Heritage Fish Consumption Rates of the Shoshone-Bannock Tribes

Final Report

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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 (FCRs) was conducted for the Shoshone-Bannock Tribes. Heritage FCRs are those fish consumption rates in practice prior to disruption of tribal culture and fisheries resources by non-tribal use of and settlement on tribal lands. 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.

It is crucial that quantitative characterization of Shoshone-Bannock FCRs, either current or heritage FCRs, be understood in conjunction with other aspects of the Tribes (e.g. the current status of the Shoshone-Bannock Tribes, the history of the Shoshone-Bannock Tribes, the role of fish and fishing in the lives of Tribal members, suppression of fisheries and fish consumption due to the impacts of non-tribal use of and settlement on Native American lands, treaties between the U.S. government and Shoshone-Bannock Tribes, the manner in which treaty language relates to tribal hunting and fishing rights, and the activities of the Tribe in relation to their fisheries). In addition to some of the background material presented here, a foreword to Volumes I-III, authored by the Shoshone-Bannock Tribes, is essential reading.

The heritage report in Volume I discuss the purpose and objectives of characterizing heritage fish consumption rates for the Shoshone-Bannock Tribes, relevant background material (in particular the suppression of current fish consumption relative to historic FCRs and the causes of suppression), approaches used to develop heritage FCRs, a discussion of the factors considered in deriving heritage FCRs, a summary of the literature discussing heritage FCRs, a presentation of heritage FCRs including a discussion of uncertainty in these FCRs, and, finally, a table summarizing heritage FCRs. Additional relevant and important material is provided in two forewords relevant to the entire report. The first forward, mentioned previously, is authored by the Shoshone-Bannock Tribes and EPA. The second, authored solely by the Shoshone-Bannock Tribes, provides the Tribes' perspective.

1.1 Purpose and Objectives

Tribal Governments in the State of Idaho worked closely with the U.S. Environmental Protection Agency (EPA) Region 10 and other stakeholders to gather data on 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 the ambient water quality criteria review process of the Idaho Department of Environmental Quality (ID DEQ)—a process that impacts tribal rights and interests. A Tribal heritage rate study was conducted as part of this effort. This study compiled and evaluated available data to determine heritage FCRs for the Shoshone-Bannock Tribes. Knowledge of past rates may help determine how current FCRs might increase in the future if current fisheries resources are improved and fish consumption is restored to past, higher levels. Information about FCRs may be used to support development of water quality standards that protect human health both on and off the Reservation.

Since a substantial portion of their diet is derived from aquatic sources, water and aquatic resources are of great importance to their subsistence lifestyle; and these resources hold significant cultural and spiritual value for the Shoshone-Bannock Tribes. As part of the survey effort, discussions with the Tribes highlighted the issue of suppression and its causes. The Tribes recognized long ago that fish consumption is suppressed due to a number of factors including: decreased fish populations due to physical habitat modification and adverse effects of chemical contamination, habitat fragmentation and loss, passage barriers, stream temperature increases, channelization and dewatering of streams for irrigation, limitations on Tribal access to fisheries resources due to privatization of public lands, exposure to contaminants in fish, limitations on access imposed by the State, fish species composition changes, and changes in fish harvesting by Tribal members associated with adaptation to economic and cultural shifts.

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 Tribes.

The Shoshone-Bannock Tribes’ primary objective for the fish consumption survey is to develop water quality standards that are protective of all cultural, ceremonial, physical and biological uses of water.

The Tribes have been working for many years to improve and return anadromous fish runs to the areas where they were traditionally found and to protect, restore, and enhance fish-related resources in accordance with the Tribes’ unique interests and vested rights in such resources. Currently, many tribal members are concerned that the water and fish are contaminated and not safe for consumption or for cultural/ceremonial use(s). Their overarching goal is to bring back ecosystem function and provide clean water resources to sustain not only human populations, but the health and welfare of forms of life in which we all depend. This survey contributes to documenting the Tribes inherent spiritual, mental, and physical connection with the natural gifts provided by the Creator, often referred to as natural resources in Western Societies.

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 FCRs is presented for the Tribes.

Certain key geographic features referred to in the following discussion are mapped in Figure 1.

2.0 BACKGROUND (Authored by the Shoshone-Bannock Tribes)

The Shoshone-Bannock Tribes have relied extensively on fish resources and fishing activities from time immemorial. A summary of fish harvest and the extensive use of fisheries resources, a brief discussion of fish consumption prior to settlement of Native American lands by non-Indians, and the causes of decline in fish availability over time, is provided for context. In order to gain a complete understanding of these issues, it is necessary to read the foreword to Volumes I-III of this report, authored by the Shoshone-Bannock Tribes. This foreword provides a rich understanding of the Tribal perspective on these issues. Importantly, the foreword also delineates subsistence fish and game harvest rights guaranteed to the Shoshone Tribes by treaty with the U.S. Government.

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).

Anadromous fish provided the Shoshone-Bannock peoples with abundant and predictable supplies of food. 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. Some anadromous species also entered the tributaries of the Snake, such as Rock and Salmon Falls creeks. Shoshone and Bannock people who did not continually live along salmon bearing streams relied upon anadromous fish and traveled annually to locations where fish could be taken (Albers, et al., 1998). Not only were the salmon and steelhead utilized for subsistence, but the Pacific lamprey was an important subsistence species of the Tribes.

Like anadromous fish, resident fisheries were and continue to be an important and reliable source of fish protein for the Shoshone-Bannock Tribes. Some resident fish harvested and utilized by the Tribes were documented by Liljeblad (1957) and Steward (1938) included: catfish, sucker, minnows, trout, cray fish, whitefish, and redside shiners. These species of fish were taken on an opportunistic basis when need arose.

Today, descendants of the Tribes include Shoshone and Bannock speaking peoples whose traditional territorial ranges encompass the Idaho-Utah boarder region, interior Oregon, Nevada, Wyoming, and Montana. Also incorporated into the reservation were bands from the Lemhi, Boise Valley, Bruneau, Weiser, and McCall areas (Albers, et al., 1998). Tribal members continue to exercise off reservation Treaty rights, and return to aboriginal homelands to practice their unique culture and traditions.

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 and degradation of habitat due to riparian and stream channel disturbance, channel dewatering for irrigation withdrawals, and environmental pollution. 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). Today, climate change is also expected to further reduce and degrade habitat for native fish through alterations of hydrologic regimes and increasing water temperatures (Gillis, et al. 2011).

One of the largest phosphate ore reserves in the United States is located in the Blackfoot and Salt River drainages of southeastern Idaho. 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). These river systems support populations of trout which have been identified to have selenium contamination and threat to the populations within these drainages (USFWS, 2006). Bioaccumulation of selenium in aquatic systems has been well documented (Presser, et al. 1994; Bowie et al. 1996; Dobbs, et al., 1996; Maier, et al., 1998; Garcia-Hernandez, et al., 2000; and Hamilton, 2002) and bioconcentration factors of 100-10,000 are possible in aquatic food organisms consumed by fish (Lemly, 1999).

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 stream banks 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). Impairment to water quality that results from lateral scouring and downcutting of stream banks due to livestock grazing and other agricultural uses is also not limited to the Reservation, but these impacts occur throughout the state of Idaho.

Non-point source pollution and water diversions are the predominant influences on surface water quality in the Upper Snake River subbasin (ID DEQ 2011). 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.

Idaho's 2012 Integrated Report to the EPA presents information about the status of Idaho's water categorized using assessment units. The leading causes of impairment in streams and rivers are temperature, sedimentation/siltation, E. coli, and cause unknown (ID DEQ 2014: 44). According to the report, of the 95,119 total stream / river miles statewide, 36% or 34,396 miles did not support the beneficial uses identified for that stream; and 34% or 32,034 miles were not assessed. The report also summarized the status of Idaho's lakes and reservoirs: based on 469,045 total acres statewide, 56% or 261,709 acres do not support beneficial uses; and 38% or 179,653 acres have not been assessed (ID DEQ 2014). In total, then, 70% of Idaho's stream / river miles and 94% of Idaho's lakes and reservoirs do not meet their designated beneficial uses or it is simply not known.

The Pocatello Region is reported to have the most miles of stream in the State that are not fully supporting designated beneficial uses (595 miles or 66%) with the Idaho Falls Region coming in second at 506 miles or 36%. The Fort Hall Reservation is within the Pocatello Region and the Idaho Falls Region, with its close proximity to the Reservation, provides significant opportunity for Tribal members to exercise reserved Treaty rights. The Fort Hall Reservation is surrounded by 303(d) listed streams. The Blackfoot, Snake, and Portneuf rivers are all on the list of water quality limited stream segments with the Portneuf receiving additional special recognition for the human health advisories for fish consumption related to mercury contamination.

There is a limited area of the state—central Idaho's wilderness—where water bodies meet designated beneficial uses. ID DEQ believes waters within designated wilderness and inventoried roadless areas meet the natural conditions provision by virtue of the fact that little to no significant human management has taken place to cause changes in water quality or affect beneficial uses (ID DEQ 2014:31).

3.0 HERITAGE FISH CONSUMPTION RATES (FCRs)

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 FCRs 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 FCRs, however this information is not suitable for development of FCR 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 FCRs 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 FCR 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 FCRs 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% 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% (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%, or 37.5% (0.375) of its beginning caloric potential, and, therefore, would retain 62.5% 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%, 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% of its initial caloric potential during spawning migration, 62.5% of its caloric potential would remain (the migration calorie loss factor). Dividing 365 pounds per year by 62.5% (0.625) gives a revised estimate of 584 pounds per year – a 60% 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% of each salmon harvested is edible (i.e., 20% 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% 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 FCRs.

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 FCRs 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][1]) 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 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

[1] 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.

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,[2] 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).

3.3.3 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 pound[3] (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

[2] 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] Calculation: 2000 cal/d * 0.5 * 1 lb/1000 cal = 1 lb/d

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 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 FCRs 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 FCRs 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) FCR 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% 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% 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% 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%, and the loss in caloric density (calories per gram) was therefore about 65%, as opposed to 75%. 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% 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% 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% of their caloric density upon reaching their spawning grounds, a maximum migration calorie loss factor of 50%, as opposed to 75%, 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 ethno historical 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%. 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%, 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%, 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%), 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%, 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% 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% of the diet (i.e., 50% 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 (FCRs)

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% 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 FCRs 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 family[4]), 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 FCRs for individual tribes, including 800 lb/yr (or 995 g/d) for the Shoshone-Bannock Tribes. 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).

[4] If the10 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).

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6.0 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	Migra-tory Caloric Loss Factor [1]	Accounts 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 Griswald 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	Migra-tory Caloric Loss Factor [1]	Accounts 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 Calories[1] (kCal)	Total Weight[1] (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 for Table 3:

All values are based on Idler and Clemens, 1959.

[1]Based on average of male and female values.

Figure 1. Key geographic features referred to in this report.