlorocyclo-pentadiene	20%		
1,2,4 Trichlorobenzene	20%		
Gamma BHC	20%		
Endrin	20%	Human exposure appears to most come from food or an occupational source. Monitoring data demonstrates it continues to be a contaminant from air, water, sediment, soil, fish, and other aquatic organisms.	Technical Fact Sheet on Endrin for the National Primary Drinking Water Regulations. http://www.epa.gov/safewater/dwh/t-soc/endrin.html

[1] EPA, 2002. National Recommended Water Quality Criteria: 2002 Human Health Criteria Calculation Matrix. EPA-822-R-02-012.
[2] EPA, 2003. National Recommended Water Quality Criteria for the protection of Human Health. 68 FR 75507-75515.

APPENDIX D: EPA's DECISION TREE FOR DEVELOPING A RELATIVE SOURCE CONTRIBUTION [2]



[2] EPA, 2000. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health. EPA 822-B-00-0004. P. 4-8.