Mercury Contamination in the Columbia River Basin: Health Risk Assessment of Tribal Exposure Through Subsistence Lifeways

Mercury Contamination in the Columbia River Basin: Health Risk Assessment

of Tribal Exposure through Subsistence Lifeways

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Abstract

In the Northwest Pacific tribal areas of the Columbia River Basin, fish consumption is important to riverine tribal cultures, and represents deeply held beliefs that have roots in spiritual practices, subsistence lifestyles and community. Therefore, typical fish consumption may exceed levels usually reported for the general U.S. population. A principal exposure pathway of contaminants to riverine tribes is through fish consumption.

This study was designed to determine if mercury concentrations in fish in regions of the Columbia River Basin where tribal members fish were high enough to be a health concern. A large Columbia River Basin database on concentrations of mercury in fish, compiled mainly from state and federal monitoring programs, was used to evaluate trends for mercury contamination in fish from the Columbia River Basin waterways for a range of consumption rates. Trends were analyzed on data aggregated by site and by state, using samples of the same fish species. Site-based trends were evaluated from 1999 to 2010. There were significant and important differences in mercury levels among species, but the locational differences were relatively small. The highest mean mercury levels were in largemouth bass (577 ppm) and smallmouth bass (297 ppm). The concentrations of mercury in the anadromous fish were lower than in resident species. Eleven of the 105 rivers had fish samples over EPA human health guideline of 0.3 ppm, and five of 105 rivers had fish samples above 0.5 ppm. The findings from this study demonstrated few fish are low enough in mercury to be safe for tribal members eating resident fish at traditional historic rates or at a moderate rate.

The traditional methodology of a health risk assessment used by the federal government is based on the use of exposure assumptions that represent the entire American population. To limit human risk to mercury residues in locally caught species, fish consumption advisories have been established to protect local populations from health risk. For regions where mercury contaminant levels are elevated, elevated fish consumption by tribal members may lead to higher exposures to mercury. These exposures represent potentially disproportionate risks for many Northwest Pacific tribes. The state's fish advisories suggest reducing fish consumption with the goal of lowering risk; in fact, this shifts the burden of avoiding risk to the tribal members who now carry the burdens of contaminant exposure, socio-economic impacts and heritage and cultural loss. Thus, tribal members are forced to choose between culture and health. Many tribal members would rather be exposed to risk than abandon their culture and religion. These issues represent the potential inadequacy of health risk assessments to reflect important cultural differences in environmental justice communities. This may warrant further mitigation to reduce mercury levels in surface waters that support commonly consumed or culturally important species.

Dedication

To Nathan, Shundea and Gabriel for all the selfless love you gave me.

You make heaven a brighter place, and I will love you always.

To my People the Sioux.

Great Spirit, Earth Mother, Wabun, Shawnodese, Mudjekeewis and Waboose with this research I offer up all that I am, all that I have been and all that I will become.

To the plants, animals, the two leggeds and stone people.

hehe ya he, hehe yahoo, hehe yahee yaa, hehe ya ho

This one sends a voice

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The completion of this thesis represents a sequence of encounters and individuals who nurtured my thoughts on environmental justice and guided me in developing a worthwhile project. Without these peoples' willingness and informed assistance my project would have been poorer in scope and result. Arriving at this finish line represents a collective fulfillment of a personal goal, for which I am pleased and profoundly grateful.

Wakan Tanka nici un. Aho

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Acronyms and Abbreviations

ADD	average daily dose of a specific chemical
AT	average time for exposure duration
ATSDR	Agency for Toxic Substances and Disease Registry
ED	exposure duration
EF	exposure frequency
EPA	United States Environmental Protection Agency
Hg	mercury
HQ	hazard quotient
IR	Ingestion Rate
LOAEL	Lowest Observed Adverse Effect Level
RfD	reference dose
RfDo	oral Reference Dose
IRIS	EPA Integrated Risk Information System
WHO	World Health Organization

Chapter I

Introduction

Health risk assessments are employed to set a health-based standard in order to understand and mitigate human exposure to chemical substances. They are used to estimate whether current or future chemical exposures will pose health risks to a broad population. The risk assessment methodology used by the U.S. Environmental Protection Agency (EPA) is a scientific procedure to determine the probability of adverse health effects from exposure to a specific contaminate. Assessments done in this way are meant to apply to the entire American population and are expressed as a central tendency exposure (average, median) or a maximum exposure (95% upper confidence limit) (Tetra Tech, 1986; Tetra Tech, 1988; U.S. Environmental Protection Agency, 2001b). Regrettably, the conventional health risk assessment framework fails to connect to social or cultural beliefs and values.

In order to best utilize and develop health risk assessments when assessing Native American exposure to contaminants, it is important to understand the context of culture, traditional lifestyles and religious activities that may shape their exposures to contaminants. The current assessment methodology fails to recognize these cultural dimensions. The EPA lacks exposure information for assessing health risks for Northwest Tribal Nations that are sustaining a tribal subsistence way of life. They recognize the need for cultural appropriate risk assessments though they do not have the means for assisting Federally Recognized Indian Tribes to develop Environmental and Health Protection Policies in Indian Country to protect tribal members who live according to their traditions (U.S. Environmental Protection Agency, 1989; U.S. Environmental Protection Agency, 1992a; U.S. Environmental Protection Agency, 1998).

The Northwest riverine tribes culture, language, education, traditional activities, medicinal, food, economy, recreational resources and Treaty Rights are enmeshed with aquatic resources. Protections of water resources are vital for the sustenance and cultural survival of these tribes and are linked to the health and well-being of their members' (Burger, 1999; Harris & Harper, 1997a; Mos et al., 2004). A principal exposure pathway of contaminants to riverine tribes is through fish consumption. The Columbia River Basin, located in Northwest region of United States (U.S.), receives an assortment of pollutant discharges leaving the 15 reservations in the vicinity with poor water quality and damaged aquatic ecological health which sustains the Northwest riverine tribes' way of life. Therefore, the Pacific Northwest tribal community faces disproportionate exposure to mercury contaminations due to subsistence lifeways compared with the average rural North American population.

Research Significance and Objectives

The goal of this research is to provide a scientific basis for the Pacific Northwest tribes in developing environmental and health protection policies that will safeguard tribal members who live according to their culture and tradition. The study characterizes the potential health risks from cultural practices of Pacific Northwest Native American tribal members. This preliminary risk assessment evaluates the potential for exposure and risk to Pacific Northwest Native American tribal members from mercury contamination in biota when fishing according to their subsistence lifeways.

This research was designed to evaluate the environmental health of a riverine system by targeting a specific cultural practice and using standardized scientific methods to conduct a preliminary screening to evaluate potential exposure to mercury and the concentrations of that contaminant in fish in the regions of Indian Country and ascertain if it is high enough to be a health concern. These tribes represent a population with individuals that may be at a high risk who may experience adverse health effects as a result of their unique reliance on their contaminated fisheries. This report presents existing data and the results of an assessment of mercury in fish and the risk estimates from consuming these fish based on the EPA's exposure limits.

Background

In 1998, EPA initiated a survey of contaminants in fish tissue within the Columbia River Basin due to the concern for Native American tribes residing in the region. The results provided information on those chemicals which were most likely to be accumulated in fish tissue and therefore posed the greatest potential risks to tribal members. The results of the study showed that all species of fish had some levels of toxic chemicals in their tissues (U.S. Environmental Protection Agency, 2002a). Given the potential for both changes in consumption patterns and fish tissue concentrations in the 17 years since the "Columbia River Basin Fish Contaminate Survey", a reassessment is warranted. Though a full analysis of all the chemicals analyzed by EPA is beyond the scope of this review, this report presents the results of this reassessment of mercury in fish and the risk estimates from consuming these contaminated fish.

Since the 1998 EPA survey, Harper and Walker (2015) have demonstrated that states' contemporary fish consumption advisory rates within the Columbia River Basin area are lower than baseline heritage rates. These rates estimated the overall dietary makeup and the calorie contribution of fish by gathering information from several types of literature (ethnographic, ecological, nutritional and archaeological) to develop a description of Pacific Northwest traditional subsistence lifestyles and diets that reflected tribal survival through activities and natural resource used to thrive in Columbia River Basin environments. To further define heritage fish consumption rates, the study also evaluated the increase in abundance, harvest and consumption rates through ethnographic and archaeological evidence over the same regional area. They found that both methods independently had the same ranges for heritage rates (Harper & Walker, 2015a).

Cultural Importance and Dependence of Fish, Fishing and Fish Consumption to Pacific Northwest Native Americans

This section provides background on the perspectives of the 15 Pacific Northwest Native American tribes affected by those aquatic ecosystems that are contaminated and depleted. I will describe and evaluate the cultural, traditional, historical, economic, legal context and health impacts of subsistence fishing for tribal communities. This section is to give a general overview of their tribal cultures. Understanding these cultures aids our understanding of their connection to the fish, fishing and the aquatic ecosystem, and provides a lens through which to understand the intricate connections between the ecology of a riverine system and the people that sustain life from this ecosystem.

Currently, 15 federally recognized tribes reside within the Northwest portion of the Columbia River Basin: Confederated Tribes and Bands of the Yakama Nation, Confederate Tribe of Warm Springs, Nez Perce Tribe, Confederated Umatilla Tribes, Confederated Tribes of the Colville Reservation, Spokane Tribe of Indians, Burns Paiute Tribe, Coeur d’Alene Tribe, Confederated Salish and Kootenai Tribes of the Flathead

Nation, Cowlitz Indian Tribe, The Confederated Tribes of Grand Ronde, Kalispel Tribe of Indians, The Confederate Tribes Grand Ronde, Shoshone-Bannock Tribes of the Fort Hall Reservation and Shoshone Paiute Tribe of the Duck Valley Indian Reservation. Figure 1. shows the locations of tribal reservations within the study area. Each tribe has its own cultural legacy consisting of customs, kinship, creation stories and economic systems. Survival as indigenous peoples over the years of contact with European explorers and subsequent colonization has depended upon their ability to practice their cultural beliefs and to remain connected to the land. Their spiritual beliefs focus around a connected and interconnected relationship to all forms of life. Native Americans do not see themselves as autonomous units but rather connected to nature. This connectedness has served as a wellspring of spiritual energy and has linked them to their ancestors. These links provide a body of knowledge that defines who they are in connection to the earth and how they must structure their lives in order to survive. Their society is deeply rooted in the natural order of the environment in which the culture functions and exists. Traditional tribal practices and relationships with natural resources form the spiritual, cultural and economic foundation for Native American tribes (Burger, 1999; Ewers, 1997; Harris & Harper, 1997a; Harris, 2000; Henderson, 1974; Mos et al., 2004; National Geographic Society, 1993; Neihardt, 1988; Waldman & Braun, 1988). Each tribe has its own distinct fundamental principles. Although each tribe has a different culture and religious practice, many of them are environmentally oriented with higher contact rates with the natural environment than the general American population.

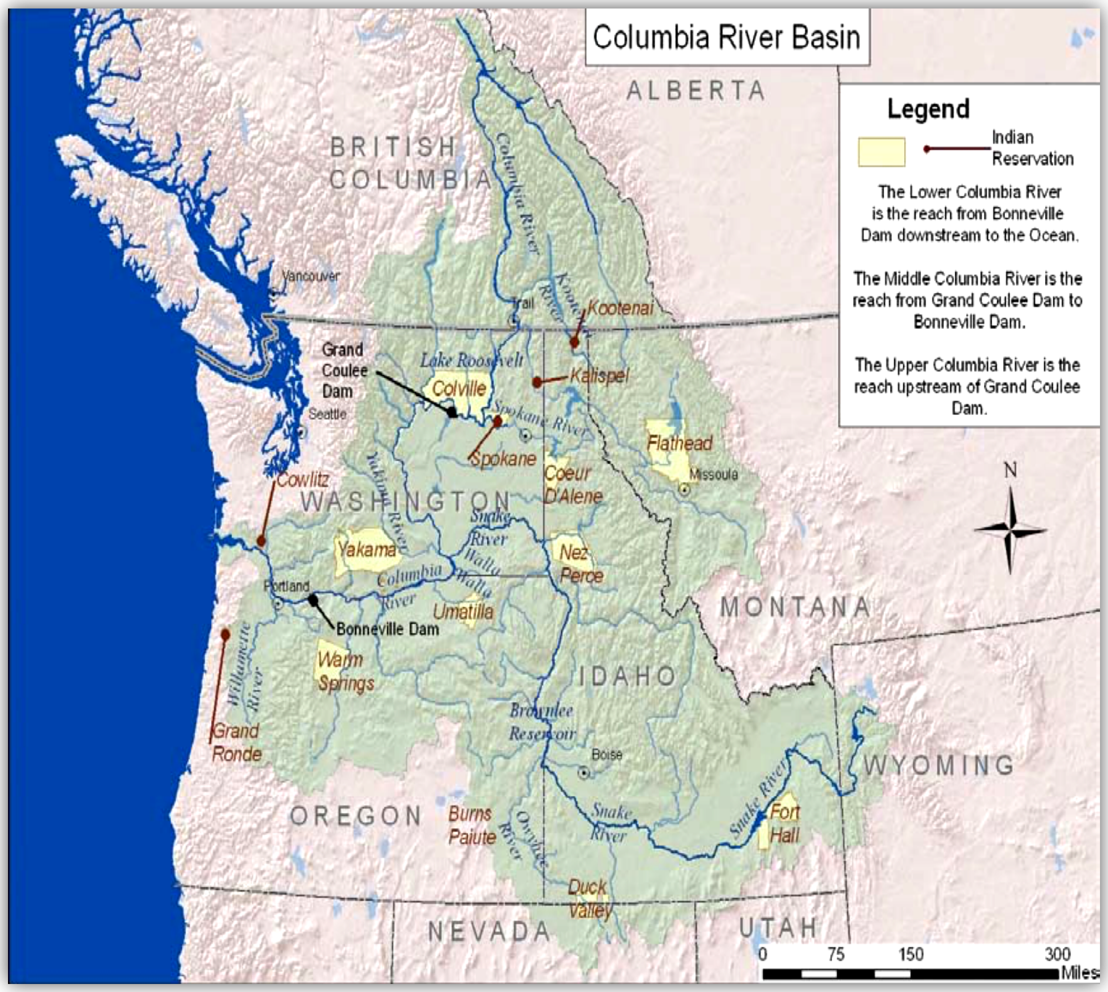

Figure1. Map of the Columbia River Basin and its tribal reservations (U.S. Environmental Protection Agency, 2009).

The Pacific Northwest coast is a region of high concentrations of aquatic resources which have become enmeshed in indigenous culture, language, education, traditional activities and in Treaty Rights with the U.S. These coastal tribal cultures perceive humans and their physical surrounds in a spiritual way. Within these principles the Pacific Northwest tribes have a set of beliefs revolving around certain economically important aquatic species that have been linked to ritual practices to ensure their return to the tribe (Collins, 1990). They see themselves enmeshed in a web of interdependent and mutually complementary life with the aquatic ecosystem (Mos et al., 2004). Due to this juxtaposition, they hold themselves as stewards of these natural resources and the ecosystem that supports these species. The tribes believe their responsibility is to maintain the spiritual quality of the natural resources within the area (Harris, 2000). Because Pacific Northwest culture and religion are bonded with water, a strong attribute of a healthy tribal community is to maintain the integrity of the aquatic ecosystem for species wellbeing (Harris & Harper, 2000). Studies suggest that cultural aspects of land use are critically for Native American subsistence (Burger, 1999; Harris & Harper, 1997b; Stoffle & Evans, 1990; Tano, Reuben, Powaukee, & Lester, 1996; Toth & Brown, 1997). For instance, reservations and tribal lands located around water depend on healthy aquatic ecosystems and the species that these ecosystems support. These cultural aspects lead to a greater dependence on fish compared to the general population.

Fish, especially salmon, are not just principal food sources, but an essential keystone to the foundation of the Pacific Northwest tribal culture. They have developed ceremonies signifying the importance of salmon. Because fish and fishing contributed a great deal to the traditional diet, great spiritual meaning was and still is given to these practices. They believe salmon have an endowed spirit. Ceremonies are rooted in the reverence to these spiritual beings to ensure the bounty and the ease of their capture (Collins, 1990). Through these ceremonies we can understand the value tribes place on them. Salmon spirits were guardian spirits who benefited the whole tribe. It is believed that salmon spirits became fish during spawning time to migrate up rivers to feed the tribes (Collins, 1990). Tribal members perceive the salmon's yearly journeys to the rivers and bays as acts of intentional sacrifice for the benefit and survival of the community. It is believed that salmon would continue to return only if their gifts of sustenance were treated with respect. Ceremonies performed show reverence to salmon through rituals of thanking them for offering themselves to sustain their tribe. The rituals verify and confirm the continuity of the tribes' relationship with them. These ceremonies remind and reinforce the bond between the salmon and the tribe. They also establish a historical bond, heritage union and a tribal identity. As noted by The Columbia River Inter-Tribal Fish Commission:

> 'Salmon are part of our spiritual and cultural identity. Over a dozen longhouses and churches on the reservations and in ceded areas rely on salmon for their religious services. The annual salmon return and its celebration by our peoples assures the renewal and continuation of human and all other life.... Salmon and the rivers they use are part of our sense of place. The Creator put us here where the salmon return. We are obliged to remain and to protect this place... The annual return of the salmon allows the transfer of traditional values from generation to generation. Without salmon returning to our rivers and streams, we would cease to be Indian people' (The Columbia River Inter-Tribal Fish Commission, 1994).

Several authors have made the point that fish contamination exposure can affect religious and cultural beliefs, as well as traditional knowledge (Arquette et al., 2002; Harper & Walker, 2015a; Harris, 2000). For many tribes, traditions, the history of tribe and spiritual knowledge are passed down orally generation to generation from senior to junior members (Berkes, Colding, & Folke, 2000). The Native American community passes knowledge across generations through both ceremonies and stories. Traditional knowledge refers to a "cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living things with one another and their environment" (Riedlinger, 2000; Riedlinger, 2001). Oral tradition is part of the Pacific Northwest lifestyle and serves as a way of recording history. These narratives established their tribal identity. Each new generation relaying the same accounts that where passed down by their elders, is a tradition that reinforces their heritage. Traditional knowledge was told to the younger generation "as part of their inheritance," and that "plants, animals, and especially places were . . . repositories for historical, social, and spiritual lessons" (National Environmental Justice Advisory Council, 2002). Many of these narratives take place during fishing expeditions.

Fish, fishing and fish consumption are fundamental for the physical, social, economic and cultural health for Pacific Northwest tribes. It is an indispensable part of what it means to be a tribal member. To be a tribal member encompasses protecting and tending to fish habitat, fishing for fish, preparing, consuming fish, all performed by traditional methods, prayers and ceremonies (Harris & Harper, 1997a; Harris, 2000; Mos et al., 2004). These activities provided a socialization union within the tribal community and a link to these historical places. However, these activities, which have been passed down for countless generations, are being lost due to fish advisories and the contamination of fish. Tribal members continue to rely on fish as a significant part of their diet in spite of the health risks due to their consumption of fish from their waters. For tribal communities there is no real just alternative to fish in their lives. Numerous regional fish consumption surveys show that there is a disproportionate health impact in Native American communities; this subpopulation eats a higher percentage in comparison to the general population (Harper & Walker, 2015a; Harper & Walker, 2015b; Harris & Harper, 1997a). Due to their higher consumption rates than the general population, their exposure to contaminants in fish may underestimate their higher risk (Department of Ecology Washington, 2013). Given the low states' baseline consumption rates (6.5 g/day), state standards disproportionately and negatively impact tribal communities. To expect a tribal member to reduce their fish consumption practices to match those of the general population or what is deemed safe is an environmental justice issue, especially in the absence of mitigation measures aimed at reducing fish tissue concentrations. Furthermore, it abjures the U.S. tribal trustee responsibilities, and the upholding of national environmental justice policies (Clinton, 1994; O'Neill, 2000). If future generations of people of the Pacific Northwest are to continue their traditional practices that make culture a source of spiritual nourishment, these vital connections must be maintained. Environmental justice issues for Pacific Northwest tribes embody religious freedom, sovereignty, treaty compliance, federal trust obligations and human rights.

Subsistence

White male heteronormative culture's definition of subsistence does not adequately portray the practices and lifestyle of Native American culture. Fishing is apt to be viewed as a recreational pastime. Therefore, to the dominant American society, it is probably thought of as an unnecessary practice. Fish consumption is therefore likely to be valued for its inexpensive source of protein and nutrients, but unlikely to be thought of as indispensable. Traditional lifestyles are often misunderstood to be a recreational supplement, rather than being a cultural lifestyle. To the Northwest Pacific tribes, fishing is a traditional lifestyle that has both nutritional and spiritual benefits, and has spiritual aspects as well as survival ones (Harris, 2000; The Columbia River Inter-Tribal Fish Commission, 1994). The Tribal Science Council defines subsistence as*:*

> 'Subsistence is about relationships between people and their surrounding environment, a way of living. Subsistence involves an intrinsic spiritual connection to the earth, and includes an understanding that the earth's resources will provide everything necessary for human survival. People who subsist from the earth's basic resources remain connected to those resources, living within the circle of life. Subsistence is about living in a way that will ensure the integrity of the earth's resources for the beneficial uses of generations to come. Tribal cultures assign great value to being thankful for the earth's resources, as well as to learning and utilizing the traditional environmental knowledge that emanates from resource use and observation. Traditional knowledge is an integral part of subsistence and is

> passed down from generation to generation. Subsistence is concerned with the inter-relationship of water, air, fish, wildlife, plants, and soils on a time scale pertinent to traditional knowledge.' (Harper & Ranco, 2009).

Subsistence is a cultural way of life that has been passed down for thousands of years. It entwines past knowledge and present day technologies to harvest and share their take with family, friends, elderly and others who are unable to fish. It is an intricate community bond. The National Park Service defines subsistence as the following:

> 'While non-natives tend to define subsistence in terms of poverty or the minimum amount of food necessary to support life, native people equate subsistence with their culture. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. It defines who they are as a people. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. While it is important to the economic well-being of their communities, the subsistence lifestyle is also the basis of cultural existence and survival. It is a communal activity. It unifies communities as cohesive functioning units through collective production and distribution of the harvest. Some groups have formalized patterns of sharing, while others do so in more informal ways. Entire families participate, including elders, who assist with less physically demanding tasks. Parents teach the young to hunt, fish, and farm. Food and goods are also distributed through native cultural institutions. Most require young hunters to distribute their first catch throughout the community. Subsistence embodies cultural values that recognize both the social obligation to share as well as the special spiritual relationship to the land and resources. This relationship is portrayed in native art and in many ceremonies held throughout the year' (Harper & Ranco, 2009; National Park Service, 2015).

By practicing a subsistence lifestyle which encompasses spiritual practices, culture, and historical, economic and legal contexts, tribal members are subjected to disproportionately higher risks simply from exercising their rights to their First Foods and practicing their religious ceremonies and culture (O'Neill, 2000; U.S. Environmental Justice Agency, 1995).

Environmental Justice and Indian Country Treaty Rights

A unique relationship exists between the U.S. government and tribal government. Environmental justice in Indian Country is a complex matter due to tribal sovereignty. Tribes are sovereign nations with legal status and are protected by a federal trust relationship with the U.S. federal government. Federally recognized Indian tribes exercise government to government relations with the U.S. government. The federal government treats tribes as separate entities capable of self-government and with jurisdiction over their people and land. In recognition of this sovereignty the federal government and not the individual states conduct official relations with Indian Nations (The White House, 1994). The term "Indian Country" is used to describe their lands and is legally defined in 18 U.S.C. § 1151 (Indian Legal Curriculum and Training Program & Kickingbird, 1977). In 1832, the Supreme Court ruled that the federal government's trust responsibility is to ensure 'the continued survival of Indian tribes as self-governing peoples,' and that the U.S. government has the duty 'to assist Indians in the protection of their property and rights' (Hall, 1981). This amounts to the federal protection of Tribal Nation's safety and well-being. The Department of Interior has interpreted the federal responsibility to be a legal responsibility to protect 'Indian lands, water, minerals, and other natural resources' (U.S. Congress & American Indian Policy Review Commission, 1977). Furthermore, the right to practice traditional lifeways is protected by treaties that include the rights to practice subsistence fishing (Ranco & Suagee, 2007).

In the 1800s, the Columbia River Basin Tribes negotiated their treaties to insure the perpetual rights to access their historical fishing sites and established the right to fish for subsistence (Cohen, 2012). This was paramount to them because they believed in taking care of and being cared for by the fish, to continue their intertwined relationship.

These rights were so sacred to them that they ceded vast expanses of their homelands to insure access to these traditional sites. Treaties protect tribal rights to take fish in perpetuity. The treaties hold the status under the Constitution as “supreme law of the land” (O'Neill, 2013). These are important aspects to note because it gives tribes the entitlement to a future in which they may exercise their rights to fish consumption on which they have historically depended upon (Hall, 1981). Hence, they have the inherent right to use Indian Country’s natural resources for subsistence, cultural and religious purposes.

Under these above fiduciary duties mentioned, the U.S. government is a trustee for Indian land and resources, and can be held liable for failing to uphold these responsibilities. One of these responsibilities is to aid tribes in their efforts to protect a reservations’ natural resources from damage or degradation. To safely and effectively exercise their Treaty Rights to fish on these lands, the natural resources upon which these rights are based must be safe to consume. Unfortunately, activities undertaken by governmental parties and industrial entities have degraded the natural and cultural resources that are important to many tribes within the Pacific Northwest region (LaDuke, 1999). This point is important because these activities have resulted in water degradation, leading to depletion and contamination of fish resources.

Tribal governance has set their own water quality standards in Indian Country to protect their waters from contamination, although tribes have no reign over the federal and state water quality standards which impact much of their water. Tribal venues have appealed to federal and state agencies about water quality degradation due to toxic contaminates of PCBs, flame retardants, dioxins, mercury and many others. Fish contamination prevents Treaty Rights from being fully exercised and may threaten the health of tribes along with traditional lifestyles' (O'Neill, 2000; O'Neill, 2013). State water quality standards are postulated on quantitative assessments of human exposure, though these agencies at the time did not have any quantitative data on tribal fish consumption. Rather the standards used (6.5 g/day) assume that tribal members consumed fish like the "average" American (O'Neill, 2013).

However, the U.S. is cognizant of the importance of fishing to the continuation of tribal identity, culture, traditional lifestyle and economy. "Heritage fish consumption rates" are traditional tribal fish consumption rates that are federally recognized in many court cases as Treaty Rights between Pacific Northwest Indian Nations and the U.S. (National Environmental Justice Advisory Council, 2002; O'Neill, 2013). The U.S. Supreme Court has acknowledged fish as a necessary cultural aspect to Native American lifestyle that ranges back 30,000 years (U.S. Supreme Court, 1905). In United States v. Washington, Judge Boldt upheld this in stating that 500 pounds per capita was a judicious number for salmon consumption on the Columbia River for Northwest Tribal Nations (Harper & Walker, 2015a).

Lastly, the U.S. government has an obligation to honor its commitments under international law to protect the rights of Native Americans, including the rights to traditional resources and subsistence fishing. The United Nations called upon the U.S. to concede that the "interests of indigenous peoples in traditional lands, territories, and natural resources," and acknowledged "that many indigenous peoples depend upon a healthy environment for subsistence fishing, hunting and gathering." (United Nations on Biological Diversity, 2015). These laws also address the subsequent need for U.S. federal and state environmental protection agencies to further thrive for environmental justice (United Nations Human Rights Council, 2006).

Environmental justice for tribes is distinct from other American minority communities. The fact that tribes have a unique sovereign status differentiates them from other environmental justice communities (O'Neill, 2000; O'Neill, 2013). Tribal social identity, heritage, beliefs, culture and subsistence are often dependent on particular places and natural resources which entitles them the right to appeal in the name of environmental justice and Treaty Rights (Ranco & Suagee, 2007). Legal obligations are in question from the federal trust responsibility, federal Indian treaties, Executive Order 12898 and from Title VI of the Civil Rights Act of 1964, due to neglecting trustee obligations of providing sustainable tribal lands and by allowing water degradation (Krakoff, 2002). Failure to honor these legal obligations raises issues of environmental justice.

Contamination in the Columbia River Basin Indian Lands

Toxic contaminants are chemicals introduced to the environment in amounts that can be harmful to environment, fish, wildlife or people. Some are naturally occurring, but many of these contaminants are manufactured. Many of these manufactured contaminates have been released into waterways through Toxic Release Inventory (TRI) facilities.

The Toxic Substances Control Act sanctions EPA to acquire information on certain chemical substances. It further authorizes EPA to control establishments emanating certain amounts of a chemical deemed to cause unreasonable risk to public health or the environment (1976). It endows EPA with the authority to require reporting, record keeping and testing requirements relating to chemical substances hence the creation of the Toxic Release Inventory Program (TRI). This is a part of the Emergency

Planning and Community Right-to-Know Act (EPCRA) (U.S. Environmental Protection Agency, 2015g).

The EPA tracks releases of toxic chemicals through the TRI. TRI permits are required from manufacturing and processing facilities: with ten or more employees, the facility is classified under Standard Industrial Classification codes 20 through 39, and if they produce, manufacture or process 25,000+ pounds or use more than 10,000 pounds of any annually EPCRA Section 313 chemicals. (U.S. Environmental Protection Agency, 2015a; U.S. Environmental Protection Agency, 2015g).

TRI facilities, ranging from industry to mining to military bases, negatively affect the health, socio-economic, heritage and culture within Indian Lands. EPA's Environmental Justice Department defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (U.S. Environmental Justice Agency, 7/2015). Unfortunately for tribal communities, environmental mitigation is significantly behind that of nontribal communities (U.S. Environmental Protection Agency, 2004). Indian Country, be it by purposeful design or institutional neglect, face some of the worst environmental desolation in the nation (Mascarenhas, 2007). Because of their subsistence lifestyles, spiritual practices and culture, tribes have multiple exposures from TRI sites that could result in disproportionate environmental risks (U.S. Environmental Protection Agency, 2004).

In Indian Country waterways, water quality standards are to protect water resources Native Americans are dependent upon. In order to improve water quality standards to protect the health of Northwest Pacific tribes whose culture is immersed with aquatic ecosystems there needs to be an understanding how these contaminants are entering waterways. This section provides an overview of facilities that may contribute to the contamination of the waterways that run through Indian Country and Treaty Rights areas.

Three of the major states that encompass the Columbia River Basin area are Idaho, Oregon and Washington. According to the TRI program, the States of Idaho, Oregon and Washington in 2013 released into the environment (air, water, soil, underground injection and off-site transfer) a total of 85.34 million pounds of chemicals from 701 processing facilities; 5,802,296 alone was released into Columbia River Basin waterways (Table 1.) (U.S. Environmental Protection Agency, 2013a). Many of these chemicals inadvertently run through reservation waterways and treaty fishing rights areas. In 2013, nationwide Idaho accounted for 1.17% of total TRI releases, Oregon 0.41% and Washington 0.48% (U.S. Environmental Protection Agency, 2013a; U.S. Environmental Protection Agency, 2013b; U.S. Environmental Protection Agency, 2013d). Figure 2., 3. and 4. show the facilities per state that release the largest amounts of TRI chemicals into the environment. Table 2. lists a sample of amount of toxins released by TRI facilities directly located on Coeur d'Alene Tribe and Nez Perce Tribe reservations. Figure 5. depicts TRI sites on or within a two-mile radius of Indian Country. Figures 6., 7. and 8. depict the production and processing facilities of each of the major states within the Columbia River Basin that release toxic chemicals.

Table 1. Releases of TRI chemicals from the three major states of the Columbia River Basin, 2013.

State	Number of TRI Facilities	Total Amount of Releases (lbs.)	Releases in Water Alone	Nationwide Ranking
Idaho	109	48,543,165	2,692,951	32
Oregon	274	16,838,230	775,166	50
Washington	318	19,959,351	2,334,179	42

(U.S. Environmental Protection Agency, 2013c).

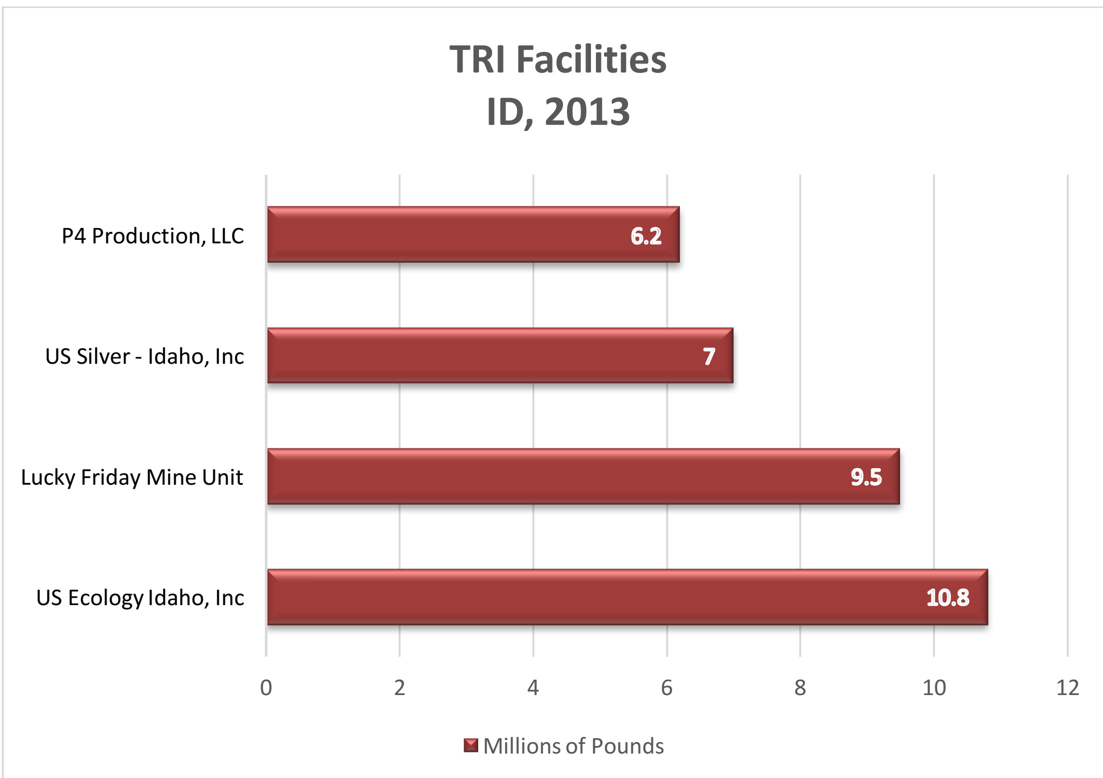

Figure 2. Top four facilities in Idaho with the largest release of TRI chemicals into the environment (U.S. Environmental Protection Agency, 2013a).

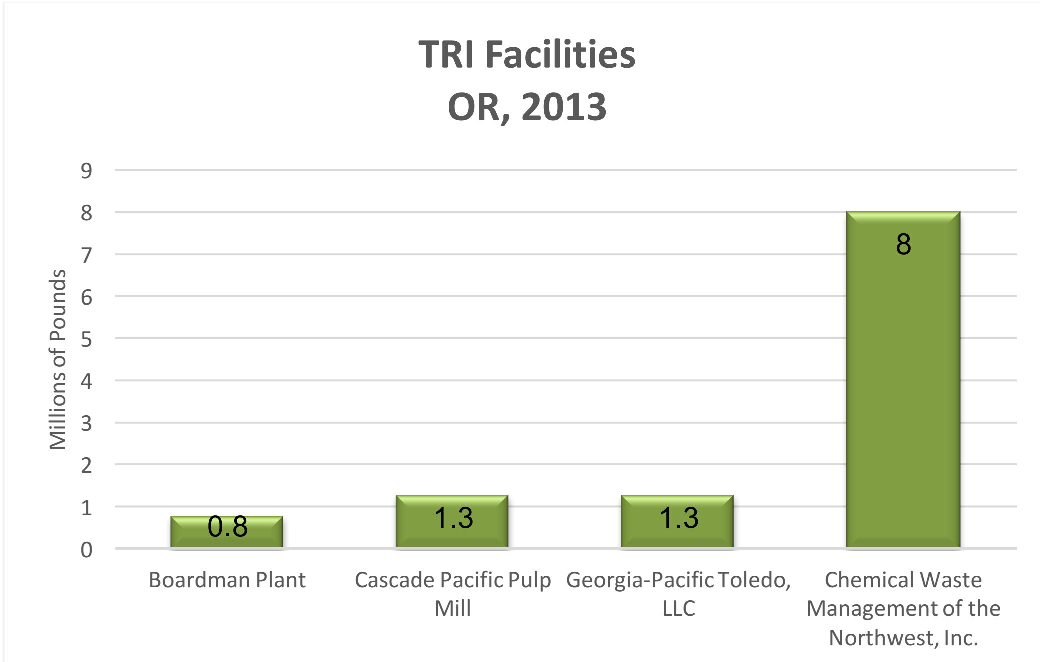

Figure 3. Top four facilities in Oregon with the largest release of TRI chemicals into the environment (U.S. Environmental Protection Agency, 2013b).

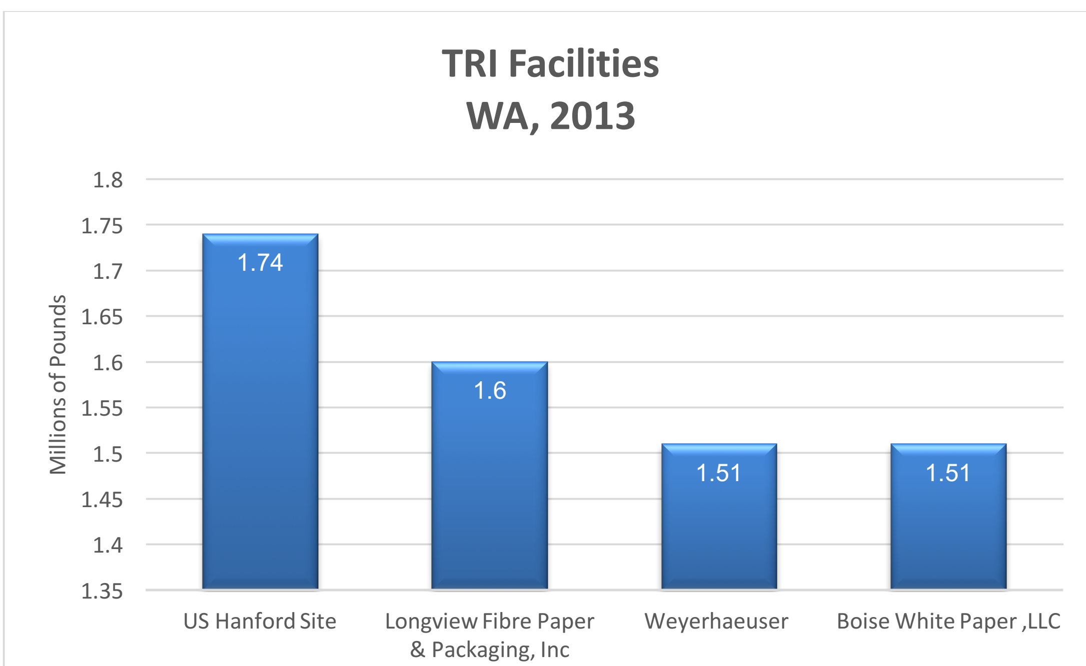

Figure 4. Top four facilities in Washington with the largest release of TRI chemicals into the environment (U.S. Environmental Protection Agency, 2013d).

Table 2. Amount of toxins released from the TRI facilities located within Indian Country.

Indian Country	TRI Facility	Amount Released (lb)
Coeur d'Alene Tribe	Potlatch Land & Lumber	40,618
Coeur d'Alene Tribe	Stimson Lumber	646
Nez Perce Tribe	Empire Lumber	23

(U.S. Environmental Protection Agency, 2013c).

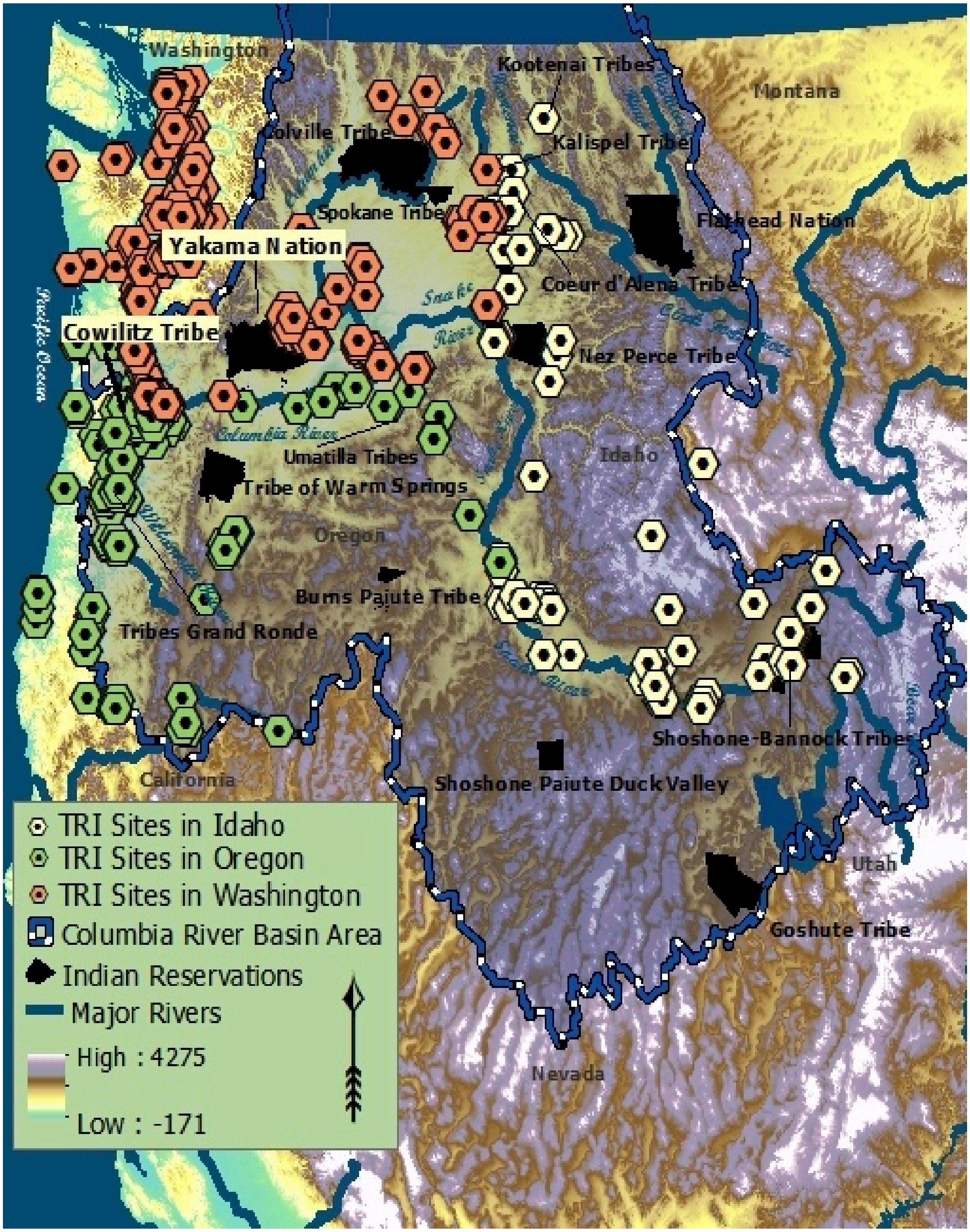

Figure 5. Indian reservations and toxic release facilities throughout the Columbia River Basin.

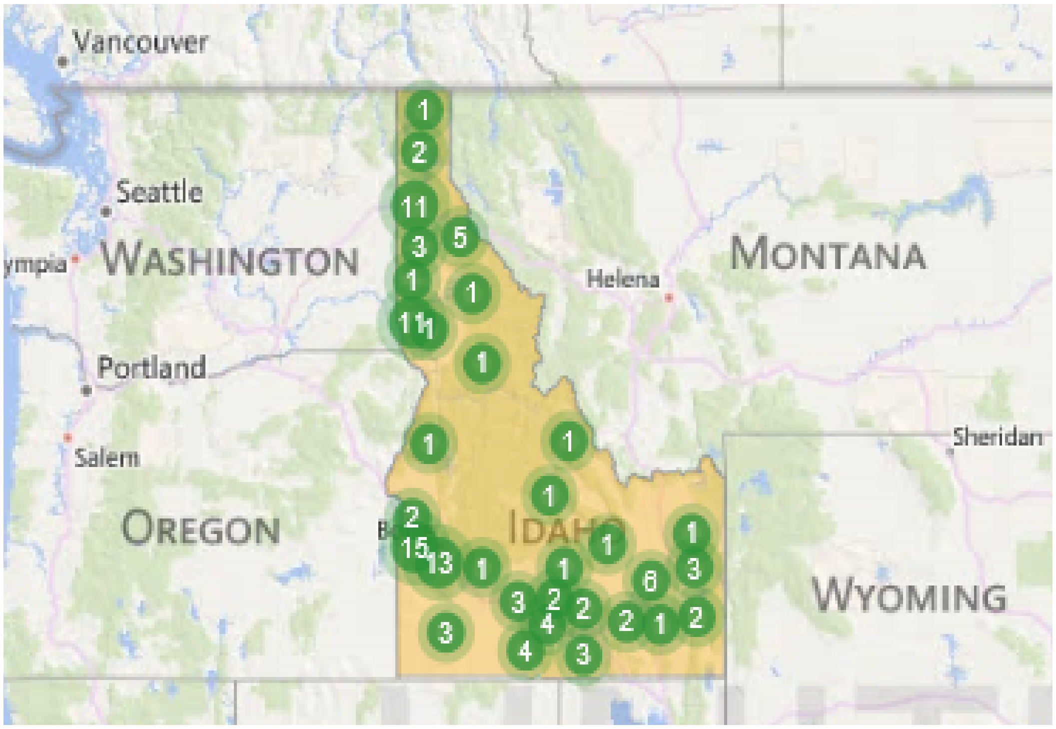

Figure 6. TRI facility sites in Idaho; number of facilities in each area are circled (U.S. Environmental Protection Agency, 2013a).

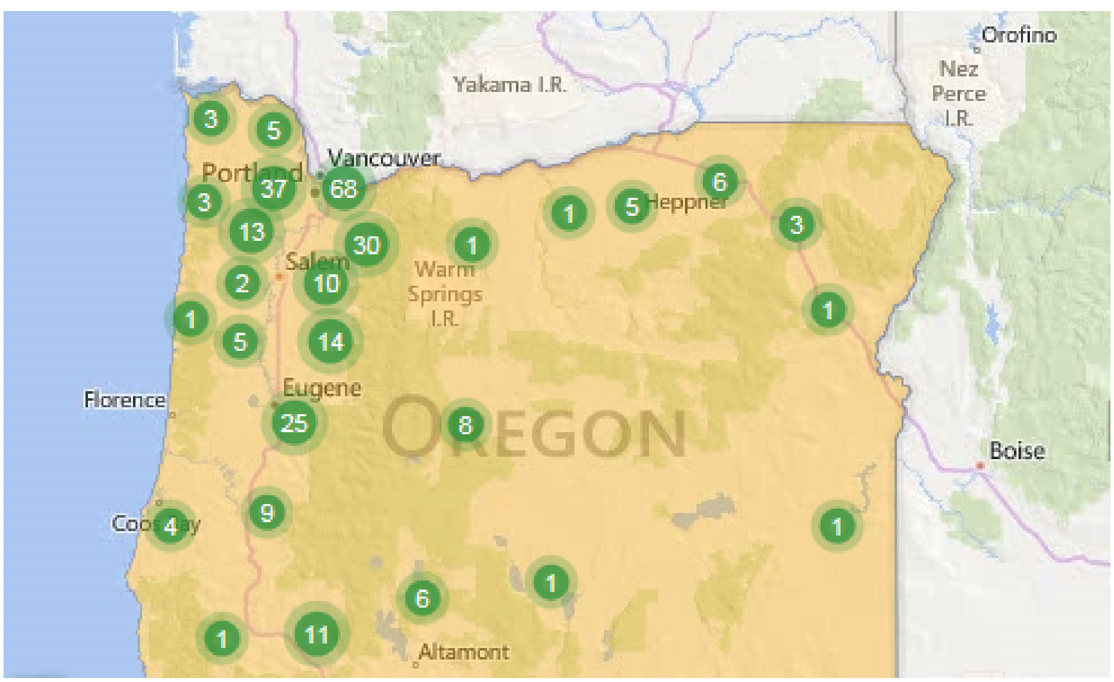

Figure 7. TRI facility sites in Oregon; number of facilities in each area are circled (U.S. Environmental Protection Agency, 2013b).

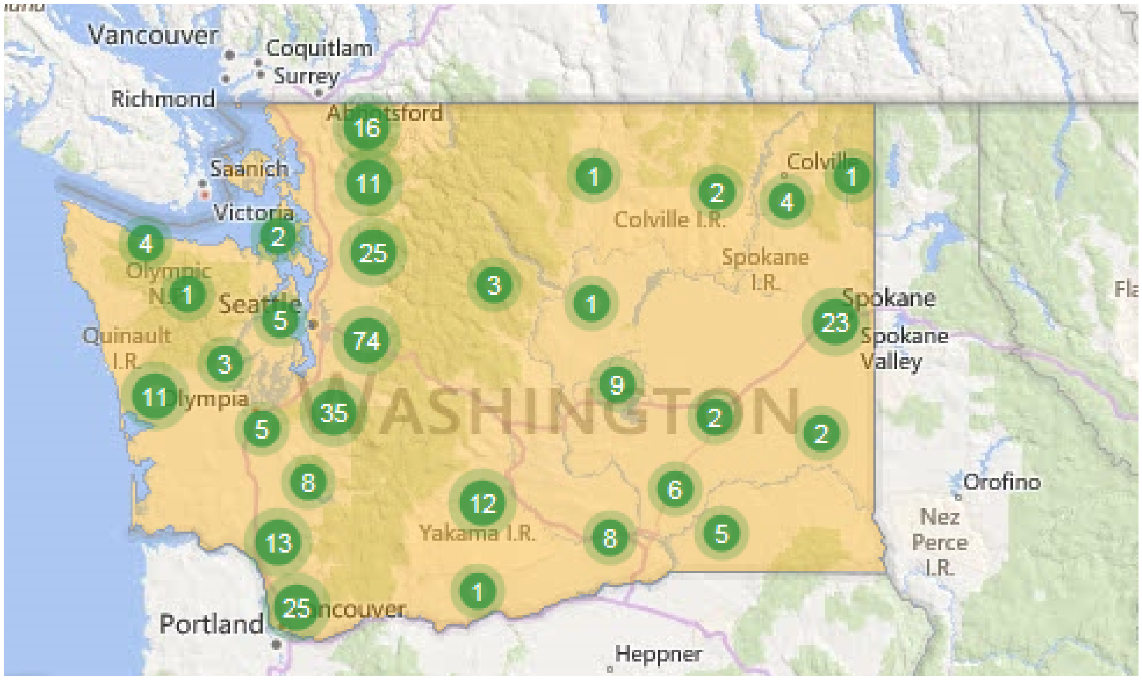

Figure 8. TRI facility sites in Washington; number of facilities in each area are circled (U.S. Environmental Protection Agency, 2013d).

My research goal was to determine if mercury might cause harm to exposed tribal members and/or ecosystems residing in the Columbia River Basin. Seventy-five percent of fish consumption advisories in the Columbia River Basin are due to mercury contamination (U.S. Environmental Protection Agency, 2009). Measuring the direct source output of mercury poses a special challenge. Data on the amounts of mercury from TRI facilities are limited. Additionally, atmospheric deposition, runoff, wastewater discharges, mines discharges and industrial and energy-related activities within and outside of the Basin contribute to the mercury pollution in the Columbia River Basin's waterways and its tributaries. Furthermore, at a watershed level, local and regional sources can be significant contributors of mercury to the Basin. Though they may be considered low in concentration, their output is a significantly amount. For example, there are 23 municipal and industrial wastewater point sources located in the Columbia

River Basin. Of those 23 mentioned, 9 alone discharged a total of 33 pounds of mercury during 2008. Just one mine alone discharges over 1,700 pounds of mercury per year. Although there is only one coal fire plant in the Columbia River Basin region, it ejects 168 pounds of mercury per year (U.S. Environmental Protection Agency, 2009).

Mercury

Mercury is a natural element that is distributed through natural and anthropogenic processes. The natural release is from atmospheric deposition of volcanic activity or erosion of rocks and soil that contains mercury in them. Major anthropogenic pathways that are attributable to mercury releases into the environment include: industrial processes involving the use of mercury; combustion of fossil fuels, coal-fired power plants; production of cement; medical and municipal waste incinerators and industrial and commercial boilers. Surface water exposure may transpire from a number of industrial processes including: chlor-alkali production facilities, mining operations and smelting, chemical manufacturing, ink manufacturing, textile manufacture, pulp and paper mills, leather tanning, pharmaceutical production, recirculation of sediments, discharge of wastewater and storm water (U.S. Environmental Protection Agency, 2015b).

Human exposure to mercury can occur through several pathways: inhalation of mercury vapors in ambient air, ingestion of drinking water and ingestion of dietary products contaminated with mercury. Dietary intake of fish will be the main focus of this thesis, and is considered the most significant source of non-occupational exposure to mercury (U.S. Environmental Protection Agency, 1997; World Health Organization, 2014).

Studies suggest that a communities' proximity to an industrial facilities involved in the production or use of mercury had increased levels of mercury in air, water, soil, plants and fish. Communities living near these facilities or subsistence fishers who routinely consume meals of fish from the contaminated area may be at risk for exposure to high levels of mercury due to the contamination of surface waters, groundwater, soils or fish (U.S. Environmental Protection Agency, 2002b).

Mercury Toxicity from Fish Consumption

Mercury is a metallic element, ergo it is never destroyed, but cycles between a number of chemical and physical forms. In the aquatic environment, deposited mercury (inorganic) can be converted by microorganisms to a more toxic form called methylmercury. Fish accumulate methylmercury from both dietary routes (bioaccumulative) sources and the uptake of water (bioconcentration) (Branson, Takahashi, Parker, & Blau, 1985; Department of Ecology Washington, 2013; Kucklick, Harvey, Ostrom, & Baker, 1996). Studies suggest that roughly 90 percent of the mercury in aquatic food webs is considered to be sequestered in the form of methylmercury, and a key dietary source of methylmercury is contended to derive mainly from fish (Agency for Toxic Substances and Disease Registry, 2015b).

Methylmercury biomagnification has been demonstrated through piscivorous predator species at the top of the food web containing elevated concentration levels of mercury compared to fish at lower levels of the food web (Figure 9.). They may bioaccumulate chemicals to one million times the concentration detected in the water column. Further research found concentrations of methylmercury detected in fish are directly related to the amount in the water column (Branson et al., 1985; Kucklick et al., 1996; U.S. Environmental Protection Agency, 1992c; U.S. Environmental Protection Agency, 2002a).

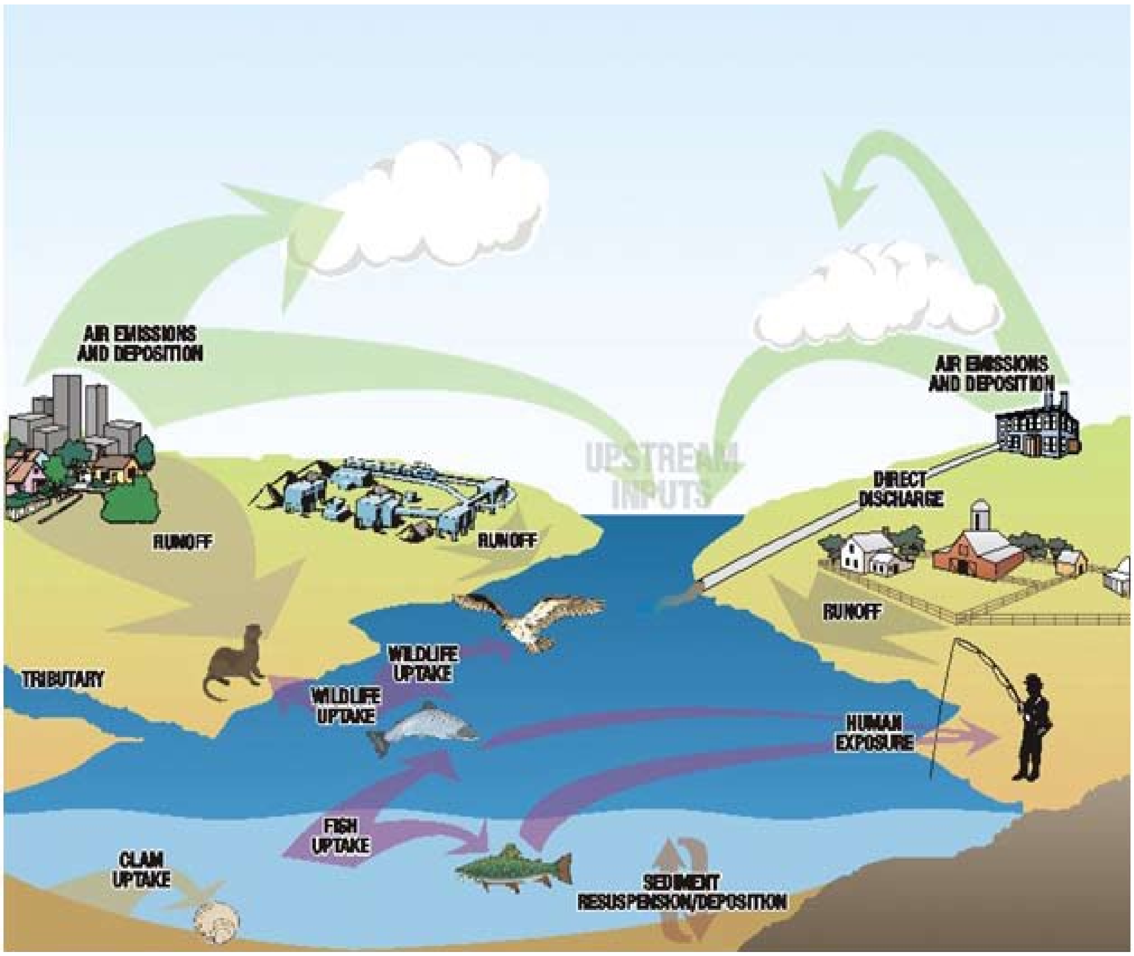

Figure 9. Bioaccumulation and biomagnification pathways in the environment.(U.S. Environmental Protection Agency, 2002a)

The consumption of fish may expose a person to the toxins concentrated in their tissues. Numerous studies have reported that the consumption of contaminated fish is considered to be the single greatest route of exposure to mercury (Agency for Toxic Substances and Disease Registry, 2015b; U.S. Environmental Protection Agency, 2002b). In addition, most of the mercury consumed in fish is in the form of methylmercury, which is easily absorbed by the stomach and intestines into the bloodstream. It is then carried by the blood to the brain and central nervous system. Methylmercury has a life of approximately 65 days in the body. Over long exposure to methylmercury the concentrations accumulate and intensify symptoms, which may include body tremors, insomnia, memory loss, headaches, paresthesia, emotional instability, muscular twitching and atrophy. (Adams et al. 1983; Bluhm et al. 1992a;, Hallee 1969; Jeffe et al. 1983; Karpathios et al. 1991; Lilis et al. 1985; McFarland and Reigel 1978; Snodgrass et al. 1981). Mercury can cause neurological, developmental and reproductive problems too. Long term exposure can permanently damage the brain, kidneys and a developing fetus (Agency for Toxic Substances and Disease Registry, 2015b).

Several studies have documented higher fish consumption rates among Native American subsistence fishers then the general population. Further studies have indicated that the Native American population who consume locally caught fish from mercury contaminated waterways can be exposed to higher mercury concentrations than individuals who consume similar amounts of commercially marketed fish (The Columbia River Inter-Tribal Fish Commission, 1994; The Suquamish Tribe, 2000; Toy, Polissar, Liao, & Mittelstaedt, 1996; U.S. Environmental Protection Agency, 2002b; U.S. Environmental Protection Agency, 2015f). According to the Agency of Toxic Substances and Drug Registry, subsistence fishers may consume larger doses of mercury due to their greater fish consumption (>100 g/day) and have higher concentrations of mercury in their tissues than the general public, which average 6.5 g/day of consumer purchased fish (Agency for Toxic Substances and Disease Registry, 2015b).

Table 3. Acceptable level of mercury intake estimated by different agencies.

Contaminant	ATSDR: Minimum risk levels	WHO: Provisional Tolerable Weekly Intake	EPA: Reference Dose
Mercury	0.0003 mg/kg/day	1.6 µg per kg body weight	1.0 x E-04 mg/kg/day

(Agency for Toxic Substances and Disease Registry, 2015a; U.S. Environmental Protection Agency, 2001a; World Health Organization, 2015).

The benchmark levels for maximum levels of mercury intake vary according to different agencies (Table 3.). All indicate toxicity levels at low ingestion rates. This research compares these against fish consumption rates of the cultural and traditional Tribal uses of the Pacific Northwest Native American, Oregon State's water quality standards and EPA.

Research Questions, Hypotheses and Specific Aims

The purpose of this thesis is to assess the Pacific Northwest Native Americans tribes' mercury exposure through subsistence lifeways. My major research questions focus on assessing:

- What are the levels of mercury contamination in the fish inhabiting the rivers used by Pacific Northwest tribes?
- Is there evidence that there is a disproportionate burden of mercury exposure on Pacific Northwest Native American lands compared to the surrounding areas?
- Is there inequitable distribution of TRI sources with respect to Native American reservations compared to other rural landscapes in the Columbia River Basin?
- Are tribal members who practice traditional, cultural and subsistence lifeways disproportionately exposed to mercury through fish consumption?

- What is the health risk to Pacific Northwest Native American people if they consume fish (with their current contaminant levels) at amounts consistent with their tradition and cultural lifestyle?
- How clean do water resources need to be in order to ensure that traditional lifestyles are safe?

I hypothesize that mercury levels will exceed the maximum fish advisory thresholds established by states and EPA. The states' thresholds represent the potential inadequacy of fish advisories to reflect important cultural differences in environmental justice communities. This may warrant further mitigation to reduce pollutant levels in surface waters that support commonly consumed or culturally important biota species.

I further hypothesize that the Pacific Northwest tribal communities face disproportionate exposure to mercury contamination due to subsistence lifeways compared with the general population. Disproportionate exposures to the Pacific Northwest Native American population may occur as a result of states' water quality standards not taking into account that tribal health includes spiritual, social, community and environment well-being.

The specific aims of this thesis are to:

- Identify the source of the mercury contamination and the media that transports the contaminant.
- Determine the contaminant concentrations.
- Examine fish contamination data to determine the exposure of Pacific Northwest tribal members while practicing cultural subsistence practices.
- Conduct an analysis on a specific targeted biota consumed regularly by Pacific Northwest tribal communities for chemical exposure to mercury.

- Identify the unique exposure pathways that the Pacific Northwest tribal communities may be exposed to by maintaining tribal subsistence practices.
- Estimate whether current or future mercury exposures will pose health risks to the Pacific Northwest population.
- Provide preliminary information that may indicate the need for a Public Health Assessment.
- Establish protocols for assessing the level of exposure to mercury for Pacific Northwest Nation tribal members as a consequence of consuming their cultural biota as a primary source of nutrition.
- Provide information regarding Tribal exposure to assist EPA regulators in determining if designated uses met the requirements of Clean Water Act and implementing regulations at 40 CFR 131.10.
- Determine if current water quality standards applicable to waterways within the Pacific Northwest reservation regions protect tribal cultural practices and resources in their subsistence lifeway patterns.
- Provide the information needed to link science to policy and regulatory decision.

Chapter II

Research Methods and Design

My methodology focused on measuring the mercury exposure of Northwestern Tribal members, with a particular objective of estimating the dietary exposure. It was designed as a preliminary risk assessment to determine if the levels of mercury exposure in fish were high enough to be a health concern to tribal members who wanted to continue to fish according to their culture and traditions. A risk assessment was performed which consisted of four parts: hazard identification, exposure assessment, toxicity assessment and risk characterization. The baseline traditional fish consumption rates or "heritage rates" were formulated from combined scientific information from 15 tribes located within the Colombia River Basin; therefore, the risk estimates in this study do not represent the risks of any specific tribe. The types of fish and sampling locations were selected based on their use by subsistence tribal members (U.S. Environmental Protection Agency, 2002b). The sampling was biased with unequal sample sizes and randomly selected predetermined sample locations. This bias was due to evaluating particular subpopulation preferences. The assessment consisted of characterizing the exposure setting, identifying the pathways and quantifying the exposure. Research data was collected and analyzed under the following research structure (Figure 10).

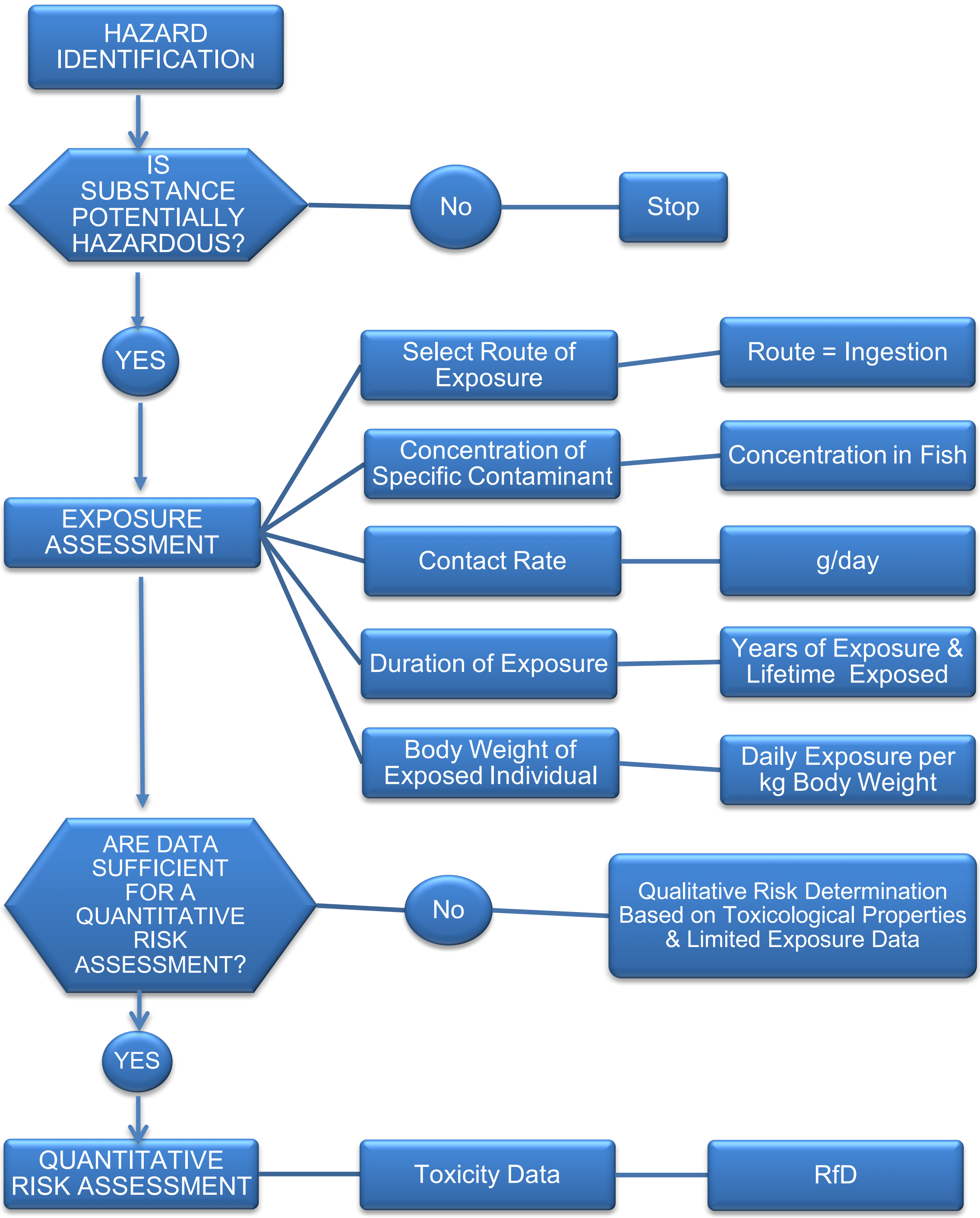

Figure 10. Conceptual structure of quantitative health risk assessment model used as a guideline for this study (U.S. Environmental Protection Agency, 1992b).

The procedural rules for calculations reported here were adapted from EPA's "Guidelines for Exposure Assessments" and "Guidance Manual for Health Risk Assessment Chemically Contaminated Seafood" and "EPA's Criteria for Water Quality Standards for the Protection of Human Health When Addressing Mercury. (Tetra Tech, 1986; U.S. Environmental Protection Agency, 1992b; U.S. Environmental Protection Agency, (2001a). Several meetings, numerous email correspondence and phone conferences with EPA's Region 1 and Region 10 and the Agency for Toxic Substances and Disease Registry (ATSDR) were held to develop an outline for assessing the level of exposure concentrations to methylmercury in fish from areas commonly used by the Columbia River Basin tribal members when gathering and fishing in the Indian Country.

Fish Samples for Mercury Concentrations

Mercury levels in fish were collated from databases of samples limited to the Columbia River Basin, a watershed of 1,260 square miles. Within the U.S. it encompasses the following states: Idaho, Montana, Nevada, Oregon, Utah, Washington and Wyoming. Within this region there are 11 major rivers that flow into the Columbia River: Cowlitz, Deschutes, Kootenay, Lewis, Okanagan, Pend Oreille, Snake, Spokane, Wenatchee, Willamette and Yakima Rivers (Figure 11.) (Department of Ecology Washington, 2015).

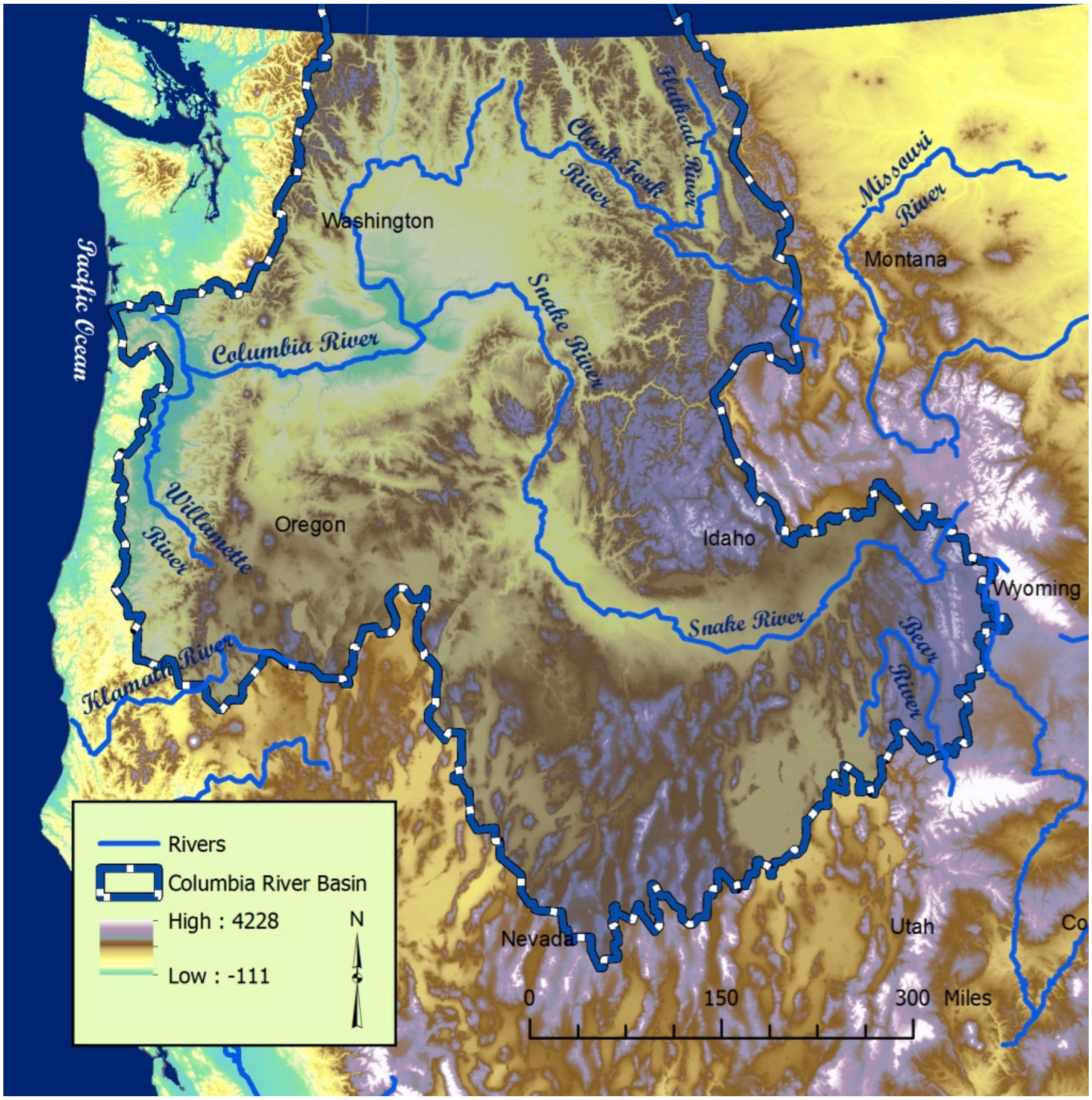

Figure 11. Geographical region of the Columbia River Basin.

The research approach for this study was comprised of two parts: selecting specific geographical locations along the popular fishing locations and identifying the most popular biota consumed by the Columbia River Basin tribal members in sustaining their traditional way of life.

Fish Sample Locations and Sample Strategy

This study was designed to estimate risks for a specific population. Therefore, the sampling locations were not randomly selected, but were those useful to characterizing risks to tribal members residing in the Columbia River Basin.

A database was compiled mainly from state and federal monitoring programs of 1687 samples of fish from 1999 to 2010 analyzed from the Columbia River Basin region's waterways. This sample was unbiased in that all available samples within this geographic region were included. Fish tissue collection, sampling procedures and laboratory analysis were performed by EPA, State of Idaho, State of Oregon and the State of Washington. All the sample values were composites of individual fish, each measured and then the average taken of mercury. The number of fish in a one composite varied with species, location and tissue type. "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*"* recommends 3 to 10 individuals should be collected for a composite sample for each specific species (U.S. Environmental Protection Agency, 2000). The type of tissue tested (whole-body or fillet) varied with species and sample location. Whole-body was analyzed because tribal members consume several parts of fish in addition to the fillet. Some data sets did not indicate if they were composites, whole-body or fillet tissue types and were assumed to be composites. Appendix 4 lists the 101 waterbodies that were analyzed. Figure 12. depicts the waterbody locations.

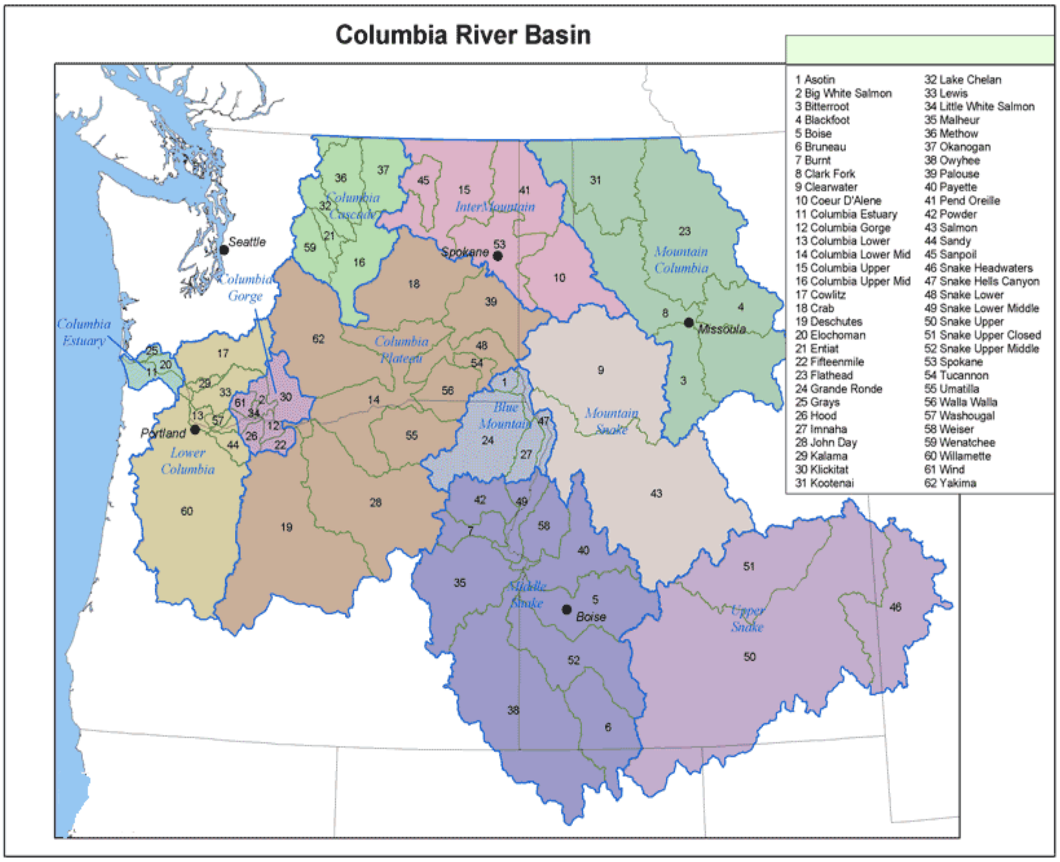

Figure 12. Geographic locations of rivers located within the Columbia River Basin (Department of Ecology Washington, 2015).

Selection of Species

The fish species included those anadromous species and resident fish species important to Columbia River Basin tribal members (U.S. Environmental Protection Agency, 2002b). The resident fish species spend their life cycle in the Columbia River Basin and include: bridgelip sucker (*Catostomus columbianus*), brown trout (*Salmo trutta),* channel catfish (*Ictalurus punctatus*), cutthroat trout (*Oncorhynchus clarkii*), largescale sucker (*Catostomus macrocheilus*), largemouth bass (*Micropterus salmoides*), largemouth sucker (*Catostomus macrocheilus*), longnose sucker (*Catostomus catostomus*), mountain sucker (*Catostomus platyrhynchus*), mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus* mykiss), redband trout

(*Oncorhynchus mykiss gairdneri),* smallmouth bass (Micropterus dolomieui), sucker (*Catostomus)*, Utah chub (*Gila atraria*), Utah sucker (*Catostomus ardens*), walleye (*Stizostedion vitreum*), white sturgeon (*Acipenser transmontanus*) and Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri).* The anadromous fish species spend most of their life in the ocean; therefore, their mercury uptake was likely to occur at sea rather than at the collected sites. Relevant species include: chinook salmon (*Oncorhynchus tshawytscha),* coho salmon (*Oncorhynchus kisutch*), sockeye salmon (Oncorhynchus nerka). Two types of samples were collected: whole-body and fillet.

Hazard Assessment of Exposure to Mercury

The hazard identification that was performed summarized and weighed the available evidence regarding mercury's potential to cause adverse health effects. A qualitative evaluation of past experimental data was done to identify intrinsic toxicity of mercury and the relevance to human health. Short-term and long term animal assays were reviewed along with human studies (Agency for Toxic Substances and Disease Registry, 2015b; Bakir et al., 1973; Centers for Disease Control and Prevention, 2015; Fitzgerald, Hwang, Bush, Cook, & Worswick, 1998; Harada, 1995; Integrated Risk Information System, 2015; U.S. Environmental Protection Agency, 2011; U.S. National Research Council, 2000; West, 1992).

Quantification of Mercury Exposure

An exposure pathway describes the route a chemical takes from the source to the exposed individual. An exposure entails the following: a source of chemical release; movement of the chemical through the environment resulting in contamination of environmental media (water); potential contact with this contaminated media and an exposure route, as in this study ingestion (U.S. Environmental Protection Agency, 1992b). The magnitude, frequency and duration of the exposure depend on an individual's activity patterns as well as the concentration of the agent. It becomes a dose when the exposure toxin crosses an absorption area (U.S. Environmental Protection Agency, 2011). There are numerous different exposure pathways Columbia River Basin tribal members could come in contact, this exposure assessment evaluates only exposure from consumption of fish. Mercury contaminant levels in fish were gathered and potential exposures through the consumption of fish were estimated. The origin of mercury contaminants and their subsequent movement through the environment into fish were not evaluated.

The chemical analysis used in this exposure assessment was performed as total mercury. For the purposes of this exposure assessment, the total mercury concentrations were assumed to be all methylmercury. To characterize the risk from consuming fish, an estimate of the amount of contamination ingested from eating fish was estimated by EPA's equation for estimating the exposure to contaminants (U.S. Environmental Protection Agency, 2000). A mean mercury concentration was determined for each species, and converted to the amount of mercury a person is exposed to over time. The below quantitative evaluation of the potential for developing adverse health effects as a result of an exposure to mercury was calculated for this study. The equation estimates Columbia River Basin tribal members' average daily ingestion of mercury in fish (Equation 1).

Equation 1

$$(ADD) = \frac{C \times IR \times AF \times EF \times CF}{BW}$$

Where:

ADD: Average Daily Dose exposure (mg/kg-day)
C: Concentration of chemical in fish tissue (mg/kg)
IR: Ingestion (consumption) Rate (g/day)
AF: Availability Factor
EF: Exposure Factor (days/year)
CF: Conversion Factor (kg/g)
BW: Body Weight (kg)

Four different ingestion rates were calculated to assess exposure rates. Rather than using nationwide default consumption rates to assess potential exposure, realistic tribal consumption rates were applied. By linking contamination information and ingestion factors for Columbia River Basin tribal members I calculated a traditional lifeway exposure. This was defined as realistic “heritage fish consumption rates” if Pacific Northwest Indian Nations were able to use natural resources in their traditional manner. This average fish ingestion rate for an adult equated to 620 g/day. A second consumption rate was calculated from Northwest Pacific tribal members who self-reported their consumption rates at 454 g/day, which equates to one pound per day (Harper & Walker, 2015b). The third consumption rate chosen was Oregon State’s water quality standards consumption level of 175 g/day. Lastly, EPA’s fish consumption rate of 17.5 g/day for the general public and sport anglers was calculated (Table 4.) (U.S. Environmental Protection Agency, 2015c).

Table 4. Fish consumption rates expressed in alternative units.

Adult Population	g/day	ounces	8-oz Meals
Pacific Northwest Tribal Member	620	21.87	19 meals/week
Tribal Responses	454	16	14 meals/week
Oregon State	175	6.17	5 meals/week
EPA General Public and Sport Anglers	17.5	0.62	2 meals /month

In the absence of population-specific fish dietary information, the U.S. EPA suggest using a default value of 8 ounces (227 grams) as an average meal size for the general adult population (70-kilogram person) for exposure assessments. (Harper & Walker, 2015b).

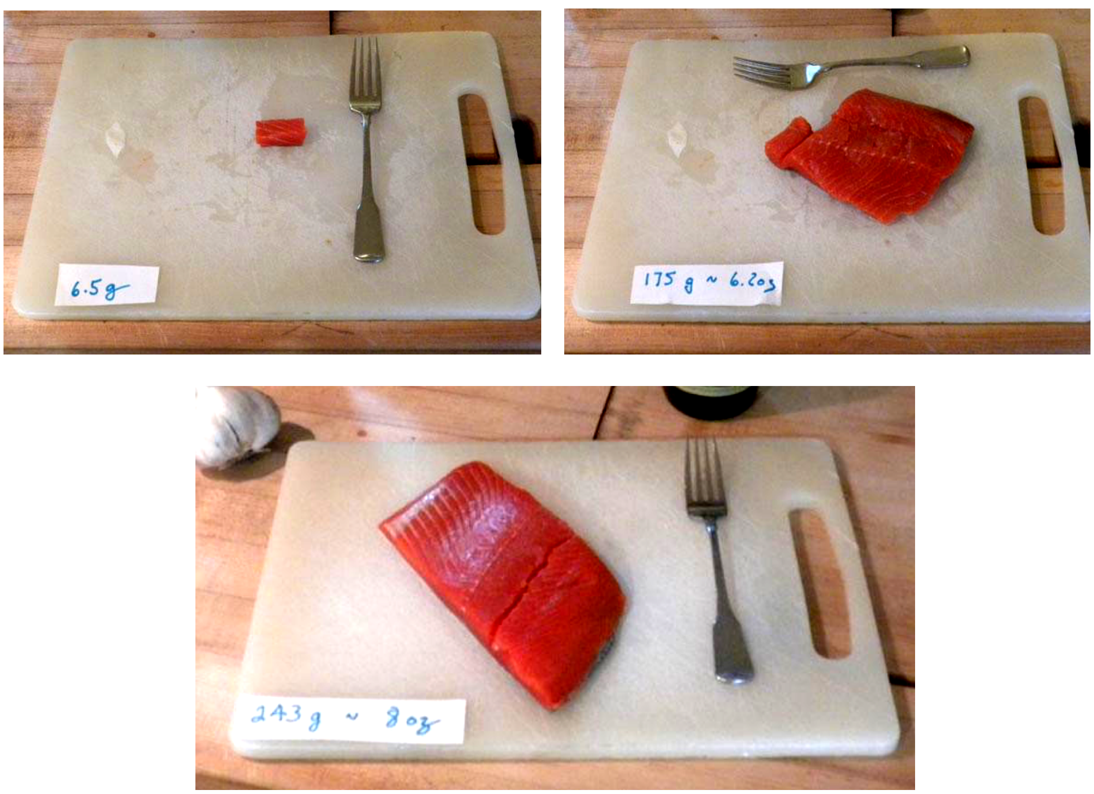

Figure 13. Portion sizes of 6.5 grams, 175 grams or 6.2 ounces and 243 grams or 8 ounces. Depicts a visual of fish consumption rates expressed in alternative units.

The exposure dose of methylmercury by the ingestion route was calculated by using the average methylmercury concentration in fish tissue and other variables shown in Table 5. (U.S. Environmental Protection Agency, 2015f). The exposure concentrations for mercury were the average mercury chemical concentrations in uncooked fish tissue, as derived from the database of Columbia Basin fish tissue samples. EPA's Exposure Factors Handbook: 2011 Edition was used for the following values. An exposure frequency of 365 days per year was assumed for the calculation of the average daily dose (ADD). This represents a likely worst case scenario. It is possible that the exposures occur less frequently (U.S. Environmental Protection Agency, 2011). The exposure factor represents a fraction of the year over which the exposures are occurring (days of exposure in one year divided by the number of days in a year). If the exposure frequency is every day (i.e., 365 days per year) than then exposure factor is 365/365 or simply equal to one. The absorption fraction is how much methylmercury is absorbed in the gastrointestinal tract; and has a default value of 0.1 (ten percent absorption). The average body weight of 70 kg over the exposure period was used for adult body weight. When the average ingestion rate is conveyed as a function of body weight, the subsequent exposure rate is referred to as the ADD, and is expressed in milligrams of a chemical taken into the body per kilogram body weight per day (mg/kg-day).

Table 5. Exposure parameters for estimating exposure to adult tribal members with Eqn. 1 for mercury.

Exposure Parameter	Abbreviation	Tribal Members
Tissue chemical concentration	C	Average
Ingestion rate (g/day)	IR	620, 454, 175, 17.5
Exposure frequency (days/yr.)	EF	1
Absorption Fraction	ED	0.1
Conversion Factor	CF	1000 x .000001
Body weight (kg)	BW	70

Toxicity Assessment

In order to determine the adverse health risks of mercury to tribal members residing in the Columbia River Basin, a toxicity assessment was conducted. A toxicity assessment is the characterization of the toxicological properties and effects of a substance, specifically the dose response relationship associated with a particular route of exposure. After the exposure assessment characterized the potential hazard of mercury, the relationship between dose of mercury and its biological effect was determined. This is ascertained through a toxicity assessment evaluating the potential for non-carcinogenic adverse health effects. A non-carcinogenic effect was evaluated against a threshold dose below which no adverse biological effects are expected to occur know as No Observed Adverse Effect Level (NOAEL). The objective was to identify what adverse health effects mercury causes and how the health response of these adverse effects depends on exposure level (dose). The dose-response provides an estimate of the relationship between the duration of exposure to mercury and the likelihood of an adverse effect occurring.

EPA characterizes non-carcinogens by a chemical specific reference called a Reference Dose (RfD) value, denoting the highest average daily exposure over a lifetime that would not be expected to produce adverse effects (U.S. Environmental Protection Agency, 2011). This risk assessment used an RfD for methylmercury of 1.0 x E-04 mg/kg/day (0.1 mg/kg/day) (U.S. Environmental Protection Agency, 2001c).

Risk Characterization of Non-Cancer Health Effects

A risk characterization combines the evidence from the exposure assessment and the toxicity factors to estimate non-cancer hazards. In this assessment, a comparison of the average daily exposure to mercury in fish tissue is compared with the RfD (as mentioned above). The ratio of the calculated exposure (ADD) for mercury to its RfD is expressed as a Hazard Quotient (HQ), a measure of the potential health hazards from non-cancer effects of mercury (U.S. Environmental Protection Agency, 2000; U.S. Environmental Protection Agency, 2001a).

The estimated ADD from fish ingestion and the RfD are in milligrams of a chemical ingested per kilogram of body weight per day (mg/kg-day) (Tetra Tech, 1986). When the ADD is less than the RfD then the HQ will be less than 1. Values of 1 or less are considered to be insignificant or of “no concern”. If the estimated exposure dose is higher than the no-effect dose, then the HQ will be greater than 1,and is considered a “potential concern” (Tetra Tech, 1986; U.S. Environmental Protection Agency, 1992b; U.S. Environmental Protection Agency, 2002b; U.S. Environmental Protection Agency, 2011).

Chapter III

Results

Fish tissue concentrations of mercury were evaluated for each study site. The results show that all species of fish had some level of mercury in their tissue. The concentrations were variable within fish, across tissue type (fillet and whole-body), across species and study sites.

Fish Tissue Mercury Concentrations

The species were evaluated in two groups: resident fish species (bridgelip sucker, brown trout, channel catfish, cutthroat trout, largescale sucker, largemouth bass, largemouth sucker, longnose sucker, mountain sucker, mountain whitefish, rainbow trout, redband trout, smallmouth bass, sucker, Utah chub, Utah sucker, walleye, whitefish, white sturgeon, Yellowstone cutthroat trout) and the anadromous fish species (chinook salmon, coho salmon, sockeye salmon). The average mercury concentrations reported in this section were applied as the exposure concentrations in the estimation of risks discussed in the risk characterization results section.

Resident versus Anadromous Fish

Basin-wide average concentrations for mercury were quite similar across species. Of the resident species, brown trout (50.5 ppm) and smallmouth bass (105 ppm) had the highest concentrations by far (Table 6.). Brown trout, largemouth bass, largemouth sucker, rainbow trout and smallmouth bass exceeded the general EPA action level of 0.3

ppm. Of the anadromous fish species, sockeye salmon had the highest basin-wide average concentrations of total mercury (0.11 ppm) (Table 7.). Compared to resident fish they had a lower concentration of mercury. This could be due to salmon's tissue concentrations changing as body fat is lost during migration to the spawning grounds due to not feeding and expending a large amount of energy on their long journey (Tomelleri, 2001). The aggregate of all resident species demonstrates there may be localized contamination conditions. Though some species have a low sample size, the fish have still integrated local contamination into their tissues. Past studies have found concentrations of mercury detected in fish are directly related to the amount in the water column (Branson et al., 1985; Kucklick et al., 1996; U.S. Environmental Protection Agency, 1992c; U.S. Environmental Protection Agency, 2002a).

Table 6. Basin-wide average concentrations of mercury in resident fish tissue from the Columbia River Basin from 1999 to 2010.

Residential Species	N	Average
Bridgelip Sucker	14	0.2
Brown Trout	90	50.3 *
Channel Catfish	35	.3
Cutthroat Trout	140	0.1
Largemouth Bass	108	0.4 *
Largemouth Sucker	6	0.4 *
Largescale Sucker	213	0.2
Longnose Sucker	9	0.1
Mountain Sucker	2	0.1
Mountain Whitefish	168	0.1
Rainbow Trout	210	8.0 *
Redband Trout	40	0.3
Smallmouth Bass	335	105.0 *
Sucker	45	0.2
Utah Chub	11	0.2
Utah Sucker	49	0.3
Walleye	6	0.3
Whitefish	9	0.2
White Sturgeon	25	0.1
Yellowstone Cutthroat Trout	28	0.2

N = number of samples. Average = ppm. * = ppm above EPA human health guidelines for fish consumption.

Table 7. Basin-wide average concentrations of mercury in anadromous fish tissue from the Columbia River Basin from 1999 to 2010.

Anadromous Species	N	Average
Chinook Salmon	28	0.05
Coho Salmon	114	0.03
Sockeye Salmon	86	0.11

N = number of samples. Average = ppm.

When analyzing the locations where the smallmouth bass samples (mean =105 ppm) were collected, the maximum levels of mercury concentrations occurred in the Canyon Creek, Clark Fork River, Coast Fork Willamette River, Owyhee River, Portneuf River, Row River and Yakima River (Table 8.). All waterways exceeded EPA health guidelines for fish consumption. The highest concentration was found in Coast Fork Willamette River in the State of Oregon. In the fish tested by EPA, high levels of mercury have been consistently found downstream of historic mining areas in the Willamette and Owyhee River Basins (U.S. Environmental Protection Agency, 2009).

Table 8. Highest concentrations of mercury found in smallmouth bass.

State	Waterway	N	Average
OR	Canyon Creek	9	0.5
MT	Clark Fork River	18	0.5
OR	Coast Fork Willamette River	10	1.6
ID	Portneuf River	2	0.7
OR	Owyhee River	1	0.6
OR	Row River	41	0.44
WA	Yakima River	6	0.62

N = number of samples. Average = ppm.

Basin-Wide Average Concentrations of Mercury for Each River

A basin-wide average of mercury concentrations was compared across waterways in the study (Table 9.). Composites, whole-body and fillet averages were calculated together as a basin-wide average. The average concentrations for mercury were quite similar across waterways. Owyhee River had the highest mean concentration at 0.6 ppm, followed by Canyon Creek, Clark Fork River, Coast Fork Willamette River and Jordan Creek Row River at 0.5 ppm. Canyon Creek, Clark Fork River, Coast Fork Willamette River, De Lacy Creek, Jordan Creek, Kettle River, Klickitat River, Owyhee River, Portneuf River, Row River and South Fork Owyhee River also exceeded the general EPA action level of 0.3 ppm (Figure 14.). These detection concentrations demonstrate local integrated mercury contamination conditions.

Figure 14 shows areas of mercury concern that exceed EPA's 0.3 ppm human health guidelines for fish consumption levels. Reservation and Treaty Right areas are highlighted. The map below shows sampling sites in Oregon with the range of 1.01 – 3.0 ppm of mercury on the Willamette River. The area is within close vicinity of several reservations and treaty fishing rights areas: Yakama, Umatilla, Warm Springs, Cowilitz, Grand Ronde and Nez Perce. It also illustrates that Oregon has the highest number of rivers with the uppermost levels of concentrations, perhaps due to having a large number of dams and TRI sites in the vicinity. TRI sites release toxins into waterways. Local dams keep them from moving and create dam pools where the toxins accumulate. Resident fish are trapped in these dam pools causing a high accumulation of mercury concentrations (Tomelleri, 2001).

Table 9. Basin-wide average concentrations of mercury in waterway from 1999 to 2010.

State	Waterway	N	Average
OR	Beaverton Creek	31	0.1
ID	Big Lost River	1	0.1
ID	Big Wood River	6	0.04
MT	Bitterroot River	9	0.1
MT	Blackfoot River	21	0.1
ID	Boise River	24	0.2
OR	Breitenbush River	1	0.04
ID	Bruneau River	1	0.1
NV	Camp Creek	5	0.1
ID	Camas Creek	1	0.1
OR	Canal Creek	3	0.2
OR	Canyon Creek	9	0.5 *
WA	Chelan River	30	0.1
WA	Chiwawa River	19	0.04
OR	Clackamas River	9	0.1
MT	Clark Fork River	18	0.5 *
OR	Coast Fork Willamette River	39	0.5 *
OR & WA	Columbia River	43	0.1
WA	Cowlitz River	3	0.1
OR	Coyle Creek	1	0.03
WA	Crab Creek	3	0.1
WY	De Lacy Creek	3	0.4 *
OR	Deschutes River	17	0.02
ID	Ditch Creek	10	0.03
OR	Duncan Creek	1	0.05
WA	Duwamish River	40	0.02
ID	East Creek	10	0.02
OR	East Fork Dairy Creek	1	0.2
WA	Entiat River	1	0.04
ID	Flint Creek	4	0.2
WY	Grey's River	1	0.03
ID	Grimes Creek	2	0.1
ID	Henry's Fork River	9	0.1
WY	Hoback River	2	0.1
OR	Horse Creek	1	0.02
WA	Icicle Creek	4	0.1
OR	John Day River	64	0.2
OR	Johnson Creek	1	0.2
ID	Jordan Creek	33	0.5 *
WA	Kettle River	1	0.04
WA	Klickitat River	1	0.4 *
ID	Kootenai River	19	0.1
WY	Leeds Creek	3	0.1
WY	Little Greys River	6	0.04
ID	Little North Fork Coeur D'Alene River	6	0.01

ID	Little Smokey Creek	6	0.03
ID	Lochsa River	2	0.1
ID	Long Meadows Creek	3	0.1
ID	Louse Creek	9	0.1
OR	Marks Creek	9	0.03
WA	Methow River	2	0.03
OR	Middle Fork John Day River	6	0.1
WA	Nason Creek	3	0.1
WA	Nisqually River	38	0.05
WA	North Fork Big Lost River	1	0.1
ID	North Fork Clearwater River	1	0.1
ID	North Fork Payette River	1	0.1
WY	North Leigh Creek	5	0.03
WA	North River	1	0.1
OR	North Santiam River	1	0.03
OR	Oak Grove Fork Clackamas River	3	0.1
OR	Ochoco Creek	9	0.1
WA	Okanogan River	21	0.2
OR	Owyhee River	1	0.6 *
WA	Palouse River	11	0.2
WA	Pataha Creek	1	0.1
ID	Payette River	8	0.1
WA	Pend Oreille River	10	0.2
OR	Powder River	1	0.3
ID	Portneuf River	22	0.4 *
ID	Priest River	2	0.2
OR	Pudding River	6	0.2
OR	Quartz Creek	1	0.04
ID	Rock Creek	3	0.2
OR	Row River	41	0.4 *
ID	Saint Joe River	5	0.1
ID	Salmon River	24	0.2
OR	Sandy River	6	0.1
WA	Sanpoil River	2	0.2
NV	Schack Creek	3	0.02
ID	Selway River	6	0.1
ID	Silver Creek	65	0.3
WA	Similkameen River	1	0.1
WA	Sinlahekin River	2	0.1
WA	Skagit River	37	0.04
ID	Snake River	290	0.3
WA	South Fork Ahtanum Creek	1	0.05
ID	South Fork Boise River	1	0.2
ID	South Fork Coeur 'd Alene River	1	0.05
NV/OR	South Fork Owyhee River	2	0.4
WA	South Fork Palouse River	14	0.2
ID	South Fork Payette River	2	0.3
WA	South Fork Skykomish River	1	0.1

ID /WA	Spokane River	65	0.1
WA	Strawberry Creek	2	0.1
ID	Texas Slough Canal	18	0.1
ID	Tributary Long Meadows Creek	3	0.1
WA	Umtanum Creek	3	0.1
WA	Walla Walla River	21	0.2
WA	Wenatchee River	43	0.04
ID	West Brownlee Creek	2	0.2
WA	White River	10	0.1
ID	Williams Creek	2	0.1
OR	Willamette River	197	0.2
WA	Yakima River	60	0.3

N = number of samples. Average = ppm. * = exceed EPA health guidelines for fish consumption.

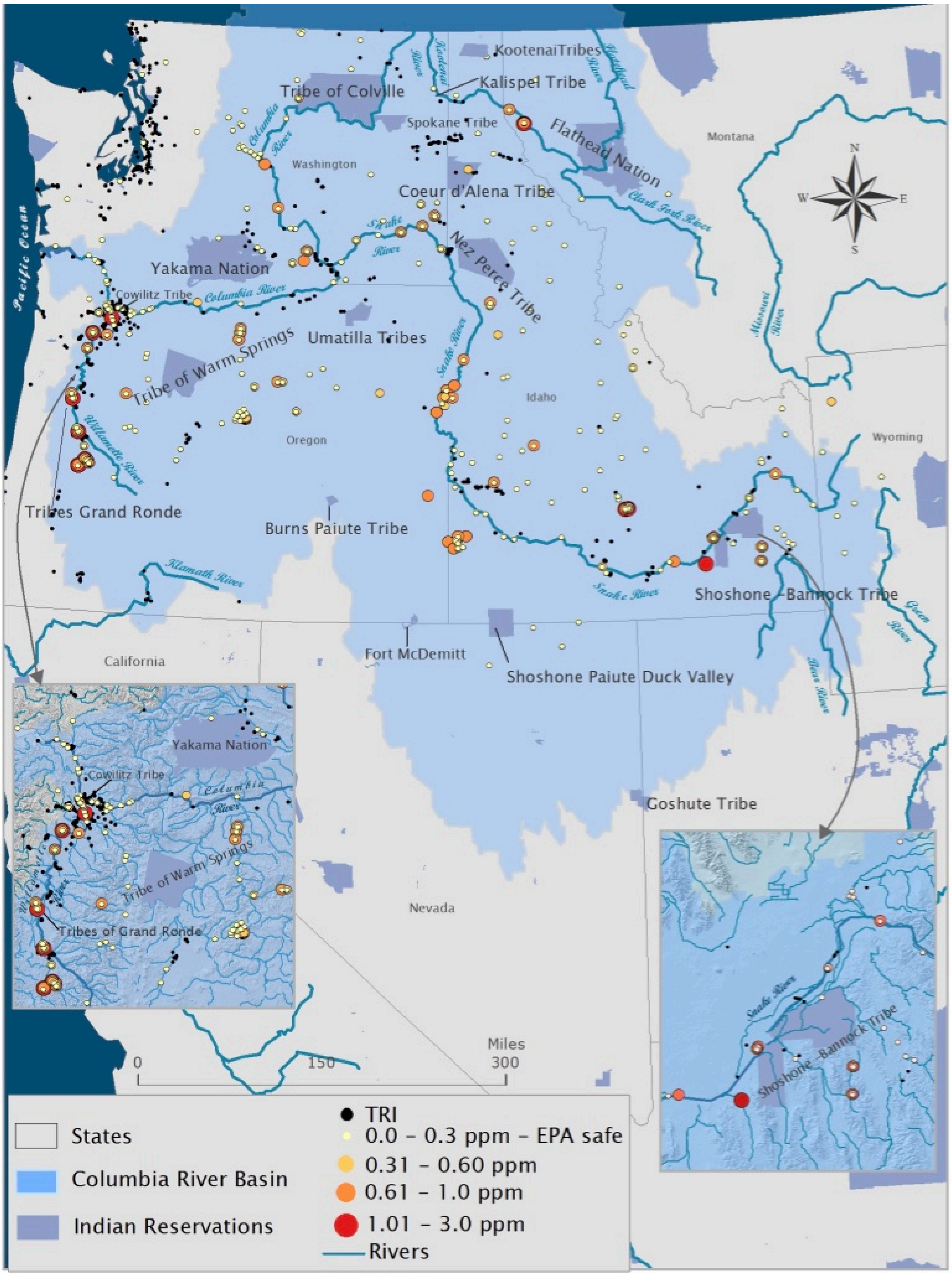

Figure 14. Mercury contaminate levels in proximity to Native American reservations, per EPA human health guidelines for fish consumption.

Fillet and Whole-Body Samples

Mercury concentrations were analyzed separately in fillet and whole-body samples; due to tribal members' custom of consuming several parts of fish in addition to the fillet, whereas the general population consumes only the fillet. The fillet samples had very low detectable concentrations of mercury compared to whole-body samples. The average concentrations in fillet samples ranged from 0.1 ppm in the mountain whitefish to 0.5 ppm in the Utah sucker (Table 10.). However, the maximum concentrations of mercury were in the whole-body fish tissue samples. These may be problematic to Pacific Northwest tribal members who consume internal organs, eyes and skin of the fish in addition to the fillet. Largemouth bass had the highest concentration (577.3 ppm), smallmouth bass (297.0 ppm) and rainbow trout (36.1 ppm). This is likely due to higher concentrations of mercury in the internal organs, bones and skin of the fish. The largemouth bass and smallmouth bass samples had the most variation between whole-body and fillet.

Table 10. Basin-wide average concentrations of mercury in resident fish tissue with fillet or whole-body samples from the Columbia River Basin.

Residential Species	N	Fillet	N	Whole-Body
Bridgelip Sucker	3	0.20	10	0.20
Brown Trout	73	0.30	3	0.03
Channel Catfish	26	0.30	3	0.20
Cutthroat Trout	60	0.10	37	0.06
Largemouth Bass	70	0.40 *	3	577.3 *
Largescale Sucker	98	0.20	89	0.20
Longnose Sucker	No data	No data	9	0.09
Mountain Sucker	No data	No data	2	0.10
Mountain Whitefish	61	0.10	75	0.06
Rainbow Trout	87	0.20	77	36.1 *
Redband Trout	30	0.30	10	0.10
Smallmouth Bass	164	0.30	94	297.0 *
Sucker	13	0.30	22	.20
Utah Sucker	23	0.50 *	13	.06
Walleye	6	0.20	No data	No data
White Sturgeon	7	0.30	19	0.10
Yellowstone Cutthroat	19	0.20	No data	No data

N = number of samples. Average = ppm. * = exceed EPA health guidelines for fish consumption.

Table 11. Basin-wide average concentrations of mercury in anadromous fish tissue with fillet or whole-body samples from the Columbia River Basin.

Anadromous Species	N	Fillet	N	Whole-Body
Chinook Salmon	No data	No data	28	0.05
Coho Salmon	57	0.03	No data	No data
Sockeye Salmon	2	0.12	No data	No data

N = number of samples. Average = ppm.

Prey and Predator Fish Species

Mercury concentrations were compared across study sites for trophic level differences (bottom feeders, top predator). Most of the prey species were at or below EPA action level of 0.3 except for largemouth suckers (Table 12.). Of the top piscivorous predator species, smallmouth bass (105.0 ppm) and brown trout (50.3 ppm) had the highest mean concentration of mercury (Table 13.). Smallmouth bass was found at the maximum concentration of all the species. Largemouth bass and rainbow trout also exceed EPA action level of 0.3 ppm. These results reflect a possible mercury bioconcentration up the food chain and in larger (older) specimens. Mercury biomagnification has been demonstrated through piscivorous predator species at the top of the food web compared to fish at lower levels of the food web (Agency for Toxic Substances and Disease Registry, 2015b).

Table 12. Basin-wide average concentrations of mercury in prey fish tissue from the Columbia River Basin.

Prey Species	N	Average
Bridgelip Sucker	14	0.2
Channel Catfish	35	0.3
Largemouth Sucker	6	0.4 *
Largescale Sucker	213	0.2
Longnose Sucker	9	0.1
Mountain Sucker	2	0.1
Utah Chub	11	0.2
Utah Sucker	49	0.3
White Sturgeon	25	0.1

N = number of samples. Average = ppm. * = exceed EPA health guidelines for fish consumption.

Table 13. Basin-wide average concentrations of mercury in predator fish tissue from the Columbia River Basin.

Predator	N	Average
Brown Trout	90	50.3 *
Chinook Salmon	28	0.05
Coho Salmon	114	0.03
Cutthroat Trout	140	0.1
Largemouth Bass	108	0.4
Mountain Whitefish	168	0.1
Rainbow Trout	210	8.0 *
Redband Trout	40	0.3
Smallmouth Bass	335	105.0 *
Sockeye Salmon	2	0.1
Walleye	6	0.3
Yellowstone Cutthroat Trout	28	0.2

N = number of samples. Average = ppm. * = exceed EPA health guidelines for fish consumption.

Mercury Concentrations by River Size

A review of the boxplot below (Figure 15) gives a visual of the effect of river sizes on the amount of mercury found in fish tissue. The distribution of ppm of mercury in small rivers has an especially long tail, which means that some small rivers are much more contaminated with mercury than the rest, similarly for medium size waterways. The boxplots illustrate that medians were similar, but some smaller rivers seem to have higher than average concentrations, either from TRI facilities or nonpoint sources, while the range of concentrations in larger rivers may be ameliorated by the volume of water flow.

However, these differences might be due merely to data handling. Large and extra-large rivers are usually averaged over many sampling locations, while small rivers have a single sampling location. Therefore, any localized hotspots in the large or extra-large rivers would be masked. Also, the way that TRI discharge permits are set is to calculate a mixing zone below the point of discharge; the larger the river volume the more a discharge is diluted. Lastly, these findings may also be due to atmospheric transport and deposition, which might be related to altitude. Mercury concentrations are higher at higher elevations and in snowpack. Therefore, tributaries in high altitude regions or closer to melting snowpack would be higher in mercury concentrations than the larger rivers into which they discharge. This would also vary by season, to some degree as the climate changes river flows might decrease and mercury might become more concentrated within the river (Harper, 2015).

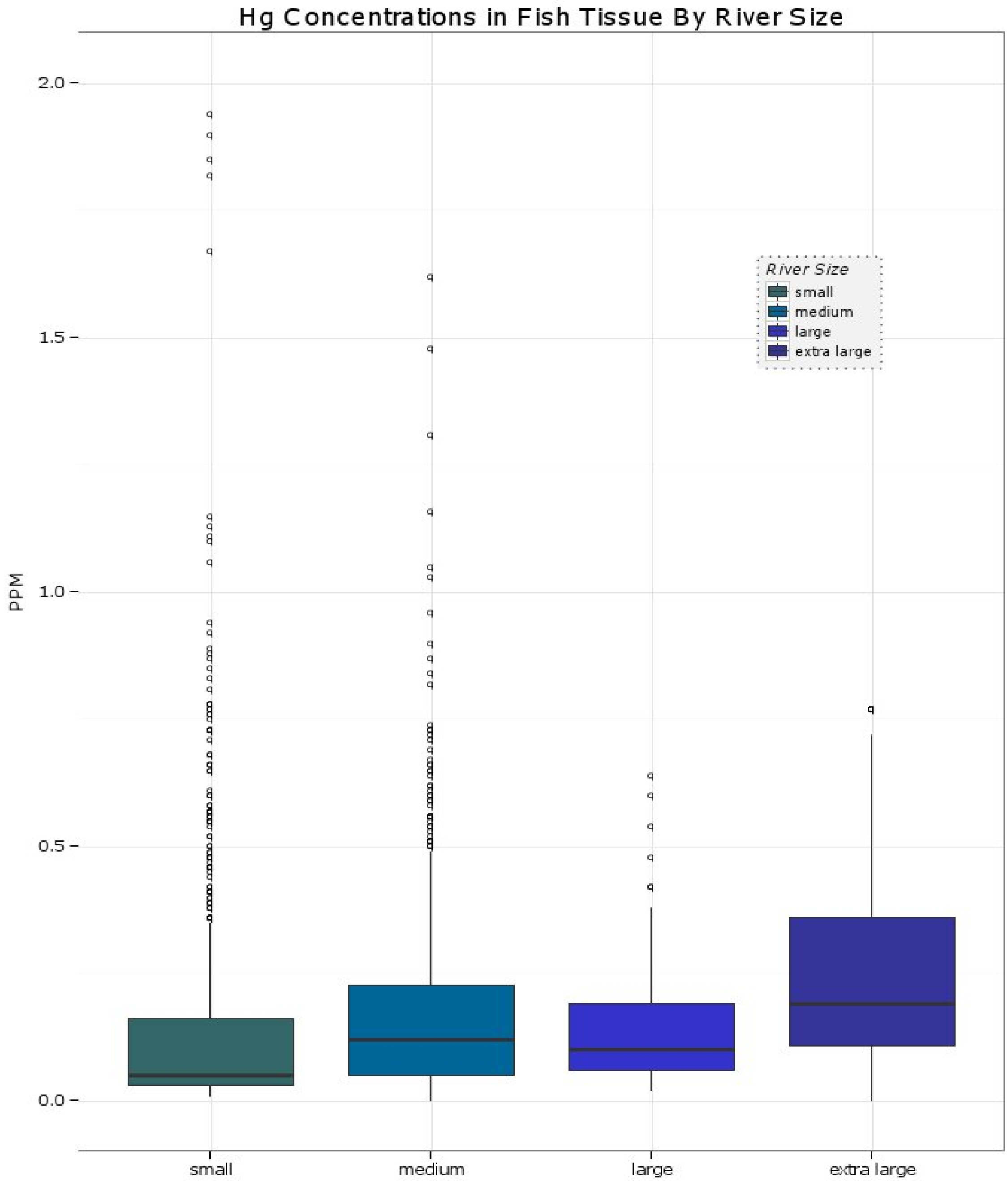

Figure 15. Concentrations of mercury found in rivers by size. The box plots represent four categorized lengths of waterways found in the Colombia River Basin. Small indicates waterways <100 miles long; medium waterways are 101- 300; large waterways are 301 to 500 miles; extra-large waterways are 501 to 1300. The horizontal line indicates the sample median, and the box encompasses 50% of the data, from the 25th to the 75th percentile. The lines encompass the 90% of the data, from the 10th to the 90th percentile.

Changes in Mercury Concentration Over Time

Due to the large amounts of data, only species of concern and river sizes were chosen for detailed comparison over time. The ranges of mercury concentrations from 1999 to 2010 stayed generally consistent. Largemouth bass and smallmouth bass showed an extreme peak in years 2008 to 2010 compared to years from 1999 to 2007. Brown trout and rainbow trout mercury concentrations decreased overtime. Overall the concentrations have not changed dramatically over this period (Table 14.).

Table 14. Species mercury concentrations ranges from 1999 to 2010.

Species	N	1999-2001	N	2002-2004	N	2005-2007	N	2008-2010
Brown Trout	3	0.05	3	0.23	1	0.16	5	0.10
Channel Catfish	N/D	N/D	11	0.15	8	0.25	14	0.35
Chinook Salmon	2	0.15	14	0.06	12	0.01	N/D	N/D
Largemouth Bass	32	0.27	47	0.35	3	0.23	27	352.9
Largescale Sucker	22	0.21	143	0.18	35	0.19	19	0.18
Mountain Whitefish	17	0.06	78	0.06	36	0.13	47	0.08
Rainbow Trout	69	0.08	89	0.10	53	0.16	18	0.08
Smallmouth Bass	69	0.33	133	0.21	38	0.39	61	205.1
Walleye	N/D	N/D	1	0.11	5	0.43	N/D	N/D

N/D = no data provided.

The boxplots below illustrate for most years there is a higher average (median) concentration of mercury in larger and extra-large rivers. In 1999 there seems to be an unusually high mercury concentration for the small sized rivers. Also, there is high variability in mercury content among the rivers, particularly small and medium sized rivers which is evident by all the high outliers (Figure 16. & Figure 17.).

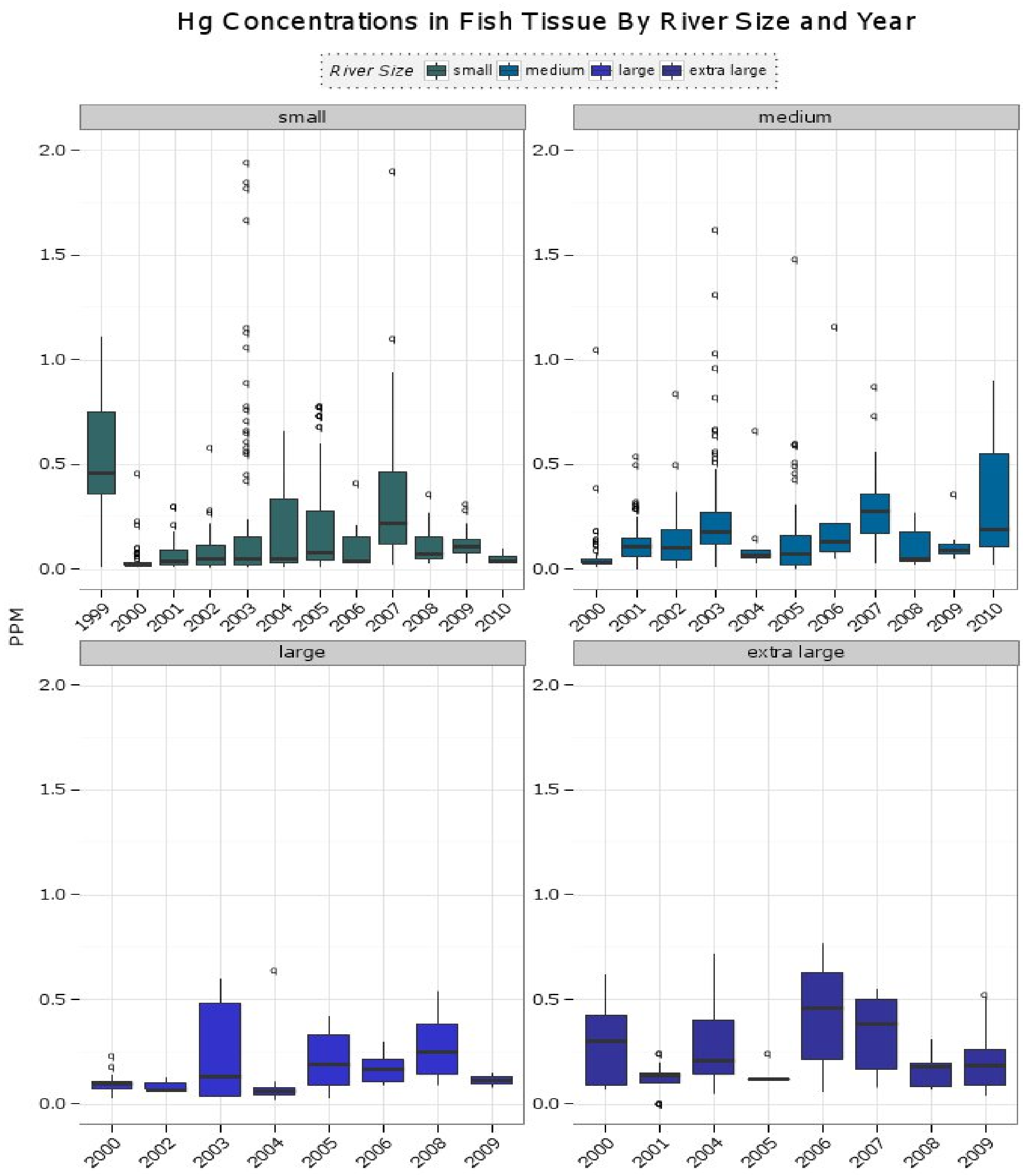

Figure 16. Box-plots of the river sizes and the amount of mercury found in each waterway per year. Each boxplot represents one of the four categorized lengths of waterways and the contamination levels each year found in the Colombia River Basin. Small indicates waterways <100 miles long; medium waterways are 101- 300; large waterways are 301 to 500 miles; extra-large waterways are 501 to 1300.

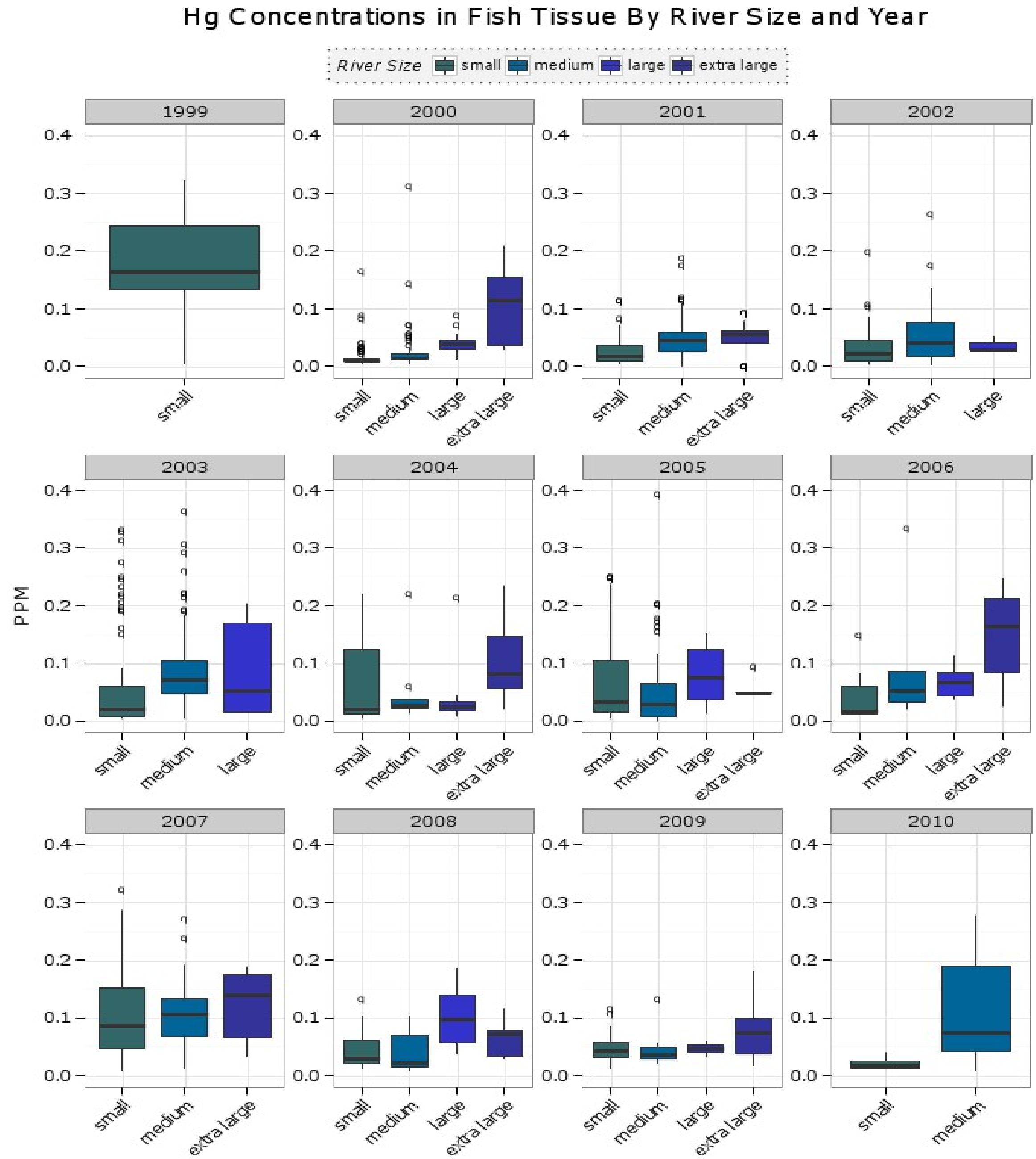

Figure 17. Box-plots of the river sizes and the amount of mercury found in each waterway per year. Each box plot represents one of the four categorized lengths of waterways and the contamination levels each year found in the Colombia River Basin. Small indicates waterways <100 miles long; medium waterways are 101- 300; large waterways are 301 to 500 miles; extra-large waterways are 501 to 1300.

Comparison to EPA Columbia River Basin Survey

This section includes a brief comparison with data reported in "EPA 1994 Columbia River Basin Survey" and "EPA Columbia River Basin Fish Contaminant Survey 1996 - 1998" (U.S. Environmental Protection Agency, 1994; U.S. Environmental Protection Agency, 2002b). These two surveys used for their results parts per billion for mercury concentrations. A conversion from parts per million to parts per billion was done for homoscedasticity.

This analysis found higher concentrations of mercury in fillets of channel catfish (300 µg/kg), white sturgeon (250 µg/kg), mountain whitefish (100 µg/kg), rainbow trout (150 µg/kg) and walleye (220 µg/kg) then concentrations found in EPA 1996 - 1998 study. Maximum concentrations of whole-body tissues were found in rainbow trout (36100 µg/kg) and smallmouth bass (297000 µg/kg) which exceeded EPA 1996 - 1998 concentrations. The mercury concentrations found in whole-body samples of bridgelip sucker (200 µg/kg) and largescale sucker (170 µg/kg) fish in this study were higher than the concentrations in the EPA 1996 - 1998 study. The maximum mercury levels of mountain whitefish whole-body samples were similar in our study and the EPA 1996 - 1998. In comparison to all three studies, EPA 1990 - 1995 study had the highest concentrations of mercury which was found in channel catfish at 2,570 µg/ kg, smallmouth bass at 3,340 µg/ kg and walleye at 3,000 µg/ kg (Table 15.).

Table 15. Comparison to EPA studies of basin-wide maximum concentrations of mercury in specific fish.

	EPA 1990-1995	EPA 1996-1998		This Study * 1999-2010	
Species	µg/ kg	N	µg/ kg	N	µg/ kg
Bridgelip Sucker	N/D	3	32 WB	10	200 WB
Channel Catfish	2,570	5	280 FS	26	300 FS
Coho Salmon	N/D	6	120 FS	57	30 FS
Largescale Sucker	N/D	42	240 FS	98	220 FS
			130 WB	89	170 WB
Smallmouth Bass	N/D	N/P	470 FS	164	300 FS
			360 WB	94	7000 WB
White Sturgeon	N/D	24	150 FS	7	250 FS
			140 WB	19	100 WB
Mountain Whitefish	N/D	24	80 FS	61	100 FS
			67 WB	75	60 WB
Rainbow Trout	N/D	19	77 FS	87	150 FS
			73 WB	77	36100 WB
Walleye	3,000	6	180 FS	6	220 FS

N= Number of samples. FS = fillet with skin. WB = whole-body. µg/ kg = ppb.
* Source data from state agencies and EPA. N/D = no data provided.

Average Daily Dose Calculations of Mercury Ingestion

Using the average daily dose (ADD) equation described previously in the methods section, the ADD were calculated for each fish species consumed at ingestion rates of 620 g/day, 454 g/day, 175 g/day and 17.5 g/day in waterways of Columbia River Basin. More detailed information on the risk characterization results are presented in Appendix 5 concerning ADDs for adult humans, each fish species, state and waterbody in this study.

Due to the large amounts of data that are presented in the Appendix 5 on the risk characterization for these species and waterways, only species of concern were chosen as an example to be discussed in detail with ingestion rates of 620 g/day, 454 g/day and 175 g/day.

ADD concentrations were compared across study sites for resident and anadromous fish. ADDs were lowest for the average ingestion rate of 175 g/day and highest for traditional tribal consumption rate of 620 g/day. The highest ADDs were found in brown trout, rainbow trout and smallmouth bass. The maximum ADD was detected in smallmouth bass in all three consumption scenarios (Table 16.). The maximum ADD for smallmouth bass in 620 g/day and 454 g/day scenario's had an ADD of 0.1 mg/kg. ADD were lowest for anadromous fish. Chinook salmon and sockeye had the lowest ADD rate. Chinook salmon having higher of the two with an ADD of 4.0E-05 in 620 g/day scenario, 3.0E-05 in 454 g/day scenario and 1.0E-05 in 175 g/day (Table 17). Figure 18. shows the ADD for specific rivers of concern per three scenario ingestion rates mentioned above. Appendix 5 illustrates the highest ADD per waterbody.

Table 16. Basin-wide Average Daily Dose of mercury in resident fish tissue from the Columbia River Basin.

Residential Species	N	Average	ADD with 620 (g/day)	ADD with 454 (g/day)	ADD with 175 (g/day)
Bridgelip Sucker	14	0.2	1.8E-04	1.2E-03	5.0E-05
Brown Trout	90	50.3	4.5E-02	3.3E-02	1.3E-02
Channel Catfish	35	0.3	2.3E-04	1.7E-04	6.4E-05
Cutthroat Trout	143	0.1	7.0E-05	5.0E-05	1.9E-05
Largemouth Bass	108	0.4	3.9E-04	2.8E-04	1.1E-04
Largemouth Sucker	6	0.4	3.1E-04	2.2E-04	9.0E-05
Largescale Sucker	213	0.2	1.7E-04	1.3E-04	5.0E-05
Longnose Sucker	9	0.1	7.0E-05	5.0E-05	2.0E-05
Mountain Sucker	2	0.1	9.0E-05	7.0E-05	3.0E-05
Mountain Whitefish	168	0.1	7.0E-05	5.0E-05	2.0E-05
Rainbow Trout	210	8.0	7.1E-03	5.2E-03	2.0E-03
Redband Trout	40	0.3	2.4E-04	2.0E-04	7.0E-05
Smallmouth Bass	335	105.0	9.3E-02	6.8E-02	2.6E-02
Utah Chub	11	0.2	2.0E-04	1.4E-04	6.0E-05
Utah Sucker	49	0.3	3.0E-04	2.1E-04	8.0E-05
Walleye	6	0.3	2.3E-04	1.7E-04	7.0E-05
White Sturgeon	25	0.1	1.2E-04	9.0E-05	4.0E-05
Yellowstone Cutthroat	28	0.2	1.6E-04	1.1E-04	4.0E-05

N = number of samples. Average = ppm. gpd = grams per day of consumed fish. ADD = mg/kg.

Table 17. Basin-wide average daily dose of mercury in anadromous fish tissue from the Columbia River Basin.

Anadromous Species	N	Average	ADD for 620 (g/day)	ADD for 454 (g/day)	ADD for175 (g/day)
Chinook Salmon	28	0.1	4.0E-05	3.0E-05	1.0E-05
Coho Salmon	114	0.03	3.0E-05	2.0E-05	8.0E-06
Sockeye Salmon	2	0.1	9.0E-05	7.0E-05	2.6E-05

N = number of samples. Average = ppm. ADD = mg/kg. gpd = grams per day of consumed fish.

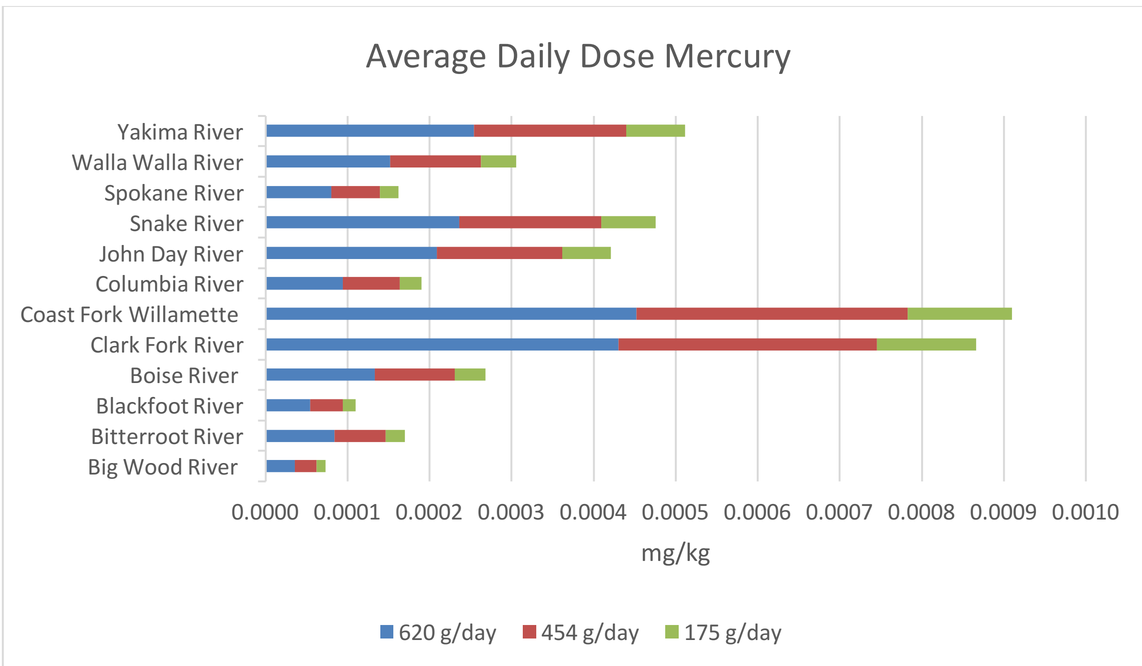

Figure 18. Shows the ADD of each river with all species in three consumption scenarios. It illustrates the relative differences in ADD in the Columbia River Basin for all species applying the high fish consumption rates for Native Americans.

Appendix 5 indices show that the magnitude of ADD increases proportionally to the estimated exposure for tribal population. The only differences in exposure for the three adult population scenarios are due to the different ingestion scenarios rates used. Thus the ADD increases proportionally as the ingestion rate of mercury increases. Pacific Northwest Indian Nations were able to use natural resources in their traditional manner

(Scenario I: 620 g/day) are exposed to the highest ADD. The lowest ADD was found to be in EPA's 175 g/day. Showing that for all species, the total ADD are highest for traditional tribal members (620 g/day) followed by Pacific Northwest Native American self-reported consumption rates (454 g/day). As seen in Appendix 5, the relationship stays consistent for each ADD calculated for each species.

Risk Characterization Results

A summary and discussion of mercury exposure to adults are presented in this section. Calculating the toxicity factors and the exposure assumptions described previously in the methods section, the non-cancer risks were calculated for each fish species consumed at the 620 g/day, 454 g/day, 175 g/day and 17.5 g/day rate, in waterways of Columbia River Basin. Exposure concentrations are based on average concentrations. The risks are summarized in Table 18. More detailed information on the risk characterization results are presented in Appendix 6 concerning each fish species and waterbody in this study.

Due to the large amounts of data that are presented in the appendices on the risk characterization for these species and waterways, only species and waterways of concern are discussed in detail. Table 18. summarizes the total HQ calculated for specific waterways and species using the four fish consumption rates for tribal members and general public mentioned above. All waterways listed in the Table 18 are areas of concern.

HQs were lowest for the general public at the average ingestion rate (17.5 g/day) and highest for traditional tribal consumption rate (620 g/day). For the general population HQs were less than 1. For traditional tribal consumption HQs were greater than 1 for several species and study sites. The calculations show that Coast Fork Willamette River has the highest total basin-wide HQ of 14.4 with an ingestion rate of 620 g/day followed by Clark Fork River, Columbia River, Jordan Creek, Owyhee River, Portneuf River and Row River having a HQ of 5 or greater. Largemouth bass had the highest and most HQs followed by walleye. HQ were lowest for coho salmon, chinook salmon, cutthroat trout, rainbow trout, mountain whitefish and redband trout.

Table 18. indices show the magnitude of HQ increases proportionally to the estimated exposure for tribal population. The only differences in HQ for the four adult populations are due to the different fish ingestion scenarios rates used. Thus the HQ increases proportional to higher fish ingestion rate. Scenario 1: if Pacific Northwest Indian Nations were able to use natural resources in their traditional manner, with a fish ingestion rate for an adult equated to 620 g/day, has the majority and highest HQ of fish consumption. The ingestion rate and exposure is lowest at the EPA's 17.5 g/day for general public and sport anglers. For all species, the total HQ risks are highest for traditional tribal members (620 g/day) followed by self-reported consumption rates (454 g/day). This relationship stays consistent for each HQ calculated for each species.

Table 18. Adult Hazard Quotient risks (at or greater than 1.0).

				Hazard Quotient			
				Native American		Oregon	General Public
State	Waterways	Species	N	620 (g/d)	454 (g/d)	175 (g/d)	17.5 (g/d)
				mg/kg	mg/kg/	mg/kg/	mg/kg
OR	Beaverton Creek	Cutthroat Trout	31	**1.3**	**1.0**	0.37	0.04
MT	Bitterroot River	Largescale Sucker	3	**1.8**	**1.3**	0.5	0.1
MT	Blackfoot River	Largescale Sucker	3	**1.5**	**1.1**	0.4	0.04

ID	Boise River	Brown Trout	2	**1.2**	0.9	0.3	0.03
ID	Boise River	Sockeye Salmon	1	**1.5**	**1.1**	0.4	0.04
ID	Boise River	Sucker	9	**2.5**	**1.8**	0.7	0.07
ID	Boise River	All Species	24	**1.3**	1.0	0.4	0.04
ID	Bruneau River	Rainbow Trout	1	**1.2**	0.8	0.3	0.03
NV	Camp Creek	Rainbow Trout	5	**1.1**	0.77	0.3	0.03
OR	Canal Creek	Rainbow Trout	3	**2.0**	**1.5**	0.6	0.1
OR	Canyon Creek	Rainbow Trout	9	**4.1**	**3.0**	**1.2**	0.1
OR	Clackamas River	Cutthroat Trout	1	**1.3**	**1.0**	0.37	0.04
MT	Clark Fork River	All Species	18	**4.3**	**3.2**	**1.2**	0.1
MT	Clark Fork River	Brown Trout	2	**3.9**	**2.9**	**1.1**	0.1
MT	Clark Fork River	Lake Whitefish	2	**1.3**	**1.0**	0.4	0.04
MT	Clark Fork River	Mountain Whitefish	3	**1.2**	0.9	0.3	0.03
MT	Clark Fork River	Smallmouth Bass	3	**4.1**	3.0	1.2	0.1
MT	Clark Fork River	Walleye	5	**9.7**	**7.1**	**2.7**	0.3
OR	Coast Fork Willamette River	All Species	39	**4.5**	**3.3**	**1.3**	0.1
OR	Coast Fork Willamette	Largemouth Bass	10	**14.4**	**10.6**	**4.1**	0.4
OR	Coast Fork Willamette	Largescale Sucker	6	**1.3**	**1.0**	0.4	0.04
OR	Coast Fork Willamette	Rainbow Trout	5	**1.3**	**1.0**	0.4	0.04
OR	Coast Fork Willamette	Smallmouth Bass	6	**2.0**	**1.5**	0.6	0.06
OR	Columbia River	Smallmouth Bass	2	**1.2**	0.9	0.3	0.03
WA	Columbia River	Walleye	1	**5.7**	**4.2**	**1.6**	0.16
WA	Columbia River	Whitefish	1	**4.3**	**3.2**	**1.2**	0.1
WA	Cowlitz River	All Species	3	**1.1**	0.8	0.3	0.03
WA	Cowlitz River	Mountain Whitefish	1	**1.8**	**1.3**	0.5	0.05

WA	Crab Creek	Rainbow Trout	3	**1.0**	0.7	0.3	0.03
WY	De Lacy Creek	Brook Trout	3	**3.4**	**2.5**	**1.0**	0.1
OR	East Fork Dairy Creek	Cutthroat Trout	1	**1.5**	**1.1**	0.4	0.04
ID	Flint Creek	Redband Trout	4	**1.5**	**1.1**	0.4	0.04
ID	Henry's Fork River	Cutthroat Trout	1	**2.4**	**1.8**	0.7	0.1
OR	John Day River	All Species	64	**2.1**	**1.5**	0.6	0.1
OR	John Day River	Bridgelip Sucker	3	**2.1**	**1.5**	0.6	0.1
OR	John Day River	Channel Catfish	3	**2.9**	**2.1**	0.8	0.1
OR	John Day River	Largescale Sucker	24	**2.3**	**1.7**	0.7	0.1
OR	John Day River	Smallmouth Bass	34	**1.9**	**1.4**	0.5	0.1
OR	Johnson Creek	Cutthroat Trout	1	**1.6**	**1.1**	0.4	0.04
ID	Jordan Creek	All Species	33	**4.8**	**3.5**	**1.4**	0.1
ID	Jordan Creek	Bridgelip Sucker	2	**5.4**	**3.9**	**1.5**	0.2
ID	Jordan Creek	Redband Trout	19	**4.3**	**3.1**	**1.2**	0.1
ID	Jordan Creek	Sucker	12	**5.5**	**4.1**	**1.6**	0.2
WA	Klickitat River	Mountain Whitefish	1	**3.3**	**2.4**	0.9	0.1
ID	Kootenai River	All Species	19	**1.1**	0.8	0.3	0.03
ID	Kootenai River	Largescale Sucker	10	**1.5**	**1.1**	0.4	0.04
ID	Kootenai River	Mountain Whitefish	3	**1.0**	0.7	0.3	0
ID	Louse Creek	Sucker	1	**1.1**	0.8	0.3	0.03
OR	Middle Fork John Day	Largescale Sucker	3	**1.4**	**1.0**	0.4	0.04
OR	North Fork John Day	Smallmouth Bass	4	**1.3**	0.9	0.4	0.04
ID	North Fork Payette	Rainbow Trout	1	**1.2**	0.9	0.3	0.03
OR	Ochoco Creek	Rainbow Trout	9	**1.0**	0.7	0.3	0.03
WA	Okanogan River	Smallmouth Bass	21	**1.4**	**1.0**	0.4	0.04

OR	Owyhee River	Largemouth Bass	1	**5.3**	**3.9**	**1.5**	0.2
WA	Palouse River	All Species	11	**1.7**	**1.246**	0.5	0.0
WA	Palouse River	Largemouth Bass	2	**1.9**	**1.4**	0.5	0.1
WA	Palouse River	Largescale Sucker	5	**1.4**	**1.0**	0.4	0.04
WA	Palouse River	Smallmouth Bass	2	**1.9**	**1.4**	0.5	0.06
ID	Payette River	All Species	8	**1.3**	**1.0**	0.4	0.04
ID	Payette River	Bridgelip Sucker	1	**2.1**	**1.5**	0.6	0.1
ID	Payette River	Channel Catfish	1	**1.7**	**1.2**	0.5	0.05
ID	Payette River	Largescale Sucker	2	**2.0**	**1.5**	0.6	0.1
ID	Payette River	Smallmouth Bass	1	**1.1**	**0.8**	0.3	0.03
WA	Pend Oreille River	All Species	10	**1.6**	**1.2**	0.4	0.04
WA	Pend Oreille River	Brown Trout	4	**1.2**	**0.9**	0.3	0.03
WA	Pend Oreille River	Largescale Sucker	6	**1.8**	**1.3**	0.5	0.1
ID	Portneuf River	All Species	22	**3.5**	**2.6**	**1.0**	0.1
ID	Portneuf River	Brown Trout	11	**4.1**	**3.0**	**1.2**	0.1
ID	Portneuf River	Rainbow Trout	8	**2.7**	**2.0**	0.8	0.1
ID	Portneuf River	Utah Sucker	1	**1.7**	**1.3**	0.5	0.05
ID	Portneuf River	Yellowstone Cutthroat Trout	2	**6.0**	**4.4**	**1.7**	0.2
OR	Powder River	Bridgelip Sucker	1	**2.9**	**2.1**	0.8	0.1
ID	Priest River	All Species	2	**1.9**	**1.4**	0.5	0.1
ID	Priest River	Largescale Sucker	1	**2.5**	**1.8**	0.7	0.1
ID	Priest River	Smallmouth Bass	1	**1.4**	**1.01**	0.4	0.04
OR	Pudding River	All Species	6	**1.6**	**1.2**	0.4	0.04
OR	Pudding River	Largescale Sucker	3	**1.0**	0.7	0.3	0.03
OR	Pudding River	Smallmouth Bass	3	**2.2**	1.6	0.6	0.1

ID	Rock Creek	Brown Trout	3	**1.5**	**1.1**	0.4	0.04
OR	Row River	All Species	41	**3.9**	**2.8**	**1.1**	0.1
OR	Row River	Cutthroat Trout	1	**1.1**	0.8	0.3	0.03
OR	Row River	Largemouth Bass	23	**5.6**	**4.1**	**1.6**	0.2
OR	Row River	Largescale Sucker	4	**4.8**	**3.6**	**1.4**	0.1
ID	Saint Joe River	All Species	5	**1.2**	0.9	0.3	0.03
ID	Saint Joe River	Brook Trout	1	**1.5**	**1.1**	0.4	0.04
ID	Saint Joe River	Largemouth Bass	1	**3.2**	**2.4**	0.9	0.09
ID	Salmon River	All Species	24	**2.0**	**1.5**	0.6	0.06
ID	Salmon River	Mountain Whitefish	13	**1.3**	**1.0**	0.4	0.04
ID	Salmon River	Smallmouth Bass	7	**3.4**	**2.5**	**1.0**	0.1
ID	Salmon River	Sucker	4	**1.8**	**1.29**	0.5	0.05
OR	Sandy River	All Species	6	**1.2**	0.9	0.4	0.04
OR	Sandy River	Largescale Sucker	3	**1.9**	**1.4**	0.5	0.05
WA	Sanpoil River	All Species	2	**1.7**	**1.2**	0.5	0.05
WA	Sanpoil River	Brook Trout	1	**2.1**	**1.5**	0.6	0.06
WA	Sanpoil River	Rainbow Trout	1	**1.2**	0.9	0.4	0.04
ID	Selway River	Brook Trout	1	**1.4**	**1.0**	0.4	0.04
ID	Silver Creek	All Species	65	**2.6**	**1.9**	0.7	0.1
ID	Silver Creek	Brown Trout	55	**2.9**	**2.1**	0.8	0.1
ID	Silver Creek	Rainbow Trout	10	**1.0**	0.7	0.3	0.03
WA	Similkameen River	Smallmouth Bass	1	**1.3**	**1.0**	0.4	0.04
ID	Snake River	All Species	290	**2.4**	**1.7**	0.7	0.1
OR/ID	Snake River	Bottom Feeders	2	**2.6**	**1.9**	0.7	0.1
ID	Snake River	Brown Trout	1	**2.2**	**1.6**	0.6	0.1

ID	Snake River	Channel Catfish	29	**2.6**	**1.9**	0.7	0.1
OR/ID	Snake River	Largescale Sucker	10	**2.8**	**2.1**	0.8	0.1
ID	Snake River	Rainbow Trout	43	**1.2**	0.9	0.3	0.03
ID	Snake River	Smallmouth Bass	91	**3.1**	**2.3**	0.9	0.1
ID	Snake River	Sucker	4	**2.1**	**1.5**	0.6	0.1
ID	Snake River	Utah Chub	11	**2.0**	**1.5**	0.6	0.1
ID	Snake River	Utah Sucker	38	**3.8**	**2.8**	**1.1**	0.1
ID	Snake River	Yellowstone Cutthroat	26	**1.3**	**1.0**	0.4	0.04
ID	South Fork Boise R.	Smallmouth bass	1	**1.6**	**1.1**	0.4	0.04
NV-OR	South Fork Owyhee R	All Species	2	**3.1**	**2.3**	0.9	0.1
OR	South Fork Owyhee R	Largemouth Bass	1	**5.3**	**3.9**	**1.5**	0.2
WA	South Fork Palouse R	Largescale Sucker	14	**1.9**	**1.4**	0.5	0.1
ID	South Fork Payette R	Rainbow Trout	2	**2.3**	**1.7**	0.6	0.1
WA	Umtanum Creek	Rainbow Trout	3	**1.0**	0.7	0.3	0.03
WA	Walla Walla River	Smallmouth Bass	21	**1.5**	**1.1**	0.429	0.04
ID	West Brownlee Crk	Rainbow Trout	2	**2.1**	**1.6**	0.604	0.06
OR	Willamette River	All Species	197	**1.7**	**1.3**	0.5	0.05
OR	Willamette River	Largemouth Bass	25	**3.0**	**2.2**	0.8	0.1
OR	Willamette River	Largescale sucker	70	**1.8**	**1.3**	0.5	0.05
OR	Willamette River	Mountain Whitefish	3	**1.3**	0.9	0.4	0.04
OR	Willamette River	Small Mouth Bass	72	**1.6**	**1.2**	0.4	0.05
OR	Willamette River	Sturgeon	7	**2.1**	**1.5**	0.6	0.1
ID	Williams Creek	Cutthroat Trout	2	**1.1**	0.8	0.3	0.03
WA	Yakima River	All Species	60	**2.5**	**1.9**	0.7	0.1
WA	Yakima River	Brown Trout	4	**1.2**	0.9	0.3	0.03

WA	Yakima River	Largemouth Bass	2	**2.8**	**2.0**	0.8	0.1
WA	Yakima River	Largemouth Sucker	6	**5.5**	**4.0**	**1.6**	0.2
WA	Yakima River	Longnose Sucker	3	**1.3**	**1.0**	0.4	0.04
WA	Yakima River	Smallmouth Bass	37	**3.1**	**2.3**	0.9	0.1

The table is a summary of the range of HQs across study sites for each species at the four ingestions rates used for adults. The bold numbers in each column indicate that there is a non-cancer risk of potential concern because the risk value exceeds 1. The numbers that are not bold indicate that the health risk is of no concern because the HQ is less than 1. gpd = grams per day of consumed fish in each consumption scenario.

Limitations

Limitations can occur in all parts of a risk assessment. In the areas of the exposure assessment, toxicity assessment and risk characterization could result in alternate estimates of risk. These limitations include the procedural process while sampling, the variability of contaminants in fish ingestion rates and the effects of food preparation. These limitations could either increase or decrease the risk estimates reported.

As discussed earlier in this study, the fish species collected and tested for mercury concentration were prepared by EPA and state agencies. The fish type, tissue type and sample location were all determined by what was provided by EPA and state environmental agencies. This type of sampling is not a random design and is biased with predetermined sample locations. Some of the sites included large and extra-large waterways; consequently, the average concentrations from these sites represent sampling areas of several miles.

The variability among individual fish is unknown. Some of the data provided was of individual fish tissues that were composited to obtain a representative sample of the mean concentrations of fish tissue. When fish are composited there is a loss of certainty in the variance among individual fish samples. It was not known if fish were collected at the same time and same size to reduce this uncertainty. It is also not known if replicate samples were collected at each study site to provide a more accurate estimate of the variance in tissue analyses. The data sets did not specify the grinding procedure. Fish were ground to make composite samples. Fish tissue can vary significantly when ground depending upon the homogeneity of the tissue sample and the grinding procedures.

The seasonal range of mercury concentrations in the fish species evaluated in this assessment is unknown. Each season dictates the fat tissue content of the salmon species. For example, fall chinook salmon has a lower fat tissue content then spring or summer chinook salmon. These seasonal differences were not specified in the data sets. The data also did not specify if fish tissue samples were scaled. Mercury concentration amounts may be affected by concentration in the fish scales.

The comparison of prey and piscivorous predator species is confounded by not knowing the age or size of the fish sampled.

The comparison of this study with EPA studies is confounded by not knowing the methods that were used in collecting their samples, the tissue type and number of their samples.

For this study, composites, whole-body and fillet averages were calculated together as a basin-wide average. Some data sets did not indicate if they were composites, whole-body or fillet tissue types and were assumed to be composites. Because this study is a preliminary assessment, it was understood that only a limited number of data were gathered and analyzed.

It is not known if the ingestion rates selected for this report are representative of the actual consumption practices of individuals consuming fish from the study areas. The ADD and HQ estimates in this report were based upon the consumption of individual fish species and tissue types hence these approximations may not be a true representation of risk to most tribal members since most people are likely to eat a diet composed of multiple fish species.

There is uncertainty about the exposure assumptions in that some people may eat more or less than the consumption amounts used in the calculation. Also, it is assumed that an adult tribal member weighs 70 kg in the study area. Consequently, this approximation may not be a true representation of risk to most tribal members since most adults are likely to have different weights.

The exposure concentrations for this report were the average chemical concentrations in uncooked fish tissue. It was assumed that the skin and fatty areas of the fish were not removed during lab preparation, and that there is no reduction in contaminant concentrations during cooking. Cooking fish may affect exposure concentrations of mercury. Mercury binds to protein causing concentration in the muscle tissue of fish. Therefore, how the fish is prepared, for example trimming and gutting, can actually result in a greater average concentration of mercury in the remaining tissues compared with the concentration in the whole fish (Gutenmann & Lisk, 1991). Mercury concentrations in trout that was pan-fried, baked and boiled the range was 1.5 to 2.0 ppm higher than in the corresponding raw portions; walleye fillet ranged from 1.1 to 1.5 ppm times higher (Morgan, Berry, & Graves, 1997).

EPA's guidance states the following uncertainties in toxicity assessment: utilizing dose-response information from short term studies to predict the effects of long term exposures; using dose-response information from animal studies to predict effects in humans; and using dose-response information from a healthy human populations to predict the effects likely to be observed in the members of the general population consisting of individuals with a wide range of sensitivities (Tetra Tech, 1986; U.S. Environmental Protection Agency, 2000).

The reference dose used to calculate the HQ does not have exact accuracy so health impacts from exposures higher than the reference dose can vary widely (U.S. Environmental Protection Agency, 2000; U.S. Environmental Protection Agency, 2011).

Only exposure from fish consumption was evaluated in this report. Several different exposure pathways could result in human exposure to mercury within the Columbia River Basin.

Chapter IV

Discussion and Conclusions

This assessment of the Columbia River Basin analyzed fish to determine the level of contaminant exposure of mercury to Pacific Northwest tribal members. It was performed with a traditional tribal subsistence lifestyle framework. The data supports a conclusion that mercury concentrations are high enough to warrant further investigation of both human health and ecological risk.

The objectives of analyzing mercury concentrations in the fish from the Columbia River Basin were to determine:

- If fish were contaminated with mercury.
- The difference in concentrations among fish species and study sites.
- If fish consumption was an exposure route for mercury among tribal members residing in the Columbia River Basin.
- The potential health risks to tribal members.

The results of the study showed that all species of fish had some level of mercury in their tissues. The concentrations were variable within fish, across tissue type (fillet and whole-body), across species and study sites. However, mercury concentrations exhibited some consistent trends.. The concentrations of mercury in the anadromous fish were lower than resident species. The highest concentration of mercury in all the species was found in whole-body samples of resident fish: largemouth bass (577.3 ppm) and smallmouth bass (297 ppm). The aggregate of all resident species data demonstrates there may be localized mercury contamination. The distribution across study sites was variable although fish collected from the Owyhee River (0.6 ppm) and the Canyon Creek, Clark Fork River, Coast Fork Willamette River and Jordan Creek Row River at 0.5 ppm had higher concentrations of mercury than other study sites.

The results indicate that concentrations of mercury in fish caught from the Columbia River Basin may be a risk to the health of Native Americans who eat them depending on: the toxicity of the chemicals, the concentration of mercury in the fish, the fish ingestion rate, fish species and tissue type (fillet or whole). Based on the results of the samples collected Pacific Northwest tribal members who eat fish at the ingestion levels of 620 g/day, 454 g/day or 175 g/day may be exposed to harmful levels of mercury. The findings from this study demonstrated few resident fish are low enough in mercury to be safe for tribal members to consume at a traditional historic rate or at a moderate rate.

In order to reduce mercury exposure from consumption of mercury contaminated fish, consumption advisories are issued by state health departments recommending that individuals restrict their consumption of specific fish species from certain waterbodies where mercury concentrations in fish tissues exceed the human health level of concern. Seventy-five percent of fish consumption advisories in the Columbia River Basin are due to mercury contamination. In Idaho, Oregon, Washington and Montana, people are advised to limit meals of fish such as bass, trout, walleye and bottom fish from particular waterway locations due to concerns about high levels of mercury (Department of Human Services, 2015a; Department of Human Services, 2015b; Montana Department of Environmental Quality, 2015; Washington State Department of Public Health, 2015). As this study demonstrated, these species have high mercury concentrations.

Environmental Justice of Traditional Levels of Fish Consumption

Most fish consumption advisories are directed at the general population and are misleading for tribal members. Given the low average public baseline consumption rates of 6.5 g/day, state standards disproportionately and negatively impact tribal communities. To expect a tribal member to reduce their fish consumption practices to match those of the general population or what is deemed safe is an environmental justice issue, especially in the absence of mitigation measures aimed at reducing fish tissue concentrations. To adequately protect tribal consumption rates there is a need to reflect much lower concentrations of mercury in fish. This can be done by a regulatory goal of improving water quality in order to protect the health of Native Americans whose traditional diets and culture dictates the consumption of fish.

In Indian Country waterways, water quality standards are to protect the water resources Native Americans are dependent upon. One of the responsibilities of the government is to aid tribes in their efforts to protect each reservation's natural resources from damage or degradation so that every tribe can continue their cultures practices. A main aspect of tribal culture is the ability to practice their subsistence fishing. To safely and effectively exercise their treaty rights to fish on these lands, the natural resources upon which these rights are based must be safe to consume. To sufficiently protect these subsistence fishing rights, the states are obligated to support human health criteria which determines how clean the waterways must be to ensure tribal members may safely consume fish for their sustenance lifeways. The Clean Water Act states, that for states to better protect their waterways from contaminants they must periodically revise their surface water quality standards to include more current and accurate data (Appendix 3) (U.S. Congress, 1972). Federal and state water quality standards generally use contemporary fish consumption data, although this need not be the case if EPA performs a subsistence health risk assessment by using a methodology that is scientifically sound and apply fish consumption rates characteristic of the Pacific Northwest traditional lifestyle, as demonstrated in this assessment.

In order for the Pacific Northwest tribes to be able to petition EPA to protect tribal use of water resources for food, medicine, cultural and traditional practices, information needs to be developed that defines the cultural uses in a quantitative format so that cultural and traditional tribal uses can be protected. The data on which the states in the Columbia River Basin area rely upon to develop their fish consumption rates for water quality standards do not take into account subsistence practices of the Northwest Pacific tribal members fishing in Indian Country, nor are they applying new findings of scientifically founded consumption levels. Section 104 of the Clean Water Act, Approval of Water Quality Standards, states that the EPA is required by law to have sufficient information from states so they can approve water quality standards applicable to Indian Country (U.S. Environmental Protection Agency, 2001a). It mandates the EPA to ensure that those fishing and cultural uses of Native American tribes are protected. Setting water quality standards directly affects the quality of fish the tribes are able to consume for their sustenance.

The results from this study showed that the Northwest Pacific state's need to revise their water quality standards to include more current and accurate data founded on scientific rationale from tribal subsistence analysis rather than using nationwide default consumption rates to assess potential exposure. If the regulatory goal is to improve water quality in order to protect the health of Native Americans, then the applicable rate is a heritage fish consumption rates of 625 g/day found in "Comparison of Contemporary and

Heritage Fish Consumption Rates in the Columbia River Basin" which defined a realistic "heritage fish consumption rate" if Pacific Northwest Indian Nations were able to use natural resources in their traditional manner (Harper, 2015).

The Pacific Northwest tribes may be the most underrepresented among the group of disparate populations exposed to mercury. As mentioned in the treaty section of this report, tribes negotiated their treaties to insure the perpetual rights to access their historical fishing sites and established the right to fish for sustenance (Cohen, 2012). As demonstrated in this assessment, full practice of these rights could be deleterious, given the current level of mercury contamination found in this report. This puts a strain on tribal members in deciding if they should consume contaminated fish that have cultural significance. Tribal members should not be expected to change their cultural practices that expose them to mercury contamination, consequently making it an environmental justice issue in accordance with Executive Order 12898 (Clinton, 1994). Northwest Pacific tribal members are among the most highly exposed and will thus disproportionately have to bear contamination risks raising the issue of environmental justice and equity. Such concerns for equity are particularly sensitive, especially if the members of a minority group have historically been subjected to discrimination or colonization. In the circumstances of exposure pathway involving fish consumption they are not shared "roughly the same" as with the general population. TRI sites ranging from industry to mining to military bases, negatively affect not only the surrounding environment, but the health and culture of the Indian Country they border. Because of subsistence lifestyles, spiritual and cultural practices, tribes have multiple exposures from resource use that could result in disproportionate environmental impacts.

Dominant society is likely to believe that there is an array of alternatives to eating fish, which would be the sensible way of avoiding the risks of fish consumption. Dominant society is less likely to attach any importance to the consumption of particular species and would find it easy to avoid the consumption of certain fish. Nor would dominant society understand the seasonal availability or ceremonial preparation requirements of certain species and would not be burdened by risk avoidance measures put out by environmental state agencies that warn to eat less fish or less frequently. Dominant society is unlikely to see these risk avoidance measures to be culturally important.

From the perspectives of Pacific Northwest tribal members, such risk avoidance measures would cause profound loss of their cultural practices. It is not perceivable to these people to consume less fish to avoid risk given that their traditional and cultural practices for thousands of years called for large quantities of fish consumption. Fish, fishing and fish consumption is not just religious, cultural and historical it is part of who these peoples are. It is an unfathomable concept for them to cease fishing and consuming fish for risk avoidance. To advise them to fish in other locations would not be appropriate or possible. Treaty Rights give them legal protections to fish in these areas and to reestablish somewhere else is simple not an option. Furthermore, they believe there is a historical bond, heritage union and a tribal identity with these waterways. Tribal members believe they are the stewards of these waterways and it is their responsibility to insure the wellbeing of the species which live in them.

In sum, as these examples help to illustrate, Northwest Pacific tribal practices have come to involve risk because environmental contamination is perceived differently by the dominant society then tribal members. Therefore, avoidance measures that ask risk-bearers (Native Americans) to forsake or alter their practices are unlikely to be understood and seen as burdensome by dominant society assessors. Due to environmental policy reflecting the dominant society's perceptions and understandings, the risk avoidance measures that are implemented will likely be the very ones that will suppress most profoundly the expression of Pacific Northwest cultures and exercising their basic rights. To rectify these risks federal and state agencies should take into consideration a subsistence traditional lifestyle when assessing contaminate levels.

Recommendations

Due to the culturally significance of fish, sustenance reliance on this resource and the potential adverse ecological effects that could happen due to food web bioaccumulation a recommendation of a more thorough research study should be conducted concerning mercury. Such a study should collect and analyze sufficient samples to statistically characterize where mercury is concentrating. The study should look at food web ecological risks and set a baseline for tracking changes overtime of mercury concentrations. Further studies should coordinate with the Native American Health Department and tribal community members in an effort to track fish consumption and health results.

Outreach programs and media materials should be available, in both English and the tribal language spoken by the community, that inform tribal members about fish contamination levels. The need for clear, concise and readily understood information is critical in these communities. This would allow tribal members to continue to practice their cultural traditions; as well, lowering their health risk from mercury. Tribal communities should be provided with the mean and maximum mercury levels to allow informed decisions, especially by those most at risk. Also, preschool, school age and community members should be informed of the locations that contain higher or lower levels of mercury contaminates.

The results of this study confirm the need for regulatory agencies to continue to work toward controlling pollutants and to remove those pollutants that have been and continue to disperse into the Columbia River Basin's waterways. Regulatory limits for TRI facilities and cleaning up existing sources of chemical wastes can help to reduce exposure. There is a need to promulgate policy regulations that will better protect indigenous communities from both local and more widespread sources of environmental contamination. Modern environmental law in North America is predicated on federal and state partnerships that did not initially account for pollution and environmental degradation of Native Americans (O'Neill, 2013). Current regulatory gaps make it difficult to prevent and rectify environmental contamination which impacts Pacific Northwest tribal communities. Mercury contamination threatens not only the health of their communities, it also infringes on their environmental justice rights, including the ability to impart cultural land use. Hence, there is a significant need for the concept of environmental justice in environmental health risk assessments.

Lastly, states should revise their water quality standards to include more current and accurate data founded on scientific rationale from tribal sustenance analysis rather than using nationwide default consumption rates to assess potential exposure. These revised water quality standards will inform state's on how clean the resources need to be in order to ensure that resources utilized by Pacific Northwest tribal members are safe.

Appendix 1

Glossary

Absorption Barrier	Any exposure surface that may impede the rate of diffusion of an agent into a target.
Bioconcentrate	The accumulation of a chemical in tissues of a fish that is greater than in the surrounding medium.
Dose-Response Assessment	Analysis of the relationship between the total amount of a toxin absorbed by a population, the changes that occur in the population in reaction to that toxin, and extrapolations derived from such an analysis with respect to the entire population. Dose-response assessment is the second of four steps in risk assessment.
Exposure	The contact between a toxin and a target.
Exposure Assessment	The process of estimating or measuring the magnitude, frequency and duration of exposure to an agent, along with the population that is exposed.
Ingestion Rate	The amount that could be ingested typically on a daily basis.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in humans or animals.
No Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on humans or animals.
Oral Reference Dose (RfD)	An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected.

Reference Dose	An estimate of a daily oral exposure to the general population that is likely to be without an appreciable risk of harmful non-cancer effects during a lifetime. It can be derived from a NOAEL and/or LOAEL.
Risk Assessment	A process to calculate the risk to a given population, following an exposure to a particular toxin. The risk assessment process includes four steps: hazard identification, hazard characterization, exposure assessment and risk characterization.
Route of Exposure	How humans come into contact with a hazardous substance. There are three exposure routes: inhalation, ingestion or dermal contact.

(Definitions all from U.S. Environmental Protection Agency, 2011)

Appendix 2

Defining the Different Types of Indian Country

Reservations Lands	Land set aside for the use of designated tribes and held out as reservations by treaty, statute, executive order or administrative procedure.
Tribal Land	The surface estate of land or any interest therein held by the United States in trust for a tribe, band and land that is held by a tribe, band, community or group of Indians, subject to federal restrictions against alienation or encumbrance, and includes such land reserved for the Bureau of Indian Affairs administrative purposes when it is not immediately needed for such purposes.
Trust Lands	Any tract, or interest therein, that the U. S. holds in trust status for the benefit of a tribe or individual Indian.
Ceded Territory	Lands within a reservation that have been sold by a tribe or taken by the U.S. Tribes may retain Treaty Rights to hunt, fish and/or gather other resources even if the ceded lands are no longer within Indian Country. Tribes retain the power to regulate members exercising these rights.
Restricted Land or Restricted Status	Land the title to which is held by an individual Indian or tribe and can only be encumbered by the owner with the approval of the Secretary of the Interior because of 'limitations contained in the conveyance instrument pursuant to Federal law.'

(Cohen, 2012; Hall, 1981).

Appendix 3

Clean Water Act

The Clean Water Act (CWA) is the principal law to protect the nation's waters from untreated sewage, industrial and toxic discharges, destruction of wetlands and contaminated runoff. It was revised in 1972 with the objective, "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters," and that all waters within the nation will be fishable and swimmable where possible. It authorizes EPA to set federal-state partnerships, federal guidelines, objectives and limits. The main administrators and enforcers of the CWA programs are intended to be the states and authorized tribes that maintain programs that fulfill the basic requirements, as overseen by EPA. The CWA established the National Pollutant Discharge Elimination System which regulates water pollutant sources that discharge toxins into waterways (U.S. Congress, 1972).

The Clean Water Act's National Pollutant Discharge Elimination System (NPDES) program monitors sources such as wastewater treatment plants, mines and pulp and paper plants to regulate the quality of water discharged into the waterways. NPDES permits regulate the amount of pollutants that can be discharged into the waterways with the goal of lessoning the impact to the waterbody receiving the discharge (U.S. Environmental Protection Agency, 2015d).

Section 104 of the Clean Water Act: Approval of Water Quality Standards

Water quality standards are typically adopted by tribes, states, and the federal government to protect water resources with the aim to protect plant, animal and human communities that are dependent upon the water resources. The development of water quality standards requires information regarding the uses of water resources, and about potential exposure pathways and impacts to humans, plants and animal. In order for the Pacific Northwest Tribes to be able to request EPA to protect tribal use of the water resource for food, medicine, cultural and traditional practices and recreation, information needs to be developed that defines the cultural uses in a quantitative format so that cultural and traditional tribal uses can be protected. One such study was done in collaboration with the Maine Tribes and is now being used to help protect Maine water Quality for tribal subsistence and treaty protected fishing rights (U.S. Environmental Protection Agency, 2015e).

Appendix 4

Sample Locations and Fish Species Sampled at Each Site

Description of study sites and the fish samples from those waterbodies from 1998 to 2012

Waterbody	Fish Species
Beaverton Creek	Cutthroat Trout
Big Lost River	Rainbow Trout
Big Wood River	Brown trout
Bitterroot River	Largescale Sucker, Mountain Whitefish, Rainbow Trout
Blackfoot River	Cutthroat Trout, Rainbow Trout, Sucker, Brown Trout, Largescale Sucker, Mountain Whitefish, Utah Sucker
Boise River	Whitefish, Sockeye Salmon, Sucker, Brown Trout, Rainbow Trout
Breitenbush River	Rainbow Trout
Bruneau River	Rainbow Trout
Camas Creek	Mountain Whitefish
Camp Creek	Rainbow Trout
Canal Creek	Rainbow Trout
Canyon Creek	Rainbow Trout
Chelan River	Lake Trout
Chiwawa River	Mountain Whitefish, Rainbow Trout
Clackamas River	Cutthroat Trout, Chinook Salmon
Clark Fork River	Brown Trout, Lake Whitefish, Largescale Sucker, Mountain Whitefish, Smallmouth Bass, Walleye
Coast Fork Willamette River	Cutthroat Trout, Largemouth Bass, Largescale Sucker, Rainbow Trout, Smallmouth Bass
Columbia River	Smallmouth Bass, White Sturgeon, Largescale Sucker, Sucker, Mountain Whitefish Walleye, Whitefish
Cowlitz River	Cutthroat Trout, Mountain Whitefish
Coyle Creek	Rainbow Trout
Crab Creek	Rainbow Trout
De Lacy Creek	Brook Trout
Deschutes River	Mountain Whitefish, Rainbow Trout
Ditch Creek	Rainbow Trout
Duncan Creek	Rainbow Trout
Duwamish River	Coho Salmon

East Creek	Redband Trout
East Fork Dairy Creek	Cutthroat Trout
Entiat River	Rainbow Trout
Flint Creek	Redband Trout
Grey's River	Cutthroat Trout
Grimes Creek	Rainbow Trout
Henry's Fork River	Rainbow Trout, Mountain Whitefish, Cutthroat Trout
Hoback River	Mountain Sucker
Horse Creek	Cutthroat Trout
Icicle Creek	Mountain Whitefish
John Day River	Bridgelip Sucker, Channel Catfish, Largescale Sucker, Smallmouth Bass
Johnson Creek	Cutthroat Trout
Jordan Creek	Sucker, Redband Trout, Bridgelip Sucker
Kettle River	Rainbow Trout
Klickitat River	Mountain Whitefish
Kootenai River	Largescale Sucker, Longnose Sucker, Mountain Whitefish, Rainbow Trout
Leeds Creek	Cutthroat Trout
Little Greys River	Cutthroat Trout, Mountain Whitefish
Little N. Fork Coeur D'Alene River	Cutthroat Trout
Little Smokey Creek	Mountain Whitefish, Rainbow Trout
Lochsa River	Cutthroat Trout
Long Meadows Creek	Rainbow Trout
Lookout Creek	Cutthroat Trout, Rainbow Trout
Louse Creek	Bridgelip Sucker, Redband Trout, Sucker
Marks Creek	Rainbow Trout
Methow River	Cutthroat Trout, Mountain Whitefish
Middle Fork John Day River	Mountain Whitefish, Largescale Sucker
Nason Creek	Mountain Whitefish
Nisqually River	Coho Salmon
North Fork Big Lost River	Brown Trout
North Fork Clearwater River	Mountain Whitefish
North Fork John Day River	Mountain Whitefish
North Leigh Creek	Brook Trout, Cutthroat Trout
North River	Cutthroat Trout
North Santiam River	Cutthroat Trout
Oak Grove Fork Clackamas River*	Cutthroat Trout, Rainbow Trout
Ochoco Creek	Rainbow Trout
Okanogan River	Smallmouth Bass
Owyhee River	Largemouth Bass
Palouse River	Largemouth Bass, Largescale Sucker,

	Smallmouth Bass
Pataha Creek	Brook Trout
Payette River	Bridgelip Sucker, Channel Catfish, Largescale Sucker, Mountain Whitefish, Smallmouth Bass
Pend Oreille River	Brown Trout, Largescale Sucker
Portneuf River	Brown Trout, Rainbow Trout, Utah Sucker, Yellowstone Cutthroat Trout
Powder River	Bridgelip Sucker
Priest River	Largescale Sucker, Smallmouth Bass
Pudding River	Largescale Sucker, Smallmouth Bass
Quartz Creek	Cutthroat Trout
Rock Creek	Brown Trout, Cutthroat Trout, Largemouth Bass, Largescale Sucker, Rainbow Trout
Saint Joe River	Brook Trout, Cutthroat Trout, Largemouth Bass, Mountain Whitefish
Salmon River	Mountain Whitefish, Smallmouth Bass, Sucker
Sandy River	Largescale Sucker, Mountain Whitefish
Sanpoil River	Brook Trout, Rainbow Trout
Schack Creek	Rainbow Trout
Selway River	Brook Trout, Cutthroat Trout, Mountain Whitefish
Silver Creek	Brown Trout, Rainbow Trout
Similkameen River	Smallmouth Bass
Sinlahekin River	Mountain Whitefish, Rainbow Trout
Skagit River	Coho Salmon, Mountain Whitefish
South Fork Coeur'd Alena	Mountain Whitefish
South Fork Skykomish River	Mountain Whitefish
Snake River	Brown Trout, Bottom Feeders, Channel Catfish, Cutthroat Trout, Largescale Sucker, Mountain Whitefish, Rainbow Trout, Smallmouth Bass, Sucker, Utah Chub, Utah Sucker, Yellowstone Cutthroat Trout
South Fork Ahtanum Creek	Cutthroat Trout
South Fork Boise River	Smallmouth bass
South Fork Coeur 'd Alene River	Mountain whitefish
South Fork Owyhee River	Bridgelip Sucker, Largemouth Bass
South Fork Palouse River	Largescale Sucker
South Fork Payette River	Rainbow Trout
South Fork Skykomish River	Mountain Whitefish
Spokane River	Largemouth Bass, Largescale Sucker, Smallmouth Bass, Rainbow Trout
Saint Joe River	Cutthroat trout
Strawberry Creek	Brook Trout, Rainbow Trout
Texas Slough Canal	Cutthroat Trout, Rainbow Trout, Utah Sucker

Tributary Long Meadows Creek	Rainbow Trout
Umtanum Creek	Rainbow Trout
Walla Walla River	Smallmouth Bass
Wenatchee River	Bridgelip Sucker, Largescale Sucker, Longnose Sucker, Mountain Whitefish, Rainbow Trout
West Brownlee Creek	Rainbow Trout
White River	Cutthroat Trout, Largescale Sucker, Mountain Whitefish
Willamette River	Chinook Salmon, Largemouth Bass, Largescale Sucker, Mountain Whitefish, Smallmouth Bass, Sturgeon
Williams Creek	Cutthroat Trout
Yakima River	Brown Trout, Largemouth Bass, Largemouth Sucker, Longnose Sucker, Mountain Whitefish, Smallmouth Bass

Appendix 5

Average Daily Dose Rates

Mercury ingestion rates of particular fish for each tribal member consumption scenario.

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
OR	Beaverton Creek	Cutthroat Trout	31	0.15	1.30E-04	9.50E-05	3.70E-05	3.70E-06
ID	Big Lost River	Rainbow Trout	1	0.08	7.10E-05	5.20E-05	2.00E-05	2.00E-06
ID	Big Wood River	All Species	6	0.04	3.60E-05	2.70E-05	1.00E-05	1.00E-06
ID	Big Wood River	Brown Trout	3	0.04	3.60E-05	2.60E-05	1.00E-05	1.00E-06
ID	Big Wood River	Rainbow Trout	3	0.04	3.60E-05	2.70E-05	1.00E-05	1.00E-06
MT	Bitterroot River	All Species	9	0.1	8.50E-05	6.20E-05	2.40E-05	2.40E-06
MT	Bitterroot River	Largescale Sucker	3	0.2	1.80E-04	1.30E-04	5.00E-05	5.00E-06
MT	Bitterroot River	Mountain Whitefish	3	0.06	5.70E-05	4.20E-05	1.60E-05	1.60E-06
MT	Bitterroot River	Rainbow Trout	3	0.02	2.00E-05	1.50E-05	5.60E-06	5.60E-07
MT	Blackfoot River	All Species	21	0.06	5.50E-05	4.00E-05	1.50E-05	1.50E-06
ID	Blackfoot River	Bridgelip Sucker	2	0.09	7.60E-05	5.60E-05	2.10E-05	2.10E-06
MT	Blackfoot River	Brown Trout	3	0.03	2.90E-05	2.10E-05	8.20E-06	8.20E-07
ID	Blackfoot River	Cutthroat Trout	4	0.05	4.50E-05	3.30E-05	1.30E-05	1.30E-06
MT	Blackfoot River	Largescale Sucker	3	0.17	1.50E-04	1.10E-04	4.30E-05	4.30E-06
MT	Blackfoot River	Mountain Whitefish	3	0.05	4.60E-05	3.40E-05	1.30E-05	1.30E-06
ID	Blackfoot River	Rainbow Trout	1	0.03	2.40E-05	1.80E-05	6.80E-06	6.80E-07
ID	Blackfoot River	Sucker	1	0.04	3.10E-05	2.30E-05	8.80E-06	8.80E-07
MT	Blackfoot River	Utah Sucker	4	0.03	2.70E-05	2.00E-05	7.60E-06	7.60E-07
ID	Boise River	Brown Trout	2	0.14	1.20E-04	8.80E-05	3.40E-05	3.40E-06
ID	Boise River	Sockeye Salmon	1	0.17	1.50E-04	1.10E-04	4.30E-05	4.30E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
ID	Boise River	Whitefish	8	0.05	4.10E-05	3.00E-05	1.20E-05	1.20E-06
ID	Boise River	All Species	24	0.15	1.30E-04	9.70E-05	3.80E-05	3.80E-06
ID	Boise River	Rainbow Trout	4	0.07	6.20E-05	4.60E-05	1.80E-05	1.80E-06
OR	Breitenbush River	Rainbow Trout	1	0.04	3.50E-05	2.60E-05	9.90E-06	9.90E-07
ID	Bruneau River	Rainbow Trout	1	0.13	1.20E-04	8.40E-05	3.30E-05	3.30E-06
ID	Camas Creek	Mountain Whitefish	1	0.06	5.40E-05	4.00E-05	1.50E-05	1.50E-06
NV	Camp Creek	Rainbow Trout	5	0.12	1.10E-04	7.70E-05	3.00E-05	3.00E-06
OR	Canal Creek	Rainbow Trout	3	0.23	2.00E-04	1.50E-04	5.80E-05	5.80E-06
OR	Canyon Creek	Rainbow Trout	9	0.46	4.10E-04	3.00E-04	1.20E-04	1.20E-05
WA	Chelan River	Lake Trout	30	0.1	8.40E-05	6.20E-05	2.40E-05	2.40E-06
WA	Chiwawa River	All Species	19	0.04	2.60E-05	2.60E-05	9.90E-06	9.90E-07
WA	Chiwawa River	Mountain Whitefish	16	0.04	3.80E-05	2.80E-05	1.10E-05	1.10E-06
WA	Chiwawa River	Rainbow Trout	3	0.02	1.80E-05	1.30E-05	5.00E-06	5.00E-07
OR	Clackamas River	All Species	9	0.08	6.70E-05	4.90E-05	1.90E-05	1.90E-06
OR	Clackamas River	Cutthroat Trout	1	0.15	1.30E-04	9.70E-05	3.70E-05	3.70E-06
OR	Clackamas R Hatchery	Chinook Salmon	8	0.07	5.90E-05	4.30E-05	1.70E-05	1.70E-06
MT	Clark Fork River	All Species	18	0.49	4.30E-04	3.20E-04	1.20E-04	1.20E-05
MT	Clark Fork River	Brown Trout	2	0.44	3.90E-04	2.90E-04	1.10E-04	1.10E-05

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
MT	Clark Fork River	Mountain Whitefish	3	0.14	1.20E-04	8.90E-05	3.40E-05	3.40E-06
MT	Clark Fork River	Smallmouth Bass	3	0.46	4.10E-04	3.00E-04	1.20E-04	1.20E-05
MT	Clark Fork River	Walleye	5	1.1	9.70E-04	7.10E-04	2.70E-04	2.70E-05
OR	Coast Fork Willamette	All Species	39	0.51	4.50E-04	3.30E-04	1.30E-04	1.30E-05
OR	Coast Fork Willamette	Cutthroat Trout	12	0.07	6.30E-05	4.60E-05	1.80E-05	1.80E-06
OR	Coast Fork Willamette	Largemouth Bass	10	1.63	1.40E-03	1.10E-03	4.10E-04	4.10E-05
OR	Coast Fork Willamette	Largescale Sucker	6	0.15	1.30E-04	9.50E-05	3.70E-05	3.70E-06
OR	Coast Fork Willamette	Rainbow Trout	5	0.1	1.30E-04	9.50E-05	3.70E-05	3.70E-06
OR	Coast Fork Willamette	Smallmouth Bass	6	0.23	2.00E-04	1.50E-04	5.70E-05	5.70E-06
OR/WA	Columbia River	All Species	43	0.11	9.40E-05	6.90E-05	2.70E-05	2.70E-06
WA	Columbia River	Largescale Sucker	3	0.1	9.20E-05	6.80E-05	2.60E-05	2.60E-06
WA	Columbia River	Mountain Whitefish	4	0.05	4.70E-05	3.40E-05	1.30E-05	1.30E-06
OR	Columbia River	Smallmouth Bass	2	0.13	1.20E-04	8.60E-05	3.30E-05	3.30E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
WA	Columbia River	Walleye	1	0.64	5.70E-04	4.20E-04	1.60E-04	1.60E-05
OR	Columbia River	White Sturgeon	18	0.1	9.20E-05	6.70E-05	2.60E-05	2.60E-06
WA	Columbia River	Whitefish	1	0.49	4.30E-04	3.20E-04	1.20E-04	1.20E-05
WA	Cowlitz River	All Species	3	0.13	1.10E-04	8.20E-05	3.20E-05	3.20E-06
WA	Cowlitz River	Cutthroat Trout	2	0.09	7.70E-05	5.60E-05	2.20E-05	2.20E-06
WA	Cowlitz River	Mountain Whitefish	1	0.21	1.80E-04	1.30E-04	5.10E-05	5.10E-06
OR	Coyle Creek	Rainbow Trout	1	0.03	2.70E-05	2.00E-05	7.50E-06	7.50E-07
WA	Crab Creek	Rainbow Trout	3	0.11	9.90E-05	7.30E-05	2.80E-05	2.80E-06
WY	De Lacy Creek	Brook Trout	3	0.39	3.50E-04	2.50E-04	9.70E-05	9.70E-06
OR	Deschutes River	All Species	17	0.02	1.90E-05	1.40E-05	5.30E-06	5.30E-07
OR	Deschutes River	Mountain Whitefish	7	0.02	1.30E-05	9.70E-06	3.80E-06	3.80E-07
OR	Deschutes River	Rainbow Trout	10	0.03	2.40E-05	1.80E-05	6.90E-06	6.90E-07
ID	Ditch Creek	Rainbow Trout	10	0.03	2.90E-05	2.10E-05	8.30E-06	8.30E-07
OR	Duncan Creek	Rainbow Trout	1	0.05	4.00E-05	2.90E-05	1.10E-05	1.10E-06
WA	Duwamish River	Coho Salmon	40	0.02	1.90E-05	1.40E-05	5.50E-06	5.50E-07
ID	East Creek	Redband Trout	10	0.02	1.70E-05	1.20E-05	4.70E-06	4.70E-07
OR	East Fork Dairy Creek	Cutthroat Trout	1	0.17	1.50E-04	1.10E-04	4.20E-05	4.20E-06
WA	Entiat River	Rainbow Trout	1	0.04	3.30E-05	2.40E-05	9.30E-06	9.30E-07

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
WY	Grey's River	Cutthroat Trout	1	0.03	2.3	1.70E-05	6.50E-06	6.50E-07
ID	Grimes Creek	Rainbow Trout	2	0.08	7.40E-05	5.40E-05	2.10E-05	2.10E-06
ID	Henry's Fork River	All Species	9	0.09	8.00E-05	5.80E-05	2.20E-05	2.20E-06
ID	Henry's Fork River	Cutthroat Trout	1	0.28	2.40E-04	1.80E-04	6.90E-05	6.90E-06
ID	Henry's Fork River	Mountain Whitefish	6	0.07	5.90E-05	4.30E-05	1.70E-05	1.70E-06
ID	Henry's Fork River	Rainbow Trout	2	0.07	5.90E-05	4.30E-05	1.70E-05	1.70E-06
WY	Hoback River	Mountain Sucker	2	0.1	9.00E-05	6.60E-05	2.50E-05	2.50E-06
OR	Horse Creek	Cutthroat Trout	1	0.02	1.50E-05	1.10E-05	4.30E-06	4.30E-07
WA	Icicle Creek	Mountain Whitefish	4	0.06	4.90E-05	3.60E-05	1.40E-05	1.40E-06
OR	John Day River	All Species	64	0.24	2.10E-04	1.50E-04	5.90E-05	5.90E-06
OR	John Day River	Bridgelip Sucker	3	0.23	2.10E-04	1.50E-04	5.80E-05	5.80E-06
OR	John Day River	Channel Catfish	3	0.33	2.90E-04	2.10E-04	8.10E-05	8.10E-06
OR	John Day River	Largescale Sucker	24	0.26	2.30E-04	1.70E-04	6.60E-05	6.60E-06
OR	John Day River	Smallmouth Bass	34	0.21	1.90E-04	1.40E-04	5.20E-05	5.20E-06
OR	Johnson Creek	Cutthroat Trout	1	0.18	1.60E-04	1.10E-04	4.40E-05	4.40E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
ID	Jordan Creek	Bridgelip Sucker	2	0.61	5.40E-04	3.90E-04	1.50E-04	1.50E-05
ID	Jordan Creek	Redband Trout	19	0.48	4.30E-04	3.10E-04	1.20E-04	1.20E-05
ID	Jordan Creek	Sucker	12	0.63	5.50E-04	4.10E-04	1.60E-04	1.60E-05
WA	Kettle River	Rainbow Trout	1	0.04	3.80E-05	2.80E-05	1.10E-05	1.10E-06
WA	Klickitat River	Mountain Whitefish	1	0.37	3.30E-04	2.40E-04	9.20E-05	9.20E-06
ID	Kootenai River	All Species	19	0.12	1.10E-04	7.70E-05	3.00E-05	3.00E-06
ID	Kootenai River	Largescale Sucker	10	0.17	1.50E-04	1.10E-04	4.10E-05	4.10E-06
ID	Kootenai River	Longnose Sucker	3	0.08	6.80E-05	5.00E-05	1.90E-05	1.90E-06
ID	Kootenai River	Mountain Whitefish	3	0.11	9.60E-05	7.10E-05	2.70E-05	2.70E-06
ID	Kootenai River	Rainbow Trout	3	0.02	1.90E-05	1.40E-05	5.30E-06	5.30E-07
WY	Leeds Creek	Cutthroat Trout	3	0.08	7.00E-05	5.10E-05	2.00E-05	2.00E-06
WY	Little Greys River	All Species	6	0.04	3.90E-05	2.80E-05	1.10E-05	1.10E-06
WY	Little Greys River	Cutthroat Trout	3	0.04	3.50E-05	2.60E-05	9.80E-06	9.80E-07
WY	Little Greys River	Mountain Whitefish	3	0.05	4.30E-05	3.10E-05	1.20E-05	1.20E-06
ID	Little N Fork Coeur D'Alene	Cutthroat Trout	6	0.01	3.90E-05	2.80E-05	1.10E-05	1.10E-06
ID	Little Smokey Creek	All Species	6	0.03	2.50E-05	1.80E-05	6.90E-06	6.90E-07
ID	Little Smokey Creek	Mountain Whitefish	2	0.03	3.90E-05	2.80E-05	1.10E-05	1.10E-06
ID	Little Smokey Creek	Rainbow Trout	4	0.02	1.50E-05	1.10E-05	4.10E-06	4.10E-07

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
ID	Lochsa River	Cutthroat Trout	1	0.05	4.30E-05	3.10E-05	1.20E-05	1.20E-06
ID	Lochsa River	Mountain Whitefish	1	0.05	4.60E-05	4.60E-01	1.30E-05	1.30E-06
ID	Long Meadows Creek	Rainbow Trout	3	0.07	6.30E-05	4.60E-05	1.80E-05	1.80E-06
OR	Lookout Creek	Cutthroat Trout	46	0.03	3.00E-05	2.20E-05	8.50E-06	8.50E-07
OR	Lookout Creek	Rainbow Trout	5	0.01	1.30E-05	9.10E-06	3.50E-06	3.50E-07
ID	Louse Creek	All Species	9	0.1	8.90E-05	6.50E-05	2.50E-05	2.50E-06
ID	Louse Creek	Bridgelip Sucker	1	0.08	7.00E-05	5.10E-05	2.00E-05	2.00E-06
ID	Louse Creek	Redband Trout	7	0.1	8.90E-05	6.50E-05	2.50E-05	2.50E-06
ID	Louse Creek	Sucker	1	0.13	1.10E-04	8.10E-05	3.10E-05	3.10E-06
OR	Marks Creek	Rainbow trout	9	0.03	3.00E-05	2.20E-05	8.60E-06	8.60E-07
WA	Methow River	All Species	0	0.03	2.90E-05	2.10E-05	8.10E-06	8.10E-07
WA	Methow River	Cutthroat Trout	1	0.03	2.90E-05	2.10E-05	8.10E-06	8.10E-07
WA	Methow River	Mountain Whitefish	1	0.04	3.30E-05	2.40E-05	9.30E-06	9.30E-07
OR	Middle Fork John Day	All Species	6	0.1	8.60E-05	6.30E-05	2.40E-05	2.40E-06
OR	Middle Fork John Day	Largescale Sucker	3	0.15	1.40E-04	9.90E-05	3.80E-05	3.80E-06
OR	Middle Fork John Day	Mountain Whitefish	3	0.04	3.70E-05	2.70E-05	1.00E-05	1.00E-06
WA	Nason Creek	Mountain Whitefish	3	0.08	7.30E-05	5.30E-05	2.10E-05	2.10E-06
WA	Nisqually River	Coho Salmon	38	0.05	4.40E-05	3.20E-05	1.20E-05	1.20E-06
WA	North Fork Big Lost R	Brown Trout	1	0.06	5.70E-05	4.20E-05	1.60E-05	1.60E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
OR	North Fork Clearwater	Mountain Whitefish	5	0.06	5.70E-05	4.10E-05	1.60E-05	1.60E-06
OR	North Fork Clearwater	Smallmouth Bass	4	0.14	1.30E-04	9.20E-05	3.50E-05	3.50E-06
ID	North Fork Payette R	Rainbow Trout	1	0.13	1.20E-04	8.60E-05	3.30E-05	3.30E-06
WY	North Leigh Creek	All Species	5	0.03	2.60E-05	1.90E-05	7.30E-06	7.30E-07
WY	North Leigh Creek	Brown Trout	3	0.03	2.70E-05	2.00E-05	7.60E-06	7.60E-07
WY	North Leigh Creek	Cutthroat Trout	2	0.03	2.50E-05	1.90E-05	7.10E-06	7.10E-07
WA	North River	Cutthroat Trout	1	0.07	6.30E-05	4.60E-05	1.80E-05	1.80E-06
OR	North Santiam River	Cutthroat Trout	1	0.03	2.50E-05	1.80E-05	7.10E-06	7.10E-07
OR	Oak Grove Fk Clackamas	All Species	3	0.09	8.10E-05	5.90E-05	2.30E-05	2.30E-06
OR	Oak Grove Fk Clackamas	Cutthroat Trout	1	0.09	7.90E-05	5.80E-05	2.20E-05	2.20E-06
OR	Oak Grove Fk Clackamas	Rainbow Trout	2	0.09	8.10E-05	6.00E-05	2.30E-05	2.30E-06
OR	Ochoco Creek	Rainbow Trout	9	0.11	1.00E-04	7.30E-05	2.80E-05	2.80E-06
WA	Okanogan River	Smallmouth Bass	21	0.16	1.40E-04	1.00E-04	4.00E-05	4.00E-06
OR	Owyhee River	Largemouth Bass	1	0.6	5.30E-04	3.90E-04	1.50E-04	1.50E-05
WA	Palouse River	All Species	11	0.19	1.70E-04	1.30E-04	4.80E-05	4.80E-06
WA	Palouse River	Largemouth Bass	2	0.22	1.90E-04	1.40E-04	5.50E-05	5.50E-06
WA	Palouse River	Largescale Sucker	5	0.16	1.40E-04	1.00E-04	4.00E-05	4.00E-06
WA	Palouse River	Smallmouth Bass	4	0.22	1.90E-04	1.40E-04	5.50E-05	5.50E-06
WA	Pataha Creek	Brook Trout	1	0.09	8.30E-05	6.00E-05	2.30E-05	2.30E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
ID	Payette River	Mountain Whitefish	3	0.06	5.30E-05	3.80E-05	1.50E-05	1.50E-06
ID	Payette River	Bridgelip Sucker	1	0.23	2.10E-04	1.50E-04	5.90E-05	5.90E-06
ID	Payette River	Channel Catfish	1	0.19	1.70E-04	1.20E-04	4.80E-05	4.80E-06
ID	Payette River	Largescale Sucker	2	0.23	2.10E-04	1.50E-04	5.80E-05	5.80E-06
ID	Payette River	Smallmouth Bass	1	0.12	1.10E-04	8.00E-05	3.10E-05	3.10E-06
WA	Pend Oreille River	All Species	10	0.18	1.60E-04	1.20E-04	4.40E-05	4.40E-06
WA	Pend Oreille River	Brown Trout	4	0.14	1.20E-04	8.80E-05	3.40E-05	3.40E-06
WA	Pend Oreille River	Largescale Sucker	6	0.21	1.80E-04	1.30E-04	5.10E-05	5.10E-06
ID	Portneuf River	All Species	22	0.4	3.50E-04	2.60E-04	1.00E-04	1.00E-05
ID	Portneuf River	Brown Trout	11	0.47	4.10E-04	3.00E-04	1.20E-04	1.20E-05
ID	Portneuf River	Rainbow Trout	8	0.31	2.70E-04	2.00E-04	7.60E-05	7.60E-06
ID	Portneuf River	Utah Sucker	1	0.19	1.70E-04	1.30E-04	4.80E-05	4.80E-06
ID	Portneuf River	Yellowstone Cutthroat	2	0.68	6.00E-04	4.40E-04	1.70E-04	1.70E-05
OR	Powder River	Bridgelip Sucker	1	0.32	2.90E-04	2.10E-04	8.10E-05	8.10E-06
ID	Priest River	All Species	2	0.22	1.90E-04	1.40E-04	5.40E-05	5.40E-06
ID	Priest River	Largescale Sucker	1	0.28	2.50E-04	1.80E-04	7.00E-05	7.00E-06
ID	Priest River	Smallmouth Bass	1	0.16	1.40E-04	1.00E-04	3.90E-05	3.90E-06
OR	Pudding River	All Species	6	0.18	1.60E-04	1.20E-04	4.40E-05	4.40E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
OR	Pudding River	Smallmouth Bass	3	0.24	2.20E-04	1.60E-04	6.10E-05	6.10E-06
OR	Quartz Creek	Cutthroat Trout	1	0.04	3.20E-05	2.40E-05	9.10E-06	9.10E-07
ID	Rock Creek	Brown Trout	3	0.17	1.50E-04	1.10E-04	4.30E-05	4.30E-06
OR	Row River	All Species	41	0.44	3.90E-04	2.80E-04	1.10E-04	1.10E-05
OR	Row River	Cutthroat Trout	1	0.13	1.10E-04	8.30E-05	3.20E-05	3.20E-06
OR	Row River	Largemouth Bass	23	0.63	5.60E-04	4.10E-04	1.60E-04	1.60E-05
OR	Row River	Largescale Sucker	4	0.55	4.90E-04	3.60E-04	1.40E-04	1.40E-05
OR	Row River	Rainbow Trout	13	0.09	7.80E-05	5.70E-05	2.20E-05	2.20E-06
ID	Saint Joe River	All Species	5	0.13	1.20E-04	8.60E-05	3.30E-05	3.30E-06
ID	Saint Joe River	Brook Trout	1	0.17	1.50E-04	1.10E-04	4.40E-05	4.40E-06
ID	Saint Joe River	Cutthroat Trout	2	0.04	3.90E-05	2.80E-05	1.10E-05	1.10E-06
ID	Saint Joe River	Largemouth Bass	1	0.36	3.20E-04	2.40E-04	9.10E-05	9.10E-06
ID	Saint Joe River	Mountain Whitefish	1	0.04	3.50E-05	2.60E-05	1.00E-05	1.00E-06
ID	Saint Joe River	Cutthroat trout	2	0.03	2.50E-05	1.90E-05	7.10E-06	7.10E-07
ID	Salmon River	All Species	24	0.23	2.00E-04	1.50E-04	5.70E-05	5.70E-06
ID	Salmon River	Mountain Whitefish	13	0.15	1.30E-04	9.70E-05	3.80E-05	3.80E-06
ID	Salmon River	Smallmouth Bass	7	0.39	3.40E-04	2.50E-04	9.60E-05	9.60E-06
ID	Salmon River	Sucker	4	0.2	1.80E-04	1.30E-04	5.00E-05	5.00E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
OR	Sandy River	Largescale Sucker	3	0.21	1.90E-04	1.40E-04	5.30E-05	5.30E-06
OR	Sandy River	Mountain Whitefish	3	0.07	6.10E-05	4.50E-05	1.70E-05	1.70E-06
WA	Sanpoil River	All Species	2	0.19	1.70E-04	1.20E-04	4.70E-05	4.70E-06
WA	Sanpoil River	Brook Trout	1	0.23	2.10E-04	1.50E-04	5.90E-05	5.90E-06
WA	Sanpoil River	Rainbow Trout	1	0.14	1.20E-04	9.10E-05	3.50E-05	3.50E-06
NV	Schack Creek	Rainbow Trout	3	0.02	2.00E-05	1.50E-05	5.70E-06	5.70E-07
ID	Selway River	All Species	6	0.09	7.60E-05	5.60E-05	2.10E-05	2.10E-06
ID	Selway River	Brook Trout	1	0.15	1.40E-04	9.90E-05	3.80E-05	3.80E-06
ID	Selway River	Cutthroat Trout	2	0.05	4.70E-05	3.40E-05	1.30E-05	1.30E-06
ID	Selway River	Mountain Whitefish	1	0.08	7.40E-05	5.40E-05	2.10E-05	2.10E-06
ID	Silver Creek	All Species	65	0.3	2.60E-04	1.90E-04	7.40E-05	7.40E-06
ID	Silver Creek	Brown Trout	55	0.33	2.90E-04	2.10E-04	8.20E-05	8.20E-06
ID	Silver Creek	Rainbow Trout	10	0.11	1.00E-04	7.40E-05	2.90E-05	2.90E-06
WA	Similkameen River	Smallmouth Bass	1	0.15	1.30E-04	9.70E-05	3.70E-05	3.70E-06
WA	Sinlahekin River	All Species	2	0.06	5.40E-05	3.90E-05	1.50E-05	1.50E-06
WA	Sinlahekin River	Rainbow Trout	1	0.05	4.80E-05	3.50E-05	1.40E-05	1.40E-06
WA	Sinlahekin River	Mountain Whitefish	1	0.07	5.90E-05	4.30E-05	1.70E-05	1.70E-06
WA	Skagit River	All Species	37	0.04	3.40E-05	2.50E-05	9.50E-06	9.50E-07

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
WA	Skagit River	Mountain Whitefish	1	0.06	5.20E-05	3.80E-05	1.50E-05	1.50E-06
ID	Snake River	All Species	290	0.27	2.40E-04	1.70E-04	6.70E-05	6.70E-06
OR/ID	Snake River	Bottom Feeders	2	0.29	2.60E-04	1.90E-04	7.20E-05	7.20E-06
ID	Snake River	Brown Trout	1	0.25	2.20E-04	1.60E-04	6.30E-05	6.30E-06
ID	Snake River	Channel Catfish	29	0.29	2.60E-04	1.90E-04	7.30E-05	7.30E-06
WA	Snake River	Cutthroat Trout	3	0.08	7.40E-05	5.40E-05	2.10E-05	2.10E-06
OR/ID	Snake River	Largescale Sucker	10	0.32	2.90E-04	2.10E-04	8.00E-05	8.00E-06
ID	Snake River	Mountain Whitefish	32	0.11	9.40E-05	6.90E-05	2.60E-05	2.60E-06
ID	Snake River	Rainbow Trout	43	0.13	1.20E-04	8.50E-05	3.30E-05	3.30E-06
ID	Snake River	Smallmouth Bass	91	0.35	3.10E-04	2.30E-04	8.70E-05	8.70E-06
ID	Snake River	Sucker	4	0.23	2.10E-04	1.50E-04	5.80E-05	5.80E-06
ID	Snake River	Utah Chub	11	0.23	2.00E-04	1.50E-04	5.70E-05	5.70E-06
ID	Snake River	Utah Sucker	38	0.43	3.80E-04	2.80E-04	1.10E-04	1.10E-05
ID	Snake River	Yellowstone Cutthroat	26	0.15	1.30E-04	9.70E-05	3.70E-05	3.70E-06
WA	S Fork Ahtanum Creek	Cutthroat Trout	1	0.05	4.30E-05	3.10E-05	1.20E-05	1.20E-06
ID	South Fork Boise River	Smallmouth bass	1	0.18	1.60E-04	1.10E-04	4.40E-05	4.40E-06
ID	S Fork Coeur 'd Alene	Mountain Whitefish	1	0.05	4.40E-05	3.20E-05	1.20E-05	1.20E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
NV/OR	South Fork Owyhee River	All Species	2	0.35	3.10E-04	2.30E-04	8.80E-05	8.80E-06
NV	South Fork Owyhee River	Bridgelip Sucker	1	0.1	8.90E-05	6.50E-05	2.50E-05	2.50E-06
OR	South Fork Owyhee River	Largemouth Bass	1	0.6	5.30E-04	3.90E-04	1.50E-04	1.50E-05
WA	South Fork Palouse River	Largescale Sucker	14	0.21	1.90E-04	1.40E-04	5.30E-05	5.30E-06
ID	South Fork Payette River	Rainbow Trout	2	0.26	2.30E-04	1.70E-04	6.50E-05	6.50E-06
WA	South Fork Skykomish River	Mountain Whitefish	1	0.06	5.40E-05	3.90E-05	1.50E-05	1.50E-06
ID/WA	Spokane River	All Species	65	0.09	8.10E-05	5.90E-05	2.30E-05	2.30E-06
WA	Spokane River	Largemouth Bass	26	0.1	9.20E-05	6.80E-05	2.60E-05	2.60E-06
WA	Spokane River	Rainbow Trout	3	0.02	1.90E-05	1.40E-05	5.30E-06	5.30E-07
ID	Spokane River	Smallmouth Bass	30	0.05	4.30E-05	3.20E-05	1.20E-05	1.20E-06
WA	Spokane River	Largescale Sucker	6	0.28	2.50E-04	1.80E-04	6.90E-05	6.90E-06
WA	Strawberry Creek	All Species	2	0.05	4.50E-05	3.30E-05	1.30E-05	1.30E-06
WA	Strawberry Creek	Brook Trout	1	0.06	5.60E-05	4.10E-05	1.60E-05	1.60E-06
WA	Strawberry Creek	Rainbow Trout	1	0.04	3.30E-05	2.40E-05	9.30E-06	9.30E-07
ID	Texas Slough Canal	All Species	18	0.06	5.00E-05	3.60E-05	1.40E-05	1.40E-06
ID	Texas Slough Canal	Cutthroat Trout	6	0.07	6.50E-05	4.80E-05	1.80E-05	1.80E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
ID	Texas Slough Canal	Utah Sucker	6	0.04	3.10E-05	2.30E-05	8.90E-06	8.90E-07
ID	Tributary Long Meadows	Rainbow Trout	3	0.07	5.80E-05	4.20E-05	1.60E-05	1.60E-06
WA	Umtanum Creek	Rainbow Trout	3	0.11	9.60E-05	7.00E-05	2.70E-05	2.70E-06
WA	Walla Walla River	Smallmouth Bass	21	0.17	1.50E-04	1.10E-04	4.30E-05	4.30E-06
WA	Wenatchee River	All Species	43	0.04	3.60E-05	2.70E-05	1.00E-05	1.00E-06
WA	Wenatchee River	Bridgelip Sucker	3	0.03	2.90E-05	2.10E-05	8.10E-06	8.10E-07
WA	Wenatchee River	Largescale Sucker	9	0.06	5.20E-05	3.80E-05	1.50E-05	1.50E-06
WA	Wenatchee River	Longnose Sucker	3	0.03	2.20E-05	1.60E-05	6.30E-06	6.30E-07
WA	Wenatchee River	Mountain Whitefish	22	0.04	3.40E-05	2.50E-05	9.60E-06	9.60E-07
WA	Wenatchee River	Rainbow Trout	6	0.04	3.20E-05	2.30E-05	8.90E+00	8.90E-07
ID	West Brownlee Creek	Rainbow Trout	2	0.24	2.10E-04	1.60E-04	6.00E-05	6.00E-06
WA	White River	All Species	10	0.06	5.60E-05	4.10E-05	1.60E-05	1.60E-06
WA	White River	Cutthroat Trout	1	0.06	5.30E-05	3.90E-05	1.50E-05	1.50E-06
WA	White River	Largescale Sucker	3	0.1	9.10E-05	6.70E-05	2.60E-05	2.60E-06
WA	White River	Mountain Whitefish	6	0.05	4.00E-05	2.90E-05	1.10E-05	1.10E-06
OR	Willamette River	All Species	197	0.2	1.70E-04	1.30E-04	4.90E-05	4.90E-06
OR	Willamette River	Chinook Salmon	20	0.04	3.30E-05	2.40E-05	9.20E-06	9.20E-07
OR	Willamette River	Largemouth Bass	25	0.33	3.00E-04	2.20E-04	8.40E-05	8.40E-06

State	Waterbody	Species	N	Mean	620 g/day	454 g/day	175 g/day	17.5 g/day
OR	Willamette River	Mountain Whitefish	3	0.14	1.30E-04	9.20E-05	3.60E-05	3.60E-06
OR	Willamette River	Small Mouth Bass	72	0.18	1.60E-04	1.20E-04	4.50E-05	4.50E-06
OR	Willamette River	Sturgeon	7	0.23	2.10E-04	1.50E-04	5.90E-05	5.90E-06
ID	Williams Creek	Cutthroat Trout	2	0.13	1.10E-04	8.30E-05	3.20E-05	3.20E-06
WA	Yakima River	All Species	60	0.29	2.50E-04	1.90E-04	7.20E-05	7.20E-06
WA	Yakima River	Brown Trout	4	0.14	1.20E-04	8.90E-05	3.40E-05	3.40E-06
WA	Yakima River	Largemouth Bass	2	0.31	2.80E-04	2.00E-04	7.80E-05	7.80E-06
WA	Yakima River	Largemouth	6	0.62	5.50E-04	4.00E-04	1.60E-04	1.60E-05
WA	Yakima River	Largescale Sucker	3	0.09	7.60E-05	5.60E-05	2.10E-05	2.10E-06
WA	Yakima River	Longnose Sucker	3	0.15	1.30E-04	9.60E-05	3.70E-05	3.70E-06
WA	Yakima River	Mountain Whitefish	5	0.1	8.40E-05	6.10E-05	2.40E-05	2.40E-06
WA	Yakima River	Smallmouth Bass	37	0.35	3.10E-04	2.30E-04	8.70E-05	8.70E-06

Appendix 6

Hazard Quotient

Adult hazard quotient risks from the Columbia River Basin. Summary of the range of Hazard Quotients across study sites for each species at the four ingestions rates used for adults.

				Hazard Quotient			
				Native American		Oregon	General Public
State	Waterways	Species	N	620 (g/d)	454 (g/d)	175 (g/d)	17.5 (g/d)
				mg/kg	mg/kg	mg/kg	mg/kg
OR	Beaverton Creek	Cutthroat Trout	31	**1.3**	**1.0**	0.37	0.04
ID	Big Lost River	Rainbow Trout	1	0.7	0.5	0.20	0.02
ID	Big Wood River	All Species	6	0.4	0.3	0.1	0.01
ID	Big Wood River	Brown Trout	3	0.4	0.3	0.1	0.01
ID	Big Wood River	Rainbow Trout	3	0.4	0.3	0.1	0.01
MT	Bitterroot River	All Species	9	0.8	0.6	0.2	0.02
MT	Bitterroot River	Largescale Sucker	3	**1.8**	**1.3**	0.5	0.1
MT	Bitterroot River	Mountain Whitefish	3	0.6	0.4	0.2	0.02
MT	Bitterroot River	Rainbow Trout	3	0.2	0.1	0.06	0.01
MT	Blackfoot River	All Species	21	0.5	0.4	0.2	0.02
ID	Blackfoot River	Bridgelip Sucker	2	0.8	0.6	0.2	0.02
MT	Blackfoot River	Brown Trout	3	0.3	0.2	0.08	0.01
ID	Blackfoot River	Cutthroat Trout	4	0.4	0.3	0.1	0.01
MT	Blackfoot River	Largescale Sucker	3	**1.5**	**1.1**	0.4	0.04
MT	Blackfoot River	Mountain Whitefish	3	0.5	0.3	0.1	0.01
ID	Blackfoot River	Rainbow Trout	1	0.2	0.2	0.07	0.01
ID	Blackfoot River	Sucker	1	0.3	0.2	0.09	0.01

MT	Blackfoot River	Utah Sucker	4	0.3	0.2	0.08	0.01
ID	Boise River	Brown Trout	2	**1.2**	0.9	0.3	0.03
ID	Boise River	Sockeye Salmon	1	**1.5**	**1.1**	0.4	0.04
ID	Boise River	Sucker	9	**2.5**	**1.8**	0.7	0.07
ID	Boise River	Whitefish	8	0.4	0.3	0.1	0.01
ID	Boise River	All Species	24	**1.3**	**1.0**	0.4	0.04
ID	Boise River	Rainbow Trout	4	0.6	0.5	0.2	0.02
OR	Breitenbush River	Rainbow Trout	1	0.3	0.3	0.1	0.01
ID	Bruneau River	Rainbow Trout	1	**1.2**	0.8	0.3	0.03
ID	Camas Creek	Mountain Whitefish	1	0.5	0.4	0.2	0.02
NV	Camp Creek	Rainbow Trout	5	**1.1**	0.77	0.3	0.03
OR	Canal Creek	Rainbow Trout	3	**2.0**	**1.5**	0.6	0.1
OR	Canyon Creek	Rainbow Trout	9	**4.1**	**3.0**	**1.2**	0.1
WA	Chelan River	Lake Trout	30	0.8	0.6	0.2	0.02
WA	Chiwawa River	All Species	19	0.3	0.3	0.1	0.01
WA	Chiwawa River	Mountain Whitefish	16	0.4	0.3	0.1	0.01
WA	Chiwawa River	Rainbow Trout	3	0.2	0.1	0.1	0.01
OR	Clackamas River	All Species	9	0.7	0.5	0.2	0.02
OR	Clackamas River	Cutthroat Trout	1	**1.3**	**1.0**	0.37	0.04
OR	Clackamas River Hatchery	Chinook Salmon	8	0.6	0.4	0.2	0.02
MT	Clark Fork River	All Species	18	**4.3**	**3.2**	**1.2**	0.1
MT	Clark Fork River	Brown Trout	2	**3.9**	**2.9**	**1.1**	0.1
MT	Clark Fork River	Lake Whitefish	2	**1.3**	**1.0**	0.4	0.04
MT	Clark Fork River	Largescale Sucker	3	0.8	0.6	0.2	0.02
MT	Clark Fork River	Mountain Whitefish	3	**1.2**	0.9	0.3	0.03
MT	Clark Fork River	Smallmouth Bass	3	**4.1**	3.0	1.2	0.1
MT	Clark Fork River	Walleye	5	**9.7**	**7.1**	**2.7**	0.3
OR	Coast Fork Willamette River	All Species	39	**4.5**	**3.3**	**1.3**	0.1

OR	Coast Fork Willamette River	Cutthroat Trout	12	0.629	0.46	0.178	0.018
OR	Coast Fork Willamette River	Largemouth Bass	10	**14.4**	**10.6**	**4.1**	0.4
OR	Coast Fork Willamette River	Largescale Sucker	6	**1.3**	**1.0**	0.4	0.04
OR	Coast Fork Willamette River	Rainbow Trout	5	**1.3**	**1.0**	0.4	0.04
OR	Coast Fork Willamette River	Smallmouth Bass	6	**2.0**	**1.5**	0.6	0.06
OR/WA	Columbia River	All Species	43	0.9	0.7	0.3	0.03
WA	Columbia River	Largescale Sucker	3	0.9	0.7	0.3	0.03
WA	Columbia River	Mountain Whitefish	4	0.5	0.3	0.1	0.01
OR	Columbia River	Smallmouth Bass	2	**1.2**	0.9	0.3	0.03
WA	Columbia River	Sucker	14	0.5	0.4	0.1	0.01
WA	Columbia River	Walleye	1	**5.7**	**4.2**	**1.6**	0.16
OR	Columbia River	White Sturgeon	18	0.9	0.7	0.3	0.03
WA	Columbia River	Whitefish	1	**4.3**	**3.2**	**1.2**	0.1
WA	Cowlitz River	All Species	3	**1.1**	0.8	0.3	0.03
WA	Cowlitz River	Cutthroat Trout	2	0.8	0.6	0.2	0.02
WA	Cowlitz River	Mountain Whitefish	1	**1.8**	**1.3**	0.5	0.05
OR	Coyle Creek	Rainbow Trout	1	0.3	0.2	0.1	0.01
WA	Crab Creek	Rainbow Trout	3	**1.0**	0.7	0.3	0.03
WY	De Lacy Creek	Brook Trout	3	**3.4**	**2.5**	**1.0**	0.1
OR	Deschutes River	All Species	17	0.2	0.1	0.1	0.01
OR	Deschutes River	Mountain Whitefish	7	0.1	0.1	0.04	0.004
OR	Deschutes River	Rainbow Trout	10	0.2	0.2	0.07	0.01
ID	Ditch Creek	Rainbow Trout	10	0.3	0.2	0.1	0.01
OR	Duncan Creek	Rainbow Trout	1	0.4	0.3	0.1	0.01
WA	Duwamish River	Coho Salmon	40	0.2	0.1	0.1	0.01
ID	East Creek	Redband Trout	10	0.2	0.1	0.05	0.01
OR	East Fork Dairy Creek	Cutthroat Trout	1	**1.5**	**1.1**	0.4	0.04
WA	Entiat River	Rainbow Trout	1	0.3	0.2	0.1	0.01

ID	Flint Creek	Redband Trout	4	**1.5**	**1.1**	0.4	0.04
WY	Grey's River	Cutthroat Trout	1	0.2	0.2	0.1	0.01
ID	Grimes Creek	Rainbow Trout	2	0.7	0.5	0.2	0.02
ID	Henry's Fork River	All Species	9	0.8	0.6	0.2	0.02
ID	Henry's Fork River	Cutthroat Trout	1	**2.4**	**1.8**	0.7	0.1
ID	Henry's Fork River	Mountain Whitefish	6	0.6	0.4	0.2	0.02
ID	Henry's Fork River	Rainbow Trout	2	0.6	0.4	0.2	0.02
WY	Hoback River	Mountain Sucker	2	0.9	0.7	0.3	0.03
OR	Horse Creek	Cutthroat Trout	1	0.2	0.1	0.04	0.004
WA	Icicle Creek	Mountain Whitefish	4	0.5	0.4	0.1	0.01
OR	John Day River	All Species	64	**2.1**	**1.5**	0.6	0.1
OR	John Day River	Bridgelip Sucker	3	**2.1**	**1.5**	0.6	0.1
OR	John Day River	Channel Catfish	3	**2.9**	**2.1**	0.8	0.1
OR	John Day River	Largescale Sucker	24	**2.3**	**1.7**	0.7	0.1
OR	John Day River	Smallmouth Bass	34	**1.9**	**1.4**	0.5	0.1
OR	Johnson Creek	Cutthroat Trout	1	**1.6**	**1.1**	0.4	0.04
ID	Jordan Creek	All Species	33	**4.8**	**3.5**	**1.4**	0.1
ID	Jordan Creek	Bridgelip Sucker	2	**5.4**	**3.9**	**1.5**	0.2
ID	Jordan Creek	Redband Trout	19	**4.3**	**3.1**	**1.2**	0.1
ID	Jordan Creek	Sucker	12	**5.5**	**4.1**	**1.6**	0.2
WA	Kettle River	Rainbow Trout	1	0.4	0.3	0.1	0.01
WA	Klickitat River	Mountain Whitefish	1	**3.3**	**2.4**	0.9	0.1
ID	Kootenai River	All Species	19	**1.1**	0.8	0.3	0.03
ID	Kootenai River	Largescale Sucker	10	**1.5**	**1.1**	0.4	0.04
ID	Kootenai River	Longnose Sucker	3	0.7	0.5	0.2	0.02
ID	Kootenai River	Mountain Whitefish	3	**1.0**	0.7	0.3	0
ID	Kootenai River	Rainbow Trout	3	0.2	0.1	0.1	0.01
WY	Leeds Creek	Cutthroat Trout	3	0.7	0.5	0.2	0.02

WY	Little Greys River	All Species	6	0.4	0.3	0.1	0.01
WY	Little Greys River	Cutthroat Trout	3	0.3	0.3	0.1	0.01
WY	Little Greys River	Mountain Whitefish	3	0.4	0.3	0.1	0.01
ID	Little North Fork Coeur D'Alene	Cutthroat Trout	6	0.4	0.3	0.1	0.01
ID	Little Smokey Creek	All Species	6	0.2	0.2	0.1	0.01
ID	Little Smokey Creek	Mountain Whitefish	2	0.4	0.3	0.1	0.01
ID	Little Smokey Creek	Rainbow Trout	4	0.1	0.1	0.04	0.004
ID	Lochsa River	All Species	2	0.4	0.3	0.1	0.01
ID	Lochsa River	Cutthroat Trout	1	0.4	0.3	0.1	0.01
ID	Lochsa River	Mountain Whitefish	1	0.5	0.3	0.1	0.01
ID	Long Meadows Creek	Rainbow Trout	3	0.6	0.5	0.2	0.02
OR	Lookout Creek	Cutthroat Trout	46	0.3	0.2	0.1	0.0
OR	Lookout Creek	Rainbow Trout	5	0.1	0.1	0.0	0.004
ID	Louse Creek	All Species	9	0.9	0.7	0.3	0.03
ID	Louse Creek	Bridgelip Sucker	1	0.7	0.5	0.2	0.02
ID	Louse Creek	Redband Trout	7	0.9	0.7	0.3	0.03
ID	Louse Creek	Sucker	1	**1.1**	0.8	0.3	0.03
OR	Marks Creek	Rainbow trout	9	0.3	0.2	0.1	0.01
WA	Methow River	All Species	2	0.3	0.2	0.1	0.01
WA	Methow River	Cutthroat Trout	1	0.3	0.2	0.1	0.01
WA	Methow River	Mountain Whitefish	1	0.3	0.2	0.1	0.01
OR	Middle Fork John Day River	All Species	6	0.9	0.6	0.2	0.000002
OR	Middle Fork John Day River	Largescale Sucker	3	**1.4**	**1.0**	0.4	0.04
OR	Middle Fork John Day River	Mountain Whitefish	3	0.4	0.3	0.1	0.01
WA	Nason Creek	Mountain Whitefish	3	0.7	0.5	0.2	0.02
WA	Nisqually River	Coho Salmon	38	0.4	0.3	0.1	0.01
WA	North Fork Big Lost River	Brown Trout	1	0.6	0.4	0.2	0.02
ID	North Fork Clearwater River	Mountain Whitefish	1	0.9	0.7	0.2	0.03

OR	North Fork John Day River	Mountain Whitefish	5	0.6	0.4	0.2	0.02
OR	North Fork John Day River	Smallmouth Bass	4	**1.3**	0.9	0.4	0.04
ID	North Fork Payette River	Rainbow Trout	1	**1.2**	0.9	0.3	0.03
WY	North Leigh Creek	All Species	5	0.3	0.2	0.1	0.01
WY	North Leigh Creek	Brown Trout	3	0.3	0.2	0.1	0.01
WY	North Leigh Creek	Cutthroat Trout	2	0.3	0.2	0.1	0.01
WA	North River	Cutthroat Trout	1	0.6	0.5	0.2	0.02
OR	North Santiam River	Cutthroat Trout	1	0.3	0.2	0.1	0.01
OR	Oak Grove Fork Clackamas	All Species	3	0.8	0.6	0.2	0.02
OR	Oak Grove Fork Clackamas	Cutthroat Trout	1	0.8	0.6	0.2	0.02
OR	Oak Grove Fork Clackamas	Rainbow Trout	2	0.8	0.6	0.2	0.02
OR	Ochoco Creek	Rainbow Trout	9	**1.0**	0.7	0.3	0.03
WA	Okanogan River	Smallmouth Bass	21	**1.4**	**1.0**	0.4	0.04
OR	Owyhee River	Largemouth Bass	1	**5.3**	**3.9**	**1.5**	0.2
WA	Palouse River	All Species	11	**1.7**	**1.246**	0.5	0.0
WA	Palouse River	Largemouth Bass	2	**1.9**	**1.4**	0.5	0.1
WA	Palouse River	Largescale Sucker	5	**1.4**	**1.0**	0.4	0.04
WA	Palouse River	Smallmouth Bass	2	**1.9**	**1.4**	0.5	0.06
WA	Pataha Creek	Brook Trout	1	0.8	0.6	0.2	0.02
ID	Payette River	All Species	8	**1.3**	**1.0**	0.4	0.04
ID	Payette River	Mountain Whitefish	3	0.5	0.4	0.1	0.02
ID	Payette River	Bridgelip Sucker	1	**2.1**	**1.5**	0.6	0.1
ID	Payette River	Channel Catfish	1	**1.7**	**1.2**	0.5	0.05
ID	Payette River	Largescale Sucker	2	**2.0**	**1.5**	0.6	0.1
ID	Payette River	Smallmouth Bass	1	**1.1**	**0.8**	0.3	0.03
WA	Pend Oreille River	All Species	10	**1.6**	**1.2**	0.4	0.04
WA	Pend Oreille River	Brown Trout	4	**1.2**	**0.9**	0.3	0.03
WA	Pend Oreille River	Largescale Sucker	6	**1.8**	**1.3**	0.5	0.1

ID	Portneuf River	All Species	22	**3.5**	**2.6**	**1.0**	0.1
ID	Portneuf River	Brown Trout	11	**4.1**	**3.0**	**1.2**	0.1
ID	Portneuf River	Rainbow Trout	8	**2.7**	**2.0**	0.8	0.1
ID	Portneuf River	Utah Sucker	1	**1.7**	**1.3**	0.5	0.05
ID	Portneuf River	Yellowstone Cutthroat Trout	2	**6.0**	**4.4**	**1.7**	0.2
OR	Powder River	Bridgelip Sucker	1	**2.9**	**2.1**	0.8	0.1
ID	Priest River	All Species	2	**1.9**	**1.4**	0.5	0.1
ID	Priest River	Largescale Sucker	1	**2.5**	**1.8**	0.7	0.1
ID	Priest River	Smallmouth Bass	1	**1.4**	**1.01**	0.4	0.04
OR	Pudding River	All Species	6	**1.6**	**1.2**	0.4	0.04
OR	Pudding River	Largescale Sucker	3	**1.0**	0.7	0.3	0.03
OR	Pudding River	Smallmouth Bass	3	**2.2**	**1.6**	0.6	0.1
OR	Quartz Creek	Cutthroat Trout	1	0.3	0.2	0.1	0.01
ID	Rock Creek	Brown Trout	3	**1.5**	**1.1**	0.4	0.04
OR	Row River	All Species	41	**3.9**	**2.8**	**1.1**	0.1
OR	Row River	Cutthroat Trout	1	**1.1**	0.8	0.3	0.03
OR	Row River	Largemouth Bass	23	**5.6**	**4.1**	**1.6**	0.2
OR	Row River	Largescale Sucker	4	**4.8**	**3.6**	**1.4**	0.1
OR	Row River	Rainbow Trout	13	0.8	0.6	0.2	0.02
ID	Saint Joe River	All Species	5	**1.2**	0.9	0.3	0.03
ID	Saint Joe River	Brook Trout	1	**1.5**	**1.1**	0.4	0.04
ID	Saint Joe River	Cutthroat Trout	2	0.4	0.3	0.1	0.01
ID	Saint Joe River	Largemouth Bass	1	**3.2**	**2.4**	0.9	0.09
ID	Saint Joe River	Mountain Whitefish	1	0.4	0.3	0.1	0.01
ID	Saintt Joe River	Cutthroat Trout	2	0.3	0.2	0.1	0.01
ID	Salmon River	All Species	24	**2.0**	**1.5**	0.6	0.06
ID	Salmon River	Mountain Whitefish	13	**1.3**	**1.0**	0.4	0.04
ID	Salmon River	Smallmouth Bass	7	**3.4**	**2.5**	**1.0**	0.1

ID	Salmon River	Sucker	4	**1.8**	**1.29**	0.5	0.05
OR	Sandy River	All Species	6	**1.2**	0.9	0.4	0.04
OR	Sandy River	Largescale Sucker	3	**1.9**	**1.4**	0.5	0.05
OR	Sandy River	Mountain Whitefish	3	0.6	0.5	0.2	0.02
WA	Sanpoil River	All Species	2	**1.7**	**1.2**	0.5	0.05
WA	Sanpoil River	Brook Trout	1	**2.1**	**1.5**	0.6	0.06
WA	Sanpoil River	Rainbow Trout	1	**1.2**	0.9	0.4	0.04
NV	Schack Creek	Rainbow Trout	3	0.2	0.2	0.1	0.01
ID	Selway River	All Species	6	0.8	0.6	0.2	0.02
ID	Selway River	Brook Trout	1	**1.4**	**1.0**	0.4	0.04
ID	Selway River	Cutthroat Trout	2	0.5	0.3	0.1	0.01
ID	Selway River	Mountain Whitefish	1	0.7	0.5	0.2	0.02
ID	Silver Creek	All Species	65	**2.6**	**1.9**	0.7	0.1
ID	Silver Creek	Brown Trout	55	**2.9**	**2.1**	0.8	0.1
ID	Silver Creek	Rainbow Trout	10	**1.0**	0.7	0.3	0.03
WA	Similkameen River	Smallmouth Bass	1	**1.3**	**1.0**	0.4	0.04
WA	Sinlahekin River	All Species	2	0.5	0.4	0.2	0.02
WA	Sinlahekin River	Rainbow Trout	1	0.5	0.4	0.1	0.01
WA	Sinlahekin River	Mountain Whitefish	1	0.6	0.4	0.2	0.02
WA	Skagit River	All Species	37	0.3	0.3	0.1	0.01
WA	Skagit River	Coho Salmon	36	0.3	0.2	0.1	0.01
WA	Skagit River	Mountain Whitefish	1	0.5	0.4	0.1	0.02
ID	Snake River	All Species	290	**2.4**	**1.7**	0.7	0.1
OR/ID	Snake River	Bottom Feeders	2	**2.6**	**1.9**	0.7	0.1
ID	Snake River	Brown Trout	1	**2.2**	**1.6**	0.6	0.1
ID	Snake River	Channel Catfish	29	**2.6**	**1.9**	0.7	0.1
WA	Snake River	Cutthroat Trout	3	0.7	0.5	0.2	0.02
OR/ID	Snake River	Largescale Sucker	10	**2.8**	**2.1**	0.8	0.1

ID	Snake River	Mountain Whitefish	32	0.9	0.69	0.3	0.03
ID	Snake River	Rainbow Trout	43	**1.2**	0.9	0.3	0.03
ID	Snake River	Smallmouth Bass	91	**3.1**	**2.3**	0.9	0.1
ID	Snake River	Sucker	4	**2.1**	**1.5**	0.6	0.1
ID	Snake River	Utah Chub	11	**2.0**	**1.5**	0.6	0.1
ID	Snake River	Utah Sucker	38	**3.8**	**2.8**	1.1	0.1
ID	Snake River	Yellowstone Cutthroat	26	**1.3**	**1.0**	0.4	0.04
WA	South Fork Ahtanum Creek	Cutthroat Trout	1	0.4	0.3	0.1	0.01
ID	South Fork Boise River	Smallmouth bass	1	**1.6**	**1.1**	0.4	0.04
ID	South Fork Coeur 'd Alene River	Mountain Whitefish	1	0.4	0.3	0.1	0.01
NV/OR	South Fork Owyhee River	All Species	2	**3.1**	**2.3**	0.9	0.1
NV	South Fork Owyhee River	Bridgelip Sucker	1	0.9	0.7	0.3	0.03
OR	South Fork Owyhee River	Largemouth Bass	1	**5.3**	**3.9**	**1.5**	0.2
WA	South Fork Palouse River	Largescale Sucker	14	**1.9**	**1.4**	0.5	0.1
ID	South Fork Payette River	Rainbow Trout	2	**2.3**	**1.7**	0.6	0.1
WA	South Fork Skykomish River	Mountain Whitefish	1	0.5	0.4	0.2	0.02
WA	South Fork Skykomish River	Mountain Whitefish	1	0.5	0.4	0.2	0.02
ID /WA	Spokane River	All Species	65	0.8	0.6	0.2	0.02
WA	Spokane River	Largemouth Bass	26	0.9	0.7	0.3	0.03
WA	Spokane River	Rainbow Trout	3	0.2	0.1	0.1	0.01
ID	Spokane River	Smallmouth Bass	30	0.4	0.3	0.1	0.01
WA	Spokane River	Largescale Sucker	6	2.5	**1.8**	0.7	0.1
WA	Strawberry Creek	All Species	2	0.4	0.3	0.1	0.01
WA	Strawberry Creek	Brook Trout	1	0.6	0.4	0.2	0.02
WA	Strawberry Creek	Rainbow Trout	1	0.3	0.2	0.1	0.01
ID	Texas Slough Canal	All Species	18	0.5	0.4	0.1	0.01
ID	Texas Slough Canal	Cutthroat Trout	6	0.7	0.5	0.2	0.02
ID	Texas Slough Canal	Rainbow Trout	6	0.5	0.4	0.1	0.02

ID	Texas Slough Canal	Utah Sucker	6	0.3	0.2	0.1	0.01
ID	Tributary Long Meadows Creek	Rainbow Trout	3	0.6	0.4	0.2	0.02
WA	Umtanum Creek	Rainbow Trout	3	**1.0**	0.7	0.3	0.03
WA	Walla Walla River	Smallmouth Bass	21	**1.5**	**1.1**	0.429	0.04
WA	Wenatchee River	All Species	43	0.4	0.3	0.1	0.01
WA	Wenatchee River	Bridgelip Sucker	3	0.3	0.2	0.1	0.01
WA	Wenatchee River	Largescale Sucker	9	0.5	0.4	0.1	0.02
WA	Wenatchee River	Longnose Sucker	3	0.2	0.2	0.1	0.01
WA	Wenatchee River	Mountain Whitefish	22	0.3	0.3	0.1	0.01
WA	Wenatchee River	Rainbow Trout	6	0.3	0.2	0.1	0.01
ID	West Brownlee Creek	Rainbow Trout	2	**2.1**	**1.6**	0.604	0.06
WA	White River	All Species	10	0.6	0.4	0.2	0.02
WA	White River	Cutthroat Trout	1	0.5	0.4	0.2	0.02
WA	White River	Largescale Sucker	3	0.9	0.7	0.3	0.03
WA	White River	Mountain Whitefish	6	0.4	0.3	0.1	0.01
OR	Willamette River	All Species	197	**1.7**	**1.3**	0.5	0.05
OR	Willamette River	Chinook Salmon	20	0.3	0.2	0.1	0.01
OR	Willamette River	Largemouth Bass	25	**3.0**	**2.2**	0.8	0.1
OR	Willamette River	Largescale sucker	70	**1.8**	**1.3**	0.5	0.05
OR	Willamette River	Mountain Whitefish	3	**1.3**	0.9	0.4	0.04
OR	Willamette River	Small Mouth Bass	72	**1.6**	**1.2**	0.4	0.05
OR	Willamette River	Sturgeon	7	**2.1**	**1.5**	0.6	0.1
ID	Williams Creek	Cutthroat Trout	2	**1.1**	0.8	0.3	0.03
WA	Yakima River	All Species	60	**2.5**	**1.9**	0.7	0.1
WA	Yakima River	Brown Trout	4	**1.2**	0.9	0.3	0.03
WA	Yakima River	Largemouth Bass	2	**2.8**	**2.0**	0.8	0.1
WA	Yakima River	Largemouth Sucker	6	**5.5**	**4.0**	**1.6**	0.2
WA	Yakima River	Largescale Sucker	3	0.76	0.6	0.2	0.02

WA	Yakima River	Longnose Sucker	3	**1.3**	**1.0**	0.4	0.04
WA	Yakima River	Mountain Whitefish	5	0.8	0.6	0.2	0.02
WA	Yakima River	Smallmouth Bass	37	**3.1**	**2.3**	0.9	0.1

The bold numbers in each column indicate that there is a non-cancer risk of potential concern because the risk value exceeds 1. The numbers that are not bold indicate that the health risk is of no concern because the Hazard Quotient is less than 1. gpd = grams per day of consumed fish in each consumption scenario. R = river. HQ are in mg/kg.

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