

**A Fish Consumption Survey
of the
[Shoshone-Bannock Tribes] [Nez Perce Tribe]
Combination Draft Final Report**

*****Note: there will be a separate final report for each of the Tribes
in September, 2015. *****

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Volume II—Current Fish Consumption Survey

Volume III—Appendices to Current Fish Consumption Survey

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Volume I—Heritage Rates

DRAFT

HERITAGE FISH CONSUMPTION RATES OF THE NEZ PERCE TRIBE

Prepared for the
Nez Perce Tribe

Prepared by
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LIST OF ABBREVIATIONS AND ACRONYMS

EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FCR	fish consumption rate
ICC	Indian Claims Commission
IDFG	Idaho Department of Fish and Game
NPT	Nez Perce Tribe

LIST OF UNITS

%	percent
cal/d	calories per day
g/d	grams per day
kCal	kilocalories
km	kilometers
lb/d	pounds per day
lb/yr	pounds per year

1.0 INTRODUCTION

A study of heritage fish consumption rates was conducted for the Nez Perce Tribe. The study was done as part of a larger fish consumption survey of federally recognized Tribes in Idaho, which was initiated by the U.S. Environmental Protection Agency in 2013. This report presents the results of the Nez Perce Tribe's heritage rate research, which was based upon an evaluation of available ethnographic literature on aboriginal fish consumption by Columbia Basin Tribes and other influential studies that have supported previous estimates of heritage rates.

1.1 Purpose and Objectives

Tribal Governments in the State of Idaho are working closely with the U.S. Environmental Protection Agency (EPA) Region 10, the State of Idaho, and other stakeholders to gather data on fish consumption rates (FCRs). The overarching goal of this process is to obtain information on fish consumption to enable Tribal governments to set water quality standards for tribal waters, and to allow Tribes to meaningfully participate as informed partners in Idaho DEQ's ambient water quality criteria review process that impacts tribal interests. A Tribal heritage rate study was conducted as part of this effort.

Recognizing that current Tribal fish consumption is suppressed due to a number of factors (e.g. decreased fish populations due to physical habitat modifications and adverse effects of chemical contamination, loss of Tribal access to fisheries resources, fears of exposure to contaminants in fish, and changes in fish harvesting by Tribal members associated adaptation to economic and cultural shifts), this study compiled and evaluated available data to determine heritage fish consumption rates for the Nez Perce Tribe (NPT). Knowledge of past rates may help determine how current fish consumption rates might increase in the future if current fisheries resources are improved and fish consumption is restored to past, higher levels. Information about fish consumption rates may be used to support development of water quality standards that protect human health.

Water quality is of great importance to the Nez Perce Tribe, since a substantial portion of their diet is derived from aquatic sources, and water and aquatic resources are of great cultural and spiritual significance. As part of the survey effort, discussions with the Tribe highlighted the issue of suppression of current fish consumption and its causes. Therefore, the survey team agreed to review and

evaluate heritage rates available in the literature, which may be more relevant than current suppressed rates to the long-term restoration goals of the Tribe.

The Nez Perce Tribe has treaty reserved fishing rights within the Columbia Basin and Snake River basins. In the Snake River Basin, the Nez Perce Tribe has quite possibly the largest number of tributary salmon and steelhead fisheries which can often occur year-round across the states of Washington, Oregon and Idaho. The NPT has usual and accustomed fishing places throughout 13 million+ acres that have been found to be exclusively used and occupied by the Tribe (including the major portions of the Snake, Tucannon, Imnaha, Grande Ronde, Salmon and Clearwater Rivers and their drainages); the mainstem Columbia River; and other locations in the Columbia/Snake River Basin.

The Nez Perce Tribe's primary objective for the fish consumption survey is to support development of more stringent water quality standards that are protective of tribal members' consumption of fish. The Tribe's culture is and always has been intimately tied to fish, which is a staple of their diet and an integral part of their society; poor water quality impedes fish survival and can affect both the quantity and availability of fish that can be harvested and safely consumed by tribal members. The NPT has a vision of restoring fish species native to the Nez Perce Treaty Territory. To accomplish this vision, the Tribe has engaged in managing the resident and anadromous fish species in the streams, lakes, and watersheds within their management authority in an effort to rebuild habitat and restore opportunities for fish harvest. Their goal is that fish will be found in all available habitats and will provide fishing opportunities for present and future generations. Increased fisheries resources will support higher fish consumption.

1.2 Study Approach

The approach for estimating heritage rates was based on a comprehensive review and evaluation of literature that is relevant to heritage rates, including historical accounts and modern studies of heritage consumption. For Tribes that harvest fish from the Columbia Basin, there is a significant volume of literature to form the basis for a range of quantitative estimates of fish consumption.

Information includes ethnographic studies, personal interviews, historical harvest records, archaeological and ecological information, and nutritional and dietary information. The quantitative assessment includes compilation and analysis of historic and heritage information across the region of the Columbia Basin.

The survey team compiled and evaluated available information regarding heritage consumption rates relevant to the Nez Perce Tribe. The development of estimates of heritage rates presented here includes a discussion of the available information, including methodologies used to develop the fish consumption estimates and factors affecting the uncertainty associated with the estimates. Based on available information, a quantitative range of heritage fish consumption rates is presented for the Tribe.

2.0 BACKGROUND

The Nez Perce Tribe has relied extensively on fish resources and fishing activities throughout time. A summary of the fish harvest and extensive use and consumption of fish historically, as well as the causes of decline in fish availability over time, is provided for context.

2.1 Summary of Historical Fish Harvest and Consumption

The Nez Perce are a large Northwest tribe with a culture tied closely to fish. Since time immemorial, the Tribe occupied a territory covering more than 13 million acres that included what is today north central Idaho, southeastern Washington, and northeastern Oregon. The Nez Perce subsistence cycle involved traveling year to year on the same well-traveled routes through the canyons of the Snake, Tucannon, Clearwater, Grande Ronde, Imnaha and Salmon Rivers, primarily to follow the salmon runs. In addition to those rivers and their tributaries, the Nez Perce historically took part in the fishing and trading that occurred between several of the region's tribes at Celilo Falls on the Columbia River, among other locations of the Columbia Basin.

The Tribe has always fished. Their economy and culture evolved around Northwest fish runs. Their persistence can be attributed in large part to the abundance of fish, which has served as a primary food source, trade item and cultural resource for thousands of years. Settlement by others in the last 150 years has disrupted people of the Tribe and the natural resources (NPT, 2005). The degree to which the Tribe is culturally coupled to fish was recognized in treaties signed between the Tribe and the United States Government. The same treaties that confined the Tribe to a fraction of their former territory also guaranteed their access to fishery resources. Article III of the Treaty of 1855 guarantees to the Tribe:

“The exclusive right of taking fish in all the streams running through or bordering said reservation ... as also the right of taking fish at all usual and accustomed places in common with citizens of the Territory.” Treaty with the Nez Perces, 12 Stat. 957 (1859).

The 1855 Treaty Council at Walla Walla and the Treaty negotiations reflect the Tribe's inherent tribal sovereignty and its “aboriginal title” to land. At the Treaty Council, the United States sought to clear title to lands; the Nez Perce sought to reserve and maintain a homeland (“Reservation”) and reserve its aboriginal

rights and way of life. The Nez Perce would not have signed this treaty without first receiving assurances that these rights, including the right to fish, would be protected into the future. Additional treaties between the two sovereigns have been made, but the reserved fishing right has remained unchanged since 1855.

In its 1855 Treaty, the Nez Perce reserved a significant portion of their aboriginal land (about 8 million acres). And, this Nez Perce homeland contained, as the United States recognized, many of the best fisheries:

Gov. Stevens said: "Here (showing a draft on a large scale) is a map of the Reservation. There is the Snake River. There is the Clear Water river. Here is the Salmon river. Here is the Grande Ronde river. There is the Palouse river. There is the El-pow-wow-wee. This is a large Reservation. The best fisheries on the Snake River are on it..."

Moreover, in addition to this homeland, Nez Perce leaders insisted on reserving off-reservation hunting, fishing, gathering, and pasturing rights. The minutes of the treaty negotiations reflect Governor Stevens' repeated assurances, on behalf of the United States, that the treaty would reserve these off-reservation rights to the Nez Perce Tribe:

You will be allowed to pasture your animals on land not claimed or occupied by settlers, white men. You will be allowed to go on the roads, to take your things to market, your horses and cattle. You will be allowed to go to the usual and accustomed fishing places and fish in common with the whites, and to get roots and berries and to kill game on land not occupied by the whites; all this outside the Reservation:"

Gov. Stevens said: "I will ask of Looking Glass whether he has been told of our council. Looking Glass knows that in this reservation settlers cannot go, that he can graze his cattle outside of the reservation on lands not claimed by settlers, that he can catch fish at any of the fishing stations, that he can kill game and can go to Buffalo when he pleases, that he can get roots and berries on any of the lands not occupied by settlers..."

Fish, as a staple of the Nez Perce diet, have always been an integral part of the Nez Perce society. Principal to the Nez Perce diet were the anadromous fish species that inhabit the rivers of the inland northwest. This is corroborated by other existing information such as those from federal court proceedings.

For example, in its 1967 decision concerning the Nez Perce Tribe, the Indian Claims Commission (ICC) made comprehensive findings based on detailed anthropological evidence from both the United States and the Nez Perce Tribe, of the Tribe's area of "exclusive use and occupancy" and "aboriginal ownership." The ICC determined that the Nez Perce had "exclusive use" and occupancy of 13,204,000 acres of land and "that salmon fishing was one of the major sources of subsistence since the main rivers through the area, which include the Snake, the Clearwater, the Salmon, and their branches, were well supplied with this fish in aboriginal times." It also concluded that their seasonal "cycle consists of specific times of the year for fishing for salmon, digging camas and other roots, hunting the game"; this "economic cycle can generally be summarized as ten months salmon fishing and two months berry picking, with hunting most of the year."¹

During the time that the treaty was negotiated, the salmon resource reserved by the Nez Perce came from "...river systems that were biologically functional and fully productive..." (Meyer Resources, 1999). The decline of salmon productivity since the mid-1800s to present, does not alter, change, or abrogate the Nez Perce treaty right to take fish. This right to take fish represents an inherent right that the Nez Perce have held since time immemorial. The fishing right is as important to the Nez Perce today as it was before contact with non-Indians.

The Nez Perce governed where fishing occurred, how many fish were to be harvested, who could participate, how to use the resource, and ways to honor and perpetuate the resource. They developed ways to harvest large amounts of fish. These were documented as proven methods to catch the substantial numbers of salmon and steelhead (as well as other species of fish). The complex, elaborate, and efficient Nez Perce fishing techniques described below document the extent of their reliance on this valuable resource and the importance of fish to its society and cultural identity.

¹ The ICC was created by Congress in 1946 to hear claims by Indian tribes for, among other things, compensation for the taking of aboriginal lands by the United States without fair payment. Compensable aboriginal title was required to be based on "actual and exclusive use and occupancy 'for a long time' prior to the cession, transfer, or loss of the property." It provided historical information regarding Nez Perce village sites, uses of natural resources, and range and extent of natural resource use.

Whenever possible, the Nez Perce historically and contemporarily have regularly fished for the following species: Chinook, Coho, and Sockeye varieties of salmon; Dolly Varden, Cutthroat, Brook, Lake, and Rainbow varieties of trout; several species of suckers, white fish, sturgeon, squawfish (Northern pikeminnow), lampreys, and some shellfish (freshwater clams). In order to harvest these fish species, the Nez Perce developed a number of fishing techniques and methods: weirs and traps; dipping platforms (either natural or man-made); fish walls and dams; canoes; spears; hook and line; gaffs; and variety of nets (dipnets, set nets, and throw nets).

The expansive territory of the Nez Perce people was rich in rivers and streams abundant in fish life. Bands fished from the Snake, Salmon, Clearwater, Imnaha, Grand Ronde, Selway, Tucannon, Rapid River and many other rivers within and outside its homeland and territory. As with other tribes, the Nez Perce did not limit their fishing to salmon. Research has been conducted by a number of people in an effort to determine how many fish were historically harvested by the Nez Perce. There are a number of methods to estimate amount of fish harvested and consumed by the Nez Perce (commonly expressed in numbers of fish harvested and annual per capita consumption).

In addition to salmon and steelhead, the Tribe has traditionally harvested Snake River white sturgeon for subsistence purposes. Tribal elders confirm the historical presence of white sturgeon throughout the Snake River, mainstem Salmon River, the Clearwater River from its mouth to above Orofino, Idaho, as well as seasonal migrations into the Grande Ronde River (Elmer Crow, Nez Perce Tribe Department of Fisheries Resources Management, Personal Communication, 2014). In addition to being an important food source, white sturgeon served many purposes in the culture of the Tribe. White sturgeon blood was used to make glue; the hides were used for bow cases and quivers, and for water proofing footwear. However, subsistence fishing has been severely limited as a result of low white sturgeon numbers between Hells Canyon and Lower Granite dams (NPT, 2005).

The traditional way of life for the Nez Perce (e.g. gathering, harvesting, ceremonies, and traditions) depends on continuance of the circle of life for all native species (plants and animals). To the Nez Perce, the rights reserved under the Treaty of 1855 must be protected such that the enjoyment of these rights resembles that envisioned by the treaty signers and Nez Perce leaders.

2.2 Summary of Causes of Decline in Fish Populations

Nez Perce tribal elders believe that one of the greatest tragedies of this century is the loss of traditional fishing sites and Chinook salmon runs on the Columbia River and its tributaries. They believe the circle of life has been broken and ask us to consider what the consequences of breaking that circle may mean for future generations. In many ways the loss of the salmon mirrors the plight of the Nez Perce people. The elders remind us that the fates of humans and salmon are linked (Landeem and Pinkham, 1999). This dependence on fish to meet dietary, spiritual, and basic subsistence needs is still a prevailing necessity of Nez Perce life. To this day, the right to a “fair share” of the salmon harvest by the Nez Perce Tribe does not occur because of the impacts to these fish by non-Indian activities and development in the Columbia and Snake basins.

The Nez Perce lived in the heart of salmon country – along the Salmon, Snake, Grande Ronde, Imnaha, Clearwater and Tucannon rivers; which historically were major salmon and steelhead producers. The Nez Perce have lived through and experienced the extirpation of entire populations of fish by blocking and altering of thousands of miles of rivers and streams as result of dams. The Hells Canyon, Oxbow, and Brownlee dams on the Snake River, Wallowa Lake Dam on the Wallowa River, Dworshak Dam on the North Fork Clearwater, the eight major dams on the Columbia and Snake rivers, and the many other smaller projects, have individually and collectively impacted fish, and thus the Nez Perce ability to fish for them.

The environment and water that support fish has been altered due to human development and enterprise over the past century and a half. This human progress has come at a cost to the fish species and “salmon people.” Current productivity of salmon- producing streams is much lower than it was historically. Many of the fish species either face extinction or are in seriously depressed conditions. As a result, tribal harvest in the present day is only a very small fraction of what the Nez Perce harvested in the mid- 1800s. Although hard to quantify, it is probable that until recently harvest has been less than 1% of historic harvest levels prior to 1855.

Causes contributing to salmon and steelhead decline encompass a variety of human activities and anthropogenic and natural phenomena. These include the following: commercial, recreational, and subsistence fishing; freshwater and estuarine habitat alteration due to urbanizing, farming, logging, and ranching; dams built and operated for electricity generation and flood control; water withdrawals for agricultural, municipal, or commercial needs; stream and river

channel alterations; hatchery production; predation by marine mammals, birds, and other fish species; competition with other fish species; diseases and parasites; and reduction in annual nutrient distribution from spawned-out salmon to the local ecosystem. These activities continue to affect fish.

Salmon and steelhead runs in the Snake Basin are not as abundant or productive as they were historically. Snake River Chinook salmon (spring, summer, and fall runs), sockeye, and steelhead are listed under the Endangered Species Act (ESA). Coho and Chinook salmon were extirpated in the Clearwater River subbasin in the 1990s, and steelhead were at very depressed levels.

Snake River spring/summer Chinook salmon were historically found spawning in the Snake River tributaries of the Clearwater, Salmon, Weiser, Payette, and Boise Rivers. A review of run size for Snake River of spring/summer Chinook salmon is provided by Matthews and Waples (1991). Their summary of research on run size reports historic runs in the Snake River probably exceeded one million fish annually in the late 1800s. By the mid-1900s, the abundance of adult spring and summer Chinook salmon had greatly declined to near 100,000 adults per year in the 1950s. Since the 1960s, counts of spring and summer Chinook salmon adults have declined considerably at the lower Snake River dams (IDFG, 2013).

The construction of hydroelectric dams on the main stem Snake and Columbia Rivers blocked access to nearly half of the historic spawning habitat and reduced survival of juveniles and adults migrating to and from the ocean. Additional effects from hydroelectric dams and water storage projects have resulted in altered hydrographs and water temperature regimes affecting run timing of juveniles and adults. Diversions in spawning and rearing streams have caused direct mortality, loss of habitat and migration barriers. Land management activities have resulted in degraded habitat with the loss of riparian cover, sedimentation and artificial barriers to passage. The addition of hatchery programs to mitigate for lost habitat and survival of fish have introduced genetic concerns about effects to wild stocks. Declining water quality from increasing development in and along river and tributary streams can affect fish populations. Introductions of non-native fish in some waters can increase predation and competition with juvenile fish (IDFG, 2013).

Salmon runs in the Clearwater River Subbasin were virtually eliminated by the construction of hydroelectric dams (Matthews and Waples, 1991). In 1910, the Harpster Dam, constructed on the lower South Fork Clearwater River, prevented all fishes from returning upstream of Harpster, ID, and eliminated access to over

95% of the watershed and its high quality spawning grounds (Schoning, 1940). In 1927, the Washington Water Power Diversion Dam constructed just above the mouth of the Clearwater River eliminated all upriver salmon runs (Parkhurst, 1950; USFWS, 1962). A crude fish ladder was built on the lower Clearwater River dam, which allowed steelhead passage during higher flow periods, but proved almost impassible during lower flows when salmon arrived (Parkhurst, 1950). The ladder was not modified for a period of 12 to 14 years; eliminating all late returning fish, like coho and fall Chinook salmon (all as cited in Everett, et al, 2006).

The cumulative loss of anadromous fish to the Nez Perce Tribe as a result of these two dams was substantial (Cramer, et al., 1993). The Harpster Dam was removed in 1963 and the lower Clearwater River dam was removed in 1972, making available most of the salmon production areas in the drainage. However in 1971, Dworshak Dam was built just upstream of the mouth of the North Fork Clearwater River. Dworshak Dam lacks fish passage, resulting in the permanent loss of productive salmonid spawning aggregates and high quality habitat. The lower Clearwater River temperature regime continues to be altered by Dworshak Dam, resulting in warmer water in the winter and cooler water in the summer (Arnsberg, et al., 1992, Arnsberg and Statler, 1995; all as cited in Everett et al., 2006).

Currently, a majority of the fisheries that occur in the Snake River basin are supported by hatchery programs. All of the anadromous fish hatcheries in the Snake River basin are mitigation hatcheries for the development of hydroelectric dams. All of the returns from these hatcheries pass through or return to the Nez Perce Tribe's usual and accustomed fishing places.

3.0 HERITAGE FISH CONSUMPTION RATES

A summary of the primary source literature reviewed for this heritage rate study is provided here, including a definition of “fish consumption,” as used differently by various authors, and certain factors and other assumptions that have been used to adjust and/or calculate consumption rates. Also presented below are the average aboriginal per capita fish consumption rates estimated for the Columbia Basin Tribes (summarized in Table 1) and rates for the Nez Perce Tribe specifically (summarized in Table 2).

3.1 Defining Fish Consumption

The focus of this effort is to compile, summarize, and evaluate estimates of Tribal fish consumption during the period when Tribes had full access to their traditional fisheries, which we refer to here as “heritage rates.” This effort is intended to provide Tribes with information that may be useful in establishing water quality criteria for the protection of human health. The information supporting heritage rates is on a per capita basis that can be used to estimate average fish consumption rates, however this information is not suitable for development of fish consumption rate distributions or percentiles of fish consumption.

As evident in review of the documentary record, the definition of fish consumption as fish *ingestion* is not necessarily shared by the various researchers who have attempted to estimate aboriginal fish consumption rates for various Tribal groups. Several researchers include all uses of fish in what they describe as a “total consumption rate.” For example, one researcher (Schalk, 1986), suggested that a previously calculated consumption estimate was too low because it “only considers human dietary demands.” Another (Griswold, 1954) stated that “[t]he tribes here required salmon for fuel as well as for food. Consequently, it may be inferred that their per capita consumption was considerably greater than that of the tribes [downstream] below.” Still another, (Walker, 1967) discussed “exceptional areas of unusually high consumption, up to 1000 lbs. per capita, per year” which are “caused not only by the high calorie demands typical of colder climates, but also by the use of fish for dog food or for fuel.”

Estimates by various researchers, therefore, may include as part of a total fish consumption rate that portion of the overall fish harvest that was used for trade, for fuel, for animal feed, or may include the inedible portion of fish not actually

ingested. To the extent that it is discussed in the literature, this report attempts to describe the assumptions involved in estimating a consumption rate, and, where possible and appropriate, identify that portion that was actually ingested.

3.2 Defining Factors Influencing Consumption Rates

Many sources of information providing estimates of heritage fish consumption rates for Tribal groups in the Columbia Basin tend to refer to or build upon previous work, in some cases revising or adjusting rates from previous reports based on new knowledge, new data, or new approaches for interpreting consumption information. Some authors have attempted to revise earlier estimates of fish consumption, particularly those estimates based on caloric intake, to account for the caloric losses that occur as a result of salmon spawning migration (“migration calorie loss factor”) and to account for the fact that not all of an individual fish is consumed (“waste loss factor”). Each of these factors and their effect on consumption estimates, as well as other variables that influence the calculation of consumption rates, are discussed below.

3.2.1 Migration Calorie Loss Factor

Eugene Hunn (1981) appears to be the first author to suggest modifying the calorie-based fish consumption estimates originally developed by Gordon Hewes (1947, 1973). While Hunn considered Hewes’ estimates of salmon consumption to be “the most comprehensive attempted to date for the region” he contends that “his interpretation of the nutritional factors is misleading.” Specifically, Hewes’s caloric calculations did not account for the calories that salmon lose during spawning migration (since migrating salmon no longer feed once they re-enter freshwater).

Citing a study by Idler and Clemens (1959), who determined that sockeye salmon lose 75 percent of their caloric potential during spawning migration in the Fraser River watershed, Hunn proposed the following approach, as transferred to the Columbia River watershed: the “migration calorie loss factor” is computed as a ratio of (a) the distance in river-kilometers (km) from the mouth of the Columbia River to the approximate middle of each group’s territory, to (b) the entire length of the Columbia River (1,936 km). This ratio was then multiplied by the average value for calorie loss during salmon migration, 75 percent (0.75), and the product was subtracted from one. For example, a salmon harvested halfway to the headwaters of the Columbia River is assumed to have lost half of 75 percent, or 37.5 percent (0.375) of its beginning caloric potential, and, therefore, would retain 62.5 percent of its beginning caloric potential ($1 - 0.375 = 0.625$), which is considered the migration calorie loss factor. Based in part on this

adjustment, Hunn suggested that Hewes likely overestimated the calories provided by salmon, and therefore salmon's contribution to the overall diet, and that "vegetable resources" likely played a larger dietary role than assumed by other authors. In fact, he concluded that the food collecting societies of the southern half of the Columbia-Fraser Plateau "obtained in the neighborhood of 70% of their food energy needs from plant foods harvested by women."

Other authors (e.g., Scholz et al., 1985; Schalk, 1986) have taken a different approach and assumed that Hewes was correct about the proportion of the diet supplied by salmon (on average 50 percent, or about 1,000 calories), but by not accounting for migration calorie loss, Hewes likely underestimated salmon consumption rates, particularly for upriver Tribes (as Schalk, 1986, stated, "some adjustment should have been made for distance traveled upstream"). To account for this, Schalk divided the consumption estimates developed by Hewes by a specific migration calorie loss factor determined for each Tribal group, following the approach described above.

Again using the example of a salmon harvested halfway to the headwaters of the Columbia River, Hewes's estimate for average per capita consumption for the Columbia Basin tribes of 365 pounds per year would be revised in the following manner: assuming a salmon has lost 37.5 percent of its initial caloric potential during spawning migration, 62.5 percent of its caloric potential would remain (the migration calorie loss factor). Dividing 365 pounds per year by 62.5 percent (0.625) gives a revised estimate of 584 pounds per year – a 60 percent increase. In other words, a person harvesting salmon halfway up the Columbia River would need to consume 584 pounds of salmon to get the same amount of calories as someone consuming 365 pounds of salmon harvested at the mouth of the Columbia. As Schalk (1986) noted, "the total annual per capita estimate for fish consumed rises significantly when a migration calorie loss factor is included."

3.2.2 Waste Loss Factor

In addition to considering calorie loss from migration, Hunn (1981) also appears to be the first author to suggest modifying the calorie-based fish consumption estimates originally developed by Hewes (1947, 1973) based upon the fact that some portion of a fish is not edible. Hunn (1981) stated that Hewes "does not allow for the fact that the edible fraction of whole salmon is generally considered to be approximately 80% of the total weight." Since many authors providing estimates of historical Tribal fish consumption did so for the purpose of estimating historical harvest rates, this factor (if accurate) was likely an important

consideration. For example, if only 80 percent of each salmon harvested is edible (i.e., 20 percent is “waste”), then a person consuming 100 pounds of salmon per year would need to harvest 125 pounds of salmon to support that consumption rate.

Schalk (1986) incorporated this “waste loss factor” into his estimates of annual salmonid catch in the Columbia Basin by revising Hewes’s consumption estimates for various Tribes and Tribal groups. Schalk stated that “the revised estimate involves dividing the per capita consumption estimate by a waste loss factor of 0.8 to get the gross weight of fish utilized. This figure is also derived from Hunn’s (1981) suggestion that 80 percent of the total weight of a salmon is edible.” While it appears that the main objective in using this factor is in estimating total catch (“the gross weight of fish utilized”), the terms “total catch” and “total consumption” are sometimes used interchangeably. Some subsequent authors have incorporated this waste loss factor into their estimates of actual fish *ingestion* when estimating aboriginal fish consumption rates.

3.2.3 Other Assumptions used to Develop Consumption Rates

In addition to the rate adjustment factors discussed above, there are a number of other assumptions that various authors have made to develop consumption rate estimates, including the following (discussed in more detail in section 4.1.3).

- Fish ingestion versus harvest and other uses (i.e., definition of “consumption”)
- Percent of diet (calories) provided by fish (versus other food items)
- Salmon (anadromous) and/or resident fish consumption
- Historical Tribal population estimates
- Number of fishing sites, fishing methods, and fishing efficiency

3.3 Columbia Basin-Wide Heritage Rates

Below is a summary of the primary source information reviewed on aboriginal fish consumption rates of Columbia Basin Tribes. Relevant information is presented from each of the following publications, including fish consumption estimates and associated assumptions (and summarized in Table 1).

- Craig and Hacker, 1940
- Swindell, 1942
- Hewes, 1947

- Griswold, 1954
- Walker, 1967
- Boldt, 1974
- Hunn, 1981

3.3.1 Craig and Hacker, 1940

In 1940, Joseph Craig and Robert Hacker of the U.S. Bureau of Fisheries estimated an aboriginal per capita salmon consumption rate of 1 pound per day (lb/d), which equates to 365 pounds per year (lb/yr) (or 454 grams per day [g/d]²) for Columbia Basin Tribes (Table 1). This estimate is based on historical ethnographic observations of extensive salmon harvest and use. The authors stated that, based on accounts of early explorers:

“Without doubt salmon, either fresh or dried, was the chief single factor in the diet of the Indians of the Columbia Basin in their native state.” (p. 140)

Other species were identified as consumed as well, including sturgeon, trout, and other fish; however, salmon was the primary species consumed. While the authors noted that it was “not possible to make an accurate estimate of the amount of salmon used by the Indians,” at the time, an approximation could serve “to illustrate the possible magnitude” of fish caught and consumed, with a wide margin of error (p. 141).

The authors stated that since significant quantities of salmon were available in the Columbia River and its tributaries during at least 6 months of the year, the Indians likely harvested and consumed large quantities of fresh salmon during this period and then consumed dried salmon for the remainder of the year. Therefore, “it appears to be well within the realms of probability that these Indians had an average per capita consumption of salmon of 1 pound per day during the entire year” (p. 142).

3.3.2 Swindell, 1942

In 1942, Edward Swindell of the U.S. Department of the Interior’s Office of Indian Affairs estimated an aboriginal per capita salmon consumption rate of 322 lb/yr (or 401 g/d) for Columbia Basin Tribes, specifically in the Celilo region prior to the installation of the

² Most sources present rates in pounds per day; this report applies a conversion to grams per day (1 pound = 454 grams) for the reader and for applicability to water quality standards.

Dalles Dam and flooding of Celilo Falls (Table 1). This estimate is based on field survey interviews (and published affidavits) with local Indian families.

Swindell agreed that the estimate reported by Craig and Hacker (1940) of per capita salmon consumption of 1 pound per day was “not unreasonable” (p. 13) and that while “the poundage of the fish used for subsistence purposes cannot be definitely ascertained... the importance of this article of food as shown by a survey of 55 representative families is shown...” in his report (p. 147). As part of this study, the author presented and compared results obtained from interviews conducted with the heads of the 55 selected families, which represented a total of 795 Indian families present “under the jurisdiction of the Yakima, Umatilla, and Warm Springs” (p. 13-14). These interviews determined an average consumption rate of 1,611 lb/yr per family. Assuming a family unit was comprised of 5 members, Swindell calculated this to be a per capita rate of 322 lb/yr. This value accounted for both fresh and cured salmon, where the dried weights were converted to wet (fresh) weights. The affidavits given by participants of the survey supported Swindell’s aboriginal fish consumption estimates.

An affidavit provided by Tommy Thompson (age 79), of the Wyam Tribe of Indians residing at Celilo, Oregon, stated that “each family of Indians, when he was a boy,³ would dry and put away for their own future use, about 30 sacks of fish...each sack would contain about 10 or 12 fish which weighed almost 100 pounds [total]... each fish after it had been cleaned, the head and tail removed, and then dried, would only weigh between 6 and 8 pounds” (p. 153). Another affidavit provided by Chief William Yallup (age 75), a Klickitat Indian of Rock Creek, stated that “when he was a boy... during the [fish] runs, they would eat fresh fish three times daily and the surplus they caught would be dried for use when no fresh ones were available” and “that in those days each family would dry for its own personal use approximately 30 sacks of fish, each of which contained about six large salmon weighing, after they had been cleaned for drying, about six pounds; that for purposes of trading, each family would put away about 10 sacks of fish” (p. 165). Further, the affidavit noted that fishing rights “have a value to the Indians which cannot be measured in the terms of dollars and cents of the white man; that the subsistence value to the Indians as a whole is enormous...” (p. 167).

³ Based on the year of the publication (1942) and the age of Tommy Thompson at the time of the affidavit (79 years), the period discussed here equates to the mid to late 1800s.

3.3.3 Hewes, 1947

In 1947, as part of his dissertation required for a Ph.D. in Anthropology, Gordon Hewes developed an estimate reflective of Craig and Hacker's (1940) per capita salmon consumption estimate of 1 lb/d (365 lb/yr or 454 g/d) for aboriginal Columbia Basin Tribes (Table 1). The justification for this estimate was based on the average human caloric requirements of 2,000 calories per day (cal/d), the assumption that nearly 50% of the Indian diet was salmon, and that the caloric value of salmon was approximately 1,000 calories per pound⁴ (p. 213-215). This assumed that salmon provided nearly all dietary protein (primary source of energy) and that other food sources (such as plants) contributed minimal caloric value to the diet.

Hewes presented various consumption rate estimates for Tribal groups in different regions of Alaska and the Pacific Northwest compiled from various sources, stating that "while we have very few quantitative hints for the regions south of Alaska, it is reasonable to suppose that per capita consumption among intensive fishing peoples in parts of the Plateau...reached amounts equivalent to at least the lower estimates..." provided for Alaska and the Pacific Northwest by other authors (p. 223), including the estimate of 365 lb/d for the Columbia Basin presented by Craig and Hacker (1940). Acknowledging the guesswork involved, the author made every effort to develop reasonable rates, based on available ethnographic data for the various Tribes in the Pacific Northwest and Alaska, weighing salmon consumption by group or area accordingly. Tribe-specific rates are further discussed in Hewes, 1973 (Section 3.4.1).

3.3.4 Griswold, 1954

In 1954, as part of his dissertation required for a Master of Arts, Gillett Griswold cited Swindell's survey of Indian families in the Celilo region of the Columbia Basin, specifically noting the input factors that, when applied together, would result in an aboriginal per capita salmon consumption rate of 800 lb/yr (or 995 g/d). This rate was not presented in his publication *per se* (and, therefore, not listed in Table 1), only the factors used to calculate the rate.

Referring to affidavits presented in Swindell's study, Griswold assumed that each family cured and stored 30 sacks of salmon for their own use and an additional 10 sacks of salmon for trade each year, with each sack weighing 100 pounds. This equates to 4,000 lb/yr per family harvested. Assuming 5 individuals per family (as stated by Swindell), this equates to a per capita rate of 800 lb/yr. It should be

⁴ Calculation: $2000 \text{ cal/d} * 0.5 * 1 \text{ lb}/1000 \text{ cal} = 1 \text{ lb/d}$

noted that this rate considers all salmon that was harvested for both ingestion as well as trade (i.e., not eaten). While this consumption rate was not presented by Griswold in his dissertation, his input factors (4,000 lb/yr per family of 5 individuals) were used in the rate calculation by another author (Walker, 1967, discussed below) to estimate a range of consumption rates.

3.3.5 Walker, 1967

In 1967, Deward Walker conducted research on behalf of the Nez Perce Tribe and estimated an average per capita salmon consumption rate of 583 lb/yr (or 725 g/d) for aboriginal Tribes of the Columbia Plateau in general (Table 1). This estimate was based on the median value of two previously reported estimates: 365 lb/yr (estimated by Craig and Hacker, 1940) and 800 lb/yr (calculated from assumptions in Griswold, 1954). Walker also estimated a rate specifically for the Nez Perce Tribe, which is discussed in Section 3.4.1 below.

Walker stated that “in light of the known annual dietary dependence on fish among aboriginal societies of the Plateau, it seems safe to conclude that the range was between 365 and 800 lbs. per capita with the average probably close to the median, i.e., 583 lbs.” (p. 19). It should be noted that the higher value of this range was calculated from Griswold, which, as discussed above, includes salmon harvested for ingestion as well as other uses such as trade. Walker noted that a typical use of fish in the Celilo region was for fuel. He also noted that determining a rate for particular groups in the Plateau would “require substantial, additional research” (p. 19).

3.3.6 Boldt, 1974

In the 1974 decision, Senior District Judge George H. Boldt ruled in the case regarding Treaty fishing rights in Washington State. The Judge stated that salmon “both fresh and cured, was a staple in the food supply” of the Columbia River Tribal fishers, and that salmon was consumed annually “in the neighborhood of 500 pounds per capita” (or 622 g/d) (p. 72) (Table 1). This case decision reaffirmed the reserved right of Native Americans in Washington State to harvest fish from their traditional use areas.

3.3.7 Hunn, 1981

In 1981, Eugene Hunn from the University of Washington, Department of Anthropology, re-evaluated the assumptions associated with Hewes' (1947 and 1973) salmon consumption estimates for Columbia Basin Tribes, suggesting that salmon likely did not provide as many calories as originally estimated in the

aboriginal diet. Although Hunn did not present fish consumption rates in his publication (and, therefore, no estimate is included in Table 1), he first introduced the concept of migration calorie loss and waste loss factors, as discussed in Section 3.2 above, and as later applied to fish consumption estimates by other authors (e.g., Scholz, et al., 1985, and Schalk, 1986).

While Hunn considered Hewes' estimates to be the most comprehensive to date, Hunn contended that the caloric calculations were based on commercial fish, which are generally the fattest species, and which are typically harvested prior to upstream migration. Hunn cited Idler and Clemens (1959), which concluded that migrating salmon in the Fraser River "lose on average 75% of their caloric potential during this migration" (p. 127). It may be assumed that fewer calories per pound of salmon upstream results in people consuming more salmon to meet their daily caloric requirements. However, Hunn stated that other foods, such as roots and bulbs, likely provided a large caloric percentage of traditional diets. In addition to migration loss, Hunn determined that only about 80% of the total weight of salmon was edible, therefore introducing the concept of the "waste loss" factor, later applied by other authors to adjust consumption rates.

3.4 Nez Perce Tribe Heritage Rates

Below is a summary of the primary source information reviewed on heritage fish consumption rates specific to the Nez Perce Tribe. Relevant information is presented from each of the following publications (and summarized in Table 2), including fish consumption estimates and associated assumptions.

- Walker, 1967
- Hewes, 1973
- Marshall, 1977
- Walker, 1985
- Schalk, 1986
- Hunn and Bruneau, 1989

3.4.1 Walker, 1967

In 1967, Deward Walker, in the same publication discussed above, estimated an average per capita salmon consumption rate of 300 lb/yr (or 373 g/d) for the Nez Perce Tribe (Table 2). This estimate was based on the following assumptions: a minimum of 300 fish harvested on a peak day, a minimum of 10 peak days per year, a minimal average fish weight of 10 pounds per fish, and a total of 50

historical fishing sites or villages (this last assumption was made from Spalding in 1936, as noted in Walker, 1967).⁵ Multiplied together, this value was divided by the total estimated population at the time of 5,000 people, yielding a total of 300 lb/yr.

Walker's (1967) assumptions were identified as minimum estimates. His informants, for example, estimated 10 to 20 peak days of fish harvest, and Hewes (1947) reported a total population of 4,000 (which would increase the per capita consumption estimate).

3.4.2 Hewes, 1973

In 1973, continuing on his previous dissertation work, Gordon Hewes presented updated aboriginal per capita salmon consumption rates for specific Tribes in Alaska, British Columbia, and the Pacific Northwest, including a rate of 300 lb/yr (or 373 g/d) for the Nez Perce Tribe (Table 2). This rate is based on caloric content and daily requirements, population estimates, and ethnographic accounts of the importance of salmon; it is also based on human dietary demands only, not including other non-ingestion uses.

Hewes initially published a general rate for salmon consumption by Columbia Basin Tribes based on assumptions about dietary caloric requirements and the contribution of salmon to aboriginal diets (see discussion of Hewes, 1947, in Section 3.3.3 above). In this report, Hewes again presents an average per capita estimate of 365 lb/yr (or 454 g/d) for the Columbia Basin Tribes as well as rates for individual Tribes. The Tribe-specific rates account for variability in salmon dependence between regions and population groups, and they reflect population numbers available at the time for each Tribe.

3.4.3 Marshall, 1977

In 1977, working on his dissertation for the Washington State University Department of Anthropology, Alan Marshall estimated an aboriginal per capita salmon consumption rate of 560 lb/yr (or 697 g/d) for the Nez Perce, based on total fish harvest (Table 2).

⁵ Calculation: (300 fish/site x 10 peak days/year x 10 lb/fish x 50 fishing sites) ÷ 5,000 people

Marshall (1977) estimated the Nez Perce rate based on the following assumptions, the majority which originated from Walker's "informants" (1967): a minimum of 300 fish harvested on a peak day, a minimum of 10 peak days per year, a minimal average fish weight of 10 pounds per fish, and a total of 94 historical fishing sites or villages. This last assumption (fishing sites) was increased from Walker's estimate of 50 (according to information from Schwede, 1966, as cited in Marshall, 1977).⁶ Multiplied together, this value was divided by the total estimated population at the time of 5,000 people, yielding a total of 564 lb/yr, which the author presents as "roughly 560 pounds" that "reasonably approximates the figure" from Walker (1967) for Columbia Basin Tribes.

3.4.4 Walker, 1985

In 1985, Deward Walker conducted ethnographic research that included information about the Nez Perce Tribe; however, the report was never published and remains unavailable due to the sensitivity of the information it contained. The data presented here is based upon citations in Scholz, et al. (1985), in which the author included estimates and quotes and, therefore, apparently had access to Walker's (1985) report. Walker calculated an average per capita total (anadromous and resident) fish consumption rate of 1,000 lb/yr (or 1,244 g/d) for the Nez Perce Tribe (Table 2). Note that this rate intended to include both salmon and resident fish consumption combined in the estimate.

According to Scholz (1985), Hewes "checked Walker's new figures for populations and per capita consumption and agrees with Walker's revisions" (Scholz, 1985, p. 73). Scholz also stated that Walker's (1985) estimates were significantly different from those of Schalk (1986), discussed below, primarily because Walker assumed higher Tribal population totals (and also includes resident fish with salmon consumption). Without the original document, however, it is unclear if Walker's estimates represent fish ingestion only or include fish used for other purposes, such as trade and fuel.

3.4.5 Schalk, 1986

In 1986, Randall Schalk calculated salmon consumption estimates for specific Tribes based on Hewes' (1947 and 1973) original estimates, including a rate of 647 lb/yr (or 804 g/d) for the Nez Perce Tribe (Table 2). This rate includes migration and waste loss

⁶ Calculation: $(300 \text{ fish/site} \times 10 \text{ peak days/year} \times 10 \text{ lb/fish} \times 94 \text{ fishing sites}) \div 5,000 \text{ people}$

factors applied to Hewes' Tribe-specific values. Schalk contended that many of Hewes' original estimates were biased low because they were based on:

- A caloric content of fish representing salmon as they enter freshwater in prime condition (i.e., having more calories than upstream salmon). Schalk stated that “since salmonids lose an average of 75 percent of their caloric content during migration (Idler and Clemens 1959), some adjustment should have been made for distance traveled upstream” (i.e., applying a migration loss factor).
- The assumption that salmon were eaten in their entirety. Schalk states that assuming the entire fish was consumed was “unrealistic” and cited Hunn (1981) to state that only “about 80 percent of the weight of a salmon is edible” (p.17).

Schalk, therefore, adjusted (increased) Hewes' consumption rates by applying a migration loss factor (variable by Tribe depending on how far upstream they harvested salmon) of 58% (0.58) for the Nez Perce Tribe. Schalk also applied a waste loss factor of 80% (0.80), citing Hunn (1981), therefore, including inedible fish parts in the fish consumption estimate.

3.4.6 Hunn and Bruneau, 1989

In 1989, Eugene Hunn and C. Bruneau of Pacific Northwest Laboratory (on behalf of the U.S. Department of Energy at the Hanford Site) estimated an anadromous fish (including salmon, steelhead, and lamprey) consumption rate of 320 lb/yr (or 398 g/d) for the Nez Perce Tribe (Table 2).

Based on the “educated guesses” of previous authors, including Craig and Hacker (1940), Hewes (1947, 1973), and Walker (1967), Hunn and Bruneau (1989) estimate 400 pounds per person per year as a “reasonable traditional gross harvest rate” for the Nez Perce. Assuming that the actual consumption was only 80 percent of the total harvest, the authors adjusted (reduced) this value (i.e., multiplied by 0.80) to account for the edible fraction only.

4.0 RATE EVALUATION AND DISCUSSION

This section further evaluates and discusses the information presented above, including the uncertainty associated with the rate adjustment factors and other assumptions influencing rate calculations.

4.1 Factors Influencing Consumption Rates

The migration calorie loss factor and waste loss factor are considered here, particularly regarding the uncertainty associated with applying these adjustment factors to heritage rates. Other factors that influence the calculation of heritage rates and that may also increase uncertainty of the estimates include population size estimated at the time, number of fishing sites, and reliability of ethnographic data in general.

4.1.1 Migration Calorie Loss Factor

For a number of reasons, the application of the migration calorie loss factor as described above introduces a high degree of uncertainty into the revised estimates of tribal fish consumption. The study that forms the basis of this adjustment (Idler and Clemens, 1959) is based on one year's run of one species of salmon (sockeye) in one watershed (the Fraser River). The conclusions of this study are then broadly applied to all salmon species within a different watershed (the Columbia River), even though it is estimated that sockeye accounted for only 7 percent of the Upper Columbia salmon harvest (Beiningen, 1976 as cited in Scholz, et al., 1986). The degree to which different salmon species lose calories at different rates or in different proportions during spawning migration, and the degree to which the Columbia River and Fraser River watersheds differ (in length, elevation change, etc.) all affect the degree of uncertainty associated with the calculation and application of a migration calorie loss factor.

The migration calorie loss factor is based on a gross percentage of calories lost by a sockeye salmon during spawning migration in the Fraser River (i.e., ending calories compared to beginning calories). However, the factor is applied in revising consumption rates as though it represents the amount of calories lost *per pound consumed*, which is not the same; salmon not only lose calories during migration, they also lose weight. Based on measurements collected by Idler and Clemens (1959), the average overall weight loss during spawning migration was 25 percent, and the loss in caloric density (calories per gram) was therefore about 65 percent, as opposed to 75 percent. Table 3 provides the total calories,

total weight (in grams), and caloric density (in calories per gram) of sockeye salmon measured at various stages in the Fraser River (from Idler and Clemens, 1959).

Further, the overall decrease in caloric potential was based on measurements of sockeye salmon that have spawned *and died* in headwater streams. Michael Kew (1986) describes the results of the Idler and Clemens study as follows:

“As a general rule, the further from the sea a salmon is, the less fat and protein it carries. The loss is considerable. Total caloric value of a sockeye, measured at the river mouth, will be reduced to nearly one-half when it reaches the Upper Stuart spawning grounds, one thousand kilometers from the sea. After the enriched gonads have been expended in spawning and the fish die on these upper streams, they will have lost over 90 percent of their fat and one-half to two-thirds of their protein (Idler and Clemens, 1959; reviewed in Foerster, 1968: 74-6).”

As Kew notes, there is a significant difference in caloric potential between the time a salmon reaches its spawning grounds and the time it has spawned and died. Based on measurements collected by Idler and Clemens (1959), the average sockeye loses almost 15 percent of its caloric density (calories per pound) between the time it reaches its spawning grounds and the time it has spawned and died. At the time a sockeye salmon reaches its spawning grounds in the upper Fraser River watershed, it has lost about 50 percent of its caloric density (Table 3).

Still further, the derivation of the migration calorie loss factor relies on the assumption that the salmon harvest location is at “the approximate middle of each group's territory” (Hunn, 1981). To the extent that a majority of salmon harvest occurs either downstream or upstream of this point, the migration calorie loss factor would either overestimate or underestimate, respectively, the effect on the consumption rate.

Mullan, et al. (1992) note that caloric losses in salmon are generally related to mileage of migration, but not directly. “Idler and Clemens (1959) show much higher energy expenditures by sockeye in some river reaches than others, and higher rates for females than males. In other words, caloric content is not linear in relation to distance.” Further, Mullan notes that in migration and maturation the fish tend to mobilize fat reserves and resorb organs (e.g., gastro-intestinal

tract), and “[t]hus they lose weight, but not necessarily caloric content, between cessation of ocean feeding and nominal freshwater capture.”

While the idea of adjusting calorie-based consumption estimates to account for migration calorie loss does not seem unreasonable, based on the uncertainty described above, it most likely tends to overestimate salmon consumption relative to Hewes’ original estimates (because it likely overestimates calorie loss per pound). Since sockeye salmon lose approximately 50 percent of their caloric density upon reaching their spawning grounds, a maximum migration calorie loss factor of 50 percent, as opposed to 75 percent, may be more consistent with the supporting research (although the existing research is limited to a single species of salmon). Hewes’s diet and calorie-based consumption estimate for the Columbia Plateau Tribes is identical to that proposed by Craig and Hacker (1940), which is not based on caloric intake but on observation and review of the ethnohistorical literature (although it is “admittedly liable to a wide margin of error”).

4.1.2 Waste Loss Factor

Incorporating a waste loss factor to revise Hewes’s fish consumption estimates has the effect of increasing the consumption rate (relative to Hewes’s estimate) by 25 percent. If the interest is in understanding how much individuals consumed (ingested), as opposed to “used,” then the use of a waste loss factor is not appropriate. Essentially, this factor adjusts a consumption rate, increasing it by 25 percent, to account for the portion of fish NOT consumed. Consumption estimates that have been revised to account for a waste loss factor (as in Scholz et al., 1985, and Schalk, 1986) would tend to overestimate consumption (ingestion) by 25 percent, relative to the “unrevised” rates.

Some estimates of consumption by Tribal groups are based on an estimate of total harvest and total population. For example, some authors estimate a total harvest (in pounds) based on the number of fishing sites, number of fishing days, efficiency of fishing techniques, average weight of fish, etc., and simply divide the total estimated harvest by the total estimated tribal population to arrive at an annual per capita consumption rate. However, this type of estimate does not account for the fact that only a portion of each fish may be edible (i.e., 80 percent), and may tend to overestimate the amount that people are actually consuming.

Mullan, et al. (1992) suggested that, because many Tribal groups prepared and consumed most parts of the salmon, including organs, eyes, eggs, etc., the

inedible waste was much less than 20 percent, arguing that “waste factor of a salmon amounted to bones only, under 10% of body weight.”

4.1.3 Other Assumptions used to Develop Consumption Rates

In addition to the rate adjustment factors discussed above, other assumptions that various authors have made in developing consumption rates introduce varying degrees of uncertainty to the estimates, including those discussed below.

Ingestion, Harvest, and Consumption

As discussed in Section 3.1, the effort here is to summarize estimates of fish ingestion which may be relevant to the development of Tribal water quality standards. The degree to which estimates of Tribal fish consumption in the various studies include uses in addition to ingestion may affect their applicability to Tribal regulatory or policy development.

Percent of Diet Supplied by Fish

The calorie-based consumption estimates developed by Hewes, which form the basis for a number of subsequent estimates, are based on the assumption that salmon account for about 50 percent of the average Columbia Basin aboriginal diet. Many authors have made similar estimates, while others have assumed either higher or lower dietary estimates. While 50 percent of the diet (i.e., 50 percent of total calories) is among the most common estimates, the degree to which a specific Tribe has a higher or lower percentage of diet supplied by fish can affect the accuracy of the calculated consumption rate.

Salmon and Resident Fish Consumption

Because of the importance of salmon to the Columbia Basin Tribes, and because many studies have attempted to evaluate the impact of the hydroelectric system on anadromous fisheries, a majority of the studies evaluated focused exclusively or primarily on the harvest and consumption of salmon. The degree to which individual Tribal groups relied on resident fish, either to supplement or to substitute for salmon consumption, will affect the accuracy of consumption estimates included in these studies relative to total fish consumption.

Tribal Population Estimates

Some authors have estimated total fish consumption for various Tribal groups by estimating an overall harvest rate and dividing that rate by the total Tribal population to develop an average per capita estimate. Therefore, the

accuracy of population estimates may directly affect the accuracy of consumption estimates developed using this approach.

Number of Fishing Sites, Fishing Methods, and Fishing Efficiency

Some authors have developed consumption estimates based on assumptions about the type and effectiveness of Tribal fishing methods and the number of harvest locations utilized by individual Tribes or Tribal groups. The degree to which these assumptions are accurate will directly affect the accuracy of consumption estimates using this approach.

4.2 Heritage Fish Consumption Rates

The heritage rates estimated for the Columbia Basin Tribes and, specifically, the Nez Perce Tribe, introduced in Sections 3.3 and 3.4 above, are evaluated in more detail below, including discussion of the assumptions and uncertainty associated with the estimates.

4.2.1 Columbia Basin-Wide Heritage Rates

Craig and Hacker (1940) presented the first estimate of per capita salmon consumption for aboriginal Tribes of the Columbia Basin of 365 lb/yr (or 454 g/d), which was based on historical ethnographic observations, although acknowledged by the authors as likely having a wide margin of error. Hewes (1947) validated this rate with additional assumptions related to average dietary caloric requirements, the contribution of salmon to the aboriginal diet, and a caloric value for salmon. These assumptions (a 2,000 calorie diet, 50 percent of the diet was salmon, and salmon contained 1,000 calories per pound), while generalized, provided additional justification for this rate. Hunn (1981) later re-evaluated Hewes' assumptions by suggesting that migration calorie loss and inedible waste loss factors should be considered. While variability exists in how many calories each salmon contained and how much of each salmon was eaten, the method for developing and applying such "adjustment factors" (discussed in Section 4.1 above), as done to aboriginal rates by other authors (Scholz, et al., 1985, and Schalk, 1986), may have added a level of uncertainty to those estimates.

Shortly after Craig and Hacker (1940) published the first aboriginal salmon consumption estimate, Swindell (1942) published a very similar estimate of per capita salmon consumption of 322 lb/yr (or 401 g/d) for the Tribes of the Celilo Falls region. This value was based on interviews with Indian families, including affidavits of extensive salmon consumption and use, and total harvest (according to sacks of fish and average weights per fish). Griswold (1954) later

cited Swindell's work, referring to these affidavits, to calculate a total annual harvest of 4,000 pounds per family. Although Griswold did not calculate a *per capita* consumption rate in his publication, Walker (1967), by assuming 5 individuals per family, calculated a per capita rate of 800 lb/yr (or 995 g/d) for an upper range of fish consumption. Based on per capita fish consumption rates ranging from 365 lb/yr (presented in Craig and Hacker, 1940, and Hewes, 1947) to 800 lb/yr (calculated from Griswold, 1954), Walker (1967) calculated an average (median) per capita salmon consumption rate of 583 lb/yr (or 725 g/d). A few years later, Boldt (1974) stated that Columbia River Tribes consumed (as food supply) a comparable rate of about 500 lb/yr (or 622 g/d) of salmon.

It is important to remember that the rate calculated from Griswold's (1954) information reflects salmon that was harvested for both consumption as well as trade (i.e., salmon not ingested). If all other assumptions hold true, based on Swindell's (1942) information (3,000 lb/yr harvested per family for consumption, 5 individuals per family⁷), a more accurate per capita upper range for fish consumption as defined for this report would be 600 lb/yr (or 746 g/d). If this alternate value is used from Griswold (1954), calculating an average rate similar to Walker's approach would result in an average rate of 483 lb/yr (or 600 g/d). See Table 1.

4.2.2 Nez Perce Tribe Heritage Rates

In addition to estimating an average consumption rate for aboriginal Tribes of the Columbia Basin in general, Walker (1967) also estimated a rate specific to the Nez Perce Tribe. He estimated an average per capita salmon consumption rate of 300 lb/yr (373 g/d) based on estimates of fish harvest on peak days, number of fishing sites, average fish weight, and total population. Hewes (1973), continuing his earlier dissertation research from 1947, published his estimates for various Tribes, including the Nez Perce, based on fish caloric content and daily requirements, population estimates, and ethnographic accounts of the importance of salmon among different Tribes. He estimated an average per capita salmon consumption rate identical to Walker (1967) of 300 lb/yr (or 373 g/d) for the Nez Perce Tribe. Marshall (1977) believed Hewes' rate to be a minimum estimate; he calculated an average per capita salmon consumption rate of 560 lb/yr (or 697 g/d) based on the same assumptions as Walker (1967), but assuming nearly twice the number of fishing sites.

⁷ If the 10 sacks of salmon that were harvested for trade are removed from the equation, the 30 sacks of fish consumed at 100 pounds = 3,000 pounds (per family).

Schalk (1986) later applied migration and waste loss factors to Hewes' estimate (dividing Hewes' rate of 300 lb/yr by 0.58 and 0.80), yielding a higher salmon consumption rate of 647 lb/yr (or 804 g/d) for the Nez Perce Tribe. Taking a slightly different approach, Hunn and Bruneau (1989) removed the inedible fraction from a total harvest estimate (multiplying a harvest rate of 400 lb/yr by the 0.80 waste loss factor), yielding a lower anadromous fish consumption rate (including consumption of salmon, steelhead, and lamprey) of 320 lb/yr (or 398 g/d).

In 1985, Walker expanded upon his previous work from 1967 and calculated Tribe-specific per capita total fish consumption rates for individual tribes, including 1,000 lb/yr (or 1,244 g/d) for the Nez Perce Tribe. Although this study remains unpublished, the estimates were presented (with supporting information) by Scholz (1985). Walker's estimates appear to be the only rates (of those presented here) that reflect use of both anadromous and resident fish; however, since the report is unavailable, it cannot be verified if these estimates account for only fish ingested or include fish used for other purposes (such as trade). See Table 2.

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TABLES

Notes/Footnotes for Tables:

¹ Includes a migration calorie loss factor (based on Hunn, 1981, citing Idler and Clemens, 1959) to adjust estimates based on caloric intake.

² Waste loss may be accounted for either in direct observation (i.e. the author is citing consumption of fish that had been prepared for consumption, as was done by Craig and Hacker and Swindell) or by adjusting the amount of fish harvested by a waste loss factor loss factor (0.8, based on Hunn, 1981) to translate from amount consumed to amount harvested. For consumption rates derived using caloric analysis, waste loss is inherently accounted for, as calories consumed are converted into edible fish mass consumed. Estimates based on ethnographic observation sometimes appear to be based on amounts actually consumed (e.g. Craig and Hacker; Swindell) and sometimes based on amounts harvested (e.g. Walker; Marshall). Those based on the amount harvested would include the inedible (waste loss) portion, and would likely overestimate consumption. They may also include harvest for other uses, although that is not specifically stated in most studies.

Different studies address “waste loss” differently. Most that use the “waste loss factor”, like Schalk and Scholz, use the factor to translate from a consumption rate to a harvest rate, so they tend to inflate the consumption rate (by dividing by 0.8). Other studies (e.g. Hunn and Bruneau, 1989) use the same factor to translate from a harvest rate to a consumption rate (by multiplying by 0.8). So both studies “account” for waste loss, but they do so to opposite effect.

Here is an excerpt from Hunn and Bruneau:

“Based on these educated guesses, I use 500 pounds per person per year as a reasonable traditional gross harvest rate for “River Yakima” and 400 pounds for the Nez Perce (cf. Walker 1973:56) and the Colville. Actual consumption is estimated at 80% for the edible fraction (thus 400 and 320 pounds respectively).”

Table 1: Average Heritage Fish Consumption Rates for the Columbia Basin Tribes

Reference	Methodology	Species Evaluated	Rate in g/day	Rate Derivation	Includes (Note: +/-/U indicates whether the way in which a particular factor was addressed causes an increase, decrease, or unknown impact on the FCR)		
					Uses Besides Consumption	Migratory Caloric Loss Factor ¹	Accounting for inedible portion ²
Craig & Hacker 1940	Ethnographic Observation	Salmon, sturgeon, trout	454	Not presented	No (+)	No (-)	Yes (U)
Swindell 1942	Ethnographic Observation	Salmon	401	1611 lb salmon/year ÷ 5 people/family x 454 g salmon/lb salmon ÷ 365 days/year	No (+)	No (-)	Yes (U)
Hewes 1947	Caloric Analysis	Salmon	454	2000 calories/day x 50% of diet as salmon x 1000 calories/lb salmon x lb salmon/454 g salmon	Yes (-)	No (-)	Yes (U)
Griswold 1954	Ethnographic Observation	Salmon	746	30 sacks salmon/year/family x 10 lb salmon/sack x family/5 people x 454 g salmon/lb salmon x year/365 days Griswold cited 40 sacks of salmon per family were obtained with 30 retained for family use and 10 used for other purposes.	No (+)	No (-)	No (U)
Walker 1967	Evaluation of Craig & Hacker 1940 and Griswold 1954	Salmon	725	Average of 454 g/day (from Craig and Hacker, 1940) and 995 g/day (from Griswold 1954). The Griswold value was based on families obtaining 40 bags of salmon, 30 for consumption and 10 for trade. 995 g/day = 40 sacks salmon/year/family x 100 lb salmon/sack x family/5 people x 454 g salmon/lb salmon x year/365 days	Yes (+)	No (-)	No (U)
Boldt 1974	Undocumented, (United States v. Washington, 384 F. Supp. 312)	Salmon	622	500 lb salmon/person/year x 454 g salmon/lb salmon x year/365 days	Unknown (U)	No (-)	Unknown (U)

Table 2. Average Heritage Fish Consumption Rates for the Nez Perce Tribe

Reference	Methodology	Species Evaluated	Rate in g/day	Rate Derivation	Includes (Note: +/-/U indicates whether the way in which a particular factor was addressed causes an increase, decrease, or unknown impact on the FCR)		
					Uses Besides Consumption	Migratory Caloric Loss Factor ¹	Accounting for inedible portion ²
Walker 1967	Ethnographic observation citing Spalding 1936	Salmon	373 ^a 466 ^b	300 fish/peak day/fishing site x 10 peak days/year x 10 lb tissue/fish x 50 fishing sites ÷ 5000 total population (from Spalding 1936) a: assumes population of 5000 b: assumes population of 4000 (Hewes 1947)	Unknown (U)	No (-)	Unknown (U)
Hewes 1973	Caloric Analysis/Ethnographic Observation	Salmon	373		No (+)	No (-)	No (U)
Marshall 1977	Ethnographic Observation citing Walker	Salmon	701	300 fish/peak day/fishing site x 10 peak days/year x 10 lb salmon/fish x 94 fishing sites x 454 g salmon/lb salmon ÷ 5000 total population Note: fishing sites increased from 50 to 94 based on Schwede 1966	Unknown (U)	No (-)	No (U)
Walker 1985	Ethnographic Observation, unpublished by cited by Scholz 1985	Salmon & Resident	1,244	Methodology not presented	Unknown (U)	Unknown (U)	Unknown (U)
Schalk 1986	Ethnographic Observation citing Hewes 1947 and 1973	Salmon	804	300 lb salmon/year/person x 454 g salmon/lb salmon x year/365 days ÷ 0.58 caloric loss factor ÷ 0.8 edible fraction. Modified consumption rates of Hewes 1947 and 1973. Hewes (1973) assumed a consumption rate of 300 lb/year. Assumed that caloric content of fish was reduced during migration. For the Nez Perce, there was a 58% reduction in caloric value. Further, not all parts of the salmon are edible. Schalk assumed 80% of the fish was consumed.	Unknown (U)	Yes (+)	Yes (+)
Hunn and Bruneau 1989	Ethnographic Observation, derived from: Craig and Hacker 1950; Hewes 1947 & 1973; Walker 1967	Salmon, Steelhead, Lamprey	398	400 lb salmon/year/person x 454 g salmon/pound of salmon x year/365 days x 0.8 edible fraction Based on review of references cited in the methodology column, Hunn and Bruneau estimated the annual salmon harvest per person at 400 lb/year	Unknown (U)	No (-)	Yes (-)

Table 3. Spawning Migration and Calorie Loss (Fraser River)

Fraser River Location	Total Calories¹ (kCal)	Total Weight¹ (grams)	Caloric Density (calories/ gram)
At River Mouth	5,173	2,585	2.00
At Spawning Grounds	2,248	2,363	0.95
After Spawning and Death	1,334	1,917	0.70
Percent Loss at Spawning Grounds	57%	9%	52%
Percent Loss After Spawning and Death	74%	26%	65%

Notes:

All values are based on Idler and Clemens, 1959.

¹Based on average of male and female values.

DRAFT

HERITAGE FISH CONSUMPTION RATES OF THE SHOSHONE-BANNOCK TRIBES

Prepared for the
Shoshone-Bannock Tribes

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LIST OF ABBREVIATIONS AND ACRONYMS

BOR	Bureau of Reclamation
EPA	U.S. Environmental Protection Agency
FCR	fish consumption rate
IDFG	Idaho Department of Fish and Game

LIST OF UNITS

%	percent
cal/d	calories per day
g/d	grams per day
kCal	kilocalories
lb/d	pounds per day
lb/yr	pounds per year

1.0 INTRODUCTION

A study of heritage fish consumption rates was conducted for the Shoshone-Bannock Tribes. The study was done as part of a larger fish consumption survey of federally recognized Tribes in Idaho, which was initiated by the U.S. Environmental Protection Agency in 2013. This report presents the results of the Shoshone-Bannock Tribes' heritage rate research, which was based upon an evaluation of available ethnographic literature on aboriginal fish consumption by Columbia Basin Tribes and other influential studies that have supported previous estimates of heritage rates.

1.1 Purpose and Objectives

Tribal Governments in the State of Idaho are working closely with the U.S. Environmental Protection Agency (EPA) Region 10, the State of Idaho, and other stakeholders to gather data on fish consumption rates (FCRs). The overarching goal of this process is to obtain information on fish consumption to enable Tribal governments to set water quality standards for tribal waters, and to allow Tribes to meaningfully participate as informed partners in Idaho DEQ's ambient water quality criteria review process that impacts tribal interests. A Tribal heritage rate study was conducted as part of this effort.

Recognizing that current Tribal fish consumption is suppressed due to a number of factors (e.g. decreased fish populations due to physical habitat modification and adverse effects of chemical contamination, loss of Tribal access to fisheries resources, fears of exposure to contaminants in fish, and changes in fish harvesting by Tribal members associated with adaptation to economic and cultural shifts), this study compiled and evaluated available data to determine heritage fish consumption rates for the Shoshone-Bannock Tribes. Knowledge of past rates may help determine how current fish consumption rates might increase in the future if current fisheries resources are improved and fish consumption is restored to past, higher levels. Information about fish consumption rates may be used to support development of water quality standards that protect human health.

Water quality is of great importance to the Shoshone-Bannock Tribes, since a substantial portion of their diet is derived from aquatic sources, and water and aquatic resources are of great cultural and spiritual significance. As part of the survey effort, discussions with the Tribe highlighted the issue of suppression and its causes. Therefore, the survey team agreed to review and evaluate heritage

rates available in the literature, which may be more relevant than current suppressed rates to the long-term restoration goals of the Tribe.

The Shoshone-Bannock Tribes' primary objective for the fish consumption survey is to develop water quality standards that will result in clean water and clean fish, both of which are vital to their existence, but which are being (or have been) lost. The Tribe has been working for many years to improve and return anadromous fish runs to the traditional fish areas and to protect, restore, and enhance fish-related resources in accordance with the Tribes' unique interests and vested rights in such resources. Currently, they cannot drink the water or eat the fish due primarily to contamination and development. Their overarching goal is to bring back full-system functionality of the entire basin and provide clean resources to sustain Tribal health and culture. This survey can help document the strong connection of spiritual, mental, and physical wellbeing of Tribal members to the natural resources.

1.2 Study Approach

The approach for estimating heritage rates was based on a comprehensive review and evaluation of literature that is relevant to heritage rates, including historical accounts and modern studies of heritage consumption. For Tribes that harvest fish from the Columbia Basin, there is a significant volume of literature to form the basis for a range of quantitative estimates of fish consumption. Information includes ethnographic studies, personal interviews, historical harvest records, archaeological and ecological information, and nutritional and dietary information. The quantitative assessment includes compilation and analysis of historic and heritage information across the region of the Columbia Basin.

The survey team compiled and evaluated available information regarding heritage consumption rates relevant to the Shoshone-Bannock Tribes. The development of estimates of heritage rates presented here includes a discussion of the available information, including methodologies used to develop the fish consumption estimates and factors affecting the uncertainty associated with the estimates. Based on available information, a quantitative range of heritage fish consumption rates is presented for the Tribe.

2.0 BACKGROUND

The Shoshone-Bannock Tribes have relied extensively on fish resources and fishing activities throughout time. A summary of the fish harvest and extensive use and consumption of fish historically, as well as the causes of decline in fish availability over time, is provided for context.

2.1 Summary of Historical Fish Harvest and Consumption

The Shoshone and Bannock people's homelands are vast and far-ranging and encompass what are now known as the states of Idaho, Oregon, Nevada, California, Utah, Wyoming, Montana and beyond. Rivers that the Shoshone and Bannock people used included the Snake, Missouri, and Colorado rivers, all of which provided past and current subsistence needs. These natural resources provided food, medicine, shelter, clothing and other uses and purposes, intrinsic to traditional practices (BOR, 2012).

Salmon provided the Shoshone-Bannock with their most abundant and predictable supplies of fish. For those who lived along the waterways of the Salmon River and its tributaries, or along the Snake below Shoshone Falls, anadromous fish were the primary aquatic food resource. On the Snake River, Shoshone Falls was the absolute limit of salmon migration, while Auger Falls, the Upper and Lower Salmon Falls, seriously impeded their upstream movements. Some anadromous species also entered the tributaries of the Snake but did not move far upstream. Even the Shoshone-Bannock, who wintered on waterways above the salmon runs, relied on anadromous fish and annually traveled to fisheries downstream where various species could be caught on a regular and recurring basis (Albers, et al., 1998).

Walker (1977, as cited in Scholz, 1985) reported that "[t]he Shoshone-Bannock, as well as their neighbors the Northern Paiute in southwestern Idaho, regularly took salmon below Shoshone Falls." Craig and Hacker (1940, as cited in Scholz et al, 1985) quote Washington Irving as stating "[t]he early traders report that Indians at Salmon Falls on the Snake River took several thousand salmon in one afternoon by means of spears." Suckley and Cooper (1860, as cited in Scholz et al, 1985) reported:

"In some of the branches of the Columbia salmon penetrate to the Rocky Mountains, but they cannot ascend the Snake above Rock Creek between Fort Boise and Fort Hall, where the great Shoshone Falls stops

them. Fort Boise is a great fishing ground for the Bannocks and other bands of the Shoshone or Snake Tribe. We found them taking vast numbers at the end of August 1849."

Historically, Shoshone and Bannock speakers commonly identified themselves and the people who lived around them by names that designated a prominent geographic feature or an important food taken at the locales through which they traveled (Albers, et al., 1998). Often, the same names were attached to peoples residing in different places. Agaideka, "Eaters of Salmon," was used simultaneously to identify people on the Salmon and Lemhi Rivers as well as those near the middle reaches of the Snake River below Shoshone Falls, while Pengwedeka, "Eaters of Fish," applied to Shoshone-Bannock who wintered near Camas Creek and those who had wintering spots near the mouth of the Bear River (Albers, et al., 1998).

In June 1867, an Executive Order established the Fort Hall Indian Reservation, as a collective place to consolidate the various bands of Shoshones, Bannocks and even other tribes, from their aboriginal lands, clearing the way for European-American settlements, such as ranchers and miners who desired the rich resources present on aboriginal lands. The United States then signed a treaty, the Fort Bridger Treaty of 1868, with Shoshone and Bannock headmen, relinquishing any further claims to lands and title, but reserving the rights to hunt and fish on unoccupied lands in the United States (BOR, 2012).

Today, descendants of the Lemhi, Boise Valley, Bruneau, Weiser and other bands of Shoshone and Bannock reside on the Reservation. Tribal members continue to exercise off reservation treaty rights, and return to aboriginal lands to practice their unique culture and traditions. The Fort Bridger Treaty of July 3, 1868 was the only treaty ratified by Congress between the Eastern Shoshone bands and the Bannocks. In the Treaty, the Shoshone and Bannock people expressly reserved off-reservation hunting, fishing and gathering rights on the unoccupied lands of the United States (BOR, 2012).

Article IV of the Treaty reserved the right for the Tribes to maintain a cultural, social and spiritual link to their ancestral homelands. Over the past 150 years the Tribes have utilized these unoccupied lands to visit significant sites, hunt, fish and wildlife for subsistence, gathered botanical species for medicine and food. In addition to the reserved Treaty rights, Tribal members also continue to exercise inherent rights including, but not limited to, visits to sacred sites or practice of traditional cultural activities (BOR, 2012).

2.2 Summary of Causes of Decline in Fish Populations

Salmon once spawned in tributaries of the Snake River throughout Idaho. In the early 1900's, the construction of dams blocked salmon from several tributaries. Many of those dams were constructed without fish ladders or were too high to allow for fish passage. Swan Falls Dam on the mainstem Snake River near Marsing, Idaho, and dams in the Owyhee, Boise, Payette, Grand Ronde, Salmon and Clearwater rivers stopped anadromous species in the early 20th century. The Hells Canyon Dam complex in the middle Snake was completed in 1967, blocking all salmon and steelhead runs above the dams. Fall chinook that spawn in the main stem Snake River are now confined to the stretch below the complex (Idaho Rivers, 2013).

The Upper Snake River subbasin is located in eastern Idaho and extends about 400 river miles from Idaho Falls to Shoshone Falls. Major tributaries include Blackfoot River, Portneuf River, Raft River, Goose Creek, and Big Cottonwood Creek (Colter, et al., 2002). The single most influential limiting factor to native fish populations within the Upper Snake River subbasin is loss of habitat due to riparian and stream channel disturbance and to channel dewatering for irrigation withdrawals. The development and operation of hydroelectric dams on the Columbia River and its tributaries has contributed to the decline of fish and wildlife populations throughout the Basin.

Habitat limitations related to agriculture and grazing include unscreened irrigation delivery systems, sedimentation, upland and in-stream habitat disturbances, loss and degradation of functional riparian areas and wetlands, elevated summer temperatures, increased developments in agriculture areas resulting in habitat fragmentation, reduced stream bank vegetation and stability. In years of low snowpack, flows in water bodies and reservoir storage can be drafted to fulfill irrigation water rights impacting the quality and quantity of water (Colter, et al., 2002).

One of the largest phosphate ore reserves in the United States is located in the Blackfoot River drainage. Environmental problems associated with phosphate mining were first documented in the 1990's, and an investigation of potential effects of selenium generated from phosphate mines on the fish and wildlife in the upper Blackfoot River drainage is ongoing (IDFG, 2007).

The distribution and abundance of Yellowstone cutthroat trout have declined in the Snake River Plain of Idaho through habitat degradation, genetic

introgression, and exploitation (Thurow, et al., 1988 and May, 1996, as cited in Colter, et al., 2002). Habitat degradation has included negative impacts from grazing (riparian loss, siltation, and widening and deepening of stream channels) and habitat fragmentation from impoundments and diversions. Many remaining populations exist as localized remnants of original sub-populations with little or no connectivity. Genetic introgression with non-native cutthroat and other trout is one of the greatest threats to remaining pure populations of Yellowstone cutthroat trout (Colter, et al., 2002). Potential threats to Yellowstone cutthroat trout in Idaho have been identified by Thurow, et al. (1988) and Gresswell (1995), as cited in IDFG (2007). Threats include genetic introgression with rainbow trout, impoundments, water diversion, road culverts, improper livestock grazing, mineral extraction, angling, and competition with non-native species. Whirling disease has been identified as a more recent potential threat (IDFG, 2007).

Riparian areas on the Fort Hall Indian Reservation have been negatively affected by lateral scouring and downcutting of streambanks caused by years of unrestricted grazing and rapid flooding and drafting of American Falls Reservoir. Negative impacts from lateral scouring and downcutting include siltation of spawning gravels, loss of cover and pool depth, increasing width to depth ratios of stream channels, and resulting increases in water temperature (Colter, et al., 2002).

Non-point source pollution and water diversions are the predominant influences on surface water quality in the Upper Snake River subbasin. Pollutants of greatest concern that have been associated with stream habitat degradation include nutrients, sediment, bacteria, organic waste, and elevated water temperature. Irrigation drainage, aquaculture effluent, municipal effluent, hydrologic modification, and dams affect water quality in the middle reach of the Snake River. Segments of the river were listed as water quality limited in 1990 because nuisance weed growth had exceeded water quality criteria and standards established for protection of cold water biota and salmonid spawning (Colter, et al., 2002). The Tribes believe that environmental, economic, and social factors have all impacted subsistence resource use.

3.0 HERITAGE FISH CONSUMPTION RATES

A summary of the primary source literature reviewed for this heritage rate study is provided here, including a definition of “fish consumption,” as used differently by various authors, and certain factors and other assumptions that have been used to adjust and/or calculate consumption rates. Also presented below are the average aboriginal per capita fish consumption rates estimated for the Columbia Basin Tribes (summarized in Table 1) and rates for the Shoshone-Bannock Tribes specifically (summarized in Table 2).

3.1 Defining Fish Consumption

The focus of this effort is to compile, summarize, and evaluate estimates of Tribal fish consumption during the period when Tribes had full access to their traditional fisheries, which we refer to here as “heritage rates.” This effort is intended to provide Tribes with information that may be useful in establishing water quality criteria for the protection of human health. The information supporting heritage rates is on a per capita basis that can be used to estimate average fish consumption rates, however this information is not suitable for development of fish consumption rate distributions or percentiles of fish consumption.

As evident in review of the documentary record, the definition of fish consumption as fish *ingestion* is not necessarily shared by the various researchers who have attempted to estimate aboriginal fish consumption rates for various Tribal groups. Several researchers include all uses of fish in what they describe as a “total consumption rate.” For example, one researcher (Schalk, 1986), suggested that a previously calculated consumption estimate was too low because it “only considers human dietary demands.” Another (Griswold, 1954) stated that “[t]he tribes here required salmon for fuel as well as for food. Consequently, it may be inferred that their per capita consumption was considerably greater than that of the tribes [downstream] below.” Still another, (Walker, 1967) discussed “exceptional areas of unusually high consumption, up to 1000 lbs. per capita, per year” which are “caused not only by the high calorie demands typical of colder climates, but also by the use of fish for dog food or for fuel.”

Estimates by various researchers, therefore, may include as part of a total fish consumption rate that portion of the overall fish harvest that was used for trade, for fuel, for animal feed, or may include the inedible portion of fish not actually

ingested. To the extent that it is discussed in the literature, this report attempts to describe the assumptions involved in estimating a consumption rate, and, where possible and appropriate, identify that portion that was actually ingested.

3.2 Defining Factors Influencing Consumption Rates

Many sources of information providing estimates of heritage fish consumption rates for Tribal groups in the Columbia Basin tend to refer to or build upon previous work, in some cases revising or adjusting rates from previous reports based on new knowledge, new data, or new approaches for interpreting consumption information. Some authors have attempted to revise earlier estimates of fish consumption, particularly those estimates based on caloric intake, to account for the caloric losses that occur as a result of salmon spawning migration ("migration calorie loss factor") and to account for the fact that not all of an individual fish is consumed ("waste loss factor"). Each of these factors and their effect on consumption estimates, as well as other variables that influence the calculation of consumption rates, are discussed below.

3.2.1 Migration Calorie Loss Factor

Eugene Hunn (1981) appears to be the first author to suggest modifying the calorie-based fish consumption estimates originally developed by Gordon Hewes (1947, 1973). While Hunn considered Hewes' estimates of salmon consumption to be "the most comprehensive attempted to date for the region" he contends that "his interpretation of the nutritional factors is misleading." Specifically, Hewes's caloric calculations did not account for the calories that salmon lose during spawning migration (since migrating salmon no longer feed once they re-enter freshwater).

Citing a study by Idler and Clemens (1959), who determined that sockeye salmon lose 75 percent of their caloric potential during spawning migration in the Fraser River watershed, Hunn proposed the following approach, as transferred to the Columbia River watershed: the "migration calorie loss factor" is computed as a ratio of (a) the distance in river-kilometers (km) from the mouth of the Columbia River to the approximate middle of each group's territory, to (b) the entire length of the Columbia River (1,936 km). This ratio was then multiplied by the average value for calorie loss during salmon migration, 75 percent (0.75), and the product was subtracted from one. For example, a salmon harvested halfway to the headwaters of the Columbia River is assumed to have lost half of 75 percent, or 37.5 percent (0.375) of its beginning caloric potential, and, therefore, would retain 62.5 percent of its beginning caloric potential ($1 - 0.375 = 0.625$), which is considered the migration calorie loss factor. Based in part on this adjustment, Hunn suggested that Hewes likely overestimated the calories

provided by salmon, and therefore salmon's contribution to the overall diet, and that "vegetable resources" likely played a larger dietary role than assumed by other authors. In fact, he concluded that the food collecting societies of the southern half of the Columbia-Fraser Plateau "obtained in the neighborhood of 70% of their food energy needs from plant foods harvested by women."

Other authors (e.g., Scholz et al., 1985; Schalk, 1986) have taken a different approach and assumed that Hewes was correct about the proportion of the diet supplied by salmon (on average 50 percent, or about 1,000 calories), but by not accounting for migration calorie loss, Hewes likely underestimated salmon consumption rates, particularly for upriver Tribes (as Schalk, 1986, stated, "some adjustment should have been made for distance traveled upstream"). To account for this, Schalk divided the consumption estimates developed by Hewes by a specific migration calorie loss factor determined for each Tribal group, following the approach described above.

Again using the example of a salmon harvested halfway to the headwaters of the Columbia River, Hewes's estimate for average per capita consumption for the Columbia Basin tribes of 365 pounds per year would be revised in the following manner: assuming a salmon has lost 37.5 percent of its initial caloric potential during spawning migration, 62.5 percent of its caloric potential would remain (the migration calorie loss factor). Dividing 365 pounds per year by 62.5 percent (0.625) gives a revised estimate of 584 pounds per year – a 60 percent increase. In other words, a person harvesting salmon halfway up the Columbia River would need to consume 584 pounds of salmon to get the same amount of calories as someone consuming 365 pounds of salmon harvested at the mouth of the Columbia. As Schalk (1986) noted, "the total annual per capita estimate for fish consumed rises significantly when a migration calorie loss factor is included."

3.2.2 Waste Loss Factor

In addition to considering calorie loss from migration, Hunn (1981) also appears to be the first author to suggest modifying the calorie-based fish consumption estimates originally developed by Hewes (1947, 1973) based upon the fact that some portion of a fish is not edible. Hunn (1981) stated that Hewes "does not allow for the fact that the edible fraction of whole salmon is generally considered to be approximately 80% of the total weight." Since many authors providing estimates of historical Tribal fish consumption did so for the purpose of estimating historical harvest rates, this factor (if accurate) was likely an important consideration. For example, if only 80 percent of each salmon harvested is

edible (i.e., 20 percent is “waste”), then a person consuming 100 pounds of salmon per year would need to harvest 125 pounds of salmon to support that consumption rate.

Schalk (1986) incorporated this “waste loss factor” into his estimates of annual salmonid catch in the Columbia Basin by revising Hewes’s consumption estimates for various Tribes and Tribal groups. Schalk stated that “the revised estimate involves dividing the per capita consumption estimate by a waste loss factor of 0.8 to get the gross weight of fish utilized. This figure is also derived from Hunn’s (1981) suggestion that 80 percent of the total weight of a salmon is edible.” While it appears that the main objective in using this factor is in estimating total catch (“the gross weight of fish utilized”), the terms “total catch” and “total consumption” are sometimes used interchangeably. Some subsequent authors have incorporated this waste loss factor into their estimates of actual fish *ingestion* when estimating aboriginal fish consumption rates.

3.2.3 Other Assumptions used to Develop Consumption Rates

In addition to the rate adjustment factors discussed above, there are a number of other assumptions that various authors have made to develop consumption rate estimates, including the following (discussed in more detail in section 4.1.3).

- Fish ingestion versus harvest and other uses (i.e., definition of “consumption”)
- Percent of diet (calories) provided by fish (versus other food items)
- Salmon (anadromous) and/or resident fish consumption
- Historical Tribal population estimates
- Number of fishing sites, fishing methods, and fishing efficiency

3.3 Columbia Basin-Wide Heritage Rates

Below is a summary of the primary source information reviewed on aboriginal fish consumption rates of Columbia Basin Tribes. Relevant information is presented from each of the following publications, including fish consumption estimates and associated assumptions (and summarized in Table 1).

- Craig and Hacker, 1940
- Swindell, 1942
- Hewes, 1947
- Griswold, 1954

- Walker, 1967
- Boldt, 1974
- Hunn, 1981

3.3.1 Craig and Hacker, 1940

In 1940, Joseph Craig and Robert Hacker of the U.S. Bureau of Fisheries estimated an aboriginal per capita salmon consumption rate of 1 pound per day (lb/d), which equates to 365 pounds per year (lb/yr) (or 454 grams per day [g/d]⁸) for Columbia Basin Tribes (Table 1). This estimate is based on historical ethnographic observations of extensive salmon harvest and use. The authors stated that, based on accounts of early explorers:

“Without doubt salmon, either fresh or dried, was the chief single factor in the diet of the Indians of the Columbia Basin in their native state.” (p. 140)

Other species were identified as consumed as well, including sturgeon, trout, and other fish; however, salmon was the primary species consumed. While the authors noted that it was “not possible to make an accurate estimate of the amount of salmon used by the Indians,” at the time, an approximation could serve “to illustrate the possible magnitude” of fish caught and consumed, with a wide margin of error (p. 141).

The authors stated that since significant quantities of salmon were available in the Columbia River and its tributaries during at least 6 months of the year, the Indians likely harvested and consumed large quantities of fresh salmon during this period and then consumed dried salmon for the remainder of the year. Therefore, “it appears to be well within the realms of probability that these Indians had an average per capita consumption of salmon of 1 pound per day during the entire year” (p. 142).

3.3.2 Swindell, 1942

In 1942, Edward Swindell of the U.S. Department of the Interior’s Office of Indian Affairs estimated an aboriginal per capita salmon consumption rate of 322 lb/yr (or 401 g/d) for Columbia Basin Tribes, specifically in the Celilo region prior to the installation of the

⁸ Most sources present rates in pounds per day; this report applies a conversion to grams per day (1 pound = 454 grams) for the reader and for applicability to water quality standards.

Dalles Dam and flooding of Celilo Falls (Table 1). This estimate is based on field survey interviews (and published affidavits) with local Indian families.

Swindell agreed that the estimate reported by Craig and Hacker (1940) of per capita salmon consumption of 1 pound per day was “not unreasonable” (p. 13) and that while “the poundage of the fish used for subsistence purposes cannot be definitely ascertained... the importance of this article of food as shown by a survey of 55 representative families is shown...” in his report (p. 147). As part of this study, the author presented and compared results obtained from interviews conducted with the heads of the 55 selected families, which represented a total of 795 Indian families present “under the jurisdiction of the Yakima, Umatilla, and Warm Springs” (p. 13-14). These interviews determined an average consumption rate of 1,611 lb/yr per family. Assuming a family unit was comprised of 5 members, Swindell calculated this to be a per capita rate of 322 lb/yr. This value accounted for both fresh and cured salmon, where the dried weights were converted to wet (fresh) weights. The affidavits given by participants of the survey supported Swindell’s aboriginal fish consumption estimates.

An affidavit provided by Tommy Thompson (age 79), of the Wyam Tribe of Indians residing at Celilo, Oregon, stated that “each family of Indians, when he was a boy,⁹ would dry and put away for their own future use, about 30 sacks of fish...each sack would contain about 10 or 12 fish which weighed almost 100 pounds [total]... each fish after it had been cleaned, the head and tail removed, and then dried, would only weigh between 6 and 8 pounds” (p. 153). Another affidavit provided by Chief William Yallup (age 75), a Klickitat Indian of Rock Creek, stated that “when he was a boy... during the [fish] runs, they would eat fresh fish three times daily and the surplus they caught would be dried for use when no fresh ones were available” and “that in those days each family would dry for its own personal use approximately 30 sacks of fish, each of which contained about six large salmon weighing, after they had been cleaned for drying, about six pounds; that for purposes of trading, each family would put away about 10 sacks of fish” (p. 165). Further, the affidavit noted that fishing rights “have a value to the Indians which cannot be measured in the terms of dollars and cents of the white man; that the subsistence value to the Indians as a whole is enormous...” (p. 167).

⁹ Based on the year of the publication (1942) and the age of Tommy Thompson at the time of the affidavit (79 years), the period discussed here equates to the mid to late 1800s.

3.3.3 Hewes, 1947

In 1947, as part of his dissertation required for a Ph.D. in Anthropology, Gordon Hewes developed an estimate reflective of Craig and Hacker's (1940) per capita salmon consumption estimate of 1 lb/d (365 lb/yr or 454 g/d) for aboriginal Columbia Basin Tribes (Table 1). The justification for this estimate was based on the average human caloric requirements of 2,000 calories per day (cal/d), the assumption that nearly 50% of the Indian diet was salmon, and that the caloric value of salmon was approximately 1,000 calories per pound¹⁰ (p. 213-215). This assumed that salmon provided nearly all dietary protein (primary source of energy) and that other food sources (such as plants) contributed minimal caloric value to the diet.

Hewes presented various consumption rate estimates for Tribal groups in different regions of Alaska and the Pacific Northwest compiled from various sources, stating that "while we have very few quantitative hints for the regions south of Alaska, it is reasonable to suppose that per capita consumption among intensive fishing peoples in parts of the Plateau...reached amounts equivalent to at least the lower estimates..." provided for Alaska and the Pacific Northwest by other authors (p. 223), including the estimate of 365 lb/d for the Columbia Basin presented by Craig and Hacker (1940). Acknowledging the guesswork involved, the author made every effort to develop reasonable rates, based on available ethnographic data for the various Tribes in the Pacific Northwest and Alaska, weighing salmon consumption by group or area accordingly. Tribe-specific rates are further discussed in Hewes, 1973 (Section 3.4.1).

3.3.4 Griswold, 1954

In 1954, as part of his dissertation required for a Master of Arts, Gillett Griswold cited Swindell's survey of Indian families in the Celilo region of the Columbia Basin, specifically noting the input factors that, when applied together, would result in an aboriginal per capita salmon consumption rate of 800 lb/yr (or 995 g/d). This rate was not presented in his publication *per se* (and, therefore, not listed in Table 1), only the factors used to calculate the rate.

Referring to affidavits presented in Swindell's study, Griswold assumed that each family cured and stored 30 sacks of salmon for their own use and an additional 10 sacks of salmon for trade each year, with each sack weighing 100 pounds. This equates to 4,000 lb/yr per family harvested. Assuming 5 individuals per family (as stated by Swindell), this equates to a per capita rate of 800 lb/yr. It should be

¹⁰ Calculation: $2000 \text{ cal/d} * 0.5 * 1 \text{ lb}/1000 \text{ cal} = 1 \text{ lb/d}$

noted that this rate considers all salmon that was harvested for both ingestion as well as trade (i.e., not eaten). While this consumption rate was not presented by Griswold in his dissertation, his input factors (4,000 lb/yr per family of 5 individuals) were used in the rate calculation by another author (Walker, 1967, discussed below) to estimate a range of consumption rates.

3.3.5 Walker, 1967

In 1967, Deward Walker conducted research on behalf of the Nez Perce Tribe and estimated an average per capita salmon consumption rate of 583 lb/yr (or 725 g/d) for aboriginal Tribes of the Columbia Plateau in general (Table 1). This estimate was based on the median value of two previously reported estimates: 365 lb/yr (estimated by Craig and Hacker, 1940) and 800 lb/yr (calculated from assumptions in Griswold, 1954).

Walker stated that “in light of the known annual dietary dependence on fish among aboriginal societies of the Plateau, it seems safe to conclude that the range was between 365 and 800 lbs. per capita with the average probably close to the median, i.e., 583 lbs.” (p. 19). It should be noted that the higher value of this range was calculated from Griswold, which, as discussed above, includes salmon harvested for ingestion as well as other uses such as trade. Walker noted that a typical use of fish in the Celilo region was for fuel. He also noted that determining a rate for particular groups in the Plateau would “require substantial, additional research” (p. 19).

3.3.6 Boldt, 1974

In the 1974 decision, Senior District Judge George H. Boldt ruled in the case regarding Treaty fishing rights in Washington State. The Judge stated that salmon “both fresh and cured, was a staple in the food supply” of the Columbia River Tribal fishers, and that salmon was consumed annually “in the neighborhood of 500 pounds per capita” (or 622 g/d) (p. 72) (Table 1). This case decision reaffirmed the reserved right of Native Americans in Washington State to harvest fish from their traditional use areas.

3.3.7 Hunn, 1981

In 1981, Eugene Hunn from the University of Washington, Department of Anthropology, re-evaluated the assumptions associated with Hewes' (1947 and 1973) salmon consumption estimates for Columbia Basin Tribes, suggesting that salmon likely did not provide as many calories as originally estimated in the aboriginal diet. Although Hunn did not present fish consumption rates in his publication (and, therefore, no estimate is included in Table 1), he first

introduced the concept of migration calorie loss and waste loss factors, as discussed in Section 3.2 above, and as later applied to fish consumption estimates by other authors (e.g., Schalk, 1986).

While Hunn considered Hewes' estimates to be the most comprehensive to date, Hunn contended that the caloric calculations were based on commercial fish, which are generally the fattest species, and which are typically harvested prior to upstream migration. Hunn cited Idler and Clemens (1959), which concluded that migrating salmon in the Fraser River "lose on average 75% of their caloric potential during this migration" (p. 127). It may be assumed that fewer calories per pound of salmon upstream results in people consuming more salmon to meet their daily caloric requirements. However, Hunn stated that other foods, such as roots and bulbs, likely provided a large caloric percentage of traditional diets. In addition to migration loss, Hunn determined that only about 80% of the total weight of salmon was edible, therefore introducing the concept of the "waste loss" factor, later applied by other authors to adjust consumption rates.

3.4 Shoshone-Bannock Tribes Heritage Rates

Below is a summary of the primary source information reviewed on heritage fish consumption rates specific to the Shoshone-Bannock Tribes. Relevant information is presented from each of the following publications (and summarized in Table 2), including fish consumption estimates and associated assumptions.

- Hewes, 1973
- Walker, 1985
- Schalk, 1986
- Walker, 1993

3.4.1 Hewes, 1973

In 1973, continuing on his previous dissertation work, Gordon Hewes presented updated aboriginal per capita salmon consumption rates for specific Tribes in Alaska, British Columbia, and the Pacific Northwest, including a rate of 50 lb/yr (or 62 g/d) for the Shoshone-Bannock Tribes (Table 2). This rate is based on caloric content and daily requirements, population estimates, and ethnographic accounts of the importance of salmon; it is also based on human dietary demands only, not including other non-ingestion uses.

Hewes initially published a general rate for salmon consumption by Columbia Basin Tribes based on assumptions about dietary caloric requirements and the contribution of salmon to aboriginal diets (see discussion of Hewes, 1947, in Section 3.3.3 above). In this report, Hewes again presents an average per capita estimate of 365 lb/yr (or 454 g/d) for the Columbia Basin Tribes as well as rates for individual Tribes. The Tribe-specific rates account for variability in salmon dependence between regions and population groups, and they reflect population numbers available at the time for each Tribe.

3.4.2 Walker, 1985

In 1985, Deward Walker conducted ethnographic research that included information about the Shoshone-Bannock Tribes; however, the report was never published and remains unavailable due to the sensitivity of the information it contained. The data presented here is based upon citations in Scholz, et al. (1985), in which the author included estimates and quotes and, therefore, apparently had access to Walker's (1985) report. Walker calculated an average per capita total (anadromous and resident) fish consumption rate of 800 lb/yr (or 995 g/d) for the Shoshone-Bannock Tribes (Table 2). Note that this rate intended to include both salmon and resident fish consumption combined in the estimate.

According to Scholz (1985), Hewes "checked Walker's new figures for populations and per capita consumption and agrees with Walker's revisions" (Scholz, 1985, p. 73). Scholz also stated that Walker's (1985) estimates were significantly different from those of Schalk (1986), discussed below, primarily because Walker assumed higher Tribal population totals (and also includes resident fish with salmon consumption). Without the original document, however, it is unclear if Walker's estimates represent fish ingestion only or include fish used for other purposes, such as trade and fuel.

3.4.3 Schalk, 1986

In 1986, Randall Schalk calculated salmon consumption estimates for specific Tribes based on Hewes' (1947 and 1973) original estimates, including a rate of 179 lb/yr (or 222 g/d) for the Shoshone-Bannock Tribes (Table 2). This rate includes migration and waste loss factors applied to Hewes' Tribe-specific values. Schalk contended that many of Hewes' original estimates were biased low because they were based on:

- A caloric content of fish representing salmon as they enter freshwater in prime condition (i.e., having more calories than upstream salmon). Schalk stated that “since salmonids lose an average of 75 percent of their caloric content during migration (Idler and Clemens 1959), some adjustment should have been made for distance traveled upstream” (i.e., applying a migration loss factor).
- The assumption that salmon were eaten in their entirety. Schalk states that assuming the entire fish was consumed was “unrealistic” and cited Hunn (1981) to state that only “about 80 percent of the weight of a salmon is edible.”

Schalk, therefore, adjusted (increased) Hewes’ consumption rates by applying a migration loss factor (variable by Tribe depending on how far upstream they harvested salmon) of 35% (0.35) for the Shoshone-Bannock Tribes. Schalk also applied a waste loss factor of 80% (0.80), citing Hunn (1981), therefore, including inedible fish parts in the fish consumption estimate.

3.4.4 Walker, 1993

In 1993, Deward Walker reviewed data from the Northwest Planning Council (Schalk, 1986), which accounted for migration and waste loss factors, to report a per capita average catch of 635 pounds for Plateau-wide Tribes. Walker estimated that this same value of 635 lb/yr (or 790 g/d) was appropriately representative of the Shoshone-Bannock Tribes fish harvest.

Walker conducted a study to reconstruct Lemhi Shoshone-Bannock fishing activities, including evaluating fishing technologies, locations, and harvest, to estimate total fish catches via “a more empirical, comparative, historical, and comprehensive methodology than has been used in previous studies” (Walker, 1993). Walker determined that the value estimated by Schalk (1986) of 179 lb/yr for the Shoshone Bannock was an underestimate and he proposed a Plateau-wide average of 635 lb/yr as more appropriate estimate for the Shoshone Bannock (and likely even higher for the Lemhi). This value represents fish caught and, therefore, may include fish used for purposes other than ingestion; the distinction is not made in the publication.

4.0 RATE EVALUATION AND DISCUSSION

This section further evaluates and discusses the information presented above, including the uncertainty associated with the rate adjustment factors and other assumptions influencing rate calculations.

4.1 Factors Influencing Consumption Rates

The migration calorie loss factor and waste loss factor are considered here, particularly regarding the uncertainty associated with applying these adjustment factors to heritage rates. Other factors that influence the calculation of heritage rates and that may also increase uncertainty of the estimates include population size estimated at the time, number of fishing sites, and reliability of ethnographic data in general.

4.1.1 Migration Calorie Loss Factor

For a number of reasons, the application of the migration calorie loss factor as described above introduces a high degree of uncertainty into the revised estimates of tribal fish consumption. The study that forms the basis of this adjustment (Idler and Clemens, 1959) is based on one year's run of one species of salmon (sockeye) in one watershed (the Fraser River). The conclusions of this study are then broadly applied to all salmon species within a different watershed (the Columbia River), even though it is estimated that sockeye accounted for only 7 percent of the Upper Columbia salmon harvest (Beiningen, 1976, as cited in Scholz, et al., 1986). The degree to which different salmon species lose calories at different rates or in different proportions during spawning migration, and the degree to which the Columbia River and Fraser River watersheds differ (in length, elevation change, etc.) all affect the degree of uncertainty associated with the calculation and application of a migration calorie loss factor.

The migration calorie loss factor is based on a gross percentage of calories lost by a sockeye salmon during spawning migration in the Fraser River (i.e., ending calories compared to beginning calories). However, the factor is applied in revising consumption rates as though it represents the amount of calories lost *per pound consumed*, which is not the same; salmon not only lose calories during migration, they also lose weight. Based on measurements collected by Idler and Clemens (1959), the average overall weight loss during spawning migration was 25 percent, and the loss in caloric density (calories per gram) was therefore about 65 percent, as opposed to 75 percent. Table 3 provides the total calories,

total weight (in grams), and caloric density (in calories per gram) of sockeye salmon measured at various stages in the Fraser River (from Idler and Clemens, 1959).

Further, the overall decrease in caloric potential was based on measurements of sockeye salmon that have spawned *and died* in headwater streams. Michael Kew (1986) describes the results of the Idler and Clemens study as follows:

“As a general rule, the further from the sea a salmon is, the less fat and protein it carries. The loss is considerable. Total caloric value of a sockeye, measured at the river mouth, will be reduced to nearly one-half when it reaches the Upper Stuart spawning grounds, one thousand kilometers from the sea. After the enriched gonads have been expended in spawning and the fish die on these upper streams, they will have lost over 90 percent of their fat and one-half to two-thirds of their protein (Idler and Clemens, 1959; reviewed in Foerster, 1968: 74-6).”

As Kew notes, there is a significant difference in caloric potential between the time a salmon reaches its spawning grounds and the time it has spawned and died. Based on measurements collected by Idler and Clemens (1959), the average sockeye loses almost 15 percent of its caloric density (calories per pound) between the time it reaches its spawning grounds and the time it has spawned and died. At the time a sockeye salmon reaches its spawning grounds in the upper Fraser River watershed, it has lost about 50 percent of its caloric density (Table 3).

Still further, the derivation of the migration calorie loss factor relies on the assumption that the salmon harvest location is at “the approximate middle of each group's territory” (Hunn, 1981). To the extent that a majority of salmon harvest occurs either downstream or upstream of this point, the migration calorie loss factor would either overestimate or underestimate, respectively, the effect on the consumption rate.

Mullan, et al. (1992) note that caloric losses in salmon are generally related to mileage of migration, but not directly. “Idler and Clemens (1959) show much higher energy expenditures by sockeye in some river reaches than others, and higher rates for females than males. In other words, caloric content is not linear in relation to distance.” Further, Mullan notes that in migration and maturation the fish tend to mobilize fat reserves and resorb organs (e.g., gastro-intestinal

tract), and “[t]hus they lose weight, but not necessarily caloric content, between cessation of ocean feeding and nominal freshwater capture.”

While the idea of adjusting calorie-based consumption estimates to account for migration calorie loss does not seem unreasonable, based on the uncertainty described above, it most likely tends to overestimate salmon consumption relative to Hewes’ original estimates (because it likely overestimates calorie loss per pound). Since sockeye salmon lose approximately 50 percent of their caloric density upon reaching their spawning grounds, a maximum migration calorie loss factor of 50 percent, as opposed to 75 percent, may be more consistent with the supporting research (although the existing research is limited to a single species of salmon). Hewes’s diet and calorie-based consumption estimate for the Columbia Plateau Tribes is identical to that proposed by Craig and Hacker (1940), which is not based on caloric intake but on observation and review of the ethnohistorical literature (although it is “admittedly liable to a wide margin of error”).

4.1.2 Waste Loss Factor

Incorporating a waste loss factor to revise Hewes’s fish consumption estimates has the effect of increasing the consumption rate (relative to Hewes’s estimate) by 25 percent. If the interest is in understanding how much individuals consumed (ingested), as opposed to “used,” then the use of a waste loss factor is not appropriate. Essentially, this factor adjusts a consumption rate, increasing it by 25 percent, to account for the portion of fish NOT consumed. Consumption estimates that have been revised to account for a waste loss factor (as in Scholz et al., 1985, and Schalk, 1986) would tend to overestimate consumption (ingestion) by 25 percent, relative to the “unrevised” rates.

Some estimates of consumption by Tribal groups are based on an estimate of total harvest and total population. For example, some authors estimate a total harvest (in pounds) based on the number of fishing sites, number of fishing days, efficiency of fishing techniques, average weight of fish, etc., and simply divide the total estimated harvest by the total estimated tribal population to arrive at an annual per capita consumption rate. However, this type of estimate does not account for the fact that only a portion of each fish may be edible (i.e., 80 percent), and may tend to overestimate the amount that people are actually consuming.

Mullan, et al. (1992) suggested that, because many Tribal groups prepared and consumed most parts of the salmon, including organs, eyes, eggs, etc., the

inedible waste was much less than 20 percent, arguing that “waste factor of a salmon amounted to bones only, under 10% of body weight.”

4.1.3 Other Assumptions used to Develop Consumption Rates

In addition to the rate adjustment factors discussed above, other assumptions that various authors have made in developing consumption rates introduce varying degrees of uncertainty to the estimates, including those discussed below.

Ingestion, Harvest, and Consumption

As discussed in Section 3.1, the effort here is to summarize estimates of fish ingestion which may be relevant to the development of Tribal water quality standards. The degree to which estimates of Tribal fish consumption in the various studies include uses in addition to ingestion may affect their applicability to Tribal regulatory or policy development.

Percent of Diet Supplied by Fish

The calorie-based consumption estimates developed by Hewes, which form the basis for a number of subsequent estimates, are based on the assumption that salmon account for about 50 percent of the average Columbia Basin aboriginal diet. Many authors have made similar estimates, while others have assumed either higher or lower dietary estimates. While 50 percent of the diet (i.e., 50 percent of total calories) is among the most common estimates, the degree to which a specific Tribe has a higher or lower percentage of diet supplied by fish can affect the accuracy of the calculated consumption rate.

Salmon and Resident Fish Consumption

Because of the importance of salmon to the Columbia Basin Tribes, and because many studies have attempted to evaluate the impact of the hydroelectric system on anadromous fisheries, a majority of the studies evaluated focused exclusively or primarily on the harvest and consumption of salmon. The degree to which individual Tribal groups relied on resident fish, either to supplement or to substitute for salmon consumption, will affect the accuracy of consumption estimates included in these studies relative to total fish consumption.

Tribal Population Estimates

Some authors have estimated total fish consumption for various Tribal groups by estimating an overall harvest rate and dividing that rate by the total Tribal population to develop an average per capita estimate. Therefore, the

accuracy of population estimates may directly affect the accuracy of consumption estimates developed using this approach.

Number of Fishing Sites, Fishing Methods, and Fishing Efficiency

Some authors have developed consumption estimates based on assumptions about the type and effectiveness of Tribal fishing methods and the number of harvest locations utilized by individual Tribes or Tribal groups. The degree to which these assumptions are accurate will directly affect the accuracy of consumption estimates using this approach.

4.2 Heritage Fish Consumption Rates

The heritage rates estimated for the Columbia Basin Tribes and, specifically, the Shoshone-Bannock Tribes, introduced in Sections 3.3 and 3.4 above, are evaluated in more detail below, including discussion of the assumptions and uncertainty associated with the estimates.

4.2.1 Columbia Basin-Wide Heritage Rates

Craig and Hacker (1940) presented the first estimate of per capita salmon consumption for aboriginal Tribes of the Columbia Basin of 365 lb/yr (or 454 g/d), which was based on historical ethnographic observations, although acknowledged by the authors as likely having a wide margin of error. Hewes (1947) validated this rate with additional assumptions related to average dietary caloric requirements, the contribution of salmon to the aboriginal diet, and a caloric value for salmon. These assumptions (a 2,000 calorie diet, 50 percent of the diet was salmon, and salmon contained 1,000 calories per pound), while generalized, provided additional justification for this rate. Hunn (1981) later re-evaluated Hewes' assumptions by suggesting that migration calorie loss and inedible waste loss factors should be considered. While variability exists in how many calories each salmon contained and how much of each salmon was eaten, the method for developing and applying such "adjustment factors" (discussed in Section 4.1 above), as done to aboriginal rates by other authors (e.g., Schalk, 1986), may have added a level of uncertainty to those estimates.

Shortly after Craig and Hacker (1940) published the first aboriginal salmon consumption estimate, Swindell (1942) published a very similar estimate of per capita salmon consumption of 322 lb/yr (or 401 g/d) for the Tribes of the Celilo Falls region. This value was based on interviews with Indian families, including affidavits of extensive salmon consumption and use, and total harvest (according to sacks of fish and average weights per fish). Griswold (1954) later cited Swindell's work, referring to these affidavits, to calculate a total annual

harvest of 4,000 pounds per family. Although Griswold did not calculate a *per capita* consumption rate in his publication, Walker (1967), by assuming 5 individuals per family, calculated a per capita rate of 800 lb/yr (or 995 g/d) for an upper range of fish consumption. Based on per capita fish consumption rates ranging from 365 lb/yr (presented in Craig and Hacker, 1940, and Hewes, 1947) to 800 lb/yr (calculated from Griswold, 1954), Walker (1967) calculated an average (median) per capita salmon consumption rate of 583 lb/yr (or 725 g/d). A few years later, Boldt (1974) stated that Columbia River Tribes consumed (as food supply) a comparable rate of about 500 lb/yr (or 622 g/d) of salmon.

It is important to remember that the rate calculated from Griswold's (1954) information reflects salmon that was harvested for both consumption as well as trade (i.e., salmon not ingested). If all other assumptions hold true, based on Swindell's (1942) information (3,000 lb/yr harvested per family for consumption, 5 individuals per family¹¹), a more accurate per capita upper range for fish consumption as defined for this report would be 600 lb/yr (or 746 g/d). If this alternate value is used from Griswold (1954), calculating an average rate similar to Walker's approach would result in an average rate of 483 lb/yr (or 600 g/d) (Table 1).

4.2.2 Shoshone-Bannock Tribes Heritage Rates

Hewes (1973) continued his earlier dissertation research from 1947 and published his estimates for various Tribes based upon fish caloric content and daily requirements, population estimates, and ethnographic accounts of the importance of salmon among different Tribes. He estimated an average per capita salmon consumption rate of 50 lb/yr (or 62 g/d) for the Shoshone-Bannock Tribes. Schalk (1986) applied migration and waste loss factors to Hewes' estimate, yielding a rate of 179 lb/yr (or 222 g/d). Walker (1993) determined that Schalk underestimated the total catch and proposed 635 lb/yr as a more appropriate estimate for the Shoshone Bannock (and likely even higher for the Lemhi). It is unclear if this value represents fish used for purposes other than ingestion.

In 1985, Walker expanded upon his previous work from 1967 and calculated Tribe-specific per capita total fish consumption rates for individual tribes, including 800 lb/yr (or 995 g/d) for the Shoshone-Bannock Tribes. Although this

¹¹ If the 10 sacks of salmon that were harvested for trade are removed from the equation, the 30 sacks of fish consumed at 100 pounds = 3,000 pounds (per family).

study remains unpublished, the estimates were presented (with supporting information) by Scholz (1985). Walker's estimates appear to be the only rates (of those presented here) that reflect use of both anadromous and resident fish; however, since the report is unavailable, it cannot be verified if these estimates account for only fish ingested or include fish used for other purposes (such as trade).

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TABLES

Notes/Footnotes for Tables:

¹ Includes a migration calorie loss factor (based on Hunn, 1981, citing Idler and Clemens, 1959) to adjust estimates based on caloric intake.

² Waste loss may be accounted for either in direct observation (i.e. the author is citing consumption of fish that had been prepared for consumption, as was done by Craig and Hacker and Swindell) or by adjusting the amount of fish harvested by a waste loss factor loss factor (0.8, based on Hunn, 1981) to translate from amount consumed to amount harvested. For consumption rates derived using caloric analysis, waste loss is inherently accounted for, as calories consumed are converted into edible fish mass consumed.

Estimates based on ethnographic observation sometimes appear to be based on amounts actually consumed (e.g. Craig and Hacker; Swindell) and sometimes based on amounts harvested (e.g. Walker; Marshall). Those based on the amount harvested would include the inedible (waste loss) portion, and would likely overestimate consumption. They may also include harvest for other uses, although that is not specifically stated in most studies.

Different studies address “waste loss” differently. Most that use the “waste loss factor”, like Schalk and Scholz, use the factor to translate from a consumption rate to a harvest rate, so they tend to inflate the consumption rate (by dividing by 0.8). Other studies (e.g. Hunn and Bruneau, 1989) use the same factor to translate from a harvest rate to a consumption rate (by multiplying by 0.8). So both studies “account” for waste loss, but they do so to opposite effect.

Here is an excerpt from Hunn and Bruneau:

“Based on these educated guesses, I use 500 pounds per person per year as a reasonable traditional gross harvest rate for “River Yakima” and 400 pounds for the Nez Perce (cf. Walker 1973:56) and the Colville. Actual consumption is estimated at 80% for the edible fraction (thus 400 and 320 pounds respectively).”

Table 1. Average Heritage Fish Consumption Rates for the Columbia Basin Tribes

Reference	Methodology	Species Evaluated	Rate in g/day	Rate Derivation	Includes (Note: +/-/U indicates whether the way in which a particular factor was addressed causes an increase, decrease, or unknown impact on the FCR)		
					Uses Besides Consumption	Migratory Caloric Loss Factor ¹	Accounting for inedible portion ²
Craig & Hacker 1940	Ethnographic Observation	Salmon, sturgeon, trout	454	Not presented	No (+)	No (-)	Yes (U)
Swindell 1942	Ethnographic Observation	Salmon	401	1611 lb salmon/year ÷ 5 people/family x 454 g salmon/lb salmon ÷ 365 days/year	No (+)	No (-)	Yes (U)
Hewes 1947	Caloric Analysis	Salmon	454	2000 calories/day x 50% of diet as salmon x 1000 calories/lb salmon x lb salmon/454 g salmon	Yes (-)	No (-)	Yes (U)
Griswold 1954	Ethnographic Observation	Salmon	746	30 sacks salmon/year/family x 10 lb salmon/sack x family/5 people x 454 g salmon/lb salmon x year/365 days Griswold cited 40 sacks of salmon per family were obtained with 30 retained for family use and 10 used for other purposes.	No (+)	No (-)	No (U)
Walker 1967	Evaluation of Craig & Hacker 1940 and Griswold 1954	Salmon	725	Average of 454 g/day (from Craig and Hacker, 1940) and 995 g/day (from Griswold 1954). The Griswold value was based on families obtaining 40 bags of salmon, 30 for consumption and 10 for trade. 995 g/day = 40 sacks salmon/year/family x 100 lb salmon/sack x family/5 people x 454 g salmon/lb salmon x year/365 days	Yes (+)	No (-)	No (U)
Boldt 1974	Undocumented, (United States v. Washington, 384 F. Supp. 312	Salmon	622	500 lb salmon/person/year x 454 g salmon/lb salmon x year/365 days	Unknown (U)	No (-)	Unknown (U)

Table 2. Average Heritage Fish Consumption Rates for the Shoshone-Bannock Tribes

Reference	Methodology	Species Evaluated	Rate in g/day	Rate Derivation	Includes (Note: +/-/U indicates whether the way in which a particular factor was addressed causes an increase, decrease, or unknown impact on the FCR)		
					Uses Besides Consumption	Migratory Caloric Loss Factor ¹	Accounting for inedible portion ²
Hewes 1973	Caloric Analysis/Ethnographic Observation	Salmon	62	Methodology not presented	Unknown (U)	Unknown (U)	Unknown (U)
Walker 1985	Unpublished, cited by Scholz et al 1985.	Salmon and Resident	995	Methodology not presented	Unknown (U)	Unknown (U)	Unknown (U)
Schalk 1986	Reanalysis of Hewes 1947 and 1973	Salmon	222	222 g/day = 62 g/day from Hewes 1973 ÷ 0.35 caloric loss factor ÷ 0.8 waste loss factor	Unknown (U)	Yes (+)	Yes (+)
Walker 1993	Review of Schalk 1986 for the Northwest Planning Council	Salmon	790	Reviewed work of Schalk 1986, determining this work was applicable to the Shoshone Bannock Tribe	Unknown (U)	Yes (+)	Yes (+)

Table 3. Spawning Migration and Calorie Loss (Fraser River)

Fraser River Location	Total Calories¹ (kCal)	Total Weight¹ (grams)	Caloric Density (calories/ gram)
At River Mouth	5,173	2,585	2.00
At Spawning Grounds	2,248	2,363	0.95
After Spawning and Death	1,334	1,917	0.70
Percent Loss at Spawning Grounds	57%	9%	52%
Percent Loss After Spawning and Death	74%	26%	65%

Notes:

All values are based on Idler and Clemens, 1959.

¹Based on average of male and female values.