Deep Time — Salmon and People in Alaska Before Contact

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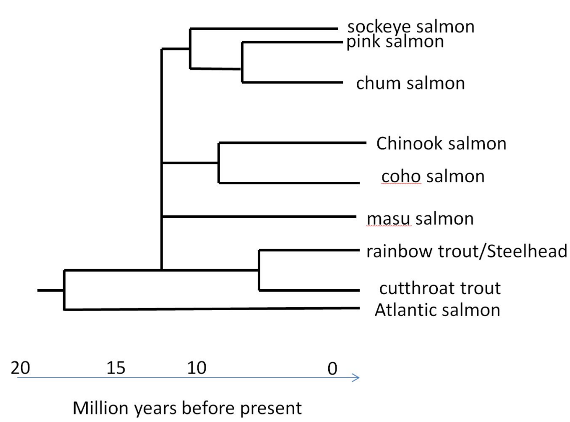
The evolution of the diverse and dynamic Alaska landscape, Pacific salmon populations, and First Alaskans are inextricably entwined. Alaska is home to five species of the genus *Oncorhynchus* that share the common life history patterns of anadromy (reproduce in freshwater and feed in the ocean) , philopatry or homing (return to natal spawning streams for reproduction), and semelparity (die after the first and only season of spawning). Although Chinook salmon (*O.tshawtyscha*) , coho salmon (*O.kisutch*), sockeye salmon (*O.nerka*), chum salmon (*O.keta*), and pink salmon (*O.gorbuscha*) differ in the extent to which they display anadromy and homing (Keefer et al. 2014, Westley et al. 2013), all die after spawning and serves to group them into a convenient category referred to as 'Pacific salmon.' In addition, rainbow trout (*O. mykiss*) often go to sea and fish that exhibit that anadromous life history are called steelhead 'trout'. In contrast to the other five species, steelhead have the capacity to spawn multiple times- a life history trait that led early taxonomists to cluster them with Atlantic salmon (*Salmo salar*). Despite this difference, many researchers including the authors here consider steelhead as Pacific salmon (Quinn 2018, Waples et al. 2008), though this project focuses on the five semelparous species. That being said, in regions such as Southeast Alaska and Yakutat, steelhead was an important subsistence resource and remains highly valued by local traditional users and sport anglers alike. However, contemporary and deep time data specific to steelhead are severely lacking. Although they do not exist on the eastern side of the Pacific Ocean, cherry salmon (*O. masu*) are important to ecosystems and People in regions such as Hokkaido and Sakhalin, and worthy of their own examination in those regions.

The evolutionary timing and relatedness among species remains debated in the scientific literature, with opposing views as to whether the ancestors of Pacific salmon were of freshwater, marine, or anadromous origins. Not long ago, scientists considered Atlantic and Pacific salmon to be 'sister taxa', based on their similar life histories, body shape, and reproduction. We now know that Atlantic salmon and Pacific salmon diverged from one another in the vicinity of 15-20 million years ago (Kinnison and Hendry 2004, Waples et al. 2008). In contrast to Atlantic salmon that remained as one -albeit diverse- species, Pacific salmon radiated into the multiple species recognized today. Why Pacific salmon evolved into multiple species and Atlantic salmon remained as one, and whether the common ancestor of Atlantic salmon and Pacific salmon was a freshwater or marine species is still a subject of debate. A widespread and current working hypothesis to reconcile this difference exists in the relative difference in landscape diversity and stability between the Pacific and Atlantic (Waples et al. 2008).

Modern genetics provides key insights into both the ages and relatedness of modern Pacific salmon species. In broad terms, sockeye salmon, pink salmon, and chum salmon form a group –termed 'clade', whereas coho salmon and Chinook salmon, and rainbow trout/steelhead and cutthroat form other clades. Similarly, the Asian species of Pacific salmon, masu and amago, form their own grouping and are among the most recent to have diverged from each other. These genetic relationships generally align with commonalities in life histories. For example sockeye salmon, pink salmon, and chum salmon all rear in large water bodies of the ocean or inland lakes as juveniles whereas coho salmon and Chinook salmon are more dependent on rivers for juvenile rearing.
Although the macroevolutionary splits in the Pacific salmon life history tree were complete by about 5 million years ago, the vast majority of the diversity that we observe and strive to protect in Pacific salmon is much younger. Much of the range of Pacific salmon in Alaska was completely buried by glaciers during the last ice age, known as the Pleistocene. Upon melting of the glaciers, newly available habitats were colonized by salmon from areas that had remained ice free, and because salmon tend to return to natal rivers to breed the populations drifted apart and individuals accumulated traits through natural and sexual selection that allowed them to thrive in local areas. Thus to understand the evolutionary patterns of diversity in salmon we must appreciate both deep and contemporary time.



Pacific salmon have evolved to use an impressive diversity of freshwater habitats, from mighty continental river systems like the Yukon and Kuskokwim to countless tiny, unnamed coastal watersheds; from cold, silty, and physically unstable glacier-fed streams to crystal-clear streams where temperature and flow are stabilized by groundwater inputs; from steep, rocky streams to sandy, meandering ones; from small wetlands to the largest of lakes. Aside from the Arctic slope, where habitat conditions are not (yet?) conducive to widespread colonization by salmon (Nielsen et al. 2013), most Alaskan fresh waters that are physically accessible to salmon are used by migrating, spawning, and/or rearing salmon. These waters represent large gradients in physical conditions such as thermal and hydrologic regimes, depth, flow rates, clarity, substrate size, frequency and magnitude of disturbances, and streambed stability.

The ability of salmon to exploit this range of conditions, aside from being a testament to their adaptability, accounts for their impressive abundance in Alaskan waters. We explore in more detail throughout this project, this habitat diversity – and the genetic and life history diversity it fosters –stabilizes year-to-year variation in the size of salmon runs and prolongs the period that salmon runs are present in freshwater, to the benefit of humans and the many other organisms that consume salmon. Thus a complex mosaic of habitat is a vital and integral feature of Pacific salmon ecosystems. The abundance of salmon across this mosaic of habitats has waxed and waned naturally through time as evidenced by paleoecological studies that have reconstructed salmon abundance and other aspects of the ecosystem for example, through analyses of stable isotopes extracted from lake sediment cores (Schindler et al. 2005). These studies provide insight into site-specific patterns of salmon abundance (see discussion of the Karluk system on Kodiak Island below) through time and reveal that across sites that population dynamics of salmon populations tend to be largely independent (Rogers et al. 2013). The asynchronous nature of the ups and downs of in salmon abundance has been likened to a diverse financial portfolio that buffers the aggregate return (in this case sum of salmon) against environmental variation, with benefits to mobile consumers, including people.

Earliest Arrivals of First Peoples

It has long been argued that the earliest human occupations in North America were arrivals in Alaska from Asia. The last ice age was at its maximum extent from 25-20,000 years ago during which time the land bridge between Alaska and Siberia known as Beringia existed due to the lowering of sea level. Even at the maximum extent of the glaciation, the Yukon River valley remained unglaciated as part of an ice-free route for animals and humans to move back and forth overland between what are now separate continents. Beginning around 15,000 years ago, the climate warmed and as the ice began retreating, sea level rose. The end of the last glacial age is dated to approximately 11,700 years ago but the impacts on coastal Alaska due to tectonic uplift and sea level rise continued for another 4-5,000 years.

Sites with the earliest evidence of humans in Alaska first appear toward the end of the last ice age. The initial colonization of Beringia was through interior east-west trending river systems between 14,000 - 13,000 years ago (Potter et al 2017: 39). An alternative oceanic route has been proposed following the coastline of southern Alaska utilizing intermittent ice-free landscapes with populations depending on marine resources (Erlandson et al 2008). Earliest evidence of human presence along the coastal route is several thousand years later, however, than the Beringian route being dated to around 9,200 year ago in southeast Alaska (Dixon 1999, Dixon et al 1997, Carlson and Baichtal 2015).

There is considerable evidence that the earliest humans who traveled south from Alaska into western North American utilized salmon as an important food source (Butler and O'Connor 2004, Sutton et al 2015). Recent archaeological research has revealed that some of the earliest people to live in Alaska made use of salmon. At the Upward Sun River site on the Tanana River in central Alaska researchers have discovered multiple phases of human occupation beginning around 13,000 years ago. The occupation level dated to approximately 11,500 years ago has produced scales of salmonids (Potter et al 2017). Genetic analysis of the scales indicate that they were chum salmon. This is the oldest known presence of salmon in Alaska demonstrating that they were present in the Yukon River and the Tanana River drainages at the end of the last ice age.

The Dene (or Athapaskan) people occupy much of the interior of Alaska primarily along the Yukon and Tanana Rivers. Views on when they arrived and how long they have lived in interior Alaska differ substantially with some scholars seeing them as the earliest occupants of the region. The language of each of the ten Athabascan societies occupying the interior in recent times includes words for all five species of Pacific salmon as well as a generic term for salmon. For all of the Athapaskan groups, except the Dena'ina and Ahtna, the word for chum salmon is also the generic term for salmon (Simeone and Kari 2002:12).

Human Expansion and Salmon Use to 4,000 Years Ago

While the Yukon River valley of the interior of Alaska was unglaciated during the last ice age, the lands to the south bordering the Gulf of Alaska were heavily glaciated extending outward from the southern slope of the Alaska Range to the Gulf of Alaska. Geologists have discovered that what is now the Copper River valley was inundated forming Lake Atna from approximately 58,000 to 11,000 years ago. The enormous amount of water filling this vast landscape was held back by a gigantic glacial dam that blocked the river outlet in the lower valley (Wiedmier et al 2010). The last Lake Atna formed about 58,000 years ago (Ferrians, 1984) and fluctuated in extent before ultimately draining via the Copper River between 10,270–11,090 years ago. The great ice dam in the valley below Chitina broke open resulting in explosive flooding that created the incredible outwash of the Copper River delta. Shortly after that event, salmon populations from all five species undoubtedly made their way up the river and began spawning in the streams and lakes of the Copper River drainage. Human presence in the valley also seems to have closely followed the dam blowout event with the oldest dated presence of humans suggested to be around 9,000 years ago (Workman 1977:34).

Vast glacial fields bordered a considerable portion of the Gulf of Alaska from the end of the Alaska Peninsula on the west to Dixon Entrance in the south during the last ice age. On the outer coast, however, ice-free areas known as refugia, made it possible for human populations to begin occupying these areas (Dixon 1999, Carlson and Baichtal 2015). Archeological research findings indicate that human populations first appeared in coastal southeast Alaska about 11-10,000 years ago possibly via the marine route sometimes referred to as the “kelp highway” or down river valleys such as the Chilkat that flow from the interior to the coast (Erlandson et al 2007). Similarly, first sites of human occupation in Bristol Bay date to around 11,000 years ago (Dumond 1998).

Human occupation of the Cook Inlet region took place from the north and south. Evidence for the earliest human appearance in the upper Susitna River drainage begins around 9,000 year ago (Wygal 2009). In Kachemak Bay, at the southern entrance to Cook Inlet, cultural materials similar to those on Kodiak Island have been dated to 5000 years ago (Reger and Boraas : 166). Some evidence of earlier occupations at sites on the shores of upper Cook Inlet has been found but dates associated with the materials are uncertain.

At present, the earliest dates of human occupation from Prince William Sound are around 5,000 years ago which maybe due to relatively late glacial retreat from that area (Steffian et al 2016). Earlier occupation may not have been identified due as the result of tectonic activity that has drastically altered the land-sea interface in this area multiple times. Resources are less abundant than in the Kodiak Archipelago (Steffian et al 2016).

Early human occupations of the Gulf of Alaska region are not found in association with salmon streams. One hypothesis suggests that processes of coastal stabilization due to tectonic rebound and sea level rise combined to cause stream environments to fluctuate significantly until around 5-6,000 years ago (Fladmark 1975). These conditions are thought to have prevented the development of large salmon populations. In southeast Alaska, sea level initially rose substantially above the current level due to glacial retreat, but then rapidly declined from 9,000 to 6,000 years ago resulting in the lengthening of streams and the expansion of spawning habitat (Carlson and Baichtal 2015). Only with sea level stabilization do stream conditions begin to make possible increased salmon populations. The focus of human resource use appears to track these changing conditions of salmon availability in southeast Alaska.

Salmon use by indigenous Cook Inlet populations becomes more evident around 2,000 years ago with the appearance of inland sites on the Kenai River at the Moose and Russian Rivers that represent a shift from earlier occupations along the coastal areas of the lower Kenai Peninsula especially in the Kachemak Bay area (Reger and Boraas 1996).

Recent paleoenvironmental research shows that Sanak Island south of the western Alaska Peninsula was ice-free by 17,000 year ago (Misarti et al 2012). The western region of Kodiak Island, the site of an independent glacial complex, was ice free by 14,000 years ago. Human populations apparently migrated south from the eastern Bristol Bay area and arrived on the southern coast of the Alaska Peninsula in the Chignik area around 8000 years ago. Shortly thereafter, they crossed Shelikof Strait and began settling around the Kodiak Archipelago after 7500 years ago (Steffian et al 2015:22).

Recently it has been suggested that the North Pacific Ocean and Bering Sea experienced a increase in overall productivity approximately 4,500 years ago (Maschner et al 2009). This increased productivity associated with a Neoglacial geologic period fueled increases in human populations demonstrated by many new sites characterized by multiple permanent structures noted throughout the coastal regions. This boost in productivity is considered to be the driver for “the most significant transition in the histories of the region” as the new technical and cultural practices that emerged at this time show strong similarities to those utilized by indigenous Alaskans at the time of the arrival of Europeans (Maschner et al 2009:34). Bering Sea populations appear to have benefitted from expanded marine mammals population while Gulf of Alaska and Bristol Bay populations benefited from larger runs of salmon (Maschner et al 2009).

Karluk: A Unique Case to Examine Human-Salmon Interaction Through Time

The Karluk system on the northwest side of Kodiak Island provides an exceptional opportunity to look at the long term consequences of human occupation and that relationship to the salmon populations of the river and lake system. In setting the stage for that discussion, it is important to provide an overview of the archeology of the region and the biological methodology for estimating the salmon populations of the system through time.

Archeologists interpret the sequential stages of human presence in the Kodiak Archipelago as the continuous development over centuries by an initial population with subsequent adaptations based on primarily on local innovations (technical and social), changing resource availability (including larger salmon runs), increasing populations, and geographic expansion (Steffian et al 2015). Three pre-contact stages (called “traditions”) of different cultural practices over the 7500 years prior to sustained contact with Euroamericans have been identified:

- Ocean Bay: 7500 – 4000 ya
- Kachemak: 4000 – 650 ya
- Koniag: 650 – 200 ya

Each tradition is defined by a set of characteristics identifiable in the archeological excavation of the sites such as technological items, location of settlements, size of settlements, architectural style, and other stylistic elements such as ornaments, masks, and type of burial. Transitional phases between traditions are identified as changes occur gradually over time rather than abruptly all at once.

Ocean Bay The location of settlements, technical equipment and faunal remains found in archeological sites from this time period indicate that the earliest Kodiak settlers of the Ocean Bay tradition relied primarily on marine mammals. Although salmon were available in the streams of the archipelago at this time, there numbers were apparently far below the levels evident at the time of contact (Finney et al 2002). It is thought that lances were used for individual fish capture and immediate consumption is considered to have been characteristic of Ocean Bay villagers salmon usage. This form of adaptation continued for about 3500 years when evidence indicates a transition to a new stage (termed Kachemak) took place.

Kachemak The Kachemak tradition period is characterized by significant human population growth as demonstrated by increases in settlements and the size, architectural quality and permanence. There is substantial evidence of more intensive utilization of salmon from increases in the numbers of artifacts associated with salmon use. Kachemak villagers applied a new technology for taking salmon consisting of nets (rock sinkers are the indicators) and their sites were located at key spots for harvesting salmon – mouths of stream tributaries and along the lake shore. Whereas lances are assumed to have been used for serial, single fish capture and immediate consumption and thought to have been characteristic of Ocean Bay villagers, Kachemak people are likely to have begun harvesting substantially greater number of salmon. Evidence for expanded processing comes from large hearths and pits both inside and outside of the houses for storing dried salmon. The ulu or stone knife began being used, large amounts of charcoal are evident and more pits are found during this period. Around 1000 years ago, a transitional period began that eventually developed into a new tradition about 700 years ago (Steffian et al 2015:43).

Koniag The settlements, populations and ways of life encountered by early Russian explorers are associated with the Koniag tradition. Population increased dramatically during this period and utilization of the entirety of the Karluk system at multiple sites in each context is evident. Seven substantial settlements existed on the lagoon, river and around the lake as well as numerous smaller sites in various locations. The larger settlements consisted of new types of buildings – large multiroom houses and community structures that were probably used for meetings, events and ceremonies with visiting populations. Another new feature of the Koniag period were much larger pits located in the houses where substantial quantities of processed salmon and other resources were stored. Koniag tradition communities practiced a rich ceremonial culture as documented by Russians and early Europeans who visited the region in the 18th century.

Alutiiq After the invasion of the Russians, human cultural traditions and salmon at Karluk changed dramatically. The interior large settlements were abandoned as the people were brought into economic vassalage by the Russians following defeat of the indigenous islanders at Three Saints Bay in 1784. In the 19th century, Russians directed much of Kodiak Islanders lives and appropriated a substantial amount of their production. Following a substantial decline in population associated with a smallpox epidemic in 1836, the Russians concentrated the Alutiiq population into seven communities around the island. The discussion of impacts at Karluk following US assumption of jurisdiction in 1867 is found in the Kodiak regional section.

The Kodiak Archipelago has many salmon streams of which the Karluk system on the northwest shore is the largest supporting all five species of salmon. The system includes a lagoon, river into which flow several streams and lake also with numerous tributary streams. The lagoon, where salt and freshwater mix, is about two kilometers in length at the head of which the Karluk River debouches. The river is 24 miles in length from the lagoon to the lake from which it exits. The lake is 13 miles in length, elongate in form and almost two miles wide at its greatest extent. The lake with its multiple tributary streams extends deep into the interior of Kodiak Island.

Data and information from biological and archeological studies of the Karluk system provide exceptional evidence concerning the history of salmon and people unavailable elsewhere in Alaska. The history of the salmon population of the Karluk system is perhaps the best known of any place in Alaska. Analysis of nitrogen isotopes deposited in lake core sediments based on the presence and abundance of salmon have demonstrated that salmon population numbers have dramatically changed through time (Finney 1998). There are four apparent phases of salmon population abundance in the Karluk system (Finney et al 2002). The earliest identified signal dates from about 2200 years ago indicating an estimated run size of 1.2 million salmon. This was followed by a sharp drop to less than 200,000 salmon, which lasted a short period before a gradual sustained increase occurred until approximately 1500 years ago. Then a relatively rapid and sustained increase in abundance occurred until about 1000 years ago when the average annual return plateaued again for a short period. After another gradual rise, a new higher plateau was achieved about 700 years ago at approximately 2.5-3 million salmon returning annually. This sustained level of abundance was punctuated by several short periods of sharp declines that quite likely were associated with increased harvests taken by the Russian American Company to provide food for its employees (Grinev 2013) coupled with periods of poor ocean survival. By the mid-1800s this "anomalous" level of abundance returned and even slightly increased in the late 1800s prior to the onset of the American commercial canned salmon industrial fishery (Finney et al 2002). Historic records of sockeye harvest kept following the onset of the American cannery period report a record harvest of 4 million fish in 1902 and a record escapement of 2.5 million fish in 1921 (Gard and Bottorof 2014:xvi).

The Karluk area was not one of the earliest locations initial settlers occupied when they arrived on Kodiak Island. Marine mammals and intertidal resources are not abundant in the lagoon area, the resources upon which the earliest occupants primarily depended (Steffian et al 2015). The lagoon area of the system was first settled as early as 6,000 years ago but identifiable evidence of human presence in settlements on the river or around the lake does not occur until around 4,000 years ago with the appearance of Kachemak tradition sites. Finney et al (2002:731) suggest "the abrupt reduction of [salmon] at 100BC appears to coincide with a major cultural change associated with the transition from the early to late Kachemak period." The Kachemak tradition pattern of Karluk occupation with small sites located throughout the lagoon, river, and lake persisted for 3,000 years. Salmon populations gradually and substantially rebuilt over that time to the level identified at 2100 years ago when Kachemak site characteristics emerged. A number of Kachemak tradition sites are associated with spawning areas (Steffian et al 2015). The 150 year transitional period leading to Koniag tradition cultural characteristics at 700 years ago "matches the change from the late [transitional] Kachemak to the transitional Koniag and Koniag periods, when population numbers rose and a strong shift towards high utilization of salmon fishing gear is evident" (Finney et al 2002:731). Finney at al (2002) matched the isotopic signal occurring just prior to the onset of the intensive American industrial fishery to the immediate period prior to contact when salmon abundance was at its highest level. Bean (1889) reported that 3,000,000 salmon were harvested at Karluk in 1887. While salmon returns fluctuate considerably, a range of total return of 3-5 million salmon to the Karluk system is defensible. If the numbers of salmon returning during the early industrial fishery were characteristic of the period prior to contact, alternating years would have seen significantly different returns largely due to major differences in pink salmon numbers from one year to the next.

Archeologists have estimated that the resident human population of the Karluk system at the time of contact was approximately 1200 people (Steffian et al 2015). Some of them may have moved to Karluk from other nearby areas where settlement size declined in the 200 years prior to contact. The people lived in dense concentrations of buildings at seven locations – lagoon (3), river (3) and lake (1) – in good-sized settlements. The primary resource on which they depended were the salmon as other resources are less abundant in the Karluk area than elsewhere in the Kodiak area. Archeologists suggest that the locations of fishing sites were owned by nearby residents who would have spent a considerable portion of the year in proximity to their communities. However, artifacts from the houses indicate that resources from elsewhere on the island were accessed and trade across Shelikoff Strait with related populations on the Alaska Peninsula was substantial. Structures in the settlements range in size and purpose. Larger houses have multiple side rooms for living, steaming and storage. There are also structures that appear to have been for ceremonial or community events utilized by a set of related households. Structures appear to have been rebuilt at 50-year intervals across the 500 years of the Koniag tradition period (Steffian et al 2015). Despite the overall appearance of thriving, healthy populations, Steffian (1994) found that skeletal remains from the region show signs of metabolic stress indicating that there were intermittent but not infrequent periods of food shortage. These most likely occurred in the spring after relatively poor salmon seasons or **at times** when winter stormy weather prevented harvesting of offshore fish or marine mammals to supplement the diet.

At Karluk, the long-term stable occupation characterized by substantial structures and a large human population is associated with sustained productivity of salmon at the highest level identified over 2100 years of documented human and salmon presence. A strong inference from this evidence is that the local Koniag harvested sufficient quantities to sustain themselves, host large ceremonies and participate in trade of salmon while at same time maintaining high salmon productivity for five centuries. Given that salmon are vulnerable to excessive exploitation, access obstruction and habitat degradation, these findings indicate that at Karluk human engagement with and utilization of salmon was driven by sophisticated understandings of salmon habitat and requirements that produced sophisticated practices resulting in sustained success for people and salmon alike.

Given a population of 1200 for the entire Karluk system and annual consumption of 600 salmon per capita, the resulting average annual harvest of 720,000 salmon represents less than 25% of a total return of 3 million salmon. Historic figures of sockeye salmon returns noted above demonstrate that this level of harvest was well below levels currently recommended for escapement goals. Even in years of below average returns, human harvests, as the record of sustained salmon abundance indicates, are unlikely to have detrimentally affected salmon runs.

Environmental Downturn and Human Response: 750 – 200 years ago

It has recently been suggested that the North Pacific ecosystem, including the Bering Sea, experienced a major decline around 750 years ago (Maschner et al 2009). Scholars note both environmental and archeological data (site numbers) as the basis for this claim. Around that period, population movements and declines in number of sites and settlements can be identified. Salmon, however, may have persisted at relatively high numbers during this period and humans may have become more dependent on them, continuing the increased use levels even when the ecosystem recovered.

At the time of contact, human populations had for thousands of years depended on salmon and had developed robust knowledge of salmon behavior. The indigenous people viewed salmon in an entirely different way than European and American who arrived on Alaskan shores in the late 18th century.

Precontact Alaska Native Salmon Utilization

Estimating the precontact utilization of salmon by indigenous Alaskans is a challenging task. Three publications considering salmon use by indigenous populations in the Pacific Northwest of North America have been reviewed and evaluated for this exercise. All three address the issue of human salmon utilization in northwestern North America. The foci of the three pieces differ in scale and areal focus but all address similar issues albeit differing in key respects. Hewes (1973) developed his precontact estimates of "fisheries productivity" for "the Pacific salmon area" based on his 1947 dissertation. Schalk (1986) used Hewes' approach and adapted it to "usage in the Columbia Basin before 1850." Simeone and Kari (2002) constructed a similar model, using the framework developed initially by Hewes (1973) but revising it as the result of careful consideration of a number of sources that discussed indigenous salmon utilization in Alaska. It is noteworthy that the estimates by Schalk (1986), Simeone, and Kari (2002) both nearly doubled Hewes' estimate for precontact salmon utilization for the populations they addressed.

In order to construct an estimate, data and assumptions about a number of variables are required. First, a population figure is necessary for each indigenous group – however, the massive loss of life due to smallpox epidemics in 1836 and 1862 prior to significant efforts at enumeration complicate efforts to estimate populations. The population figures used by Hewes (1973) are based on late 19th century counts that did not take into consideration of the huge declines in population due to disease. Both Schalk (1986) and Simeone and Kari (2002) roughly double the population figures used by Hewes (1973).

Estimates of salmon utilization are also difficult to determine from historical records. Hewes (1973) created a model of salmon consumption by indigenous groups in the salmon region of the Pacific Northwest based on the following assumptions:

1. average daily caloric intake necessary to maintain a healthy adult (2000 cals)
2. proportion of the diet derived from salmon (50%)
3. average weight of salmon (2.3 kg, or 5 pounds)

Simeone and Kari (2002:60-62) developed a revised model of Ahtna salmon utilization by comparing and averaging demographic figures from a number of sources to more than double the population used by Hewes (1973). They also increased the estimate of annual consumption based on anthropological and historical sources from the level used by Hewes (Simeone and Kari 2002:60). Using the new assumptions, Simeone and Kari (2002:61) increased the estimated salmon utilization of the Ahtna by 33% to 440,000 fish. The authors noted that this level would be approximately one-third more than estimates based on consumptions levels recorded from early historic records.

Schalk (1986:1-20) constructed a model of indigenous consumption of salmon at contact for the Columbia River basin again using Hewes (1973) as a starting point. Schalk (1986) did not modify Hewes' (1973) population figures. However, he identified three factors that Hewes (1973) had not considered. Schalk (1986: 22-25) revised the number of salmon used by humans upward by 1) adjusting the caloric value to 75% of live weight, 2) adjusting consumable quantity to 80% edible, and 3) using a migration caloric loss factor based on decline of value as salmon move upstream. Using these adjustments, Schalk's (1986:19) estimate of take nearly doubled the figure proposed by Hewes (1973). Schalk (1986:20) went to note that the harvest level he estimated – roughly 5 million salmon annually – was slightly less than 50% of the total return of 11 million salmon at the onset of the industrial salmon fishery. Finally, he states, "this approach provides a *minimum,* rather than an average estimate" (Schalk 1986: 21).

The Alaska Native salmon utilization estimate provided below is based on the following considerations derived from the articles discussed above. Hewes' (1973) four variables are used with several adjustments. First, Hewes (1973) population figures for indigenous Alaska are too low. Langdon (2013) and other sources as listed in the table have been used that result in nearly tripling the population figure Hewes used. Second, no adjustments or computations have been made concerning fresh or dried weight of fish; the average of them has been used. Third, despite primary dependence on different species in different regions (sockeye in Bristol Bay, king in Kuskokwim, pinks in Kodiak), a single average weight based on sockeye salmon has been used for all regions. Fourth, no adjustment for edible weight has been used.

Several other considerations have gone into this exercise that were not previously considered. First, Alaska Native populations along the upper Yukon and Kuskokwim Rivers access fewer salmon at lower caloric value than those populations living downstream or on the coast. Therefore, it might be assumed that they had lower dependence on salmon. However, Lovell (1984:100) conducted stable carbon isotope analyses of a number of British Columbia skeletal remains from indigenous populations on the upper Fraser and Columbia Rivers. Stable isotope analyses show the proportion of the diet derived from saltwater resources. A sample of 11 skeletons from 120 miles up the Fraser River showed a 61% index and another 40 miles up the river, the signal was still strong with 15 persons averaging 55%. There have been no comparable analyses in Alaska so it is likely that the upriver Yukon and Kuskokwim populations show similar patterns of use as demonstrated in British Columbia. Hewes' (1973) of 50% dependence on salmon appears to be supported by these figures. Second, Norton Sound and Kotzebue Sound populations have access to substantial marine mammal populations and salmon runs tend to fluctuate widely so a lower average annual consumption rate has been assumed for these areas. Finally, due to the absence or low numbers of salmon historically, the populations of the St. Lawrence Island, the Arctic Slope and the Bering Strait Islands have not been included in these computations.

A couple of final comments are in order. The Hewes (1973) and Simeone and Kari (2002) estimates of salmon use are based on individual consumption and do not consider production for trade, production for ceremonial ritual giving/hosting or the likelihood of following the maxim of "a little bit more" to produce enough in case of the failure of other resources characteristic of subsistence societies. All three of these considerations if adjusted for would increase the figures based only on direct consumption by some fraction.

The estimates below are presented with the caveat that they are based on general rather than regionally specific salmon figures. A thorough examination would require a more complete review of multiple Alaskan sources and would benefit from more detailed attention to regional differences. They should also be considered a minimum level of harvest rather than average. Regardless of precise values, the patterns observed here solidify what should be the obvious- that Alaska Natives were the first stewards and managers of the fishery and accomplished this complex task for millennia.

Table 1: Precontact Alaska Native Salmon Utilization

Region	Group	Population	Per Capita Salmon	Total Salmon	Source
Southeast	Tlingit	15,000	600	9 million	Langdon (2013)
	Haida	1,800	600	1.08 million	Dawson (1836)
Copper River	Eyak	500	600	300,000	Hewes (1973)
	Ahtna	1,100	400	440,000	Simeone and Kari (2002)
Prince William Sound	Chugach Alutiiq	3,000	400	1.2 million	Langdon (2013)
Cook Inlet	Alutiiq	500	400	200,000	Langdon (2013)

	Dena’ina	1,500	600	900,000	Kari and Fall (2002)
Kodiak, Chignik	Koniag Alutiiq	15,000	700	10.5 million	Steffian et al (2015)
Alaska Peninsula/ Aleutian Islands	Unangan/ Aleut	16,000	400	6.4 million	Laughlin (1977)
Bristol Bay	Alutiiq	2,000	600	1.2 million	Langdon (2013)
	Yup’ik	5,000	600	3.0 million	Langdon (2013)
	Dena’ina	800	600	480,000	Langdon (2013)
Kuskokwim	Yup’ik	8,000	500	4.0 million	Langdon (2013)
	Dena’ina	500	500	250,000	Langdon (2013)
Yukon	Yup’ik	5,000	500	2.5 million	Langdon (2013)
	Deghitan	3,000	500	1.5 million	Langdon (2013)
	Holikachuk	1,000	400	400,000	Langdon (2013)
	Koyukon	3,000	400	1.2 million	Langdon (2013)
	Gwich’in	3,000	400	1.2 million	Langdon (2013)
Norton Sound	Inupiat	5,000	300	1.5 million	Langdon (2013)
Kotzebue	Inupiat	4,000	200	800,000	Langdon (2013)

TOTAL	Alaska Natives	101,700		56,160,000	

Aamasuuk (Alutiiq),Iqalugruaq (Inupiaq, Utqiagvik), iiliksak (Alutiiiq), Chinook salmon-king salmon- (English), *Oncorhynchus tshawytscha*, yee (Tsimshian), te’ya’lee (Eyak)

Qakiiyaq, uqurliq,caayuryaq, coho salmon-silver salmon, *Oncorhynchus kisutch*, qavlunaq, ciayuryar, ƱƱx, ta’ay

Aashát (Tlingit), steelhead, *Oncorhynchus mykiss*

Niklliq, amartuq, sayak, sockeye salmon-red salmon,*Oncorhynchus nerka*, cayak, cayag, miso, tahi’id

Iqalugruaq, alimaq, kangitneq, mac’utaq, chum salmon-dog salmon-silvers (upper Yukon River), negpik, mac’utar, gaynii, tiitl’

Amaqtuuq, amaqaayak, luuqaanak, amaqaayak, amaqsuq, luqaanak, terteq, qakiiyaq, uquriliq, caayuryaq, qavlunaq, ciayuryar, ü̈üx , ta'ay, pink salmon-humpback salmon-humpy, *Oncorhynchus gorbuscha*

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