BABINE WOOD-STAKE FISH WEIRS IN AN ELEVEN KILOMETER STRETCH OF THE BABINE RIVER AND NILKITKWA LAKE, NORTH CENTRAL BRITISH COLUMBIA

by

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Abstract

In north central British Columbia, the Lake Babine Nation used wood stake fish weirs for many centuries. Weirs facilitated the reliable capture of sufficiently large numbers of salmon (*Onchorynchus* spp.) to enable the Babine and other Indigenous groups in the area to support significantly larger and more sedentary populations than would otherwise have been possible. Little research has been carried out on similar weirs in the adjacent Fraser watershed, but no archaeological research has been conducted on the Babine weirs until recently. This thesis begins to fill this gap.

The present study begins with a survey of the global scholarly literature on riverine and lake wooden fish weirs to ascertain the factors that must have constrained weir design, construction, and management in Babine territory. Environmental factors and other criteria are important to understanding how and why weirs were used in the study area, and why they were so successful prior to their forced removal in 1906. An example of extant remains of a weir on the Babine River is discussed, and information from historic and oral historic sources is provided to develop a better understanding of the Babine weirs, and how they relate to the development of social complexity.

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Chapter 1: Introduction

Fish weirs are a barrier or channelling device for fish, located in parts of, or across streams. Humans have used wood stake fish weirs in many places around the world for many centuries. In the British Columbia interior Indigenous people manufactured these –fences” that are placed in flowing streams to capture various species of fish, using a wide variety of locally available materials. This thesis examines Aboriginal wood stake fish weir technology along an eleven kilometer stretch of the Babine River and Nilkitkwa Lake, in north central British Columbia (Figure 9), as part of the larger Babine Archaeology Project (BAP). The project was undertaken to better understand the design, construction, operation, and maintenance of Babine weirs, and its implications of the technology use on Babine culture and social complexity. These weirs were an important component of Babine subsistence before they were removed in 1906 (see Chapter 6). Since then, the knowledge of weir operation, construction and design has been almost lost. In 2012 the Babine Archaeology Project (BAP), directed by Farid Rahemtulla from UNBC, surveyed the remnants of wood fish weir stakes on the Babine River. Working in conjunction with the Lake Babine Nation Treaty Office and residents of Ft. Babine, the project located several wood stakes adjacent to Smokehouse Island that matched historical descriptions of weirs at this location (see Harris 2001). Many of the stakes were mapped in 2014, but little was known about the operation of these weirs. The lack of archaeological research and scholarly literature on fish weirs in the Babine area presented significant challenges to understanding Babine precontact culture.

Fortunately, there is substantial scholarship on wood stake fish weirs elsewhere to guide scholars, although much of this work has focused on typology. Scholars have categorized weirs according to differences and similarities in design, and according to environmental and physiographic variables (Connaway 2007). To date the Babine weirs have never been categorized. This work begins by studying the Babine weirs in the context of those typologies. One goal is to construct a general functional typology of wood riverine weirs based on apparent operational and environmental characteristics, within the context of the broader literature. A more specific goal is to determine how weir design was adapted to the specific environmental characteristics of the study area, and how weirs were managed and operated.

The Babine watershed receives up to 90% of the annual Skeena River sockeye run, making it an ideal place for the capture of large numbers of that species (Waples et al. 2008). Not surprisingly, ethnographic and historic records attest to the importance of these and other fish, within the Babine subsistence economy. Globally, salmon reliant groups developed various approaches to the management, capture, and preservation of salmon (Rabnett 2000: 18). Each fishery system was managed with great consideration relevant to the environmental characteristics of the area.

Guided by a general application of Optimal Foraging Theory (Smith 1983) this thesis argues that Aboriginal communities organized their fishing activities to maximize the harvest of these high caloric value resources through the use of fish weirs. Aboriginal communities organized their fishing activities so that a high-quality nutritious resource was harvested efficiently. This was accomplished by ensuring that the weirs were not placed in the water until sufficient fish had passed to spawn. Complex social and economic management systems facilitated the harvest of this resource over a long time. Fish weirs increased food predictability and security for fisheries-dependent groups (Connaway 2007; Prince 2014), and they could potentially ensure that sufficient caloric stores were procured for the winter months, in a short time (Cox 1832: 234). The geographic restriction of riverine environments creates a spatial focus to fishing activities, and reliable timing of the salmon runs in turn allows for a temporal focus to subsistence activities. Other advantages for the use of fish weirs are presented by Rostlund (1952), who argued that the ease of use of wood stake fish weir technology would suit the early post-glacial environment in British Columbia, while Connaway (2007:12) argued that the technology although complex in design and function, could be constructed and maintained by relatively few people. In addition, forest cover increased steadily over time, which increased the efficacy of weir technology because raw materials became more abundant, and shorelines more stable.

The Babine watershed was, and is, an important area for both the Babine and neighbouring First Nations for the resources it provides. Of the many salmon stocks available in north central British Columbia, the Babine River salmon, especially sockeye, were among the most highly prized (Rabnett 2000: 18) because the salmon had to travel a relatively short distances to reach their spawning grounds (Rabnett 2000: 18). The shorter travel distance meant that the fish suffered less damage from their journey and retained higher fat content (Plew 1983; Ballard 1957; Hewes 1973). With the temporal spacing of the various salmon runs in the Babine River, the Babine procured their winter stores of food in a relatively short period of time (Rabnett 2000: 15). One of the reasons the Babine people did not subsist year round on the stored salmon is that many of the surpluses were traded or given away to neighbouring groups (Fiske and Patrick 2000). The reliability and quality (less muscle wasting and higher fat content) of the salmon placed the Babine people in an advantageous position in comparison to other groups without salmon streams, such as First Nations in the north-east of the province. The longer salmon season in the Babine also resulted in a higher volume of fish captured by the Babine relative to other salmon–reliant groups in the neighbouring Fraser watershed in north-central interior of British Columbia (Bouchard 2012: 57). Terrestrially based diets were less reliable and predictable (Essington et al. 2006) in this area, and were not likely abundant enough to sustain a large population like that of the Babine and the neighbouring First Nations peoples. Consequently the Babine relied more heavily on salmon (*Onchorynchus* spp.) than on any other terrestrial or aquatic resources available to them (Fiske and Patrick 2000).

Little archaeological work has been done on the nature of Aboriginal resource procurement in the study area. Most of the focus of archaeological research to date has looked at terrestrial food sources, with little attention paid to fishing. A survey undertaken by Mohs in 1974 and by Mohs and Mohs in -1975 and 1976 identified many village sites, including one in the study area, GiSq-004, Nass Glee, which contained over 1100 cultural features (Mohs and Mohs 1974: 12; see also Rahemtulla 2012 and Hackett 2017). Until recently, limited archaeology work was conducted in the Babine Lake area as part of cultural resource management or other surveys, and they did not focus on the documentation of fish weirs explicitly. Although there has been evidence that wooden fish weirs were used in the Babine River, the focus has been on coastal areas in adjacent regions (except Prince 2014; 2005). More recently the Babine Archaeology Project directed by Rahemtulla (2012) in partnership with the Lake Babine Nation began and it continues to investigate past Aboriginal subsistence strategies in the area, including wood stake fish weirs.

Chapter 2 focuses on the global use of riverine wood stake fish weirs and the environmental contexts in which they are situated. Situational environmental characteristics are critical factors in the design and successful use of wood stake fish weirs and therefore, variations in local environments lead to alternative weir construction and use strategies. Understanding these relationships requires a large dataset, and given the lack of such studies at the regional and national levels, a global perspective is necessary. This is used as the background from which to specifically type and locate the Babine weirs in the local environmental context.

Chapter 3 examines the interplay between environment and cultural management of fish weirs, in order to tease out general patterns. Chapter 4 is a specific examination of the Babine study area in terms of weir fishing. Chapter 5 examines Babine weirs using archaeological, historical, oral and documentary evidence. Chapter 6 provides a discussion of the weirs located within Babine territory, specifically at Smokehouse Island, and how these weirs relate to current typologies. The post-contact period in the study area is examined as it is during this period that intensive use of the Babine weirs came to a sudden end.

Chapter 2: Global and Regional Studies on Fish Weirs

Archaeological evidence shows that Aboriginal people commonly used three technologies to capture riverine fish: weirs, nets, and fishing lines. All three could be used in combination or separately, depending on the situation. Weirs are a complex technology that is used around the world to harvest many species of fish, including salmon. Weir effectiveness can be enhanced by using local riverine geomorphology to maximize fish capture rates. Weir technology varies greatly but the outcomes of operation are similar: increased harvest of fish with reduced overall labour requirement for individual fishers. The higher capture rates, however, increase labour requirements in processing the catch. This thesis focuses on the use of wooden fish weir technology, and from this point on, the term weir refers to wooden weir constructions.

A worldwide survey reveals that capture methods are associated with specific riverine environmental characteristics, and that the primary determining factor for weir placement and design is riverine flow and fish abundance (Connaway 2007; Mahaffy 1978). Each component of a weir is determined by specific flow characteristics of the stream and headwaters. In addition, overall weir design is largely based on local riverine characteristics. It is useful to delve into such global studies in greater detail, to understand the relation between weir design and local environmental and physiographic variables. This includes a basic discussion of riverine/stream and lacustrine (lake) characterization and classification.

Riverine Environments

Geomorphological characteristics largely determine where, how, when, and why weirs are placed at a riverine location. Wooden weirs have strength and flexibility, which allow them to be used in a variety of conditions. In Australia, areas with sustained high fish density, or temporary, high density of one fish species, are the most likely to contain wood stake fish weirs (Rowland and Ulm 2011: 40). Weirs recovered by archaeologists in riverine environments are usually highly fragmented (Connaway 2007: 57) making functional determinations more difficult. On the other hand weir placement can reveal much about why certain locations were favoured. Weirs tend to be placed in narrow or in shallow areas where fish densities are more concentrated (Connaway 2007; Mahaffy 1978; Moss and Erlandson 2001), and in areas where the flow creates eddies with dense congregations of fish. Rivers are the most suitable for weir placement since they are major transport corridors for aquatic species, and weirs are specifically designed so that the energy required to capture fish is aided by water flow (Fladmark 2009: Connaway 2007; Mahaffy 1978). Many variables factor into weir design and placement, such as flow patterns, knowledge of geomorphological and hydrological conditions, and availability of fish resources by specific location in the river system. Understanding riverine flow systems is important in deciphering weir design and placement.

Rivers represent less than 1% of the liquid water on earth but they capture 38% of the rainfall on the terrestrial landscape (Russell-Hunter 1970: 137). A river system can be divided into a number of components (Figure 1), each with different environmental and flow characteristics.

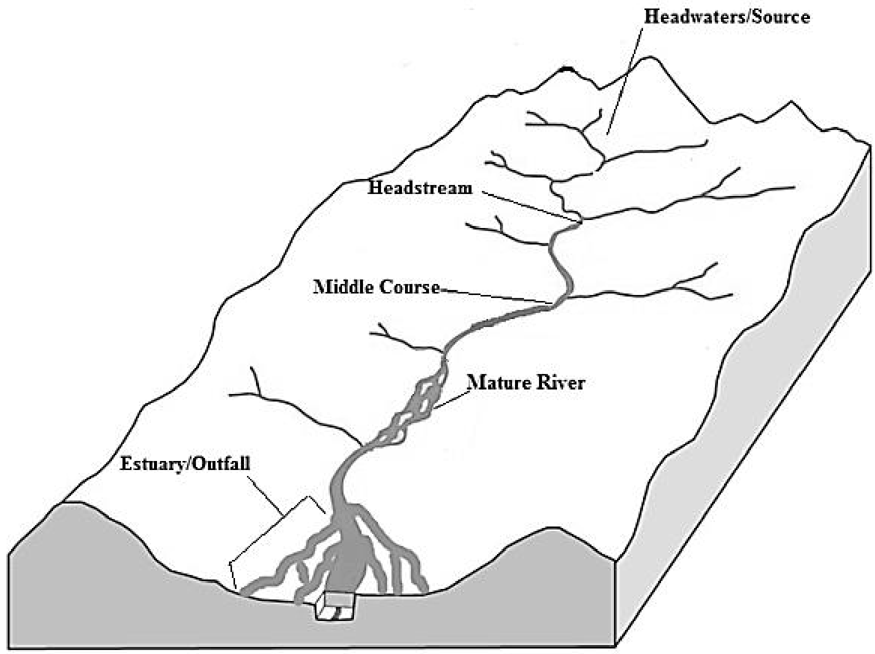

Figure 1: Physical Components of a River (Russell-Hunter 1970:139)

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In a simplified river system the flow velocity of water decreases from source to outfall (Russell-Hunter 1970: 139). This change in velocity requires different fishing strategies depending on location within such a system. On the other hand, multiple water in-feeds (tributaries) increase the flow rate of the main channel as distance from the headwaters increases, so weir styles and fishing strategies must be designed to suit local conditions. Adjacent landforms such as terraces, levees, and channels are most likely to have fish weirs, while beds along mid river courses contain more gravel and silt (Dincauze 2000: 206), which allows weir stakes to be driven further into the riverbed (Connaway 2007). This also increases the overall weir strength by providing a more stable mounting structure for braces, traps, and barricades (Groot 1966: 10). As distance from headwaters increases, temperature range of the water also increases (Russell-Hunter 1970: 139), which affects the biota of that section of stream. There is less aqueous oxygen coupled with smaller sediment particles as distance from the source increases, which creates more productive salmon bearing environments (Russell-Hunter 1970: 139). Distance from headwaters also affects what fish species are available. Upstream locations are characterized by greater flow velocity that provides desirable spawning habitats for mid to large size fish (Russell-Hunter 1970: 140).

Stream Type	General Description	Landforms
Aa+	Very steep, deeply entrenched, debris transport streams	Very high relief, erosional, bedrock or depositional features, deeply entrenched stream, vertical steps with deep scour pools and waterfalls
A	Step, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils, very stable if bedrock or boulder dominated channel	High relief, erosional, or depositional with bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool morphology
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile, stable banks.	Moderate relief, colluvial deposition and/or residual soils. Moderate entrenchment and width/depth ratio. Narrow gently sloping valleys, rapids predominate with occasional pools
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains	Broad valleys and terraces in association with floodplains, and alluvial soils. Slightly entrenched with well-defined meandering channel.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks	Broad valleys with alluvial and colluvial fans. Glacial debris and depositional features. Active lateral adjustment, with abundance of sediment supply
DA	Anastomosing (multiple channels) narrow and deep with expansive well vegetated floodplain and associated wetlands. Very gentle relief with highly variable sinuosities. Stable streambanks	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Multiple channel geologic control creating fine deposition with well-vegetated bars that are laterally stable with broad wetland floodplains
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable well-vegetated banks. Low width/depth ratio
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio	Entrenched with highly weathered material. Gentle gradients with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates.
G	Entrenched ―gulley" step/pool and low width/depth ration on moderate gradients	Gulley, step-pool morphology with moderate slopes and low width/depth ratio. Narrow valleys or deeply incised in alluvial or colluvial materials. Unstable with grade control problems and high bank erosion rates.

Table 1: Stream Classification System (Rosgen 1994: 176-177)

The most likely streams to contain weirs are C, D, DA, and E (Table 1). This is predominantly due to the more gentle flow of the water in these stream types (Rosgen 1994).

Watersheds are configured in many different shapes (Figure 2), and the different physical forms of these headwaters and drainages affect river flow. Dendritic, Sub-Dendritic, Rectangular, Parallel, Sub-Parallel, Pinate and Trellis watersheds all drain many valleys towards a singular outfall (Figure 2) (Russell-Hunter 1970: 165). However, Radial and Annular streams do not flow into a centralized drainage, but are considered geographically the same watershed (Russell-Hunter 1970).

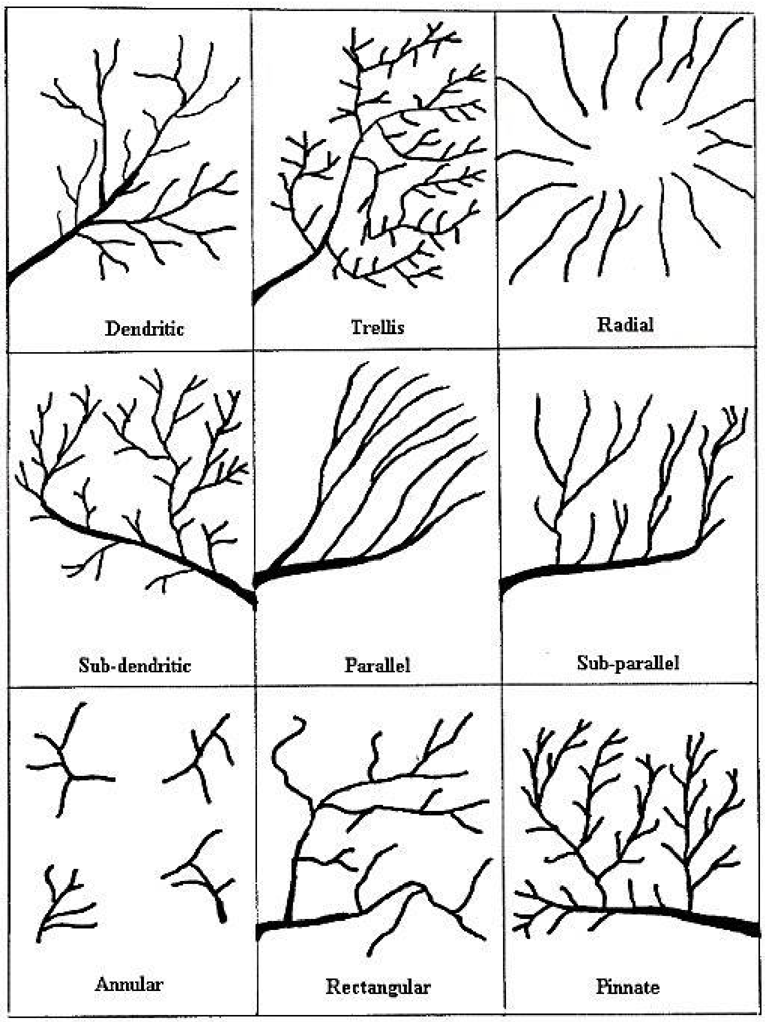

Figure 2: Watershed Geomorphological Styles (Russell-Hunter 1970)

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No riverine environment can be fully described without looking at the whole watershed, including the headwaters. For many river systems the headwaters are a lake and specific characteristics of the lake can determine how the river or lake –behaves”. Potentially all parts of a river system can be suited for wood stake weir technology if localized conditions allow (Figure 1), except for estuaries (outfalls), which are considered a tidal fishing environment (Russell-Hunter 1970: 140). Shallow water areas are ideal for wood stake fish weir construction and maintenance as deeper water reduces human manoeuvrability. Chapter 3 discusses weir structural variation based upon environmental characteristics. Estuarine weirs have similar construction to the interior wood stake fish weirs. However, they differ in design as daily changes in tide levels necessitate taller structures than what is required in non-tidal rivers. Classifying rivers in archaeological contexts is problematic because of the rapid and/or long-term changes in fluvial geomorphology (Russell-Hunter 1970: 139). The transitory nature of the river courses and shorelines can damage any archaeological materials located there. Fish weir sites are difficult to identify, because of poor preservation of organic archaeological materials (Godwin 1988: 52). Seasonal floods and droughts increase erosion, which alters the aquatic, including shoreline environment in which an archaeological site resides (Webb and Hemmings 2001: 3; Limp and Reidhead 1979: 77). These riverine shifts can also reveal archaeological sites, but may destroy valuable contextual information as well. Present day riverine variables in a given situation are not always an analogue for what might have existed in that location in the past. This can make locating ancient weirs difficult, but there are other lines of evidence such as oral histories, which can be an effective guide for an archaeological survey.

Fishing and Riverine Environments

Any implementation of subsistence fishing technology requires that people in an area have an in-depth understanding of the environment. Each localized environment requires a specific type of fishing technology. The following are results of a global survey of known archaeological wood stake fish weirs and their local environmental variables. The goal is to elucidate correlations between environmental/physical variables and weir design.

The movement of a river, depth, current, and curvature of flow (Lyons 1969a: 16), is a critical factor in the design of a weir's structure. Shallower sections of a river carry a higher density of fish, which is important to the design of a weir (Garson 1980: 564) , as weirs are most efficient when placed in other areas of high fish density, such as immediately before or after waterfalls, bends, or confluences (Losey et al. 2012). Stream width is another important factor in the design of weirs (Jones 2005: 167); moderate width (3m-20m) streams are the most efficient combination of water pressure and fish densities (Jones 2005: 167). The higher relative biomass of rivers and lakes allows for mass-capture technologies (weirs, traps, nets) to be used more extensively (Limp and Reidhead 1979: 76). In the process of the review of available literature on pre-contact fishing methods, there were some trends noted in locations of use. In the case of riverine wood stake fish weirs, they are typically found on a curve of a river, or in straight sections (Figure 3 and Figure 4).

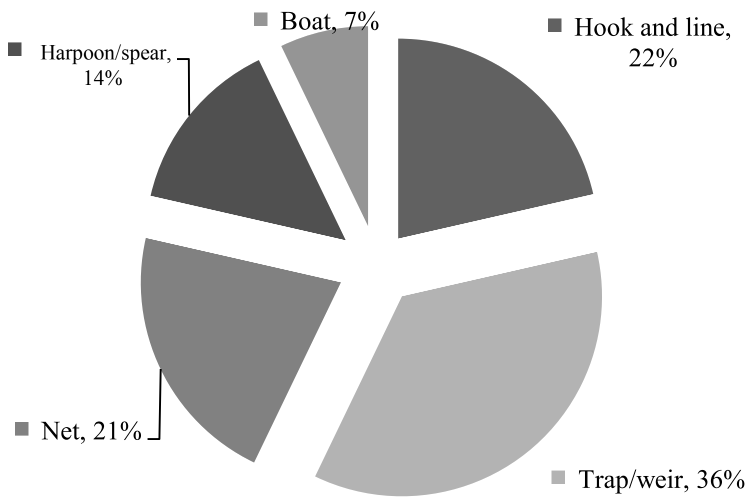

Figure 3: Straight Flow River Capture Technologies (Alexander 1992; Allen 1992; Ames 1994; Ball 2004; Ballard 1957; Betts 1998; Byram 1998; Campbell and Butler 2010; Carlson 1998; Chaney 1998; Cleland 1982; Colannino 2011; Colt 1999; Connaway 2007; Donahue 1977; Erlandson and Rick 2009; Fiske and Patrick 2000; Fosbrooke 1934; Fowler and Bath 1981; Gobalet 2004; Godwin 1988; Gould and Plew 1996; Hackler 1958; Haggan et al. 2006; Harris 2001; Johnston and Cassavoy 1978; Kasten 2012; Kennett et al. 2002; Losey et al 2012; Mahaffy 1978; Martin 1989; Moss 1989; Moss and Erlandson 1990; Moss and Erlandson 1998; Moss and Erlandson 2001; O'Leary 1992a; Oswalt 1976; Romanoff 1992; Rostlund 1952; Rowland and Ulm 2011; Walker 1994; Went 1954; Wepler and Cochran 1988)

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Capture technologies, nets, harpoon/spear, boat, hook and line, for streams that are straight with moderate to high flow are fairly evenly distributed but traps/weirs dominate numerically (Figure 3). Traps refer to removable sections of basketry that can be used independently or in conjunction with a weir. With straight flow riverine capture sites however, fish availability is less constrained/less predictable, so there is a need for more efficient capture technologies. One response is to place weirs from bank-to-bank as fish would be unable to swim beyond such a structure.

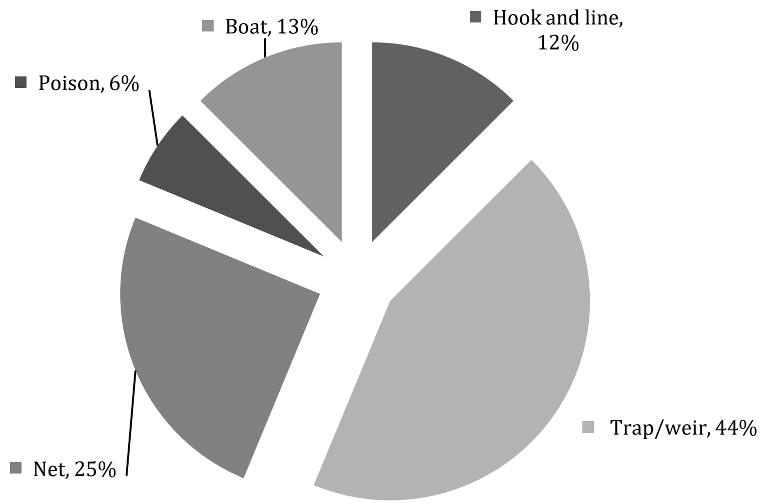

Figure 4: Curved Flow River Capture Technologies (Alexander 1992; Allen 1992; Ames 1994; Ball 2004; Ballard 1957; Betts 1998; Byram 1998; Campbell and Butler 2010; Carlson 1998; Chaney 1998; Cleland 1982; Colannino 2011; Colt 1999; Connaway 2007; Donahue 1977; Erlandson and Rick 2009; Fiske and Patrick 2000; Fosbrooke 1934; Fowler and Bath 1981; Gobalet 2004; Godwin 1988; Gould and Plew 1996; Hackler 1958; Haggan et al. 2006; Harris 2001; Johnston and Cassavoy 1978; Kasten 2012; Kennett et al. 2002; Losey et al 2012; Mahaffy 1978; Martin 1989; Moss 1989; Moss and Erlandson 1990; Moss and Erlandson 1998; Moss and Erlandson 2001; O'Leary 1992a; Oswalt 1976; Romanoff 1992; Rostlund 1952; Rowland and Ulm 2011; Walker 1994; Went 1954; Wepler and Cochran 1988)

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Curved flow rivers include rapids and waterfalls and they show the highest incidence of weir/trap use as the flow patterns direct fish towards certain locations along the banks (Figure 4). Designs of weirs used in these locations utilize the flow pattern of that section of stream to push the fish towards trap openings. Fish typically swim closer to the inside corner of a stream so as to cover less distance and speed, so weirs would be more likely to be on the short edge of a river curve rather than the longer –outside" edge. These locations would require only a small section of the channel to be targeted with weirs.

Riverine weirs are placed in locations where water is shallow or in areas that are narrow with high flow, where fish are forced into denser groupings, and the total force on the weir is lessened (Fowler and Bath 1981: 177; Connaway 2007: 7). Connaway (2007:15) noted a trend in the Mississippi River drainage area, where the weirs are located directly downstream from a sharp bend in the river. These areas were selected because of the flow patterns of the river and the swimming behaviour of the species being sought (Connaway 2007: 20). Bank topography adjacent to the stream is also important as processing the fish after capture requires large flat areas close to the capture area (Connaway 2007: 13). The proximity of the capture location to a suitable processing site decreases the distance the full traps have to be moved. The proximity of plateaus/terraces that make for ideal processing locations is another factor in considering where a weir is located. These areas are likely to be found along a D type stream (Table 1) (Rosgen 1994: 169). Once the salmon has been processed and preserved, the distance these can be transported increases significantly (Morin 2004).

Wood Stake Fish Weirs

Fishing has allowed human populations to utilize a wider array of environments than would be otherwise possible (Steffian et al. 2006: 99). The development of mass capture technology expanded harvest areas further into marine environments (Steffian et al. 2006: 66). Construction and operation of weirs vary greatly worldwide, but certain operational characteristics are common in all situations. Wood-stake fish weirs reflect local environmental characteristics in relation to the types of raw materials (plant and tree species) used in construction, the abundance of the construction materials, and settlement patterns of those who build the weirs (Smith 2011: 15). The technology allowed for increased harvest predictability, potentially leading to in an increase in human population. Weirs are indicative of, at least temporary, conglomerations of people harvesting and processing fish (Godwin 1988: 56). The origins of riverine wood-stake fish weir technology are unknown, but this technology has been employed worldwide and over a long period of time (Table 2; Figure 5).

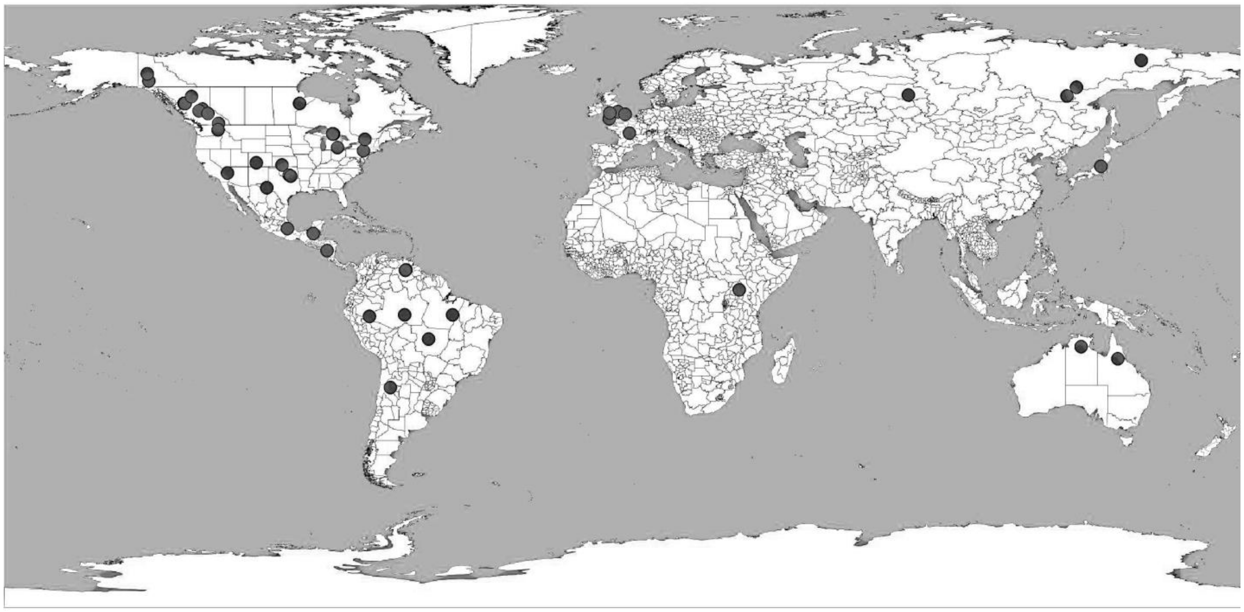

Figure 5: Global Wood Stake Fish Weir (Interior-Riverine) Locations (Alexander 1992; Allen 1992; Ames 1994; Ball 2004; Ballard 1957; Betts 1998; Byram 1998; Campbell and Butler 2010; Carlson 1998; Chaney 1998; Cleland 1982; Colannino 2011; Colt 1999; Connaway 2007; Donahue 1977; Erlandson and Rick 2009; Fiske and Patrick 2000; Fosbrooke 1934; Fowler and Bath 1981; Gobalet 2004; Godwin 1988; Gould and Plew 1996; Hackler 1958; Haggan et al. 2006; Harris 2001; Johnston and Cassavoy 1978; Kasten 2012; Kennett et al. 2002; Losey et al 2012; Mahaffy 1978; Martin 1989; Moss 1989; Moss and Erlandson 1990; Moss and Erlandson 1998; Moss and Erlandson 2001; O'Leary 1992a; Oswalt 1976; Romanoff 1992; Rostlund 1952; Rowland and Ulm 2011; Walker 1994; Went 1954; Wepler and Cochran 1988)

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Figure 5 shows locations of intact archaeological riverine wood stake fish weir sites like those used by the Babine people. Coastal variants, although constructed using similar methods, are not included in the map because they are designed differently and tend to target different species. On the plains in central Canada and in the United States, archaeological evidence suggests that the Omaha, Cheyenne, Arikara, Blackfoot, and Cree also employed wood stake fish weir technology (Rostlund 1952: 102). Table 2 (below) shows a sample of recorded wood weirs in North America. Amongst these the Columbia River weir is the oldest on record, at approximately 9000 B.P. (Ames 1994: 216; Carlson 1998: 23; Turner and Ommer 2004: 13). Older weirs may exist but because of the transitory nature of rivers, and preservation factors, they remain unknown at present. Dates in this table show the oldest in the region; however, many weirs have multiple dates associated, likely indicating repeated maintenance and use of weirs.

Weir Location	RC Date (B.P. Years)	Reference
Columbia Rv., B.C./Oregon	9000 (uncalibrated)	Turner .and Ommer 2004: 13
Milliken Site, Fraser River	7,600 (Uncalibrated)	Carlson 1998:32
Boylston St. Weir, Maine	6005 (uncalibrated)	Connaway 2007: 19
Glenrose Cannery Site (DgRr 6), B.C.	5300 – 4420	Moss and Erlandson 1999: 439
Sebasticook Lake, Maine	5135 (uncalibrated)	Connaway 2007: 19
Kennebec River, Maine	5080 ± 90	Peterson et al. 1994
Boston, Mass., Back Bay Fish Weir	4900 - 4500 ± 165	Decima and Dincauze 1998:157
Glenrose Wet Site	4590 ± 50	Moss and Erlandson 1998: 187
Atherly Narrows, Ontario	4560 ± 115	Johnston.and Cassavoy 1978: 701
Cosmos Cave Weir	3635 ± 65	Moss and Erlandson 1990
Prince of Wales Island	3465 ± 80	Moss and Erlandson 1990
Oregon Coast	2400 (uncalibrated)	Moss and Erlandson 1999: 439
Coquille Estuary (main river channel weir)	940 ± 50	Byram 1998: 209
Kitwancool Lake (GiTa 19)	770 ± 40	Prince 2005: 74
Montana Creek Fish Trap, SE Alaska	640 ± 50	Betts 1998: 241
Salton Basin, Calif.	~500 (uncalibrated)	Gobalet et al. 2000: 516

Table 2: Wood Stake Fish Weir Dates

On the coast of British Columbia, populations grew rapidly after 5000 B.P., which may be partially attributable to the intensification of fishing (Moss 1989:22). Many other areas (worldwide) show signs of population increase correlated to the use of weir technology. This may be a direct result of weir fishing or may have been symptomatic of the increased populations. Evolutionary biologists argue that there was an increase in salmon populations at this time, resulting in an increase in harvest of these species (Larkin and McDonald 1968: 245). As of 1990, 450 weirs sites in British Columbia and 190 in Alaska have been identified, and these date from the middle Holocene period up to European contact, (Moss and Erlandson 1990: 150).

Wood Stake Fish Weir Construction Methods

Weir refers to the entire structure usually consisting of at least two elements, the *trap* and the *barricade* (Peterson et al. 1994: 215; Moss and Erlandson 1998: 180). The efficacy of weirs is directly tied with regular maintenance, because any structural weakness could greatly hamper efficiency or even cause complete malfunction (Rowland and Ulm 2011: 40). Initial construction of a weir required significant investment of labour, but once built, maintenance took significantly less effort (Rowland and Ulm 2011: 40). Natural forces weaken wood weirs over time, so structural elements often need to be repaired or rebuilt (Connaway 2007; Mahaffy 1978; Olson 1936). Patching and rebuilding of support beams can be required for weirs that were minimally damaged from the previous winter (Jeffery 2013:3). There are instances of weirs lasting two to three years before replacement was required (Olson 1936: 62). Weir longevity is affected by flow characteristics of the stream, where high flow areas are more likely to carry large debris that could potentially damage the weir. Weirs and traps are used tidally and seasonally (where tides do not occur – rivers, creeks, lakes), although some southern latitude riverine weirs were used year-round (Allen 1992: 189; Godwin 1988: 51). Traps and weirs are most effectively used for mid to large sized fish (salmon and trout (*Onchorynchus spp)*, grayling *(Thymallus spp)*, and cod (*Gadus spp)*) as the holes in some of the traps are often too large to effectively capture smaller species (Colaninno 2011: 340). Coastal and some estuarine weirs rely on tides for capture, and due to the directionality of the current allows for a similar construction design (Byram 1998: 211).

The success of weir technology is attributable to the relative simplicity of construction, and to efficiency of design. Weirs can be operated without human presence, passively, or with extensive human labour, actively (Rabnett 2000, Oswalt 1976: 146). Weirs can span an entire channel or a small portion of a stream, depending on the behaviour of the selected species and flow patterns of the stream (Byram 1998: 206). Understanding weir construction is important to understanding how they operate. Fish weirs, especially wood stake variants, need significant investments of labour to ensure proper functioning.

Fish Weir Construction Materials

In general, fish weirs can be constructed from either wood or stone, or a combination of both (Erlandson and Rick 2009; O'Sullivan 2003: 449). In the case of wood stake fish weirs, construction materials are selected for their strength, flexibility, and regionally available wood species. Non-local materials were not normally used (Oswalt 1976:121). Each weir is designed so that the strongest parts of the structure are set where they are subject to the most force, arising from the pressure of water flow or migrating fish (Connaway 2007; Mahaffy 1978). Weir components were designed to increase the overall strength of the structure, and care was taken to ensure that weak components did not cause failure under full capture load. Construction and maintenance materials also change with the season of use. For example stronger materials would be required in temperate climates to resist high spring water flows.

In northern British Columbia people typically utilized three to five year old cedar (where available), alder, aspen, willow, and poplar branches for their strength and flexibility (Morice

1893; Connaway 2007: 15; Moss and Erlandson 1990; Betts 1998: 239; Mahaffy 1978). A study on the mechanical properties of wood indicates that deciduous trees account for the strongest type of wood (Green et al. 1999: 5) (Table 3).

Species	Diameter (cm)	Maximum Strain (KN/m^3) Perpendicular to grain
Poplar	10	29
Cottonwood	10	34
Western Red Cedar	10	34
Lodge pole Pine	15	39
White Spruce	10	41
Trembling Aspen	10	44
Black Spruce	10	51
Red Willow	10	98
Yellow Birch	10	111
Paper Birch	10	112

Table 3: Mechanical strengths of Various Wood Species (Green et al. 1999: 5-8)

The species above (Table 3) were used to form the main body of the weir, with smaller sticks and branches acting as the barricade. The success of a weir is often limited by the strength of material used; weaker materials would not hold up against the current plus the weight of the fish in the traps (Connaway 2007; Mahaffy 1978). The immobility of the barricade is important for the successful operation, but this inflexibility can also cause the weir to wash out occasionally under flood conditions (Went 1954: 57). There are different types of riverine weirs, and all utilize a wide variety of materials. For the structural pieces opportunistic use of sufficiently strong wood species was practiced, although certain species may have been selected specifically for their mechanical resiliency (Betts 1998: 239; Mahaffy 1978).

Fish Weir Components

Weirs are constructed with two end goals in mind: obstruction and impoundment (Rostlund 1952: 101; Morice 1893: 84). The obstruction guides the fish towards an opening and the impoundment focuses on mass capture (Rostlund 1952: 102). Some weirs are composed solely of a barricade to entrap fish in a pen so they can be speared or collected with a dip net, which is an obstruction weir (Connaway 2007; Moss and Erlandson 1990: 144; Oswalt 1976: 143). Many wood stake fish weirs utilize the barricade portion of the weir to direct fish into the trap openings. Portable fishing equipment (nets, traps, set lines) would have been removed after use, so these are not typically found in archaeological association with the main structure (Connaway 2007: 57). Each component works in conjunction with the others to increase the overall success of the weir.

Trap

Trap refers to the *impoundment* portion of the weir, and ranges from net-like apparatuses to complex box-style traps (Figure 6) (Connaway 2007; Moss and Erlandson 1998; Mahaffy 1978). These are usually fitted into openings of the weir barricade, although some traps are attached to the river-bed as well (Prince: 2003: 382). The trap shapes are highly variable including: conical, cylindrical, lenticular, free-form or rectangular shapes (Walker 1994: 225; Fowler and Bath 1981: 180), as shown in Figure 6.

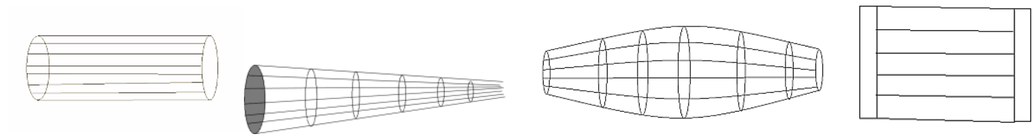

Figure 6: Trap Structural Shapes (Stewart 1982)

Trap size varies, but most riverine traps measure 1-2 meters in length and 0.5-1 meters in width (Fowler and Bath 1981: 180). These traps are highly variable in design even for similar species harvest (Betts 1998: 245). They either have removable portions or the entire trap can easily be removed (Betts 1998: 245). Removable traps are constructed with wooden staves for structure, and woven bark or plant roots for the netting (Betts 1998: 246; Ball 2004: 42; Morice 1893). The cylindrical shaped traps have a conical inlet inside of the main trap structure so the fish are funnelled into the trap and restricted from escape back through the opening (Betts 1998: 245). Salmon in British Columbia are robust species, so mesh and slat sizes are important to the functioning of the trap (Byram 1998: 178). For net-style traps, gauges are used to ensure even gaps across the whole net (Stewart 1982: 84). The use of signalling strings by the Paiute in conjunction with weirs has been documented, these involve hanging the strings down into the trap or near it, which are then triggered to bob when a fish passes by them into the trap (Fowler and Bath 1981: 181, Olson 1976). This signals the labourers to either pull the trap up, net, or spear the fish (Fowler and Bath 1981: 182, Olson 1976). Additionally, some weirs use an ancillary second trap to catch the fish that would jump over the weir (Fowler and Bath 1981: 181). The second traps are placed near the surface on the upstream side of the weir (Fowler and Bath 1981: 182). Some weirs were used exclusively at night, so the fishers would pave the riverbeds with flat stones of a consistent colour to help them see the fish in low light conditions

(Fowler and Bath 1981: 185). This was done in areas where the water is exceptionally clear and when the fish would not swim into the trap opening in daylight, when they could see the trap (Fowler and Bath 1981: 185).

Barricade

The barricade portion of the weir must be porous enough to lessen the strain on the structure but sturdy enough to act as an impasse to fish (Oswalt 1976: 121). To construct the barricade, sets of stakes are first pounded into the river bottom, with horizontal cross-braces lashed to them (Stevenson 1998:228). The stakes must be high enough to reach 10-20 cm over the water's surface, and they act as anchor points for the cross braces; however, a stake that is too long would increase flexural strain on the weir (Mahaffy 1978; Connaway 2007; Green et al. 1998 5-8). Stakes are sharpened with stone adzes or abraded, and the ends pounded into the riverbed are fire hardened (Connaway 2007; Mahaffy 1978). The stakes are pounded into the river bottom by using either wooden pounding tools or stone mauls, and this was done by standing in the river if the water is shallow enough, or from a canoe, or by divers when the water was deeper (Kasten 2012: 82).

The barricade portion of the weir consists of one or more ―wings," which are one linear section of the total weir (Mahaffy 1978: 1). The barricade portion of the weir is usually constructed using woven bark or brush sweeps, to force the fish towards the trap opening (Stevenson 1998: 228). The further weir stakes are driven into the riverbed, the stronger the entire structure (Jeffery 2013: 10). If weir stakes cannot be driven into the riverbed to an adequate depth, piles of rocks are placed around them for support (Jeffery 2013: 10; Olson 1936: 25). Lacustrine weirs are constructed with only impoundment in mind, as the water movement is not sufficient to aid in capture. These sections are supported by a series of stakes ranging from 5 to 25 cm in diameter, depending upon the fish species sought and the flow characteristics of the river (Byram 1998: 207; Mahaffy 1978). Stakes can be either one piece of wood or several pieces lashed together. Lashing works best in deep water to aid in the structural stability of the weir (Johnston et al. 1978: 702), and these are further supported by braces that slant downstream, and vary in length according to the flow pattern (Morice 1893: 84). The barricade portion of the weir is the first to be constructed with additional supports and traps added afterwards (Morice 1893: 85). The supports are usually arranged in a tripod with logs placed horizontally between the tripods (Coale 1956: 349; Ballard 1957: 38). These logs were used to walk on the weir to pull a trap or to cross the river (Coale 1956: 349; Morice 1893: 84; Ballard 1957: 39). Additionally, the logs were the attachment point for the rest of the brush or staked barricade between the trap openings (Coale 1956: 349; Prince 2003; Fowler and Bath 1981: 180). The closer-knit lattice type weirs are constructed from the flexible new branches of willows, and these are woven in amongst the larger weir support stakes (Lyons 1969a: 17). Closer knit lattices work best in slow moving tidal cases, because stronger currents would overwhelm them (Stevenson 1998: 228). Many wood stake fish weirs were built across entire streams, although in some areas flow patterns did not require or allow for a complete blockage (Prince 2003: 383). Spacing of the stakes determines the strength of the weir; Morice (1893:84) noted that weirs in the Northern Interior of British Columbia had structural stakes every 2-5 meters. The barrier is then ready to mount the traps or chutes into the openings of the barricade (Figure 7).

Chutes

Some riverine fish weirs have chutes or funnels to direct the fish towards the traps (Mahaffy 1978: 3; Morice 1893: 86). These are either a part of the barricade itself or they are removable parts of the traps. They are built with a wide opening that narrows as the fish get closer to the trap. The shapes of the chutes (Figure 7) act to channel fish to specific locations to increase the density of fish while also causing the fish to surge forward into the traps (Connaway 2007; Mahaffy 1978).

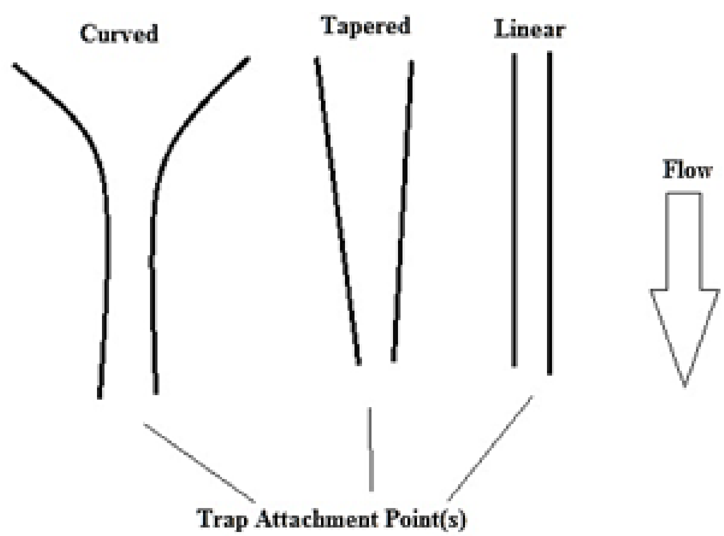

Figure 7: Weir Chute Styles (Connaway 2007: 15)

Image made with Paint.net ©

The narrowing of the chutes causes the fish to surge forward into the trap and the higher density of fish prevents them escaping the trap (Mahaffy 1978). Most chutes are supported via a combination of piled cobbles and wood stakes, although some are constructed solely from stone or wood.

Cordage

All components are held together with some form of cordage, usually made from woven fibrous bark (willow, alder, aspen, stinging nettle, high cranberry brush, or white spruce wattle)

(Oswalt 1976: 120; Morice 1893: 84; Stewart 1982: 79). Cordage is constructed by beating or by separating the fibres by hand, which are then palm-rolled, or braided to knot up the fibres (Stewart 1982: 83). Alternatively plant or tree roots were used by first making them pliable through pounding or by running a smooth rock over them repeatedly to separate fibres (Ball 2004: 43). Betts (1998:245) states that spruce roots are flexible but strong enough to hold together even the largest traps without the need for further braiding or knotting. Salls determined various cordage strengths of plant materials, running tests on fishing lines, where a ply rating of seven or more is best used in structural rope (Salls 1989: 186). Most netting, however, requires a ply rating of two or three (Stewart 1982: 79; Salls 1989: 186). Oral accounts of a Skeena River wood stake fish weir states that reeds and roots were used to make the cordage (Ball 2004: 42). Woven bark cordage was prepared similarly to root-based cordage, but involved a greater amount of work to ensure that the weaving of the fibres held up to the weight of the catch (Ball 2004: 43).

Riverine Wood Stake Fish Weir Typologies

Mass-capture devices including weirs and traps are indicators of increasing population densities in specific environments (Allen 1992: 188). Archaeological remains of weirs and traps usually consist of stubbed-ends of wooden stakes or rock rings. Configurations of stakes (Figure 8) may reflect individual or group ownership, or more likely, the selection of species for harvest (Smith 2011: 23). Some weirs placed in streams are v-shaped with a trap at the apex(es) (Connaway 2007: 6). Straight weirs that span the width of the stream are used most commonly in streams that contain salmon, to ensure higher capture efficiency due to the relatively short salmon run (Connaway 2007: 9). Weir shapes are highly variable but the Figure 8 shows the most common flowing stream variants.

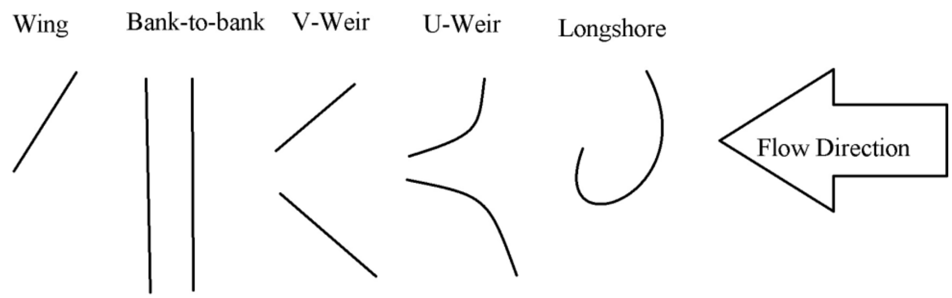

Figure 8: Riverine Fish Weir Structural Forms (Connaway 2007; Morice 1893; Byram 1998, Oswalt 1976, Johnston and Cassovoy 1976; Moss and Erlandson 1990)

Base Layer Image made with Paint.net ©

Wing style weirs are also referred to as a channel margin weir, and bank-to-bank style are also called cross-channel, non-tidal weirs (Byram 1998: 206; Connaway 2007). These styles include a barricade and may or may not feature traps. Double fence traps, which act as an impoundment so the fish can be netted or speared, are included in this style as well. U-weirs are typically made from stone, but wood stake variants of this shape have been recorded as well (Byram 1998: 206; Connaway 2007). U-weirs are centrally placed in a stream and guide fish from the entire width of the stream into a central trap location. Additionally, they may be formed into multiple U-alignments, depending on the size of the stream. Longshore style variants rely more on a slow flow stream or on a lakeshore with denser barricades, as the flow here is negligible (Connaway 2007: 12). When Longshore variants are located on a stream, they are placed on the inside edge of a curve to target species swimming against the current (Connaway 2007: 12). Mahaffy (1978) constructs a riverine fish weir typology based on 15 variables (Table 4).

Number of components	Width of river spanned by singular component (all/partial)
Wing alignment (straight/curved)	Angle between wings and river axis (narrow/wide)
Presence of wood	Angle between strike of bedrock strata and river axis (narrow/wide)
Weir association (who owns?)	Length of single components (long/short)
Average angle for entire weir (narrow/wide)	Length of entire weir (long/short) – in relation to river width
Angle between wings for single components (narrow/wide)	Alignment of weir components to river axis (angle) (narrow/wide)
Width of river (narrow/wide)	Total length of weir in reference to river axis (long/short
Width of river spanned by weir (all/partial)	

Table 4: Variables in Determining Fish Weir Typologies (Mahaffy 1978)

In this typology/functional analysis, generally the longer the weir length, the more components there are to it (Mahaffy 1978: 10). Although Mahaffy made the first attempt at creating a typology for fish weirs, he focused almost solely on stone riverine fish weirs with some minor wooden components. Moss and Erlandson (1990) discuss more functional variations of wood stake fish weirs, with their studies based on southeastern coastal Alaska. These include ―open-tip v-shaped" weirs, and straight bank-to-bank weirs (Moss and Erlandson 1990: 144). Connaway (2007:5) develops a simpler typology of fish weirs, which he delineates into *flowing stream weirs, tidal weirs* and *longshore weirs.* Each of these weir types has specific conditions that allow for use of that type and some weirs, notably bank-to bank, can be used in conjunction with multiple local environments. Flowing stream weirs utilize the movement of a stream or estuary as the principle means of fish capture (Connaway 2007). Utilizing the above information (Mahaffy 1978; Connaway 2007; Moss and Erlandson 1990) a generalized typology of riverine wood stake weirs has been synthesized and was used to construct the typology form for this research (Table 4)

Tidal weirs also utilize water movement, but rely more on the rise and fall of the tides to aid in capture. Longshore weirs rely upon the movement of fish in a lake to catch the fish. On the Kluksu River in Yukon Territory, the fish weirs were constructed similar to a lobster pot, with little or no woven cordage (O'Leary 1992a: 60). The weirs there were repaired or replaced every two to three years or as needed (O'Leary 1992a: 60). These weirs have three traps on them, as the width of the stream limits a fourth trap placement (O'Leary 1992a: 62). These weirs are a more permanent structure, and indicate that the flow of the river does not significantly change over the seasons.

Wood Stake Fish Weirs in British Columbia

Wood stake fish weirs in the interior of British Columbia are similar in construction to those described by Mahaffy (1978) and Connaway (2007). Kew (1992:204) states that weir technology moved inwards from the coast, with the latticework weir trap type as the first interior riverine weirs in British Columbia. Many explorers in the early European contact periods described various weirs on river systems. Alexander Mackenzie described weirs in north central British Columbia in his chronicling of his journey to the Pacific:

> The stream is stopped nearly two thirds by it. It is constructed by fixing small trees in the bed of the river in a slanting position (which could be practicable only when the water is much lower than I saw it) with the thick part downwards; over these is laid a bed of gravel, on which is placed a range of lesser trees, and so on alternately till the work is brought to its proper height. Beneath it the machines are placed, into which the salmon fall when they attempt to leap over. On either side there is a large frame of timber-work six feet above the level of the upper water, in which passages are left for the salmon leading directly into the machines, which are taken up at pleasure. At the foot of the fall dipping nets are also successfully employed. (Mackenzie 1801: 274).

In contrast to weirs that target smaller species, whitefish, trout, and others, wood stake fish weirs in British Columbia target salmon, a strong fish that travels in large numbers (Moss and Erlandson 1998). Cox (1832) describes the use of a weir-like device on the Columbia River that also suggests a high capture rate and labour requirements of a weir:

> The salmon fishery commences about the middle of July, and ceases in October. This is a busy period for the natives; for upon their industry in saving a sufficiency of salmon for the winter depends their chief support. Their method of catching the salmon is ingenious, and does not differ much from that practised by the upper natives of the Columbia. A certain part of the river is enclosed by a number of stakes about twelve feet high, and extending about thirty feet from the shore. A netting of rods is attached to the stakes to prevent the salmon running through. A conical machine, called a *vorveau,* is next formed: it is eighteen feet long, and five feet high, and is made of rods about one inch and a quarter asunder, and lashed to hoops with *whattap*.* One end is formed like a funnel to admit the fish. Two smaller machines of nearly equal length are joined to it. It requires a number of hands to attach these *vorveau* to the stakes. They are raised a little out of the water; and the salmon in their ascent leap into the *boot* or broad part, and fall into the enclosed space, where they are easily killed with spears. This contrivance is admirably calculated to catch fish; and when salmon is abundant, the natives take from eight to nine hundred daily (Cox 1832: 320).

Most weirs in British Columbia target the various salmon species where they are available (Moss and Erlandson 1998). Intensification of salmon fishing is apparent on the Northwest Coast by at least 3,500 B.P. (Ames 1994: 217) when rivers had stabilized, potentially providing opportunities for interior salmon fisheries as well. Harmon also describes fish weirs in northern British Columbia:

> We now have Salmon in abundance which the Natives take in the following manner:—They make a Dam across the River and at certain places leave spaces, where they put a kind of long Basket Net, which generally is about fifteen feet in circumference & fifteen or twenty in length, one end of which is made like a wire Mouse Trap, & into that the Salmon enter, but when once in cannot go out, till the Basket is taken ashore, when they open a Door made for that purpose & turn them out, and in one of those Baskets they often will take four or five hundred Salmon that will weigh from five to seven pounds each— (Harmon 1819: 126).

Harmon's description of the weirs is similar to those identified in archaeological contexts on the Northwest Coast and in other parts of British Columbia. Logically one can conclude that the construction, use and maintenance of this technology were continuous for a number of centuries at the least.

Discussion

Riverine environmental characteristics are important in the design and placement of wood stake fish weirs. Characteristics of a stream and its headwaters may also play a role in the timing of use of a weir, as well as the structural integrity needed to operate the weir while minimizing the risk of failure. Local flow patterns further influence styles of weirs possible at each location. Weir design is also predicated by season of use and general capture numbers, as a smaller component weir would be used to catch smaller fish in a smaller stream, whereas a larger, multi-component weir would be used to catch larger fish in larger streams. Regardless of the particular weir used, in general they are a highly efficient technology that can provide potentially large volumes of nutrition to users, even in comparison to the high level of labour involved in the construction and maintenance of the weir, as well as the processing of the fish.

Local environmental knowledge is reflected in weir technology, and the continuous use of this technology indicates a long history of knowledge transmission. For the purposes of this research understanding environmental characteristics is necessary if we are to discern how and why these weirs were so successful in supporting many generations of Aboriginal populations. The wide variety of riverine fishing environments results in a number of possible weir designs, and the first step in the current research is to create a typology suitable to the context of the

Babine weirs. The global typologies employed in this chapter are broad and generalized, but they can help us better understand the Babine weirs.

Chapter 3: Labour and Fish Weir Capture

Construction, maintenance, and operation of weirs require a significant investment of time and labour but the return (in productivity) is significantly higher than for other capture methods. Extensive use of weirs could potentially deplete fish resources, so effective management of stocks must also be practiced. Long-term observations (possibly over generations) guide the timing and placement of the weirs along with intimate knowledge of the behaviour of the species sought and local environmental conditions. Weirs need to be effectively managed to prevent overharvest and to ensure viable breeding stocks to replace the future year's runs. Cultural aspects play a role in how weirs are used, for example fish weirs are used *actively* or *passively* (Wepler and Cochran 1988: 95). Active use of weirs requires more investment of labour but leads to higher yields, while passive use requires less labour input and leads to relatively lower yields (Wepler and Cochran 1988: 95). Weirs can be used in either way, with the labour availability as the limiting factor.

Fish Weirs and Fisheries Management Systems

All species of Pacific salmon are a temporally limited and in many places mass-capture was, and still is, practiced as a means to procure sufficient nutrition for winter consumption. The use of weir technology requires some form of management so that the devices can be used sustainably (Campbell and Butler 2010: 15). If used in an indiscriminate manner weir capture rates (Table 4) can lead to decimation of fish stocks. The lengthy global (Table 2) and local (Babine) use of this this technology indicates that fish populations and weir harvests were managed effectively wherever they were operated.

Management strategies can include compensating for poor returns in specific years. Many anadromous fish (including the various species of Pacific salmon) can have cyclically poor run years, ranging from every three to seven years, so in years with poor runs, other resources are harvested, so the target stocks can replenish themselves (Haggan et al. 2006: 14). This is also another reason why the Babine did not rely solely on salmon as a year-round resource. Other management strategies include removal of blockages in streams and widening of spawning channels (Haggan et al. 2006: 18; Lepofsky and Caldwell 2013). Weir design is also tied to management, as certain mesh size allows smaller salmon to swim through but obstruct the larger ones (Lepofsky and Caldwell 2013: 4). Weir placement aided selective harvest of species, to avoid depleting other fish stocks (Lepofsky and Caldwell 2013). Weirs were usually placed into the water two to three weeks after the runs had begun, to ensure a viable breeding population could be maintained (Lepofsky and Caldwell 2013: 4).

In some areas, cultural regulations play a role in the use of fishing devices and the management of the resource. Practices for fishing varied by group, but certain events such as the First Salmon Ceremony, are common across different cultures (Fowler and Bath 1981: 185). Many cultural and spiritual practices in regards to fishing have a basis in ecology, such as the proper disposal of fish remains, to ensure a viable food source for remaining fish in the river (Johnson-Gottesfeld 1994: 445). Sustainable practices are also reflected in stream and trail management, as this allows for people to quickly get to an area in need of a response (Kennett et al. 2002: 939). At the Hell's Gate landslide in 1911, Aboriginal groups gathered fish from below the slide, and carried them in buckets past the obstruction (Turner and Ommer 2004: 25). They were then released so that they could carry on to their spawning grounds (Turner and Ommer 2004: 25).

Agreements between Aboriginal fishing communities allowed for all groups along the river to obtain catches from the same salmon stocks (Kasten 2012: 70). These agreements would set out that people further downstream would wait until an appropriate amount of time had passed from the onset of the salmon run, before placing weirs in the streams (Kasten 2012: 70). This ensured a viable spawning population and allowed groups further upstream to obtain sufficient nutrition for the winter. Weirs were also constructed in a manner so that they did not stick too far vertically out of the river, to allow some fish to jump over when the density of fish was high (Kasten 2012: 78), although some weirs have ancillary traps that are used in highest density fish runs to allow for a higher capture rate. On the Kluksu River in the Yukon, rights to fish in an area were controlled through matrilineal title (O'Leary 1992a:62). Many other groups in North America also managed access rights this way, although some areas were controlled through other means. No one but the titleholder to that weir or fishing area was permitted to fish there and control of access to the area fell to the aforementioned titleholder (O'Leary 1992a: 62). As with other wood stake fish weirs, the barricade section of the weir was removed from the water once a sufficient number of fish were obtained (O'Leary 1992a: 63). The significant investment of labour that went into the construction and operation of these weirs indicates that people have shifted from the foraging/opportunistic feeding to a more seasonally sedentary subsistence practice (Gould and Plew 1996: 70). Weirs represent a specialized food-procurement site; some weirs are correlated with a winter residence site, especially in northern or seasonally limited areas (Chatters 1995: 360; Moss and Erlandson 1990: 145). This reduces the transport labour of the fish, and provides a centralized resource/habitation area for preservation.

Capture Rates

To successfully harvest sufficient calories from a riverine setting, the capture methodology must be efficient enough to work in a relatively short period of time and it must outweigh the costs of the harvesting method. Wood stake fish weirs as a technological adaptation are successful because of their high level of labour, capture, and processing efficiency. The need for this efficiency is attributable to fish inhabiting a spatially and temporally restrictive area (Fosbrooke 1934: 15). Exact capture numbers are available for some weirs, but for many, run sizes had been estimated. Riverine capture technology differs from the coastal variants as there are fewer species, and fewer numbers of fish available as distance from the ocean increases (Kew 1992: 203). The density of fish in any given river is determined by different characteristics such as latitude, seasonal temperature, and distance from the ocean (Perlman 1980: 295). The higher the latitude (in the ―Salmon Area"), the higher the density of fish is, as there is less species diversity so less competition for resources (Perlman 1980: 301).

Pre-contact salmon population sizes cannot be accurately determined, but studies of tree growth rings provide links to salmon abundance (Drake and Naiman 2002: 2973). One study examined the amounts of marine derived nutrients (MDN) in trees near salmon bearing streams, which show growth rings proportional to the size of the salmon run (Drake and Naiman 2002: 2974). Capture rates (Table 5) for riverine weirs in western North America have been estimated from historic accounts, and may not be an accurate representation of pre-contact numbers.

Place/River Name	Capture Numbers/weir	Reference
Clearwater River	300-700/weir/day	Moss and Erlandson 1990
Snake River	300-700/weir/day	Moss and Erlandson 1990
California	166kg/year/person	Moss and Erlandson 1990
B.C. Interior Plateau	230kg/person/year	Moss and Erlandson 1990
Ceilo Falls	99 kg/day/weir	Moss and Erlandson 1990
Nez Perce	202 fish/person/weir	Jones 2005
Lehmi-Shoshone-Bannock	200 fish/day/weir	Jones 2005
Weister-Boise Fishery	200 fish/day/weir	Moss and Erlandson 1990
Hagerman-Shoshone Falls	200 fish/day/weir	Moss and Erlandson 1990
Kodiak and Cook Inlet	422 kg/person/year	Moss and Erlandson 1990
Prince William Sound	227 kg/person/year	Moss and Erlandson 1990
Aleut (Alaska)	136 kg/person/year	Moss and Erlandson 1990
1879 British Columbia	264 kg/person/year	1879 DFO Report
1819 Ft St James	400-500/trap/day	Harmon 1819

Table 5: Capture Rates for riverine wood stake fish weirs

From the data gathered on capture numbers (Table 5) a general model can be constructed estimate population size. In general, yields from weirs could effectively feed 100 people for seven months based upon 2000 Kcal/person/day, as long as there are thirty capture days. The daily required caloric intake is of course highly variable based on activity levels and latitude (Plew 1983: 59). The following formula was used to estimate yield rates needed to feed a population of a certain size:

(Capture Days (C) x Weir Capture Numbers (WC)) x (Caloric Value for average weight salmon (AW) ÷ Daily required caloric intake (CI)) ÷ non-capture days (NC) or to put it more simply:

$$\frac{\underline{(((CxWC)\ x\ (AW)) \div CI)}}{NC}$$

The seven-month period covers the winter months as well as the transition time between winter and spring. This is a very general exercise that is built on a number of assumptions and so it should be viewed with some caution. The first assumption is the very generalized caloric intake for an adult, the second is the uniformity in capture numbers, and the third and final assumption, is that the group in question can steadily capture fish for thirty days (not always viable). In addition, this limited exercise only takes into account dietary contributions of salmon, and no other possible sources of nutrition. The available calories from a 5.98 kg salmon is roughly 6104 Kcal (Plew 1983: 62), enough to feed three people for a day (Table 6).

Nutritional Component /100gm of fish	Raw	Smoked
Potassium (mg)	399.00	0.00
Vitamin A (mg)	310.00	0.00
Phosphorous (mg)	301.00	245.00
Sodium (mg)	45.00	0.00
Protein (mg)	19.10	21.60
Fat (mg)	15.60	9.30
Ash (mg)	1.10	9.40
Riboflavin (mg)	0.23	0.00
Thiamine (mg)	0.10	0.00
Calcium (mg)	0.00	14.00
Iron (mg)	0.00	0.00
Niacin (mg)	0.00	0.00
Caloric Value (Kcal)	222.00	176.00

Table 6: Nutritional components of raw versus smoked salmon (Plew 1983; Ballard 1957; Hewes 1973)

Caloric availability in smoked salmon is not significantly different from that of fresh salmon. Preserved salmon can last for one year or more (Harris 2001: 59), which allows for insurance if there is an especially long winter, or if the salmon runs in the following years is poor (Harris 2001; 60; Cox 1832: 80). Any minor caloric loss from smoking/drying is mitigated by the extended period of reliable storage of the fish.

As discussed earlier, Moss and Erlandson (1990) identified 450 weir sites in British Columbia; from the above model this indicates that the identified weirs in British Columbia could sustain an approximate population of 45,000 (Moss and Erlandson 1990: 150). In an assumed population in a given location of 100, operation of a weir requires approximately 20-30 people (Connaway 2007), leaving 70-80 people not directly involved in the harvest/processing practices. Wood stake fish weirs could indicate the need to feed larger populations or this technology could be the cause of the population growth.

Salmon Processing and Labour Requirements

Much of the information on precontact dietary patterns comes from isotopic analyses of human bone from archaeological remains (Perlman 1980: 257). In addition to analysis of human bones, bear bones are used as proxies for human bones, because bear diets are similar to human diets (Hilderbrand and Farley 1996: 2081). The development of pre-contact dietary models is relatively new, which places emphasis on ecosystem productivity as a means to defining past human diets (Campbell and Butler 2010: 15). The dietary models are based on the concept of minimizing risk and effort, but also maximizing caloric returns (Perlman 1980:259). One model proposes that the higher productivity areas in the interior are those close to rivers (Perlman 1980: 285), and larger seasonally sedentary populations are most likely to be located near areas of high riverine ecosystem productivity.

Archaeologically, the initial use and subsequent intensification in use of fish weirs obviously reflects an increase in capture rates, with a proportional increase in required labour. Weirs are an example of a resource intensifier (Steffian et al. 2006: 96). Weir fishing activities are spatially and temporally constrained to focus the labour to develop surpluses (Steffian et al. 2006: 99). In areas that have high yields but temporally limited availability, preservation of fish is essential to ensuring calories during times of nutritional scarcity (winter, drought, poor salmon runs) (Losey et al. 2012: 133). Salmon weirs have the highest capture rate compared to other mass capture strategies (Table 7).

Capture Technologies	Capture Rates (Kg/hour)	Processing Rate
Weirs	34.00	
Jigging (Hook and Line)	6.55	
Gill Net/Dip Netting	1.84	11.69kg/hour/person
Angling	1.20	
Purse Seine Netting	6.55	

Table 7: Salmon Capture Methods/Rate and Processing Rate (Losey et al. 2012; Colaninno 2011; Doe et al. 1998; Morin 2004)

Capture rates are averages based on data from many sources, primarily ethnohistorical reviews of fishing technologies. With a capture rate of 34.0 kg/hour of fish from one trap on a weir (Table 7), the processing rate of 11.69 kg/hour/obviously suggests that more labour is required for processing than for capture. To meet daily caloric requirements traps would have to capture approx. 655/day (2,000 people x 2,000 Kcal/person = 4,000,000 kcal/day total needed for a population of 2,000). That leads to 4,000,000 divided by 6,100 Kcal a fish = 655 fish needed a day to meet caloric requirements. If there are multiple traps on the weir, then the capture rate increases as well (Mahaffy 1978). In some cases children or the elderly with sticks or rocks would drive the fish towards the trap openings (Oswalt 1976: 108). The capture was undertaken by adult males and the processing was conducted predominantly by women (Prince 2003: 384). From data in Table 7, three people are needed to process the catch from one trap on a weir for each hour of operation. This intense labour requirement over a short time would require a number of people to operate the weir. Once the traps are full of fish, they are removed by canoe (Graesch 2007: 579), or by foot if the water is shallower (Morice 1893).

Processing requires labour to gather firewood, maintain fires, build smoking racks, clean the fish, hang the fish, and store the preserved catch (Cleland 1982: 779). The processing of the captured salmon is almost more important than the catch itself, as this ensures a stable food supply over the winter months. The ―labour bottleneck" is the limiting factor for all pre-contact fisheries (Essington et al. 2006: 3173; Prince 2003; Ames 1994: 217). Smoking and/or drying removes as much moisture as possible and acts to preserve some of the fat content of the fish (Romanoff 1992: 234). For salmon, moisture content of less than 12% is considered safe to store and eat (Romanoff 1992: 234; Doe et al. 1998: 25; O'Leary 1992a).

The procedure for processing varies with individual groups, but it usually requires that the salmon is filleted, and then hung to dry (Romanoff 1992: 235). This is achieved through wind drying, smoking, or fermentation (Doe et al.1998: 74; Alexander 1992: 124). The tools used for processing the catch are equally variable, consisting of a wide variety of materials including hafted microblades, shells, or groundstone knives (Graesch 2007: 581). These tools are used to first remove the entrails and head (Graesch 2007: 581). The fish is then filleted and cut laterally to increase the surface area (Graesch 2007: 581; O'Leary 1992a; Morice 1893: 92). The tails are sometimes left attached to the two fillets to hang the fish in the smokehouse (Graesch 2007: 581; O'Leary 1992a). The structure in which they are hung is covered on top to avoid the sun hitting the fish, as this would cause the fat to run and turn rancid (Romanoff 1992: 235). The sides of the structure are left open to let the wind in to aid in the drying process, however, for smoked fish in the interior, the sides are walled in to increase the concentration of smoke, this is also due to inconsistent wind patterns in the Interior of British Columbia (Romanoff 1992: 235; Lyons 1969a: 18).

The ―scrap" portions of the fish (head, organs, bones, skin), are either fed to the dogs, and fish heads are boiled down to obtain the remaining oils from the fish (Morice 1893: 92). These oils are a fat source consumed with dried foods, and they are stored in salmon-skin, or birch bark bags (Morice 1893: 93; Cox 1832: 221). Processing time is dependent upon a number of variables but as a general baseline, one person can process 50-60 salmon in a day (Romanoff

1992: 235). So if a weir catches 500-600 salmon per day, then 10 people would be required to process this catch. Areas with intensive fish processing are more likely to have significant seasonal cycles and are regions most likely to contain weirs (ElMahi 2000: 92; Testart 1982: 530). The greater seasonal shifts mean that food resources are scarcer during winter months, and effective surplus resource extraction must be practiced.

All ages and sexes participate in salmon processing, males typically were in the canoes to pull the traps from the water, and this usually required three or four individuals to lift the full traps from the weir (Ball 2004: 42; O'Leary 1992a). A full trap of salmon can weigh between 500-1000 kgs, and would require extensive efforts to bring onto shore (Plew 1983: 62). Part of the surplus catch was distributed amongst people unable to catch or process their own (the ill, the elderly, and the injured) (Prince 2003: 389). The exact numbers of people working at harvest and capture is not known, but harvest is most likely completed by five to seven people. Some weirs were owned by families and not entire communities, so these capture numbers would be lower with an assumed smaller family group (Martin 1989: 601).

Effective storage of the preserved fish was as important as processing efficiency. Some areas on the Southern Plateau of British Columbia and Yukon show evidence of raised caches, but typically, surpluses were stored in subsurface cache pits (Chatters 1995: 376; O'Leary 1992b: 84; Alexander 1992: 129). Testart (1982) postulates that storing hunter-gatherer economies were direct precursors to sedentism and increased social complexity. In this scenario surpluses were either at social storage settings, where interactions with neighbouring populations assured stores for the winter, or direct material storage of the procured resources (Christakis 1999: 13). Storage occurred directly at the site of procurement, the household, or at some other external site along a travel corridor (Frink 2007: 351).

Discussion

No weir could be effectively used without specific management of labour resources as well as harvesting restrictions. The technology was highly efficient and could completely destroy fish resources if used indiscriminately. And yet the length of time indicated in the use of this technology globally indicates that Indigenous peoples everywhere understood the complexity of fish population management. The technology requires significant labour in construction, maintenance, and operation, but the return is much higher than for any other riverine fishing technology. One potential result is that weirs are able to sustain larger human populations, and they can convey an advantageous economic position in relation to their terrestrial-resource dependant neighbours. The geographic and temporal limitations of streams allow for a reliable nutritional resource supplemented by terrestrial mammal harvests.

Chapter 4: Study Area

The study area consists of the outlet of Babine Lake, including Nilkitkwa Lake and the Babine River, up to the confluence with Nilkitkwa River (Figure 9; Figure 10). Babine Lake is located in the central interior of British Columbia and is unique in its biogeophysiology. Babine Lake is the largest natural lake that lies entirely within British Columbia, at a length of 150 km and a surface area of 490 km^2.

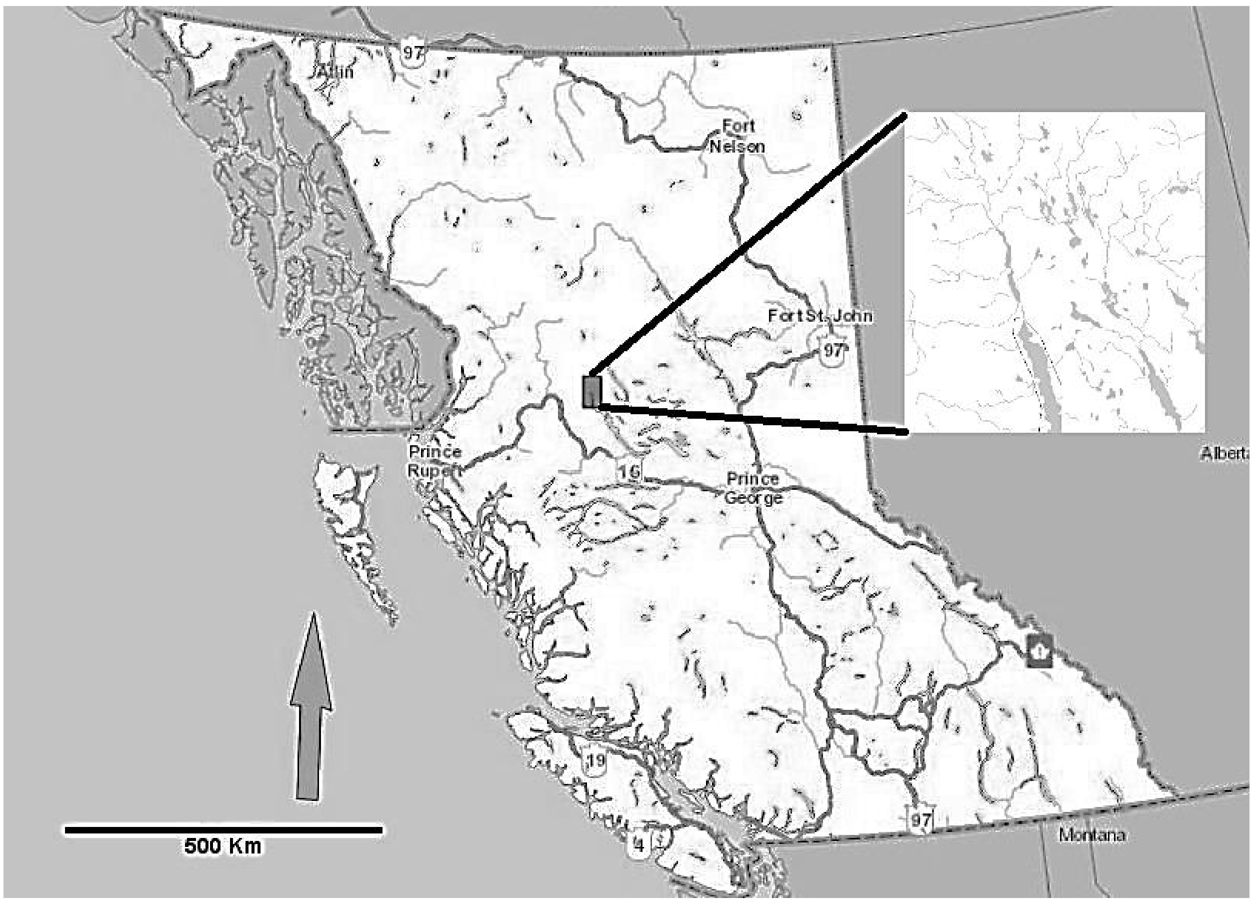

Figure 9: Geographic Location of Babine Lake and Study Area in British Columbia

IMap BC Base Layer, Map made with QGIS ©

Babine Lake is likely to have existed before glaciation in some form as the depth of the bedrock would have naturally formed a water body before glaciation (Groot 1966; Russell-Hunter 1970). It is located within the Sub-Boreal Spruce Biogeoclimatic Zone, although some parts of the lake are located within the Interior Western Hemlock Zone (Fladmark 1982: 98;

Fladmark 2009: 559; Rabnett 2000; Sinclair 1997; Wood et al. 1998: 1). The forest cover was dominated by pine and spruce after 9000 B.P. when the remaining glacial lakes disappeared (Donahue 1977: 21). Babine Lake and Babine River are located between the Nechako Plateau and the Babine Range of the Hazelton Mountains (Stumpf 2001: 60). This land base was formed during the late Cretaceous, (180 million years ago), and consisted of shallow seas and volcanic islands, and during this time period the bedrock layers and minerals were laid down (Mesozoic/Palaeozoic) (Rabnett 2000: 8; Donahue 1977: 12). Peat and pollen cores from Babine Lake indicate that this area was not glaciated at 43,000 B.P., but after this time ice began to advance into the area (Mathews 1979: 149). The landscape was significantly altered during the last major glaciation (Fraser Glaciation) (Stumpf 2001: 6). At the Last Glacial Maximum (17,000 B.P.), all of British Columbia was covered by ice sheets (Fladmark 2001: 31). Most areas around Babine Lake would have been covered by an ice sheet between 1 and 2.5 km thick (Fladmark 2001: 31), or even two to three kilometers thick (Rabnett 2000; Stumpf 2001). The Cordilleran Ice Sheet subjected the landscape to extreme weight and water flow, causing the underlying bedrock to be exposed creating an impervious layer to water (Stumpf 2001: 6; Rabnett 2000: 8). Some drainage now occurs from the south end of the lake into the Fraser River system, but the majority of moisture drains into the Babine River, which in turn drains into the Skeena River system (Stumpf 2001: 15; Rahemtulla 2012: 6). This area, similar to the rest of the continent, is undergoing isostatic rebound and this alters the water table and riverine flow patterns (Stumpf 2001: 6). The increased water in the system altered the sediment load in the streams, which affected the biological carrying capacity of those streams (Rabnett 2000: 8). By 9000 B.P. glacial lakes in British Columbia, including Babine, completely drained to near modern levels and the hydrology and riverbanks downstream stabilized shortly thereafter (Donahue 1977: 16).

The mouth of the Skeena River was rapidly deglaciated around 14,500-15,000 B.P. (Fladmark 2001: 31). Deglaciation followed up the Skeena River Valley to the confluences of the Bulkley River and further north to the Babine River at 10,600-10,700 B.P. (Fladmark 2001: 31). Paired with the rapid glacial retreats, rising sea levels would have driven some coastal groups further inland along the rivers (Fladmark 2001: 31). At 10,500 B.P., the isostatic depression of the landscape made the interior portions of the Skeena River Valley a coastal area (Fladmark 2001: 35). The sea levels reached their current levels at 8,000-8,500 B.P., which also influenced the flow patterns of the rivers further inland (Fladmark 2001: 35; Mathews 1979). Deglaciation also increased the amount of water in the Babine and Skeena Rivers, causing an increase in landslides (Fladmark 2001: 39) and tectonic events that affected the salmon in British Columbia's river systems (Mathews 1979). With its last eruption Mount Edziza caused significant shifts to the hydrology of the Interior Plateau at 8,300-8,600 B.P. (Fladmark 2009: 564). After 6,000 B.P. rivers stabilized in British Columbia, and looked similar to modern conditions (Mathews 1979), although they would have had higher volumes of water than current levels.

The Babine River headwater is Babine Lake, and the study area is in the headstream portion of the river. The outfall for the Babine River is the Skeena River estuary near Prince Rupert, British Columbia. Babine River, which flows to the confluence with the Skeena River, is a Trellis-style river (see Figure 2; Chapter 2) (Dincauze 2000: 202; Russell-Hunter 1970). The proximity of the study area to the headwaters suggests a higher velocity of water (Russell-Hunter 1970), which is corroborated by hydrometric data (Figure 11, Figure 12). Stream bed sediments consist of river rolled pebbles, gravels, and cobbles (Dincauze 2000: 203). Based upon Rosgen's (1994: 164) stream classification guide, the Babine River is a D style river.

The environment in the study area is unique in comparison to other interior riverine environments in the region. Because of the size and depth of the lake, Babine Lake’s waters buffer seasonal weather variations somewhat (Rabnett 2000: 16; Russell-Hunter 1970: 169). As the temperature range of the water here is more regulated, fish species are more abundant here than in other areas downstream (Russell-Hunter 1970). Lakes seasonally shift water temperatures, this —overturning” allows fish species to remain active at lower depths during the winter months (Russell-Hunter 1970: 129). These characteristics have important ramifications for Babine subsistence. Deeper lakes are relied upon for longer periods of time during the year because fish species do not go completely dormant (Russell-Hunter 1970: 170), so that other types of fish are available even in the winter. This physical environment allowed the Babine to develop a complex regional economy, but the mainstay was the capture of salmon (Rabnett 2000: 16).

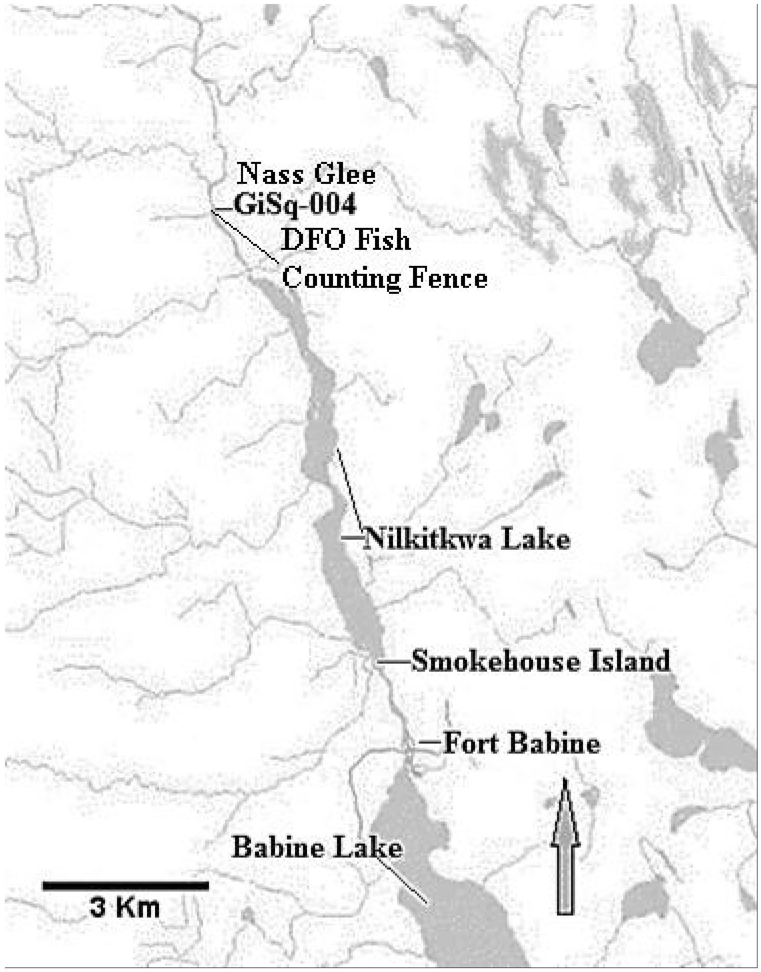

Figure 10: Study Area

Map credit: public domain DataBC base layer map made with QGIS ©

The large village site, GiSq-004, Nass Glee, (Hackett 2017) is located at the current Department of Fisheries and Oceans fish counting fence (Figure 10) (Mohs and Mohs 1975; Fladmark 2009). Mohs and Mohs (1975) mapped this village site that contains many house depressions, cache pits, and the remains of a fish weir nearby. Initial research excavations were undertaken by Rahemtulla in 2010 and in 2012 and revealed a basal date of at least 1,300 RCYBP (Rahemtulla 2012). Part of one of the house depressions was excavated in 2012 and yielded a range of historic and pre-contact fishing-related artifacts and some fauna, including a small number of salmon bones (Rahemtulla 2013). Mohs and Rahemtulla identified a number of cache pits along the river in the study area (Rahemtulla 2012; Mohs1974). Mohs (1974), Rahemtulla (2012, 2013), and cultural resource managers in the region have identified this as a resource-rich procurement area. The depth of time of occupation revealed by the excavations, and the size of the site, suggest that substantial populations were sustainable thanks to the large salmon runs, and the use of weirs to capture them.

Babine River Flow Characteristics in the Study Area

The Babine River flows out from Babine Lake in a northerly direction. From the outlet at Babine Lake the river flows for 2.1 km where it reaches Nilkitkwa Lake and Smokehouse Island. The flow here is slow and shallow, even at full water load (Figure 12). The river then curves to the northwest around both sides of Smokehouse Island and into Nilkitkwa Lake. Nilkitkwa Lake consists of three main portions with the largest section in the south (Figure 10). Beyond Nilkitkwa Lake, the Babine River turns north again towards GiSq-004 (Nass Glee) (Hackett 2017) (Figure 10). After the DFO fence, the Nilkitkwa River turns back into the Babine River and flows west/northwest until it joins the Skeena River. From the outlet of Babine Lake to the confluence with the Skeena is a distance of 97 km (O'Donnell 1987: 1). The total distance to the ocean via the Skeena River is 570 km (Groot 1966). Early European explorers stated that the river was not navigable by boat after approximately 32 km from the lake, and suggested that they use the overland trail from Hagwilget to bypass the rough section of the river (O'Donnell 1987: 2).

Hydrometric data – historic flow

Flow rates in the study area are based on modern data (1930-2011), although a generalized trend of flow change over the years can be applied to past levels, and a best fit model has been constructed from the earliest Hydrometric data (1930). Retreats and advances of glaciers in the watershed cause significant fluctuations in the river's behaviour (Chatters 1995: 385). Post-glaciation collapse of ice dams would have flash-flooded the system with debris and changed the shorelines and river bed significantly (Chatters 1995: 386).

The hydrometric data explain why and when the fish weirs were used in the study area annually. The Babine River in the study area (see Figure 11) shows a peak flow around or near the end of June (Figure 11) (http://www.wateroffice.ec.gc.ca/index_e.html). Weirs are not used during peak flow times, because the strain on the weirs is too great, and most salmon do not start running until after this peak flow period (Fiske and Patrick 2000; Harris 2001).

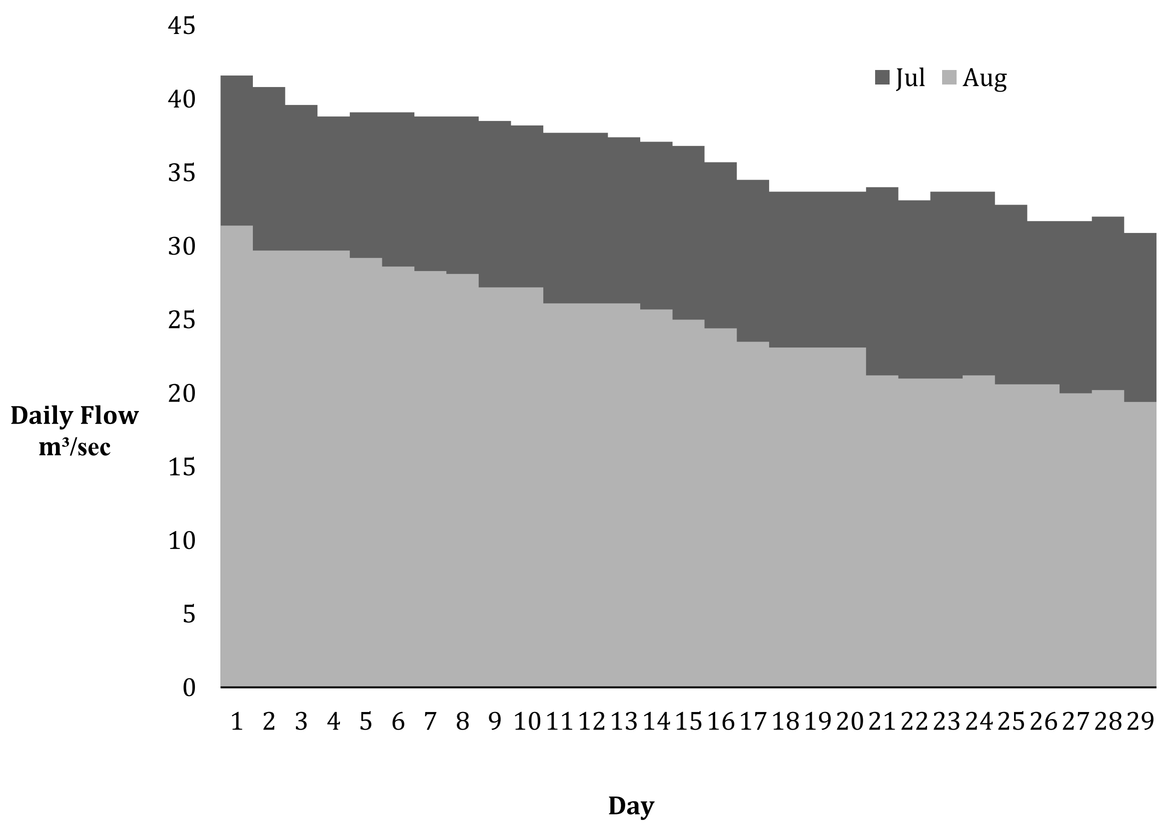

Figure 11: Hydrometric data (1930) for July and August at outlet of Babine Lake (Environment Canada Water Office)

Data credit: (http://www.wateroffice .ec.gc.ca/index_e.html)

After the end of June the flow rate drops significantly, so July and August are the most likely times of weir use (Figure 11) (http://www.wateroffice .ec.gc.ca/index_e.html).

Lower strain from the current would have less influence on the raw materials used in weir construction (see discussion on mechanical strength properties of wood species in Chapter 2) (Table 3). From the middle of July until the end of August the flow rate is slow enough to allow placement of the weir in the water (Figure 11). After September, river levels are too low to use wood-stake fish weirs efficiently, so at this time, hook and line, gaffs, or dip nets were used (Fiske and Patrick 2000; Harris 2001). Flow averages (Figure 11) were combined with depth of water to determine the total force exerted upon the weir. Using this calculation the total force exerted by the water on the weir during peak flow time is close to 300 Kilonewtons (kN), so that that each weir component is subjected to this force, including stakes, posts, traps and cross braces.

The season of weir use is also dependent upon the timing of the selected species' run (Chaney 1998: 254). Salmon-reliant groups are more seasonally limited since runs only occur in early spring to mid fall (Gobalet 2004: 809), which allows for more preparation devoted to weir construction and maintenance. Other groups can harvest fish resources year-round, for instance, in the Great Lakes Region in Ontario (Martin 1989: 595); there intensive salmon harvest occurs during spawning months (April-September), while other fish species are sought year-round (Martin 1989: 595). For the Babine, oral histories indicate that July through mid-September are the intensive salmon fishing months, with white fish capture occurring during the winter (Fiske and Patrick 2000; Joe Michel personal communication 2011).

Salmon

Salmon have a high mortality rate from egg to mature/spawning adult. From the egg to smelt stage there is a 3% survival rate (Lyons 1969b: 243). The survival rate is nearly zero for one salmon egg batch (Lyons 1969b: 243), which also makes the salmon population more susceptible to environmental disturbances. Evolutionary studies have placed the *Onchorynchus* speciation date at the mid-Miocene, approximately 9.23 million years ago (Waples et al. 2008: 189). At this time the various salmon species split off from the main family group of tetraploids (Waples et al. 2008: 189). The success of the salmon species is based on three environmental conditions: suitable pebbled spawning beds, access to a sea, ocean, or large lake, and water temperature ranges that allow for growth of the salmon from egg to fry (Rostlund 1952: 151). At the time of deglaciation, river systems were too turbulent to support fish migrations; afterwards salmon began to populate rivers where they are currently found (Waples et al. 2008: 190). Radiocarbon dates from Kamloops Lake indicate that salmon had made their way into interior British Columbia by 15,500-18,000 B.P. (Carlson 1998: 26). Although these are landlocked salmon, they originated from a migratory proto-species of salmon (Waples et al. 2008).

After river systems stabilized, 10,000 modern stocks of salmon began to populate the current 3,600 salmon bearing streams in British Columbia (Haggan et al. 2006: 1). The major watersheds now populated by salmon species are the Fraser, Skeena, and Columbia systems (Waples et al. 2008: 196). Five salmon species now occur in the Skeena watershed: sockeye (*Onchorynchus nerka),* coho (*O. kisutch*), chinook (*O. tsawytscha*), pink (*O. gorbuscha*), and chum (*O. keta*) (Waples et al. 2008: 191). Salmon population levels in the rivers stabilized at 5,000-3,000 B.P and were presumed to be at the pre-industrial harvest levels (Fladmark 2009: 555).

Species	Average Living Weight (kg)
chinook (*O. tsawytscha)*	14.0
kokanee (*O. nerka spp.)*	6.8
chum (*O. keta)*	3.6-6.8
coho (*O. kisutch)*	3.6
sockeye (*O. nerka)*	2.7
pink (*O. gorbuscha)*	1.6-1.8
Total average weight	5.98

Table 8: Average Weights of Salmon Species (Kew 1992; Plew 1983**)**

The various species range in size and fat content, with chinook being the largest and pink salmon the smallest (Table 8). Oral histories state that pink were the preferred salmon on the coast because they were easier to preserve there, but for the Babine, and other interior groups, the sockeye were the most sought after, primarily due to taste, but the fat content is also ideal (Harris 2001; Rabnett 2000; Fiske and Patrick 2000).

The study area falls in the Pacific Drainage, or the “Salmon Area;” rivers falling into the Arctic Drainage or into the rest of the continent are considered to be the “Non-Salmon Area” (Fladmark 2009: 555; Donahue 1977: 19). Babine Lake produces a predominant feeder stock of salmon to the rest of the Skeena watershed; the lake is responsible for over 90% of the stock (Donahue 1977: 19; Larkin and McDonald 1968: 231; Wood et al. 1998: 1; Newell 1989: 27; Fladmark 2009). The Babine sockeye come from three *deme*s, or genetic populations, the main lake deme covers the southern portion of Babine Lake to Granisle (Groot 1966: 11). The second deme comes from the northern portion of the lake and Nilkitkwa Lake (Groot 1966: 11) and the third deme comes from the river and creek tributaries to the Babine River (Groot 1966: 11).

In the Babine Lake/River system all five salmon *Onchorynchus* species are present, and they are thought to have been present by 6000 B.P. (Waples et al. 2008: 193). Of the entire

Skeena watershed, the Babine River drains 26 salmon nursery lakes (Groot 1966: 12). As stated previously, the Skeena River, including the Babine River is 570 km long, whereas the Fraser River to Stuart Lake is 1022 km in length (Rabnett 2000: 29). This affects the quality of salmon, as longer travel distances deplete higher amounts of protein (Table 9). The higher fat loss of the Babine salmon did allow for more effective preservation of the catch (Rabnett 2000: 29).

	Stuart Lake			Chilko Lake			Babine Lake		
	Male	Female	Average	Male	Female	Average	Male	Female	Average
Fat Loss	91%	96%	94%	78%	91%	84%	85%	94%	90%
Protein Loss	31%	53%	42%	42%	61%	52%	37%	57%	47%
Total Caloric Expense (Kcal)	1398	1644	1521	1293	1903	1598	1185	1253	1219
Total Distance of Run (km)	1021.933			595.457			570.12		
Average Protein loss/km	0.04%/km			0.09%/km			0.06%/km		
Average Fat loss/km	0.09%/km			0.14%/km			0.12%/km		
Average Caloric expense/km	1.49 Kcal/km			2.68 Kcal/km			2.08 Kcal/km		

Table 9: Caloric expenses and fat loss of salmon in various river systems (Plew 1983; Groot 1966)

In comparison the Babine River Canyon is the only rough section of the river, and the salmon only have to swim approximately 20 km of rough water (Groot 1966; Rabnett 2000). The presence of five salmon species in the river also increases the variety and quantity of fish for the Babine. The major spawning grounds of the Babine River salmon are as follows (Table 10):

Lower Babine River	Upper Babine River	Nine Mile Creek
Morrison (Hatchery) Creek	Lower Thalo (Salmon) Creek	Sockeye Creek
Fulton River	Pierre Creek	Twain Creek
Pinkut Creek	Gull Wing (Six-mile) Creek	Four Mile Creek
Shas (Grizzly) Creek	Tachet Creek	

Table 10: Spawning Channels on the Babine River (Department of Fisheries and Oceans 2014)

The Babine River is classified as a major salmon bearing stream according to McDougall's (1987: 7) *Classification of British Columbia Salmon Stream Escapements by Species and Sub-District*. Babine Lake is the largest producer of sockeye (*O. nerka*) in Canada (Larkin and McDonald 1968: 229; Wood et al. 1998: iv). In the ocean, salmon range over the entire west coast of North America, with some ranges extending to the Asian east coast (www.dfo.gc.ca). With such large ranges, many precontact groups relied on the harvest of single populations of salmon, which has implications for sustainable precontact management of the stocks before western management strategies were implemented.

Proto-Historic /Historic Salmon Availability in British Columbia

Larkin and McDonald (1968: 241) indicate that there was a drop of 50% in the sockeye salmon escapements between 1910 and 1948. This is likely due to an increase in commercial fishing activities, both on the Skeena River and in the Pacific Ocean. Research on British Columbian salmon runs have largely focused on the Fraser and Columbia Rivers, and work done on the Skeena/Babine Rivers has focused on population biology and age ranges of the stocks (Fisher 1977: 29; Johnson-Gottesfeld 1994: 450; Lyons 1969a: 110; Meggs 1991: 45). The early estimates of salmon runs are projections by the Department of Fisheries and Oceans (then Department of Marine and Fisheries) Guardians reports. The reports of the Fisheries Guardians recorded the capture numbers by the canneries and not the escapements, which is an indirect measure of salmon abundance. Fladmark (2009:684) states that there can be no direct indications of precontact salmon availability, but sea-level histories can indicate the available environment for salmon to utilize. Department of Marine and Fisheries reports state that four-year-old salmon are the most likely breeding population (Department of Marine and Fisheries Reports 1889-1905), although some three or two year old jack (non-breeding) salmon were available and harvested (Harris 2001; Fiske and Patrick 2000). Babine salmon escapements are mostly unknown from the 1870s until the 1890s and any reference to the amount of fish was limited to qualitative reports of the Fisheries Guardians (Department of Marine and Fisheries Annual Reports 1873-1890). Capture numbers for the 1880s to the 1910s (Figure 12) are treated as a representative sample of the available salmon stocks. Artificial spawning channels and hatcheries were in operation by this time, and they bolstered the stocks to more than what was naturally available according to the Department of Marine and Fisheries Annual Report 1900. Annual escapement (fish returning to spawn) data were not available until the implementation of the Department of Fisheries and Oceans fish counting fence, which was initially opened in 1948, but qualitative reports were available from the Fisheries Guardians of the Skeena River in the late nineteenth century.

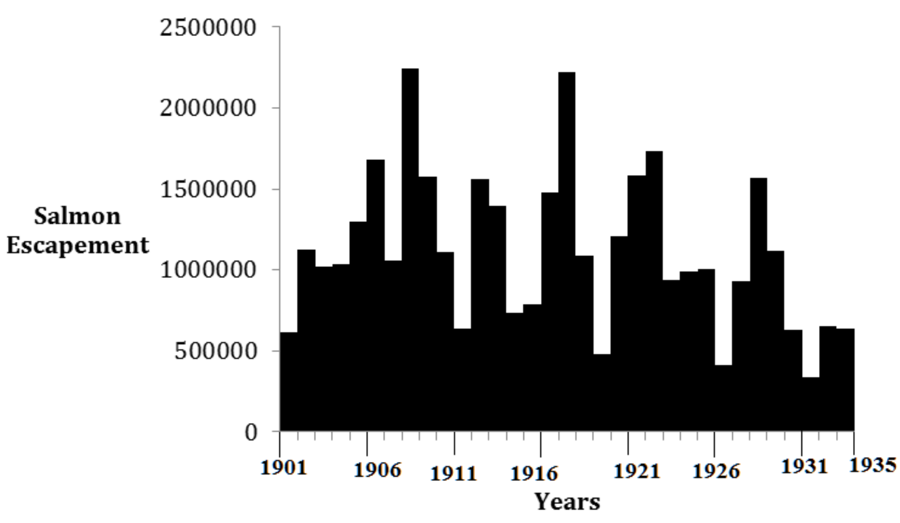

Figure 12: Salmon Escapements Babine River 1901-1935 (Taylor and Dickie 2008; Department of Marine and Fisheries Reports 1901-1935)

The Babine sockeye salmon data show a seven year cycle of abundance (Figure 12), in comparison with the four year cycle for the Fraser River salmon stocks (Drake and Naiman

2002: 2968). This seven year cycle fits in with the earlier data of poor commercial catches. Salmon numbers increased in 1901 due to the construction of a new hatchery on the Babine River (see Chapter 5) (Department of Marine and Fisheries Annual Reports 1901-1910). These data clearly show that the salmon hatchery at Babine Lake had positive effects on the stocks later on, but this still does not show the impact that the rapid expansion of canneries and commercial fishing had upon the stocks from 1880-1906.

Discussion

The environmental characteristics in the study area are ideal for weir operation targeted at various species of salmon. The availability of fish in this area indicates that weirs are the most efficient means of capturing sufficient resources for the winter months. The high level of nutrition available from salmon in the study area is attributable to the shorter distances from the ocean (Table 9). The high level of fish availability in the area also allows for an increased rate of capture from weirs. The growth of the commercial fishery in the late nineteenth and early twentieth century dramatically reduced the number of salmon reaching the upper sections of the Skeena and Babine Rivers (Harris 2001). The physiography and river flow suggest that the most efficient weir design is straight bank-to-bank style, multiple component wood stake fish weirs. Other weir styles were deployed in the area; however, the narrowing of the river near bends and islands dictates the most likely locations for successful weir operation. At Smokehouse Island a multi-component, bank to bank style of weir makes sense given the local conditions. At GiSq-004, Nass Glee (Hackett 2017), a linear, bank to island style of weir is more fitting, while at the narrowing between the two larger sections of Nilkitkwa Lake, a wing style or a longshore weir seems logical. These three locations are the most suitable for weirs; but weirs were also placed in other locations in the study area. The capture rates for these weirs would be similar to that at other rivers, at 300-700 fish/weir/day, depending upon the run size. If these three potential weir locations were the only ones in the Babine area, they could still provide sustenance for many people if all three were in full operation. The technological responses to the environmental conditions in the study area (Figure 10) are clearly a response from a long period of occupation. Further discussions on the weirs located in the study area will be provided in Chapter 5.

Chapter 5: Ethnohistory of Babine Wood Stake Fish Weir Use

Many Aboriginal groups in British Columbia are situated on or in proximity to major salmon-bearing rivers and lakes. The Aboriginal groups residing in the Skeena River watershed are Tsimshian, Gitxsan, Witsuwit'en, Nisga'a and Babine (Fiske and Patrick 2000: 18). These groups had a complex relationship in terms of salmon harvests and negotiated agreements in terms of when and where to catch fish (Fiske and Patrick 2000: 19). Archaeological and ethnographic investigations reveal that they have relied, and continue to rely, heavily on salmon fishing (Taylor et al.and Dickie 2008: 18). The people residing near Babine Lake call themselves Ned'ut'en, meaning ―people of the lake" (Rabnett 2000). The Babine or, Ned'ut'en, and neighbouring Dakelh (Carriers) are included in the Subarctic Culture Area, and they are linguistically Athapaskan speakers (Muckle 2007: 36; Fladmark 1982; Fladmark 2009: 555; Wissler 1914: 454; Poser 2006: 3; Fiske and Patrick 2000; McHarg and Cassidy 1980, Morice 1925: 479; Rabnett 2000; Hackler 1958) although the Babine are close to the assumed line between the Northwest Coast and Sub-Arctic Culture Areas (Fladmark 1982: 99). Fladmark (2009:558) further delineates the Babine as a part of the ―Skeena-Bulkley-Nass" archaeological region, the Babine language that shares linguistic structural similarities to Witsuwit'en to the south (Fladmark 1982: 100). Both Babine and Witsuwit'en are Athapaskan languages (Poser 2006; Hargus 2007). This can be evidenced by the similarities of clan names between the Babine and the Witsuwit'en (Poser 2006; Hargus 2007). Witsuwit'en means people of the lower drainage in comparison to the Babine River which joins the Skeena much further north than the Bulkley River (Morin 2004: 11).

Early European explorers in the area noted that the Babine were distinct from Dakelh groups further inland in dialect and in other cultural features (Fiske and Patrick 2000; Morice

1925). Although the length of occupation in the study area is not known, it does go back at least 1,300 years (Rahemtulla 2012). During this known occupation the abundance and successful harvest of salmon has been a focal part of Babine subsistence. Rivers and lakes in the study were important resource extractive locations, travel corridors, and habitation sites (Fiske and Patrick 2000: 16). This aided the Babine in obtaining their winter stores of food, but it also allowed them to develop surpluses (Fiske and Patrick 2000; Harris 2001), which in turn put them in a position to trade in all directions in precontact times, as well as into the early contact period (Harris 2001; Fiske and Patrick 2000). The surplus salmon economy was crucial to the Babine seasonal adaptations as this improved their trade stance with other groups (Rahemtulla 2012: 9).

Social Organization

The term ―Babine” comes from the early explorers and voyageurs who noted the use of labrets worn by the women in the villages (Morice 1925: 481; Bishop 1987: 74; Ogden 1853: 71), the term translated from French literally means lips. Work on the precontact Babine emphasizes non-hierarchical (egalitarian) social organization; although a modest social hierarchy was present (Fiske and Patrick 2000). By the time of contact the Babine displayed a significant amount of social stratification, and each resource patch, including fish weir sites, required management to ensure sustainable harvests (Rabnett 2000; Earle and Ericson 1977: 5; Bishop 1987). Access to harvest and various resource areas were controlled through matrilineal descent within specific clans with Hereditary Chiefs (Lowie 1914; Kobrinsky 1982, Bouchard 2012).

Evidence for social hierarchies include noble birth women having labrets or lip plugs (Hackler 1958: 3; Bishop 1987), as these were a sign of high status individuals (Hackler 1958). Babine social organization is similar to the Gitxsan/Witsuwit’en, primarily due to their close geographic proximity (Rahemtulla 2012: 8; Morice 1893). Hackler (1958: 36) also states that Babine social organization before contact was influenced by their proximity to coastal Aboriginal groups. The most likely route for the transfer of shared cultural practices was via Tsimshian to the Gitxsan and up the Skeena River toward the Babine, or even possibly from the Witsuwit'en on the Bulkley River (Hackler 1958: 5). This social structure were also maintained by trade because neighbouring groups came to the area during the salmon runs of late summer to obtain high quality salmon stores for the winter (Hackler 1958: 6). It is likely that this social organization existed before the time of European arrival (Rahemtulla 2012: 8; Bouchard 2012).

Neighbouring Groups

The main trading partners/neighbours of the Babine were the Takla Lake (north east), the Nak'azdli (Stuart Lake) (east), the Witsuwit'en (southwest), the Tsimshian (west) and the Gitxsan (south west) (Rabnett 2000:9; Bouchard 2012). Trade networks were linked by "grease trails," named after the movement of oolichan grease along these trails as well (Rabnett 2000: 19), although many other commodities moved over these trails (Table 10). Beyond trade, the trails were an important connection between neighbouring groups, which allowed information sharing between groups (Mills 2011: 324). The trails are extensive and cover much of the landscape of British Columbia; they act as travel corridors, as well as boundary markers between territories (Rabnett 2000: 20). These trails have been in existence for thousands of years, and each section of the trail falls under a different family or clan's management area (Muckle 2007: 29; Harris 2001; Fiske and Patrick 2000). Trails were managed through the use of tolls or outright restriction of use in certain areas (Muckle 2007: 29; Harris 2001; Fiske and Patrick 2000). These trails were in place well before the Europeans arrived and facilitated European explorers’ access into the interior of B.C., which facilitated the establishment of the Trade Forts (Muckle 2007: 29; Harris 2001; Fiske and Patrick 2000). These groups came to Babine Lake, more specifically Fort Babine (Wit’at) to ―lease” fishing locations for the season (Fiske and Patrick 2000: 56).

Carrier or Dakelh peoples reside in the northern interior of British Columbia, and they are typically mobile hunter-gatherer-fishers (Fladmark 1979: 62) and the Babine are included in this group. The Babine traded with, and intermarried with the Dakelh (Morice 1893). The Dakelh people in general rely heavily on fish from the Fraser River and other salmon stocks (Muckle 2007: 58), while the Babine relied primarily on salmon from the Skeena watershed. Dakelh affiliated with the Babine would routinely harvest salmon from the Babine/Skeena Rivers because the fish there were of a higher nutritional quality than the salmon reaching the northern limits of the Fraser River watershed (Table 9) (Harris 2001: 38). Through trade and marriage alliances, neighbouring groups would access the right to harvest salmon if there was a poor run year in their area, or if no salmon could be harvested elsewhere (Harris 2001: 37). Early Europeans in the area estimated approximately 1200 people who traded at Wit’at over the course of a few months (Hackler 1958). Donahue (1977: 46) writes that in 1826 there were 28 people at the community of Nass-Glee. This low number of people may have been a result of diseases affecting the area from earlier contact with Europeans. There was one Chief responsible for this site and the group, which was predominantly operating the weir (Donahue 1977: 46).

Yearly fluctuations of salmon in the Babine River (Figure 12) led to increase surplus capture during high salmon run years (Prince 2005: 82). Terrestrial hunting and trade with neighbouring groups also acted as insurance against poor salmon run years. Before Europeans came into the Babine River area, the Babine traded terrestrial resources with the Gitxsan and

Tsimshian at Hagwilget (Morice 1906: 209). The Babine could conversely harvest salmon from the traditional areas of the above groups if they had poor run years (Harris 2001; Fiske and Patrick 2000).

Items traded from Coast to Interior	Items traded from Interior to Coast
Oolichan and grease	Salmon
Herring	Berries
Kelp	Meats
Seaweed	Obsidian
Shellfish	Hides/furs
Copper	Nephrite
Canoes	Flint and arrowheads
Dentalia	Jet
Yew wood	Wooden products – digging tools, arrow shafts
Abalone	etc.

Table11: Trade Items between Coast and Interior (Rabnett 2000)

Babine Traditional Management of Salmon Fishing

Each weir location was owned, but some could be ―leased" to neighbouring groups (Harris 2001: 74). Each of the Babine hereditary groups is identified by a certain clan animal and crest, and each area is identified by these clan animals either with totems, or some other form of territory marker (Brown 2002; Hackler 1958: 37). Responsibility for each area falls to a Chief, and conflicts are dealt with during balhats (Fiske and Patrick 2000: 57). The larger Babine Nation traditionally consists of four matrilineal houses: the *Lakchibu / Likc'ibu / C'itDinT'en* (Bear), the *Jilhtsehyu* (Frog), the *Gilantin* (Caribou/ Mountain), and the *Likhtsemisyu* (Beaver) (Fiske and Patrick 2000: 48, Keddie 1989). Most oral histories and traditional use studies undertaken by the Lake Babine Nation indicate that the weirs were managed and operated by one of the clans (Hackler 1958). In precontact times the Babine economy also relied on trade and leasing resource procurement spots for hunting, fishing, and gathering (Rabnett 2000: 18).

In the study area (Figure 10) the *Likhtsemisyu* (Beaver) were the dominant clan (Figure 13), but certain weir locations within this area were leased by other clans or by neighbouring groups (Hackler 1958: 58). Use of these weir fishing locations came with the responsibility to not over harvest, and to ensure groups further upstream or along the lake have sufficient salmon (Harris 2001; Fiske and Patrick 2000).

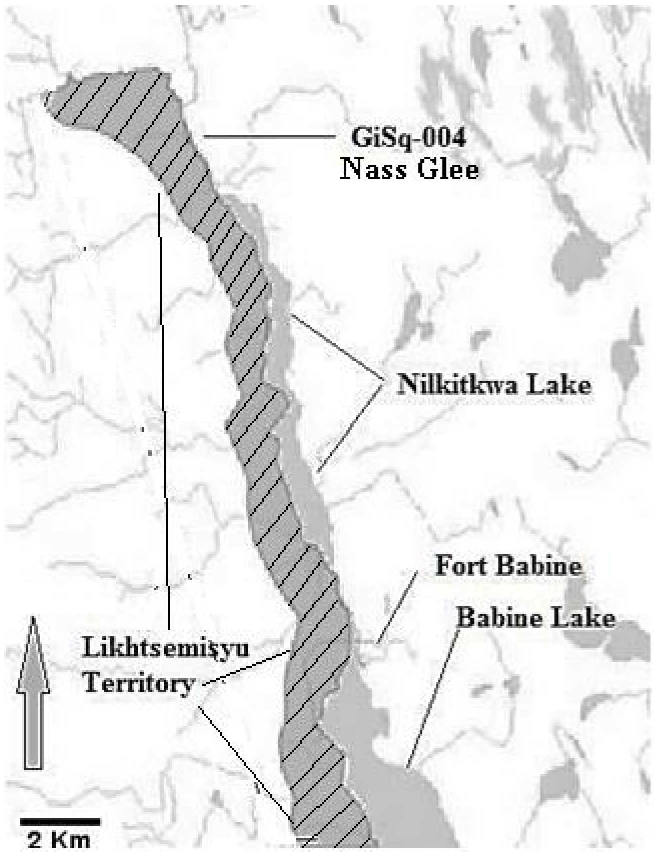

Figure 13: Partial Clan Ownership in Study Area (Hackler 1958: 20-21)

Data BC public domain base layer. Map made with QGIS ©

This ownership area does not cover the entirety of the Likhtsemisyu (Beaver) clan area, but shows the extents of ownership in the study area. Areas further south and north are owned by other Babine clans, and some weir fishing locations within this area were owned by other groups. The clans were intermarried and all clans had site where they could fish in Babine Villages such as Nass Glee (Fiske and Patrick 2000; Harris 2001). These fishing locations will be discussed later on. Various management and maintenance issues were important to the successful operation of fish weirs. The Indigenous groups in British Columbia, and elsewhere, have a system of ownership rights to fish in certain areas, and stewardship responsibilities are paired with the ownership rights (Haggan et al. 2004: 14). Examples of this stewardship include: clearing debris from streams, trail maintenance along salmon streams, and in some extreme cases moving the salmon past a blockage in the stream (Haggan et al. 2004: 17; Furniss 2004; Brown 2002; Bouchard 2012). Other maintenance responsibilities included clearing of obstructions to salmon pathways. Rockslides, such as one recorded on the Babine River in 1951 (O'Donell 1987: 14), and on the Fraser River in 1913 and 1914 (as noted earlier) could have completely destroyed salmon stocks, but Indigenous groups in those respective areas ensured that enough salmon returned to their spawning grounds (Haggan et al. 2006: 7). This was achieved by physically transporting the salmon past the blockage in birch bark baskets (O'Donell 1987: 14). When similar events occurred in pre-contact times, the response of resident groups was similar. Other examples of stewardship responsibility are demonstrated via a study that showed Aboriginal groups transported fertilized eggs from one stream to a different stream to create a new salmon population, in a previously non-salmon bearing stream (Haggan et al. 2004: 19). For the Babine such rules and regulations are set up and enforced through potlatches (*Balhats*) and kinship laws (Rabnett 2000: 19, Romanoff 1992: 223). *Balhats* gave legitimacy to specific Hereditary Chiefs to own/maintain weir locations (Fiske and Patrick 2000: 33; Bouchard 2012). The Chiefs in turn acted as administrators and could decide who was permitted to use the weirs (Johnson-Gottesfeld 1994: 450), and they also ensured that harvests did not exceed rates of replacement (Johnson-Gottesfeld 1994: 444). These rules and regulations developed over a very long period of occupation, and suggest that sustainable resource management was clearly recognized as an important common goal of the Babine, Witsuwit'en and Gitksan (Johnson-Gottesfeld 1994: 444).

The Babine managed salmon to ensure a viable breeding population, to ensure sustained harvest for themselves, and for other groups relying upon the salmon catch. This included leaving some debris in the river to act as shelter for migrating salmon (Fiske and Patrick 2000; Harris 2001). There was the expectation at each weir location to allow enough fish through the traps to ensure a viable spawning population as well as sufficient fish for capture by groups further upstream (Hackler 1958: 14).

Summer maintenance activities included preparation for harvest and processing of the catch (Sinclair 1997: 13). During peak use these weirs allowed capture of a large amount of salmon per day (500-600/weir) (Department of Marine and Fisheries Annual Report, 1906), with post-catch processing time and labour as the deciding factor. There was a complicated system of management in place to ensure proper respect and protocol was adhered to (Fiske and Patrick 2000: 17). These management systems still remain in some form, even after the ban on balhats in 1884 (Fiske and Patrick 2000: 15). The management regime for salmon is extremely complex; ensuring a viable breeding stock enters the lake (Harris 2001: 45).

As stated earlier, weirs remained inactive until three weeks after the runs had begun (Hackler 1958: 25). Once active, weirs could not be operated over long periods (Chapter 2; Table 2) unless harvest rules were enforced and adhered to. Due to the richness and predictability of the Babine sockeye, the Babine were among the wealthiest groups in the region (Sinclair 1997: 8). Babine traditional territory has often been referred to as the ―breadbasket of the north" (Fiske and Patrick 2000: 15). Such natural resource endowment allowed for a more permanent form of occupation typified by socially complex societies (Muckle 2007: 28).

An interview with a Babine elder/knowledge holder in 2011 revealed that traditionally preserved salmon can be consumed one year or more after processing (Joe Michel, personal communication 2011). This is achieved if the moisture content becomes below 12%, allowing for long-term storage (Garner and Parfitt 2006:5). This gave the Babine some flexibility with seasonal variations in salmon runs (Garner and Parfitt 2006: 5; Romanoff 1992: 234; Doe et al. 1998: 25; O'Leary 1992a), so that stores from highly productive seasons could be used to offset lean years The Babine stored their surpluses in cache pits, with woven bark or some other form of lining (Chatters 1995: 375).

First Contact with Europeans

The first recorded meeting between the Babine and Europeans was documented in Daniel Harmon's 1800 journal, *Sixteen years in Indian Country*, in which Harmon described a distinctive group of people west of Fort St. James (reffered to by Rabnett 2000: 26; Harmon 1819: 134; Lamb and Bond 1957; Morice 1928: 61). Harmon also revealed that some Europeans had come down the Babine River in the north, but could not provide any further information at this point (Harmon 1819: 125). It was during this time that Harmon also described the operation of a Dakelh weir at Fort St. James, which appears similar to ones used by the Babine:

> We now have Salmon in abundance which the Natives take in the following manner:—They make a Dam across the River and at certain places leave spaces, where they put a kind of long Basket Net, which generally is about fifteen feet in circumference & fifteen or twenty in length, one end of which is made like a wire Mouse Trap, & into that the Salmon enter, but when once in cannot go out, till the Basket is taken ashore, when they open a Door made for that purpose & turn them out, and in one of those Baskets they often will take four or five hundred Salmon that will weigh from five to seven pounds each— (Harmon 1819: 126-127)

Harmon also noted that there were close to 2000 people across three communities on Babine Lake (Harmon 1819; Rabnett 2000: 26; Lamb and Bond 1957). Oral history accounts state that other Europeans were seen at, or around this time (Hackler 1958: 13). After this initial contact, William Brown of the Hudson's Bay Company established a Fort at what is now known as Fort Kilmaurs, and then was moved to Old Fort (geographically about 200 meters apart) (Bouchard 2012: 17). In 1825, Brown traveled from Fort Kilmaurs down the Babine River to visit the Gitxsan (Ball 2004: 29), and he described the river between Fort Babine and the Babine River Canyon, but was unable to paddle further down the river (Ball 2004: 29). As noted earlier, Brown recommended that access from the Bulkley River area be over the trail network and not via the river (Ball 2004; 29). The Hudson's Bay Company closed the store at Old Fort in 1840 and established a store at the mouth of the Babine River, Fort Babine (Rabnett 2000: 28).

Once Europeans arrived, the fur trade intensified extraction of furbearers at the behest of the Hudson's Bay and other European companies (Sinclair 1997: 21; Ogden 1853: 72). In addition to the fur trade, albeit later on, the dramatic increase in salmon fishing by industrial/commercial interests also affected the Babine (Harris 2001). During this time, canneries at the mouth of the Skeena were engaged in commercial fishing and this reduced the salmon stocks, which affected all Indigenous fish harvesters upstream, including the Babine as discussed below.

Babine Fish Weirs in Historic Literature

Weirs that merely entrap fish do not require constant human presence but the removable trap weirs of the Babine needed significant human labour during operation (Rabnett 2000, Oswalt 1976: 146). Morice (1893:84) wrote on Western Dene material culture and discussed construction methods of weirs at nearby Stuart Lake. Morice's descriptions of weir design and construction are similar to the Babine weirs described by the Fisheries Guardians (Department of

Marine and Fisheries Annual Report 1904; cf. Morice 1893). These weirs span the entire breadth of the river with support stakes every 12-15 m (Morice 1893: 84). More stakes or brush was added to barricade all but the openings for the traps, which are large and require significant support to maintain their rigidity (Morice 1893: 85). Basket traps used at Stuart Lake are conical and some have a box trap at the end of the cone, and large conical baskets can be removed, and they are scooped up with a wooden hook from the river bottom (Morice 1893: 86). These designs are used in slower moving streams; for faster moving water, sturdier trap structures are necessary to withstand the force of the water (see Table 3) (Morice 1893: 88). Some of the Babine weirs are similar to Dakelh ones (wing fence and trap), but others would not work in the Babine area (Kew 1992: 204). In areas where water is too turbulent for traps, the barricade is still constructed but the fish are collected with dip nets on the downstream side of the barricade, where the fish accumulate as they attempt to get past the obstacle (Morice 1893: 91).

Salmon Consumption by British Columbia Aboriginal Groups

Hewes (1973) constructed a model to compare precontact Aboriginal fish harvesting volumes versus post contact commercial fishing. He postulated an average intake of 2000 calories per person per day with salmon forming one half of the caloric intake (Hewes 1973: 134). From this, precontact salmon consumption works out to 365.00 lbs. (165.56 kgs)/person/year, and for the population estimates for the ―Salmon Area," Hewes (1973:134) stated that the total Aboriginal catch was 15% of the total commercial catch. Hewes (1973: 137) estimated the precontact population of the Babine at 8,500, and a yearly consumption of salmon at 600.00 lbs. (272.15 kgs) per person. From early reports of the Fisheries Guardians, Aboriginal peoples on salmon streams consumed approximately 227.00 kg of salmon/per person annually

(Haggan et al. 2006: 6; Department of Marine and Fisheries Annual Reports 1898-1905). Lovell et al. (1986:104) argue that precontact peoples on salmon streams obtained one-half to two-thirds of their diet from this fish. These numbers would not deplete salmon stocks, barring environmental disaster (fires, flood, and slides).

At the start of the fur trade in the area there was a significant increase in the need for salmon (Harris 2001: 87). The ―boat brigade crews" or *voyageurs* employed by the fur trade consumed close to nine kilograms of salmon/day, which placed a huge demand on salmon stocks (Haggan et al. 2006: 6). The quality of the salmon in the Babine River was a major reason for the positioning of Hudson's Bay Company Forts (Morice 1906: 208). The increasing harvest of salmon by commercial fishermen for the canneries in all watersheds began to deplete fish stocks by the early 20th century.

Rising Coastal and Skeena/Babine Commercial Fisheries and the Barricades Conflict of 1904

It is important to note that increasing demands upon the Skeena salmon stocks placed an additional pressure on a traditional resource. These impacts were then used as a means of restricting First Nations harvests in the area, most notably through the use of weir technology. The increased demand for salmon by European industrial development caused conflicts with the Babine. In fact, in response to pressure exerted by cannery operators on the lower Skeena River, the federal government forcibly removed the weirs used by the Babine and other groups in the early twentieth century. Meanwhile coastal fishermen used seine nets to capture large quantities of salmon (Harris 2001: 25). A significant issue with the rise of commercial fishing in British Columbia is that 70% of the commercial harvest comes from eight sockeye stocks (5 Fraser, 2 Skeena and 1 Rivers Inlet) (Haggan et al. 2004: 9). Precontact fish consumption was restricted to specific sections of streams for use by relatively small populations. With commercial fishing, the target consumers were no longer local, they were worldwide (Harris 2008: 19). Increased demands for high quality Skeena salmon led canneries to harvest and produce more canned fish for the global market (Harris 2008: 20).

Commercial fishing began on the Skeena River in 1873 near Port Essington, at the mouth of the Skeena River (Department of Marine and Fisheries Annual Report 1873). During the 1873 season no canneries were in operation, and although commercial fishing boats were used, the Fisheries Guardians did not report on capture numbers (Department of Marine and Fisheries Annual Report 1873). Between 1874 and 1875 there was a rapid increase in the number of fishing boats on the Skeena River, and by 1876 the Guardians reported a commercial catch of 927,943 lbs. (420,908 kgs.) of salmon (Department of Marine and Fisheries Annual Reports 1874-1876). Based on average live weights of sockeye (see Table 7) at 5.98 kg this works out to 70,386 salmon (Plew 1983: 62). The first cannery on the Skeena River was built in 1877, and by 1890 six more canneries were operating in the area (Department of Marine and Fisheries Annual Reports 1877-1890). Cannery owners reported large runs between 1880 and 1890, and the harvests increased proportionately (Department of Marine and Fisheries Annual Reports 1880-1890). The 1880s and 1890s witnessed a further rapid growth in fishing and canning on the Skeena River (Department of Marine and Fisheries Annual Reports 1880-1889) as shown in Figure 14. By then, federal government employees and cannery operators reported that overfishing was causing depletion, so the Fisheries Guardians proposed the construction of a hatchery to augment fish stocks (Department of Marine and Fisheries Annual Report 1885). Additionally, in 1888 federal legislation prohibited the sale of salmon by Aboriginal peoples to cannery owners (Department of Marine and Fisheries Annual Report 1888).

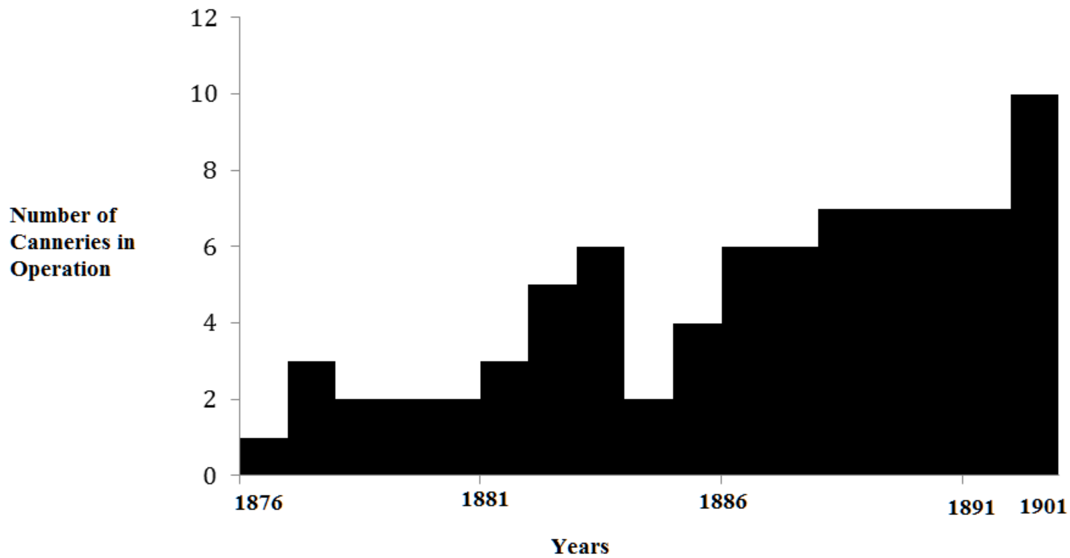

Figure 14: Number of Canneries in Operation on Skeena River 1876-1901 (Department of Marine and Fisheries Annual Reports 1876-1901)

The growth in the commercial harvest and ineffective regulation likely caused the poor salmon runs noted by the Guardians in the years before 1906 (Department of Marine and Fisheries Annual Reports1877-1923). The Fisheries Guardians of District Two, (which included the Skeena River and its tributaries) stated that a few fines were imposed upon cannery owners. For the entire Skeena River and tributaries, six fines were issued to cannery operators in the years 1873-1898, with the remaining fifteen of the fines issued to Aboriginal fishermen (Department of Marine and Fisheries Annual Reports 1873-1998). Each cannery also had many fishing stations and camps associated with the main hub (Department of Marine and Fisheries Annual Reports 1877-1923). Reports of the Guardians briefly mention the smaller fishing camps, but their main focus was the salmon-pack at the cannery proper (Department of Marine and Fisheries Annual Reports 1877-1923). Each cannery had many boats that increased the capture rates of salmon/cannery, but also increased the area of impact for that cannery (Department of

Marine and Fisheries Annual Reports 1877-1923). Figure 15 shows the increase in number of fishing vessels associated with the canneries in Figure 14.

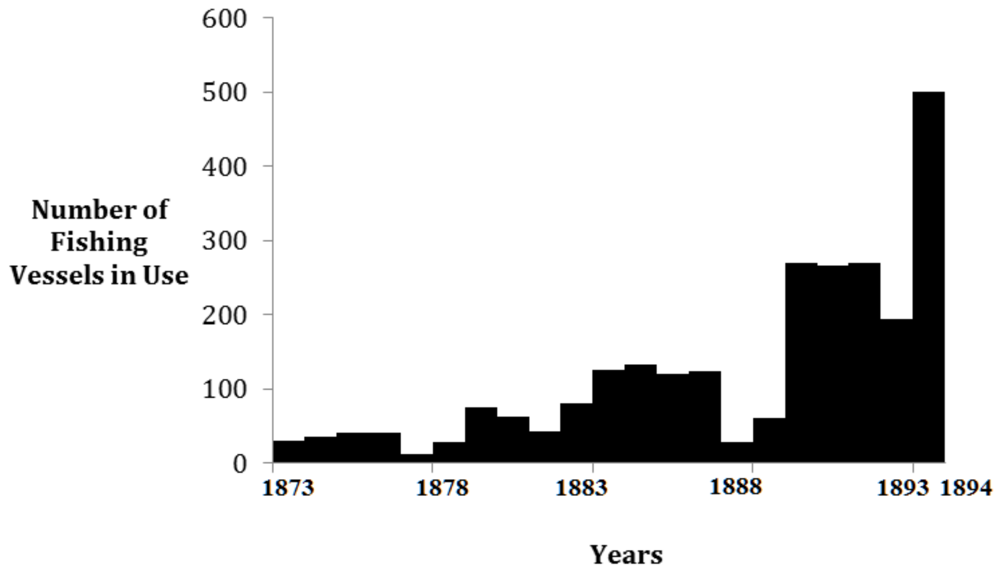

Figure 15: Number of Fishing Vessels on Skeena River 1873-1894 (Department of Marine and Fisheries Annual Reports)

The expansion in the number of fishing vessels in the years leading up to the Babine Barricades conflict (1888-1894) (Figure 16), was a clear indication of increasing scale of industrial harvest on the Skeena. Greater discussions on the Barricades conflict is provided on page 75. Initially commercial fishing on the Skeena was not regulated by the Department of Marine and Fisheries and, as such there was little to no incentive to control harvest volumes (Department of Marine and Fisheries Annual Reports 1873-1880). Once regulations were enforced in the area, impacts on the stocks were already apparent.

As commercial salmon harvest intensified in the 1880s on the Skeena River, eventually leading to decimated stocks, the Babine were targeted as a source of over harvest up the river. Fisheries Officials increasingly demanded of aboriginal peoples to reduce their capture of salmon by weirs. Cannery owners blamed Indigenous groups upstream such as the Babine, who they claimed were using fish weirs to over harvest the salmon runs. Government policies were developed after reports from Fisheries Guardians stated that the Babine weirs were completely blocking off salmon from escape (Department of Marine and Fisheries Annual Reports 1886-1906). The Guardians did not remain in the area for long enough to realize that the traps and barricades were removed when the weir was not in operation (Department of Marine and Fisheries Annual Reports 1886-1909; Harris 2001: 46; Fiske and Patrick 2000: 18), and that the fish easily passed through the barricade unhindered when the weir was not in use (Department of Marine and Fisheries Annual Reports 1886-1909; Harris 2001: 46; Fiske and Patrick 2000: 18). The salmon-pack (caught, preserved and canned) data for the District is more regular and reliable beginning in 1875 after the first cannery was constructed (Department of Marine and Fisheries Annual Reports 1873-1880). Figure 16 shows salmon-pack (48 lbs. cases) volumes for Skeena canneries between 1886 and 1917.

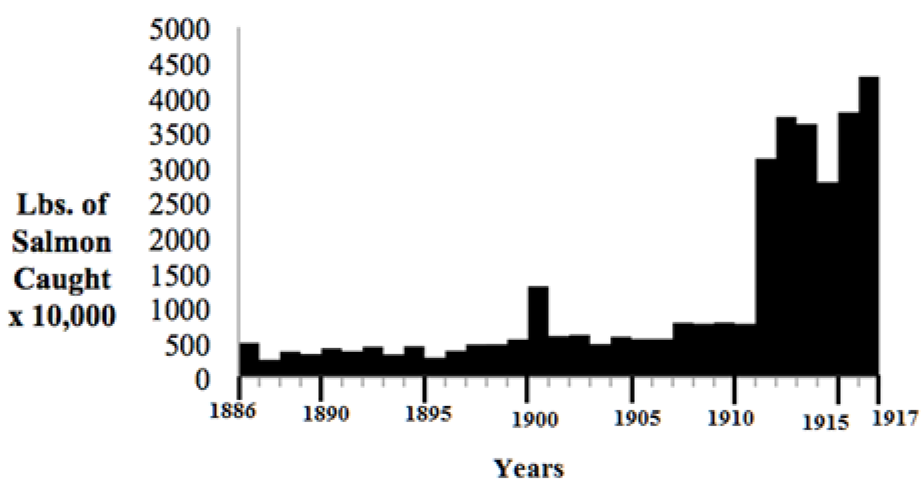

Figure 16: Salmon Catch for Skeena 1886-1917 (Department of Marine and Fisheries Annual Reports)

A dramatic increase in salmon-pack occurred in 1912 (Figure 16) after the construction of the new hatchery at Babine Lake in 1900, according to the Department of Marine and Fisheries Annual Reports 1886-1901. The hatchery released 4,000,000 eggs in 1901 (Department of Marine and Fisheries Annual Report 1901). These 4,000,000 extra fish added into the river each year further skewed the available data in term of natural availability and health of fish and fish populations. The four to seven year life cycle of Pacific salmon resulted in the increase in escapements after 1910 (Department of Marine and Fisheries Annual Reports 1886-1901). The assessments of the salmon stocks prior to 1900 would have indicated the cyclical nature of salmon. During this time canneries on the Skeena sent their surplus salmon packs (additional canned salmon over and above their required shipments) to other districts that were having poor salmon run years (Department of Marine and Fisheries Annual Report 1903). The installation of the new hatchery had obvious effects on the salmon stocks in the watershed (see Figure 12).

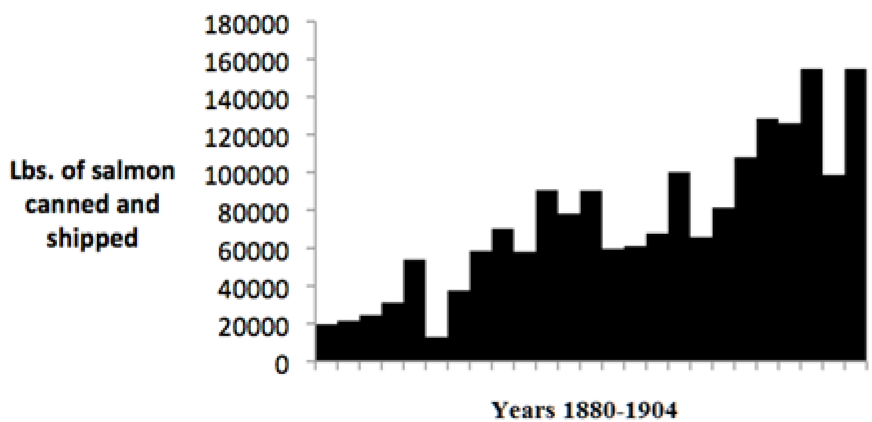

Figure 17: Cannery-Packs 1880-1904 (Lyons 1969a; Department of Marine and Fisheries Annual Reports)

After 1910 (Figure 16), salmon pack production at the Skeena canneries grew, but cannery owners still argued that the Babine weirs were hindering the salmon stocks. By this time the hatchery at Babine Lake was in full operation, which likely accounts for the sharp increase of available fish (Department of Marine and Fisheries Annual Reports 1901-1910). Prior to that time, reports from Fisheries Guardians argued that worsening runs of salmon were directly correlated to the use of fish weirs or barricades by the Babine (Newell 1989: 27). By 1895 there were thirteen canneries operating on the Skeena, and the Guardians stated that the previous four years had poor salmon runs (Department of Marine and Fisheries Annual Reports 1891-1895). At the end of the 19th century, the Guardians began to accuse the Babine of intentionally destroying salmon stocks, most notably through the use of wood stake fish weirs (Department of Marine and Fisheries Annual Report 1898). The provincial Fisheries inspector began to push for the enforcement of legislation that was already enforced on the Fraser River system, to the Skeena River fisheries (Department of Marine and Fisheries Annual Report 1899). Additionally, all northern fisheries districts in British Columbia fell under this legislation once implemented. In 1903, Fisheries Inspector Hans Helgesen noted the use of wood stake fish weirs by the Babine (Department of Marine and Fisheries Annual Report 1903: 251). Helgesen's 1906 report on the weirs at Babine Lake is as follows:

> The Barricades were constructed of an immense quantity of materials, and on scientific principles; I will endeavour to describe them. There were posts driven into the bed of the river which is 200 feet wide, and from two to four feet deep, and running swiftly at the intervals of 6 or 8 feet.
>
> Then sloping braces well bedded in the bottom and fastened at the top of the posts, then strong stringers all the way on top and bottom, in front of the posts, then panel[s] beautifully made of slats woven together with bark set in front for all, those were set firmly into the bottom and reaching 4 feet above the water. This made a magnificent fence which not a single fish could get through.
>
> On the upper side of the dam were placed twelve big traps or fish bins. Opposite holes made in the panels for fish to enter the traps, prepared with slides to open and shut, and if the traps did not have a sufficient quantity of fish in them, when the women wanted more fish on the bank, the men would take their canoe poles, wade out in a line and strike the water, making a noise which could fill the traps in a moment, then shut down the slides, take a canoe on either side of bin, raise the false bottom, by some contrivance so as to elevate

the fish, then load up canoes with gaff hooks (Department of Marine and Fisheries, Helgesen Report, 1906: 205-207).

Helgesen did not state how long he observed the fishing activities at the weir sites, but oral histories state that the traps were pulled from the water when not in use, If the traps were left in the water in the manner Helgesen reported, the weirs would have destroyed the salmon stocks well before European contact (Marvin Williams, personal communication 2012; Fiske and Patrick 2000; Harris 2001). In 1903 Fisheries Guardians indicate that the Babine were catching between 500 and 600 fish per day at one of the weir locations on the river (Fisheries Guardians report 1903). They argued that this catch rate was unsustainable (Fisheries Guardians report 1903 in Department of Marine and Fisheries Annual Report 1903).

This led the government to order the removal of barricades along the Babine River and tributaries in 1904. The government also ordered a 50% reduction to the canneries' salmon pack, leading to increasing pressure from cannery operators to address the poor salmon run years (Department of Marine and Fisheries Annual Report 1904). At this point the fisheries officers determined that it was more cost effective to target the Babine weirs than to remove natural debris from the streams or limit the commercial catch (Department of Marine and Fisheries Annual Report 1904). The most vocal opponents of the aboriginal traditional fisheries were Fisheries Inspector Helgesen, and Fisheries Guardian Roxburgh (Department of Marine and Fisheries Annual Reports 1901-1910).

The ruling to destroy the weirs was difficult for the Babine to accept, because they believed that they had the right to fish according to their own laws. The Babine people had successfully managed the salmon stocks for generationscenturies without external control or enforcement. By 1905, there were still some weirs in use, so the Fisheries Guardians brought in second-hand nets to the Babine Nation to replace the weirs that were to be taken down

(Department of Marine and Fisheries Annual Report 1905; Hackler 1958: 11). When Fisheries Guardian Helgesen reached Babine, he noted a large group of people at one of the weir locations on the River (Figure 18).

Figure 18: Babine Standing in Front of a Wood Stake Fish Weir (1904) (Department of Marine and Fisheries Annual Report 1905)

National Archives of Canada; Department of Marine and Fisheries Reports 1904; RG 23, file 583, pt. 1

Helgesen described that they were confronted by ―warriors" when they came to destroy the weir (Figure 18) (Department of Marine and Fisheries Annual Report 1904). Oral historic accounts indicate that it was not warriors that met the fisheries officers, but a group of Babine women and elders (Fiske and Patrick 2000). Mills (2005: 3) states that during this conflict Helgesen was knocked into the water by some Babine women who subsequently sat on him which, Helgesen reported as an attack by Babine ―warriors." This conflict was the first step that led to the complete removal of wood stake fish weirs, not only on the Babine and Skeena rivers, but all other rivers in British Columbia over several years (Harris 2001). After this conflict with the Babine, Helgesen requested armed escorts to ensure weirs were removed (Lane 1978; Department of Marine and Fisheries Annual Report, 1906).

This led to the Barricades Agreement, at a meeting in Ottawa of Inspector Helgesen, Father Coccola, and two Babine Chiefs, Chief Big George, and Chief Tzak (Department of Marine and Fisheries Annual Report 1906/07; Newell 1993; Bishop 1987). The terms of the agreement were that no weirs or barricades were to be built after 1906, and so the removal of weirs from most other salmon bearing streams in BC and Alaska occurred in subsequent years.

Based on erroneous assumptions, the fisheries officers felt that the removal of the weirs resulted in a significant increase in salmon runs during the 1907 fishing season (Department of Marine and Fisheries annual Report 1906/07). The true explanation for the improved run was the implementation of the Hatchery in 1901, because 4,000,000 extra salmon had been released each year afterwards (Department of Marine and Fisheries Annual Reports 1901-1907). Based on the data discussed earlier, the cyclic nature of salmon would have poor run years as well as good run years (Figure 12). With more European industrial interests along much of the North Pacific Coast (British Columbia, Oregon, Yukon), changes to the salmon and the streams themselves increased (Taylor 1999: 58). The fur traders also drastically reduced the number of beavers, and in the process they removed beaver dams, which had played a vital role in aiding salmon runs (Taylor 1999: 58). Historic data (Figure 12, Figure 14) suggest that it was not aboriginal fisheries that were to blame for the poor salmon runs in the year leading up to 1906 but the increase in commercial activities (Harris 2001).

Results of removal of fish weirs

The Babine are the last in line to intercept salmon runs before the stocks head into the Babine Lake watershed, and yet they were subject to more stringent regulations on fishing than were the canneries near the outlet of the Skeena River (Fiske and Patrick 2000; Harris 2001). Federal rules imposed on the Babine to cease their traditional harvest to ―improve” stocks were merely another means of restricting traditional lifeways. After 1904, the Guardians sought to combat these poor runs by implementing rules on the Babine by forcibly removing weirs (Department of Marine and Fisheries Annual Report 1904: 231). By 1905, Fisheries Guardian Hans Helgesen had begun to remove the Babine and other weirs from the streams. The removal of weirs was noted in his reports as taking place under ―dangerous conditions” because the Babine were unwilling to accept the newly imposed rules (Department of Marine and Fisheries Annual Report 1905). In 1906 the Babine used their wood stake fish weirs for the last time. Continued use of weirs after the barricades were removed resulted in prison sentences for individuals still using this traditional technology (Lyons 1969b: 256). Forcible removal of the weirs was devastating not only for the Babine, but for all Indigenous peoples in British Columbia that had relied on weirs. The Department of Marine and Fisheries gave the Babine used nets to replace the weirs, although little to no training on the use of the nets was given (Fiske and Patrick 2000: 92) and the nets were old and ineffective (Harris 2001).

As a result, Babine communities faced starvation from not being able to capture enough resources for the winter (Joe Michel, personal communication 2011; Fiske and Patrick 2000). This had drastic effects on the Babine, because they no longer sustained themselves in the manner in which they had for hundreds, if not thousands of years (Fiske and Patrick 2000: 31).

There were many reports of starvation and conflicts in the years following the Barricade Treaty (Fiske and Patrick 2000: 31; Harris 2001).

Discussion

With the increase in cannery operations near the Skeena estuary salmon stocks were depleted until the construction of the hatchery in 1901 (Department of Marine and Fisheries Annual Report 1901-1906). The early construction of canneries on the Skeena River combined with little or no legislation protecting the salmon stocks led to stock decimation and poor runs noted in Figure 12. Indigenous use of wood stake fish weirs would not have significantly reduced the salmon stocks as believed by the Fisheries Guardians. Rather the 20 years of commercial salmon capture before the Barricades Agreement was the cause of the poor runs noted in the years before 1906 (Lane 1978), and not the Babine weirs as stated in the reports.

Overharvesting by industrial interests is identified by Price et al. (2013) as the reason for poor salmon runs in the early twentieth century. Commercialized capture is far more likely to have depleted salmon stocks than traditional means of salmon capture did (Price et al. 2013). By the time the weirs were removed, the salmon stocks were already affected by the canneries further downstream on the Skeena (Figure 12). The consequences of legislation on aboriginal fishing for the Nez Perce First Nations in Idaho are presented in three categories: economic/subsistence, social, and spiritual (Jones 2005: 177). Economically speaking, the Babine lost their advantageous position in relation to their neighbours, because the highly efficient means of weir capture allowed other groups to also rely on the same stocks the Babine did. The control of use and access to the weirs was a source of much wealth and prestige for the Babine, and the loss was detrimental to their economic power regionally (Hackler 1958: 12).

Previously, they traded some of their surpluses to Fort Babine, and even after the removal of the barricades there was the expectation for a certain percentage of the catch to be continually traded to the Fort (Hackler 1958: 13). The canning industry did employ some aboriginals from the Babine communities, but the removal of a traditional means of maintaining their economy shifted much of the economic power in the region (Harris 2001).

In terms of subsistence, removal of the weirs had a large impact, considering the nets given to the Babine were in such disrepair that they were next to useless. To replace the non-functioning nets, the Government of British Columbia subsequently sent new nets to the Babine but unfortunately, the nets were delivered too late to catch salmon for that season (Lyons 1969b: 256). Oral historic accounts describe periods of starvation in the communities at the north end of Babine Lake after the weirs were removed (Fiske and Patrick 2000; Joe Michel, personal communication 2011). Removal of the barricades disrupted the traditional power held by the Chiefs at each weir location (Hackler 1958: 14). Manufacture, maintenance, and operation of weirs had facilitated social cohesion, so the sudden removal of these elements undermined that cohesion (Hackler 1958: 14).

Removal of the traditional capture methods was extraordinarily damaging to the Babine (Fiske and Patrick 2000). Social opportunities associated with the maintenance of the weirs were restricted when the use of weirs was made illegal (Jones 2005: 181). Jones' (2005) work with the Nez Perce showed that after traditional fishing rights were curtailed, Nez Perce quality of life deteriorated. The salmon resource deteriorates because of the ―tragedy of the commons," and management of the resource was not closely adhered to until very recently (Colt 1999: 3), writing about salmon fish traps in Alaska. The management of these resources was almost non-existent from the canneries, so the salmon stocks declined further in British Columbia (Lane

1978). The spiritual impacts of the removal of fish weirs are much harder to identify but the sudden removal of a traditional subsistence practice had wide-reaching effects.

Chapter 6: Wood Stake Fish Weirs in the Study Area

Accounts of Indian Agents, Babine oral histories, and Traditional Use Studies undertaken by the Lake Babine Nation indicate that there were many weirs within the study area (Figure 10). A.G. Morice (1893) described the Babine weirs, which allowed the Babine to catch many salmon, stretching across the entire river (Hackler 1958: 11). In these historical descriptions, traps stayed in place, and gaff hooks were used to collect the fish from the traps, but before contact traps would be removed entirely and then replaced after the contents had been emptied (Morice 1893). The area is a hub of trade and other activities that bring in other groups from surrounding territories (Harris 2001: 18). The salmon harvested here is of exceptional quality in comparison to the other salmon stocks in the Fraser, Columbia, and Snake rivers (Groot 1968: 29). The efficient means of salmon capture employed by the Babine allowed them to obtain their winter stores of food and surpluses for trade (initially to the neighbouring groups, then to the fur traders and other Europeans). The specific weir design allowed the Babine to develop a complex management system for fish resources (Harris 2001: 68; Lepofsky and Caldwell 2013).

Historic information suggests that this area was heavily used by not just the Babine but by many allied groups as well (Harris 2001). Access and trade were facilitated through the use of trail systems, which were noted in the early historic descriptions (Harris 2001). These trails head northeast to Takla Lake, southwest to Hagwilget, and north along the Nilkitkwa River. Clearly these weirs were of great importance not only to the Babine, but to the wider regional population.

This is the first in-depth analysis of the wood stake fish weirs in the study area. The removal of these weirs during the barricades conflict impacted the condition and preservation of weir sites, but through Babine informants the Babine Archaeology Project was able to locate preserved remnants of wood stake fish weirs adjacent to Smokehouse Island, on the Babine

River. This chapter describes the weirs at Smokehouse Island and where they fit into the overall typologies and designs of wood stake fish weirs.

Babine Fish Weirs

There have been a few archaeological investigations of fish weirs further down the Skeena River, such as Prince's (2005: 69) study of wooden weirs at Kitwancool Lake outlet, which appears to be placed in a similar geomorphological area to Babine. Prince (2005: 73) argued that each weir or cluster of weirs is associated with a village site. These weirs have been radiocarbon dated to between 770 B.P. and the historic period (Prince 2005: 83). Prince argues that each village's nutritional catchment area included several spawning valleys. Harris (2001) and Groot (1968) noted the operation of these mass-capture devices necessitated management strategies to maintain viable spawning populations. Human groups relying solely on a single stream or valley can deplete stocks, so such limitations were identified and fishing practices were modified (Prince 2005: 82).

Two archival photographs (Figure 18 and 19) of Babine fish weirs illustrate the design and operation of the weirs. The study area (Figure 10) is in the final section of the river before the spawning salmon reach the lake, so the fish are relatively weaker than they were downstream. This location has highly variable water flow rates and stream morphologies, ranging from high flow river, slow flow river, inlet and outlet of lakes and marsh/creek boundaries. These varied environments require differential designs for capture of the fish. Seasonal changes in water rate flow are important considerations, as the spring freshet would increase the amount of water and rate of flow relative to the lower levels during the summer and late summer/fall.

Weirs that span the entire width of the river (Figure 19) are installed in areas that allow for the operation of such structures. They are also in areas where land is available for processing the catch.

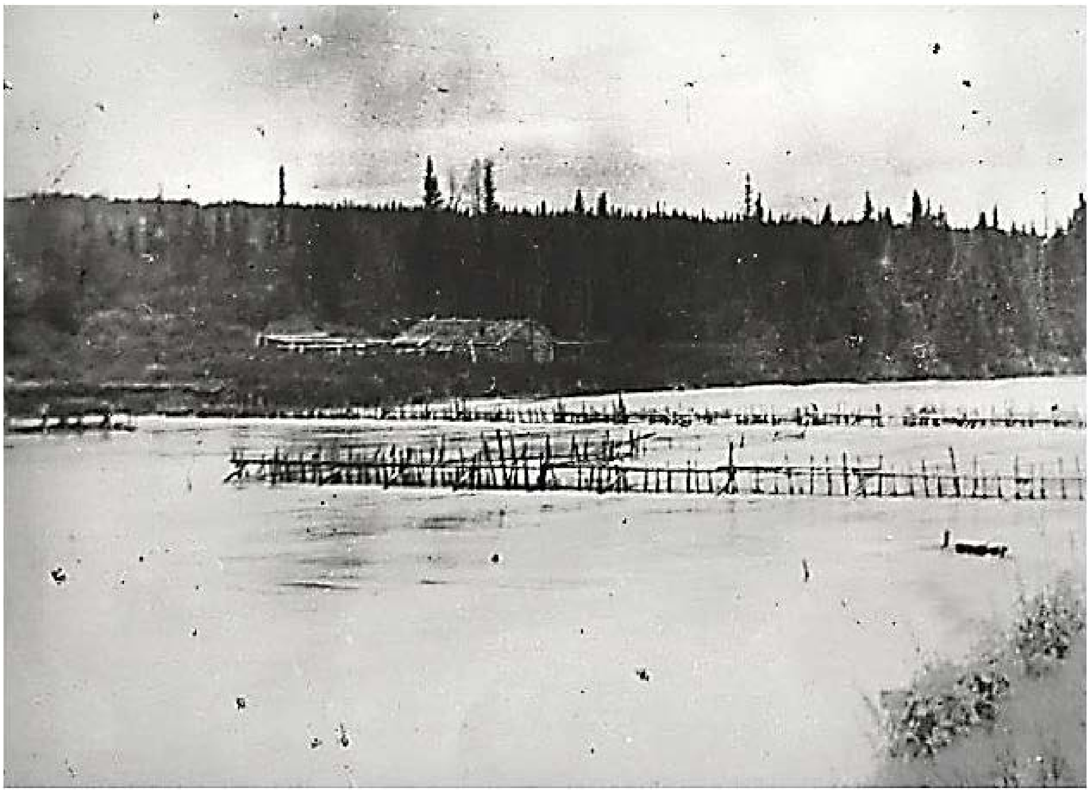

Figure 19: Wood Stake Fish Weir on Babine River

Lake Babine Nation Treaty

In the weir depicted in Figure 19, the near section of the weir could accommodate up to seven traps, leaving enough space between the traps to permit a canoe (Harris 2001). Each of the support beams probably contained a trap attachment. The weirs consisted of tripod pole supports and additional poles to block the fish and guide them toward the trap openings. Helgesen (Department of Marine and Fisheries Annual Report 1905) stated that the Babine weirs were ―scientifically constructed" to ensure capture of all of the salmon when the traps were in the water. He estimated that when he observed the operations, between 500 and 600 fish were taken per day (Helgesen in Department of Marine and Fisheries Guardians Reports 1906: 211). However, this number could have been inflated by Helgesen to portray an increased impact to salmon in the area as there would have been several years of overharvesting. This over-estimation of salmon capture by weirs would have supported Helgesen's initial claims that the weir technology was reducing the naturally available salmon stocks.

This weir in Figure 19 is a multi-component, bank-to-bank style wood stake fish weir as described by Mahaffy (1978) and Connaway (2007). The Ned'ut'en placed traps parallel to the current with access/attachment sections running perpendicular (Harris 2001; Connaway 2007). People processed the fish on either shore, on suitably flat and dry areas. The Ned'ut'en used the weirs during August and September when the sockeye salmon were abundant (Harris 2001: 80). A Babine knowledge holder, Joe Michel stated that the Babine used birch bark rope as cordage for the weirs in the area (Joe Michel, personal communication 2011).

The main village (GiSq-004) Nass Glee (Hackett 2017) in the study area is located at the current Department of Fisheries and Oceans fish counting fence and complex. This area is approximately two kilometers from the confluence of the Babine and Nilkitkwa Rivers. The area is rich in archaeological resources including trails, cultural depressions, house depressions, lithics, and culturally modified trees (Mohs and Mohs 1976). Each of the weirs in the study area was operated by Babine clans external to the host (Beaver) clan (Figure 13). The Tsayu clan managed weir one, where the main village site is located (Figure 21) and the Likhtsemisyu (Beaver) clan managed weir two (Hackler 1958; Alexander 1992: 163). Weirs one and two (Figure 21) provided the salmon catch for villagers at GiSq-004, Nass Glee (Hackett 2017). Weir three (Figure 22) was at Smokehouse Island and it was managed by Jilhtsehyu (Frog), and finally, weir four, at the outlet of Babine Lake was managed by Likhtsemisyu (Beaver) (Figure

22; Figure 23) (Hackler 1958). Hackler (1958) also identified two more weirs further south on the lake, but these fell outside of the study area. The location of many of the weir sites that Helgesen visited in 1906 were south of the study area.

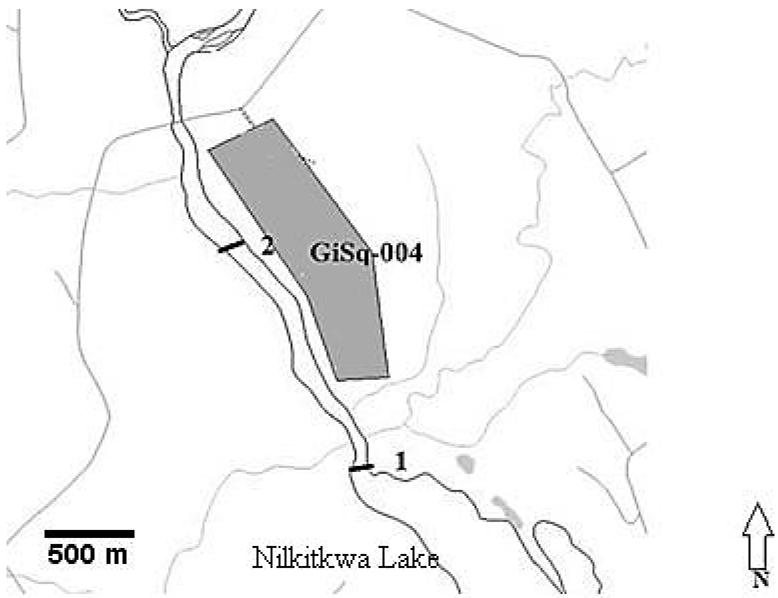

Figure 20: Fish Weir Locations at GiSq-004, Nass Glee (Hackler 1958; Hackett 2017)
Map base layer DataBC, Map made with QGIS

Figure 20 locates GiSq-004, Nass Glee, one of the main village sites in the study area. The second and more well-known village site is Fort Babine (Wit'at), which had the two weirs identified by Hackler (1958:18). The Babine Archaeological Project (BAP) field reconnaissance in 2012 located some stakes in the water but river flow at the time prevented them from being recorded. Helgesen (1904) also identified these two weirs in his report during the removal of the barricades in 1904 (Harris 2001: 88). Hackler (1958: 13) identified only weir two as belonging to the Tsayu Clan (see Figure 20). Weir one was managed by Likhtsemisyu (Beaver) (see Figure 20), as was the entire study area, with the exception of the specific weir sites (Hackler 1958: 13). The removal and destruction of the weirs left only a few remaining stakes to map in, hampering reconstruction of overall structural design. That said, some stakes are clearly aligned in rows, which provide a glimpse into weir sections.

The next clustering of weirs is adjacent to Smokehouse Island (see Figure 21, Figure 22, and Figure 23, based on Harris 2001 and Hackler 1958). This island was in use primarily during the maintenance and operation of the weir, so it was not a long-term residential site. The closest village is Wit'at, where Fort Babine is currently located. GiSq-004, Nass Glee (Hackett 2017), is somewhat further in distance but nearby.

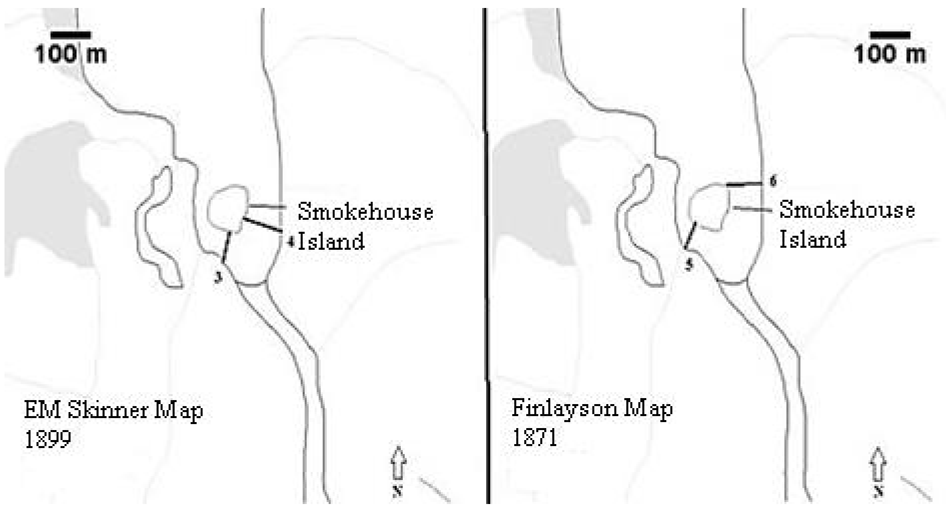

Figure 21: Wood stake fish weirs at Smokehouse Island (Harris 2001)

Map made from DataBC Base layer, made with QGIS ©

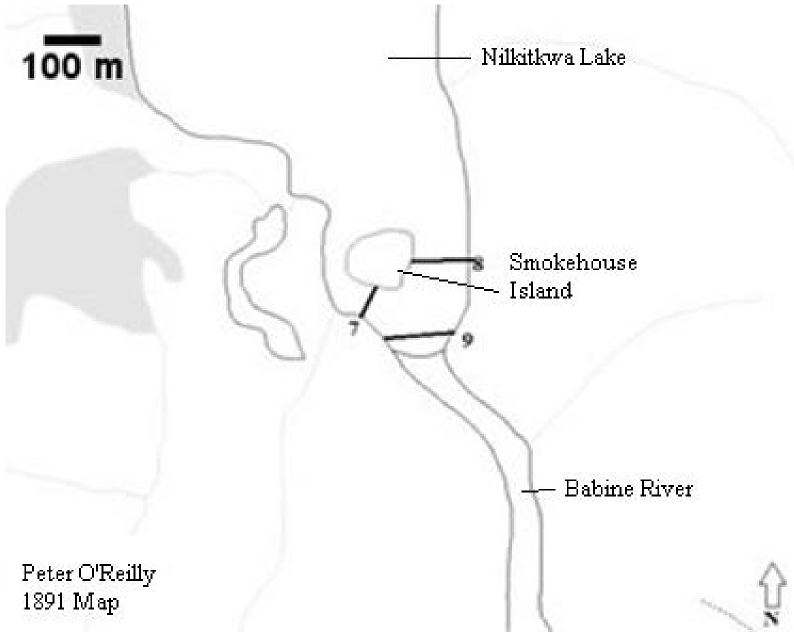

Figure 22: Wood Stake Fish Weirs at Smoke House Island 2 (Harris 2001)
Map made from DataBC Base layer, made with QGIS ©

O'Reilly (cf. Harris 2001) (Figure 22) identified three weirs adjacent to Smokehouse Island in his 1891 survey near Smokehouse Island Weirs while E.M. Skinner noted two weirs in 1899 (Figure 21). The differences in weir numbers in these records are due either to mistakes in original mapping, or to seasonal use of the third weir. Weirs five and six were identified in 1871 by Roderick Finlayson (cf Harris 2001); weir five seems to be the most re-used location (as this is close to weirs 3 and 7). These weir locations noted in the historic maps may have been the same weirs but may have been mapped differently by the historic explorers.

Smokehouse Island appears to be the most active area for weir use, where the structures were seasonally rebuilt and used over an extensive period of time. The flow around the island allowed for weir use on both the west and east sides. After mid-September, however, the use of weirs at Smokehouse Island would not have been possible because of low water levels, and other weir sites would be used if salmon were still available. The only non-flowing stream weir identified by early historic explorers was between two sections of Nilkitkwa Lake (number 11 in

Figure 23). This area would have been used because the narrowing in the lake would cause the fish to surge forward and become spatially constrained. Less effort would have been expended here to build the barricades and remove the traps as there would be slower flow during the later salmon runs. This area would not have been used as intensively as other locations in the study area, as river flows make weir capture more efficient.

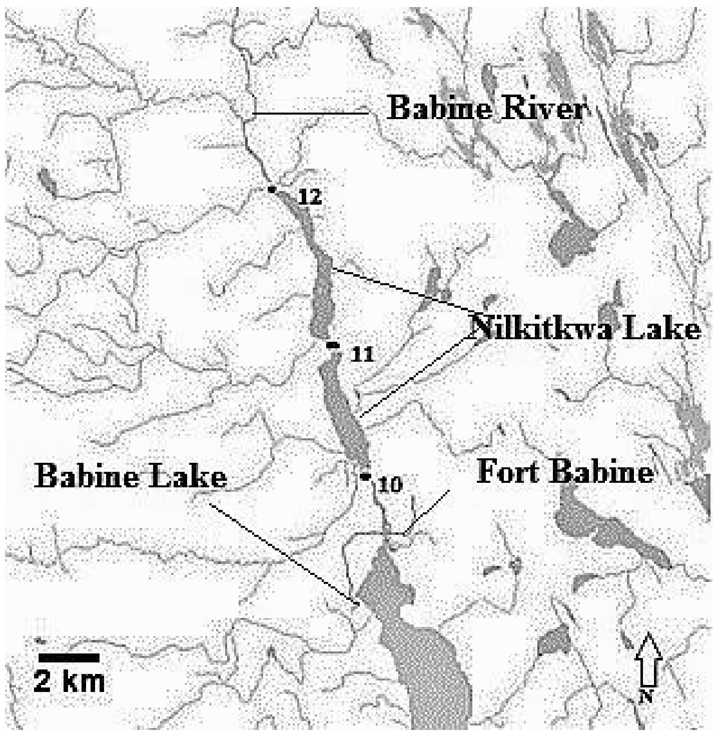

Figure 23: Loring's Survey of Weirs (1905) (Harris 2001)

DataBC Base map layer, made with QGIS ©

Figure 23 shows Loring's 1905 map of remaining weir locations (10-12) after removal of the barricades by Helgesen in 1904 (Harris 2001:82). These weirs were removed from all streams along the Babine River as well as the study area. Weir 12 was located at the outlet of Nilkitkwa Lake and weir 10 was at Smokehouse Island, but the exact placement is unknown. The weirs removed by Helgesen were the last wood stake weirs in the Babine area.

Babine Fish Weir Survey 2013/2014

During the fall of 2013, a survey of the study area was undertaken to locate possible weir remnants in the Babine-Nilkitkwa corridor. The crew consisted of University of Northern British Columbia students Brigitte Aubertin, Delaney Prysnuk, Adam Kantakis, and faculty member Dr. Farid Rahemtulla, with the assistance of Lake Babine Nation Members Roger Patrick and Sonny West. The survey focused on areas north of the outlet of Babine Lake, to the Department of Fisheries and Oceans fish counting fence.

Most of the study area was surveyed by boat or on foot, with much of the area inaccessible. Weir stakes were discovered at Smokehouse Island only. No stakes were located at the other weirs sites identified by Hackler (1958), and Loring (Harris 2001). However, the water level was high at these locations, making visibility poor. The GiSq-004, Nass Glee (Hackett 2017) site is the most probable location for one of the weirs as it is associated with an island in the middle of the river (Figure 24). This is likely to be weir two noted in Hackler 1958, noted as located across the river from GiSq-004, Nass Glee (Hackett 2017). The most probable location for the weir is at the leading edge of the little island, however, the river is deep and fast here, so access into the middle of the stream is not possible without a boat.


Figure 24: Potential Weir Location (Photo: Kantakis 2014)

Faunal remains from the Babine Archaeology Project excavations at GiSq-004, Nass Glee (Hackett 2017), in 2010 and in 2012 did not reveal direct evidence of intensive salmon consumption; however, organic preservation is quite poor in most parts of the interior. On the other hand there is much indirect evidence for intensive salmon processing and storage in the forms of smokehouse depressions and hundreds of cache pits, respectively (Rahemtulla 2012).

In 2014 and 2015 Babine Archaeology Project excavations took place at Smokehouse Island under the direction Farid Rahemtulla. The crew consisted of Lake Babine Nation community members and University of Northern British Columbia students. In addition to a very high density of artifacts, 33 weir stakes were located and mapped in the south west channel. The projects took place in the late summer months, when river levels and water flow were relatively low making stakes more visible above and under the water. Many of the stakes were in original context but some had been moved. Stakes were mapped in 2014 by Rahemtulla and Josh Vickers with the aid of a geo-referenced Total Station ©. Using these data the author constructed a map showing stake locations (Figure 25).

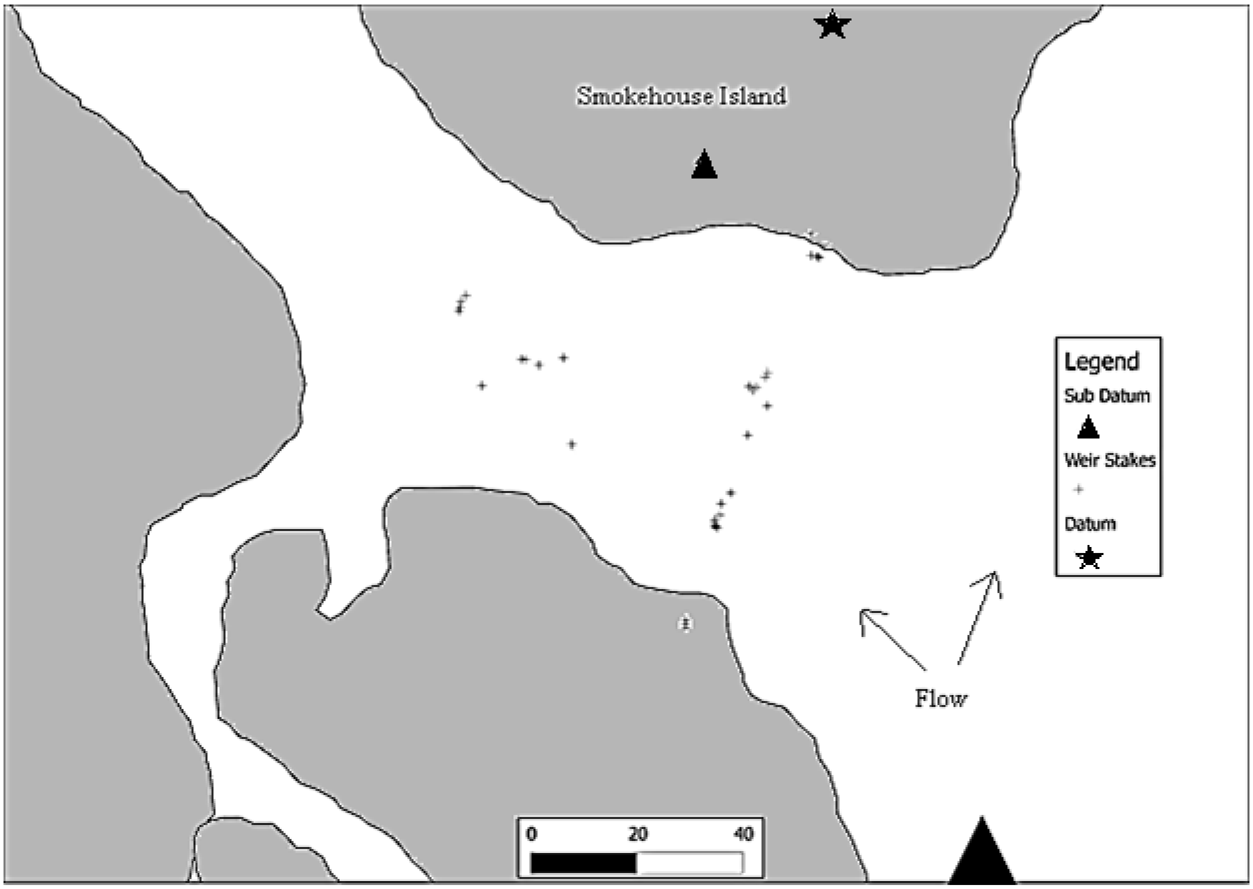

Figure 25: Mapped Weir Stakes, Smokehouse Island, 2014

QGIS Map

In situ weir stakes were closest to the shore, indicating a bank-to-bank style of weir (Figure 25). The stakes closest to the main flow of the stream extend further along the north end of the island. Six stakes at the northern part of this map are likely from a historic or proto-historic dock. Alternatively, they could represent a seasonally or temporally different weir placement. Sub surface soils on the island are a dark black organic, which are reminiscent of midden deposits (Rahemtulla, personal communication 2014). This may be an indication that large amounts of salmon were processed in the area.

The survey identified three weir complexes to the south of the island (Figure 26), and one on the eastern side; however, the eastern weir stakes were not mapped as they are not in their original context. The stakes on the south side of the island were the most intact, showing a few linear sections. These were the impoundment portion of this weir, with the trap attachment sections running perpendicular to the current (Figure 26).


Figure 26: Southern Weir Stakes at Smokehouse Island (Photo: Kantakis 2014)

It seems evident that these weirs spanned the width of the river, the specific morphology likely matching ones in the archival photo (see Figure 19 and Harris 2001). The location of the weir stakes generally match the historic accounts presented in Harris (2001). Historically the weirs here were recorded as being in operation for over 30 years as Finlayson noted them in 1871, O'Reilly in 1891, and with their removal in 1904 (Harris 2001). Further north in the study area, early Europeans noted more wood stake weirs at the outlet of Nilkitkwa Lake as well as at the archaeological site GiSq-004, Nass Glee (Hackett 2017), and oral histories also support this (Roger Patrick, personal communication 2013). If each weir was producing 500-600 fish/day at the peak, we can interpolate that five weirs could produce 2,500-3,000 fish daily. It is important to remember that these numbers are peak numbers, and that they would not have a significant impact on the overall salmon stocks.

Structural Stakes

Stakes were sharpened using splintering and they were hardened using fire (Connaway 2007). Some of the upended stakes showed the splintered sharpened ends, a few of these appeared to be recently exposed as they showed little signs of weathering through dulled edges (Figure28). Sediments at the river bottom are sands and silts, with some gravel. The sharpened stakes may have been pounded into the river bottom using a heavy stone or wood mallet. The above sediment portion of in situ stakes range in length from 5-65 cm, and a few are long enough to be visible above the water line. Some stakes are clustered in groups of two to five, which likely indicate seasonal re-construction of sections of the weir. Stake diameters range from 5 to 20 cm, with smaller stakes the least likely to remain in situ. A radiocarbon sample was obtained from a stake located on the south bank (Figure 26), and this returned a date of 995 Radiocarbon Years BP (Rahemtulla, personal communication 2014). Since that time the Babine Archaeology Project has obtained several other radiocarbon dates that support weir construction and use at Smokehouse Island by 1,000 years ago (Rahemtulla, personal communication 2016). These dates indicate that the Babine were utilizing mass-capture technology as early, if not slightly earlier than other groups in nearby areas (Prince 2014). This however, could be a sampling issue as there are minimal data on the antiquity of use of this technology in the interior of the province.

One stake was located on the east side of the island, and historic maps also show a weir on this side (Harris 2001). Water flow on this side is significantly higher as the channel is deeper and wider, so this weir was likely used in the fall when water levels would have been at their lowest during the salmon runs. Unfortunately this side is currently a high boat traffic area, so weir stakes are not in their original context. The latter were recorded in current approximate position, and these were included in the approximate position on the map (Figure 27).

Figure 27: Sharpened out-of-situ weir stakes. (Photo: Kantakis, 2014)

The stake on the left in Figure 27 is relatively recent and it was shaped with a metal axe, whereas the stake on the right is more rounded, indicating more weathering or a splintered style of shaping. The latter is more consistent with shaping by stone tools. The sediments here allow for stakes to be pounded in relatively easily, and they may not have needed significant bracing if the stakes were driven in far enough. The in situ stakes appear to have been driven into the ground 45-55 cm below the current river bed, and they did not show any movement when lightly pushed at the top.

Figure 28: Clustered Weir Stakes (Photo: Kantakis, 2014)

Figure 28 shows a cluster of three weir stakes; it is likely these were repairs or replacements for a section of a weir. Reconstruction and maintenance evidenced by the clusters of stakes indicates that the Babine had sophisticated knowledge of flow patterns, weir stressors, and structural requirements. Flow patterns and nature of river sediment around Smokehouse Island would constrain placement and design of weirs and traps. There would also be significant impacts on the structure by snow and ice during the winter (many stakes are completely out of the water once winter arrives). Removal of the weirs by Department of Marine and Fisheries officers after the Barricades Agreement would have significantly affected stakes and other structural elements. Remaining stakes have further been affected by thawing and freezing or by the movement of powered boat traffic.

Discussion

Weir remains were located in the survey and they show that Smokehouse Island was used for a long period of time. The length of use of the weirs also implies that this technology was used sustainably, by information that was passed down through the generations. For example, riverine fluctuations would require different responses, as the water level rises and drops. Early season capture when the river is high requires use of traps, however when the river is low the weirs would be used as barricades to slow the fish, so they could be speared or netted. Smokehouse Island appears to have been a central location for the Babine salmon harvest and ongoing research indicates a long period of use (Rahemtulla, personal communication 2016).

The pattern of the fish weir stakes re-located at Smokehouse Island can be used to compare with fish weir typologies discussed in Chapter 2. These weirs are a flowing stream style of weir according to Connaway (2007), and are further delineated as a bank to bank, multi component weir (Mahaffy 1978). Based upon the other characteristics identified by Mahaffy (1978), the Smokehouse Island weir has the following characteristics:

Number of components	8	Width of river spanned by singular component (all/partial)	partial
Wing alignment (straight/curved)	Straight	Angle between wings and river axis (narrow/wide)	n/a
Presence of wood	Yes	Angle between strike of bedrock strata and river axis (narrow/wide)	n/a
Weir association (who owns?)	Lachibu	Length of single components (long/short)	Short
Average angle for entire weir (narrow/wide)	90^{o}	Length of entire weir (long/short) – in relation to river width	Long
Angle between wings for single components (narrow/wide)	90^{o}	Alignment of weir components to river axis (angle) (narrow/wide)	90^{o}
Width of river (narrow/wide)	Moderate	Total length of weir in reference to river axis (long/short)	Short
Width of river spanned by weir (all/partial)	all		

Table 12: Smokehouse Island Weir Assessment (Mahaffy 1978)

The Smokehouse Island weir, although bank-to-bank, was not linear based upon the recorded stakes; it had multiple components that may have been used as a fish impoundment areas as well as trap attachment areas. Fish weirs where general patterns could not be deciphered were omitted for the typology portion of this project. The weirs were either completely removed in 1905 or they have since been damaged in other ways.

Chapter 7: Conclusions

Archaeological evidence shows that the Babine River/Nilkitkwa Lake corridor was a significant resource procurement and habitation area. The fluvial/lacustrine characteristics of the river and lakes in the study area make them prime fish bearing habitats. With relatively large numbers of various species of salmon runs annually, there was a seasonal influx of a major resource into the Babine area. Historically and archaeologically, Babine subsistence was based largely around the use of mass-capture technologies such as wood fish weirs. The quality of the fish stocks and the ability to capture large volumes at this location allowed for large surpluses for subsistence and for trade. The unique ecological conditions allowed the Babine to obtain a significant portion of their nutritional stores for the winter over a short period of time.

Knowledge of weir design, use, and maintenance was sophisticated and likely passed down through generations. For example geophysical characteristics at various locations along the river constrained weir design and function. Physical strength of different construction materials was an important variable in structural efficiency and flexibility. Babine fish weirs were in use during summer and fall, and other terrestrial and lacustrine resources were exploited in other seasons. Each weir had the capacity to provide surpluses for Babine clans and affiliated groups, leaving enough for trade with other groups. Processing of surpluses from mass capture via wood stake fish weirs is very labour intensive to avoid spoilage of the catch. Harvesting and storage en masse allowed the Babine to have seasonally sedentary settlement patterns, to a greater degree than other central interior groups.

Salmon has been, and remains, an important resource for many aboriginal groups in British Columbia. The Babine have a long history of reliance upon salmon and the ability to capture large volumes through the use of fish weirs conferred subsistence/economic advantages over many of their neighbours. Even in comparison to other groups relying on salmon from the Fraser watersheds, the Babine sockeye fisheries were more predictable and reliable. Archaeological evidence indicates Babine weir use as far back as 1,000 years ago. Such a length of use indicates successful management strategies as the risk of overfishing could have disastrous consequences for future generations. A survey for remnant fish weirs revealed stakes adjacent to Smokehouse Island, and one wood stake fish weir in the study area was identified as having a multi-component design. Each of these weirs held many traps, and they used the flow characteristics of that section of stream to aid in capture. The fish weirs in the study area appear to fit into the typologies determined for other areas.

Weirs are also evidence for sophisticated systems of social management on the part of the Babine clans and their affiliated neighbours. The technology has the capacity to destroy a salmon stock, but there is no evidence this occurred before European contact. The careful interaction of efficient harvest paired with ecological knowledge could only have been accomplished with management of labour resources. With the long period of resource use, complex management would have been implemented early to avoid resource depletion. The salmon harvested by the Babine and neighbouring groups had less of an impact than commercial harvests, which caused major changes to the salmon stocks. The Babine could catch approximately 500-600 fish per day from a weir, which would have given them a substantial source of stored food, which could be accessed after the salmon season was over.

The removal of the weirs in 1906 significantly reduced their archaeological visibility. With no overtly obvious evidence in many locations identified historically, it will take greater efforts to locate other fish weirs. Weir locations with intact stakes were also heavily impacted by commercial and by recreational activities on the river and lakes. In the Babine Area there is at least one weir with intact stakes, and this gives us an insight into precontact Babine weir construction and use. The lack of previous archaeological work on Babine fish weirs limits our knowledge, so a descriptive analysis was sought as part of this project. Typological analyses and functional studies on wood stake weirs have been limited to mostly coastal cases in British Columbia. Review of historic documents revealed only the use of the weirs, and not detailed descriptions on how they functioned.

Future research in the area may include but is not limited to further archaeological investigations at Smokehouse Island, and underwater surveys of areas too deep to identify weir stakes by boats and by Light Detection and Ranging (LIDAR) surveys of shorelines to identify fishing structures on shore. The 995 B.P. date for fish weirs at Smokehouse Island clearly indicates that the Babine have been harvesting salmon via wood stake fish weirs for much longer than previously thought. The sudden removal of this technology by Department of Marine and Fisheries officials was detrimental to the Babine traditional way of life. The destruction of a traditional form of subsistence was another example of colonial forces attempting to control Aboriginal peoples that had devastating consequences.

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Hydrometric Data

http://www.wateroffice.ec.gc.ca/index_e.html

Data Credits

Base Layers for maps obtained from public access DataBC and ImapBC, and further edited with QGIS

Environment Canada Water Office - https://wateroffice.ec.gc.ca/report/historical_e.html?stn=08EC001

Image Credits

Kantakis 2014/2013 – Field reconnaissance of Smokehouse Island and Study Area

Figure 18 - National Archives of Canada; Department of Marine and Fisheries Reports 1904; RG 23, file 583, pt. 1

Figure 19 - Lake Babine Nation Treaty Office

Software Credits

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Note on Maps and Graphs

Data was collected from review of the references, and tabulated into Excel © 2010 then this was used to make the graphs. The maps were made using public domain (open license) base layers and then mapped using QGIS.

Notes on Personal Communications

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