SUBSISTENCE SALMON FISHING IN BEAUFORT SEA COMMUNITIES

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Abstract

Environmental change, combined with observations of increasing numbers of salmon in subsistence fisheries, has generated a need for more information about salmon use, abundance, and distribution in the Arctic. Ethnographic research was conducted in Barrow and Nuiqsut, Alaska, in 2010 and 2011 with 41 active fishermen and elders. Salmon catches were perceived to be increasing; however, perceptions about changing salmon abundance were mixed. While pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) have been observed in subsistence fisheries in the central North Slope region for over 50 years, only within the last 10 to 20 years has local use of these resources begun to increase. In this region, salmon are less important as a subsistence resource compared to whitefish species (*Coregonus* spp.). However, many fishermen participating in the Elson Lagoon gill net fishery near Barrow have begun to target salmon. Harvest estimates for this fishery in 2011 indicated that chum salmon and pink salmon catches comprise the majority of all fish caught (42% and 23%, respectively). Chinook salmon (*O. tshawytscha*) have been increasingly targeted, but catches are generally low. While sockeye salmon (*O. nerka*) numbers were perceived to have increased on the North Slope, catches of this species are rare. Only a few stray coho salmon (*O. kisutch*) have been captured in this region. Informants identified new stream systems where salmon are present and spawning, suggesting possible distribution shifts. Fishermen in both communities reported developing knowledge of salmon and are increasing their use of salmon as a subsistence resource.

Table of Contents

List of Tables

List of Figures

List of Appendices

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Chapter 1
Introduction and Background

1.1 Introduction and Background

Local observations of increasing numbers of salmon in subsistence fisheries in the North Slope region of Alaska has generated a need for more information about salmon use, abundance, and distribution in Arctic waters. Ethnographic research with local elders and active fishermen in Barrow and Nuiqsut, Alaska (Figure 1.1) will help to better document the historic and current harvest and use of salmon as a subsistence resource, the values that motivate current fishing practices, and the larger context of climate and ecological change in the North Slope region. Traditional ecological knowledge (TEK) of fish species in the North Slope region of Alaska has rarely been documented (Brewster et al. 2008) or, if documented, is not available (e.g., Schneider and Arundale 1982). Biological data on anadromous fish species have been collected across the North Slope region, but have tended to focus on whitefish (*Coregonus*) species that are more abundant and have much higher harvest numbers than salmon in this region (Fechhelm et al. 2009). The continued documentation of TEK will provide a valuable contribution to the state of knowledge about salmon and other fisheries in the region, as well as to the understanding of the importance of subsistence fisheries to Iñupiat peoples (Brewster et al. 2008). In addition to ethnographic research conducted with elders and fishermen, fishing effort and harvest data collected for one local fishery are also summarized in this thesis to better document salmon catches in an important emerging fishery.

1.2 Climate Change in the Arctic

While the political dimensions of global climate change continue to produce debate, a scientific consensus has emerged that global temperatures are increasing with particularly dramatic impacts predicted for Arctic ecosystems (Arctic Climate Impact Assessment 2005, Ford and Furgal 2009, Hansen et al. 2012). Since the 1950s, air temperatures in the Arctic have increased by between 2 and 3°C during summer and 4°C in winter (Arctic Climate Impact Assessment 2005). It is anticipated that by 2100 the air temperature will have risen an additional 5 to 8°C (Leiserovitz et al. 2006). Warmer air temperatures cause permafrost thawing, a reduction in summertime sea ice extent, and decreasing sea ice thickness, glacial retreat, increases in precipitation, decreases in the length and thickness of snow cover, increased riverine runoff, and increased organic carbon inputs to the Arctic Ocean from river systems (Arctic Climate Impact Assessment 2005, Holmes et al. 2013). In September 2012, Arctic sea ice retreated to the lowest extent since data recording began in 1979 (National Snow and Ice Data Center 2012).

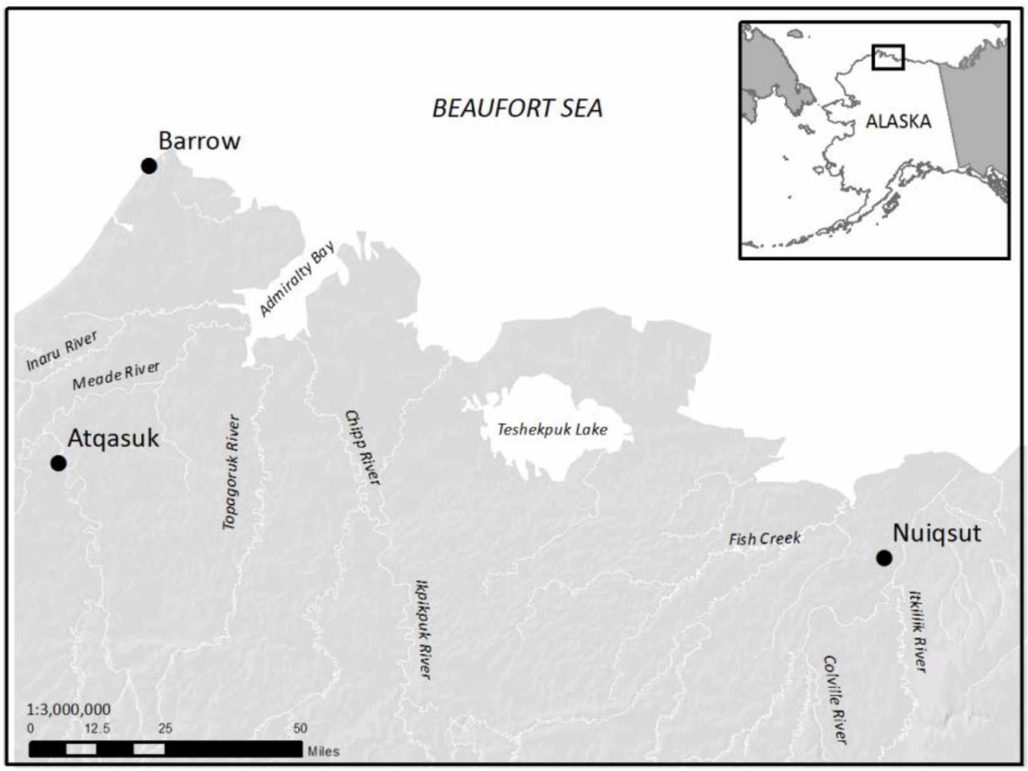


Figure 1.1: Map of the central North Slope Borough region showing Barrow and Nuiqsut and area waters. Map produced by Christine Woll, School of Fisheries and Ocean Sciences, Alaska, University of Alaska Fairbanks.

The Beaufort and Chukchi seas have shown a 2 to 3°C increase in mean fall sea surface temperature over the last 30 years (Steele et al. 2010). The effects of climate change on fisheries in the Arctic are multiple (Schrank 2007). Increasing freshwater inputs impact Arctic Ocean marine environments by creating increased stratification which is important for stenohaline fish species (Wassmann et al. 2011). Warmer ocean conditions and increases in food sources are predicted to extend the range of habitat suitable for fish species, such as walleye pollock (*Theragra chalcogramma*) and Pacific salmon (*Oncorhynchus* spp.) northward. Although an increase in temperature and nutrient availability may create more favorable conditions which can result in range expansions for Pacific salmon species, a negative feedback loop may also inhibit expansion. Increases in temperature and photoperiod can create an increase in nutrient availability, leading to an overall biomass increase. Along with salmon, other species occupying similar trophic levels may also increase in abundance. The result may be higher competition among salmon, as well as salmon and other marine species, for favorable food sources such as zooplankton (Morita et al. 2001, Ruggerone et al. 2007, Moss et al. 2009). Recent research (e.g., Benner et al. 2005, Holmes et al. 2008, Dunton et al. 2012) has suggested that climate change impacts that increase the transport of terrestrial dissolved organic matter into marine environments may have negative consequences for higher trophic levels of Arctic food webs. These impacts may have pronounced impacts on subsistence users who depend upon Arctic fishes.

The global phenomenon of climate change and the regional intensity of change in the Arctic is experienced at local scales. In the Iñupiat communities of the Arctic North Slope, people share a close physical, social, cultural, and for many, spiritual connection with the land. Predicatbility of weather patterns and other natural patterns, such as ice conditions and resource distribution, are important for survival and effective subsistence hunting, fishing, and gathering. The shifts brought about by climate change have important implications for the persistence of safe and effective subsistence practices in the Arctic (Reidlinger 1999, Leiserovitz et al. 2006, Schrank 2007, Eisner et al. 2009, Ford 2009).

1.3 Marine Environment

The oceanography of the Arctic is influenced by both the Pacific and Atlantic oceans. Freshwater inflow from the large Mackenzie and Colville river systems and the 200 stream systems that flow from the North Slope region into the Beaufort and northeast Chukchi seas also shapes the marine dynamics (Craig 1989a). There is a strong current through the Bering Strait that brings in Pacific Ocean water, which is cold and comprises the upper layer of the Arctic Ocean, and Chukchi and Beaufort seas. Warmer, more saline water from the Atlantic Ocean exists at depths greater than 200 m (600 ft), below the halocline. Winter temperatures of the upper layers are generally sub-zero, which is lethal for salmon. The warmer water of the Atlantic layer, generally near 0°C, may produce a winter refuge for salmon. However, it is unclear if salmon utilize this zone of warm water, migrate to the Bering Sea, or have adapted to overwinter in fresh or brackish water (Irvine et al. 2009; Figure 1.2).

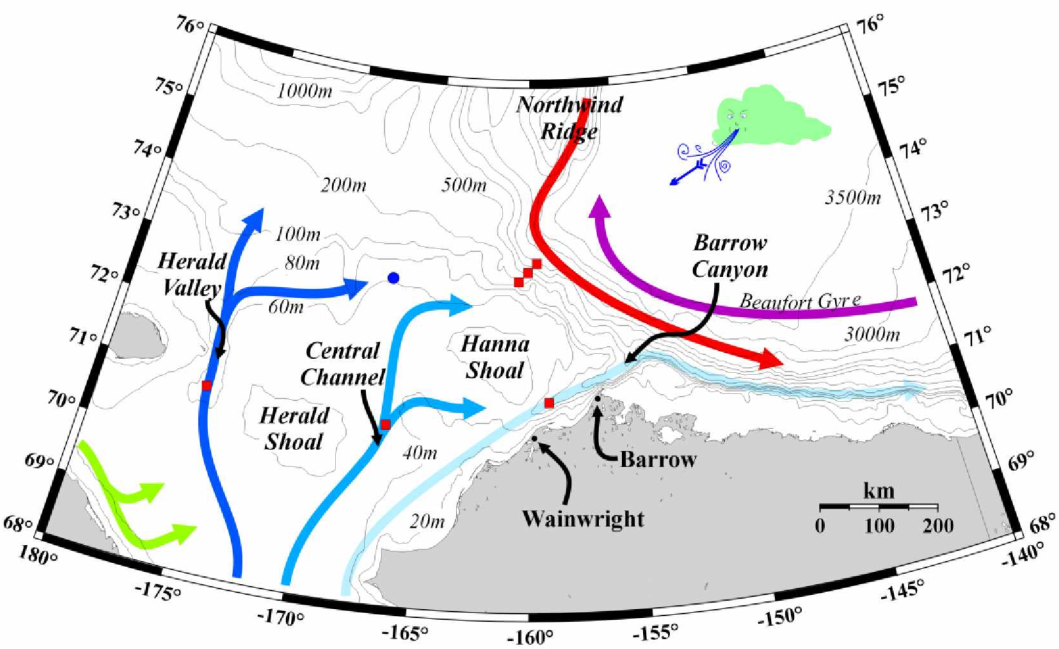


Figure 1.2: Major ocean currents of the Chukchi and Beaufort seas with Barrow, Alaska, labeled. The Chukchi Sea is located west of Barrow, and the Beaufort Sea is located east of Barrow. Reproduced from Weingartner et al. (2001).

The continental shelf of the Beaufort Sea is shallow, averaging a depth of only 37 m (121.4 ft). Except for a short period from late July through September, these shelf waters are covered by ice. The Beaufort Gyre circulates in a clockwise direction in offshore waters and wind patterns in nearshore waters tend to produce dominant westward currents (Craig 1989a). Predominant wind patterns in the summer are out of the northeast (Fechhelm et al. 2009). During summer months, a band of brackish water, generally 2 to 10 km (1.2 to 6.2 mi) wide, is an important feeding area for both anadromous and marine fishes (Craig 1984). While all five species of Pacific salmon have been observed in the Alaskan and Canadian Arctic, only pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) have been currently documented in the scientific literature to sustain small runs between Point Hope, Alaska, and the Mackenzie River (Irvine et al. 2009).

1.4 Salmon Distribution and Catch in the Beaufort Sea Region

Pink salmon are the most numerous species of salmon in Beaufort Sea coastal waters off Alaska, and comprised about 85% of the salmon catches in biological surveys of this region during the 1980s (Craig and Haldorson 1986). As of 2011, eleven streams west of Barrow have been documented to support small spawning populations of pink salmon (Alaska Department of Fish and Game 2011). Craig and Haldorson (1986) identified eight streams, and biologists from the Alaska Department of Fish and Game have recently added three additional streams to their Anadromous Waters Catalog (Alaska Department of Fish and Game 2011). Some sources noted that streams east of Point Barrow are not known to support any self-sustaining salmon runs (Craig and Haldorson 1986). However, locals in Barrow identified the Ikpikpuk and Itkillik rivers as streams supporting spawning populations of pink salmon (George et al. 2009). In addition, spawned-out pink salmon have been observed in the Sagavanirktok River, but no spawning activity has been observed (Fechhelm et al. 2009).

Presence and catch of pink salmon is cyclical, with pink salmon runs peaking in even-numbered years, which is consistent with the trend throughout western Alaska (Craig 1989b). Pink salmon appear to be increasing in catches in recent years. For example, in 2008, Lemke et al. (2011) estimated that 1,551 pink salmon were harvested from gill nets in the subsistence fishery in Elson Lagoon in Barrow. That same year, Fechhelm et al. (2009) reported that 284 pink salmon were caught in fyke nets at the Endicott Development, an oil field located about 16.1 km (10 mi) northeast of Prudhoe Bay. These numbers of pink salmon were noted to be higher compared to previous years. The authors stated that the pink salmon caught in these studies were in spawning condition; males had well-developed humps, and eggs and milt were extruded when the fish were handled. This recent shift in abundance may mark a new trend, or may merely represent a short-term anomaly (Stephenson 2006, Fechhelm et al. 2009, Irvine et al. 2009). A recent study by Moss et al. (2009) suggested that an increase in abundance of pink salmon and chum salmon in the Bering and Chukchi seas is occurring because of favorable oceanic conditions, including a promotion of increased juvenile growth of chum salmon.

Chum salmon are also distributed widely in Arctic waters, but are less abundant than pink salmon, except in the Mackenzie River watershed (McLeod and O'Neil 1983, Irvine et al. 2009). While chum salmon have been observed to spawn in the Colville River (Bendock 1979, Craig and Haldorson 1986), some dispute whether these spawning events can produce sustainable runs of chum salmon (e.g., Bendock and Burr 1984). Stephenson (2006) reported an increasing frequency of high catches of chum salmon in the Mackenzie River. In 1979, for example, thousands of chum salmon were caught, compared to “normal” years when only a few dozen fish were typically captured. Stephenson (2006) also noted that 1998 and 2003 were high chum salmon years.

Pink salmon and chum salmon are relatively cold tolerant as they do not require overwintering time in freshwater, compared to Chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), and sockeye salmon (*O. nerka*) that generally require one to three years freshwater residence time (Craig and Haldorson 1986). Pink salmon and chum salmon can exist in regions where streams completely freeze during winter months due to their unique life-history patterns. Both species swim into estuarine or marine environments once hatched and complete their growing phases outside freshwater (Babaluk et al. 2000, Irvine et al. 2009).

As noted above, winter surface temperatures in the Beaufort and Chukchi seas are considered to be lethal for salmon (Irvine et al. 2009). Juvenile salmon emerging from streams in the spring must either travel to the Bering Sea and utilize the deep (200 m (656 ft)) Atlantic water layer underneath the cold Pacific surface waters, or adapt to overwinter in freshwater refugia (e.g., river mouths, spring-fed streams, pockets of flowing water in large rivers, and beaver ponds) as do other anadromous species in the Arctic (Irvine et al. 2009). Fechhelm et al. (2009) stated that while sampling nets are placed in the waters near the Endicott Development in June, pink salmon were not caught until July, suggesting that pink salmon might travel from other areas such as the Bering Sea.

Recent studies in the Arctic documented catches of Chinook salmon, coho salmon, and sockeye salmon in the Beaufort Sea region, but concluded that these catches do not necessarily indicate an increase in abundance or range (Babaluk et al. 2000, Fechhelm and Griffiths 2001, Stephenson 2006, Irvine et al. 2009). While Chinook salmon are relatively uncommon in coastal Chukchi and Beaufort seas from Point Lay to Kaktovik, Barrow fishermen regularly harvest this species (George et al. 2009). Fechhelm et al. (2009) noted that sampling nets used to study the long-term effects of oil and gas development on fish populations are designed to catch the smaller species that are more abundant in Arctic waters. These nets likely excluded Chinook salmon and larger chum salmon from being caught. Fechhelm et al. (2009) reported catching only 49 chum salmon and one Chinook salmon over the 26 years of their study. Stephenson (2006) listed Kotzebue Sound as the northernmost spawning population of Chinook salmon and sockeye salmon, although George et al. (2009) reported that local fishers identified the Kugrua River (Near Kuk River, Figure 2.4) as a likely spawning site for Chinook salmon. Kassam et al. (2001) stated that near Wainwright salmon catches are increasing and new species of salmon, not previously characterized in the fishery, are becoming prevalent. Reidlinger (1999) recorded observations of sockeye salmon and pink salmon catches in the 1990s on Banks Island, Northwest Territories, located in the Beaufort Sea. This is an area where salmon had not been previously caught.

While high catch years are more common now than in the past, Stephenson (2006) stated that it is not possible to conclude whether salmon numbers are actually increasing in the Arctic or if new programs to gather data on salmon have only made it appear that there are now greater catches of salmon. He concluded that there is "little evidence to suggest that Pacific salmon are more common in the Canadian Western Arctic today than they have been over the past 90 years."

1.5 Study Communities and Overview of Subsistence Fisheries

While whaling often dominates Iñupiat subsistence practices, fishing has historically been and is currently an important subsistence mainstay (Craig 1989b, Brewster et al. 2008). Fish are a key resource utilized in times when other subsistence foods are scarce (Schneider et al. 1980), and today serve as an important role in modern diets and subsistence activities (Brewster et al. 2008). Fishing is increasingly viewed as an important family activity central for well-being.

The communities of Barrow and Nuiqsut were approached to participate in an ethnographic study of salmon use and knowledge due to accounts of increasing salmon catches in marine and freshwater (Colville and Itkillik rivers near Nuiqsut) fisheries (Brewster et al. 2008).

1.5.1 Barrow

Barrow is located on the coast of the Chukchi Sea, approximately 16.1 km (10 mi) south of Point Barrow, the northernmost point in the United States (Figure 1.1). This community serves as the economic and administrative center of the North Slope region. The population is 4,380 people (State of Alaska 2012), 61% of whom identify as Iñupiat (U.S. Census Bureau 2010). Fishing areas for Barrow residents range from coastal areas near Wainwright to Teshepuk Lake and inland to the headwaters of the Chipp River (Figure 1.1). The primary fish species harvested include: broad whitefish (*Coregonus nasus*), least cisco (*C. sardinella*), Dolly Varden (*Salvelinus malma*), Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), and lake trout (*S. namaycush*) (George et al. 2009).

Pink salmon and chum salmon, and occasionally other salmon species, are a subsistence resource for people in the Barrow area, but have been harvested in lower numbers than whitefish species (Brewster et al. 2008). Braund and Associations (1998, 2010) estimated that only about 0.5 to 1 kg of salmon are harvested per household per year. Only 12% of households were estimated to harvest salmon, so there are a large number of households that access few salmon through sharing or no salmon at all, and a smaller proportion of households that harvest relatively large numbers of fish (Stephen R. Braund and Associates 2010). For these households, fish, including salmon, may be a particularly important and valued resource. Fishermen travel to fish camps along the Chipp and Ikpikpuk rivers as well as other local stream systems to gill net spawning whitefish during summer, fall, and winter months (Figure 1.1). Salmon may also be caught in these areas, but the majority of salmon near Barrow are caught in Elson Lagoon (see Chapter 4). Local biologists indicated that it is unclear if the abundance of salmon has increased, or if more fishermen are now targeting them (J. Bacon, personal communication, 2010).

1.5.2 Nuiqsut

Nuiqsut is a small village of about 434 residents (State of Alaska 2012), 87% of whom identify as being Iñupiat (U.S. Census Bureau 2010). The community is located approximately 56.3 km (35 mi) from the Beaufort Sea coast, on the west bank of the Nechelik (Nigliq) Channel of the Colville River. In the early 1990s, fish comprised over 30% of the subsistence harvest of Nuiqsut households (second to caribou (*Rangifer tarandus)*), which accounted for 58% of total subsistence harvest) (Brower and Opie 1998, citing Pedersen unpublished work). However, salmon comprised a small portion of the subsistence fisheries in this community. Fechhelm et al. (2009) stated that Colville River pink salmon catches are incidental and that they are not a target species of Colville River fishermen. Chum salmon are caught frequently, but are not targeted and only comprise a small portion of the fall subsistence fishery in Nuiqsut (Fechhelm et al. 2009). Craig (1989b) stated that 438 salmon were harvested in Nuiqsut in 1985-86. Bacon et al. (2009) listed 35 salmon taken in Nuiqsut in 1995 and seven salmon were taken in 2000. During interviews described in Stephen R. Braund and Associates (2010), Nuiqsut fishermen stated that they do not specifically target salmon, but rather they set nets to catch salmon, cisco species, Dolly Varden, and broad whitefish.

1.6 Organization of Thesis

This thesis explores subsistence salmon fisheries in two Beaufort Sea communities and is structured into five chapters, including this introduction (Chapter 1). Chapter 2 presents an ethnographic description of knowledge and use of salmon in Barrow and Nuiqsut based on two summers of ethnographic field research. Chapter 3 also draws upon ethnographic research to explore the cultural values and economic needs that motivate fishing in Elson Lagoon near Barrow. Chapter 4 presents fishing effort, catch composition, and salmon harvest estimates for the 2011 Elson Lagoon fishery based on collaborative research with the North Slope Borough Department of Wildlife Management. Chapter 5 provides a summary and conclusion to the thesis.

Chapter 2
Knowledge and Use of Salmon in Barrow and Nuiqsut

2.1 Introduction

Environmental change, combined with local observations of increasing numbers of salmon in subsistence fisheries, has generated a need for more information about salmon use, abundance, and distribution in the Arctic. Ethnographic research with local elders and active fishermen in Barrow and Nuiqsut, Alaska, will help to better document the historic and current use and importance of salmon as a subsistence resource and the larger context of climate and ecological change in the North Slope region.

The Iñupiat peoples of the North Slope have historically had, and many continue to have, a seasonally migratory lifestyle pursuing various animals, fishes, birds, and plants. As archaeological evidence and early written accounts have documented, fish protein has often been a secondary source of protein for the North Slope Iñupiat, as bowhead whale (*Balaena mysticetus*) and other marine and terrestrial mammals have been the primary subsistence foods and important trading goods (Murdoch 1892, Fogel-Chance 2002). Although fish resources are secondary in total volume, they are a reliable source of food, especially in times of scarcity (Schneider et al. 1980). Fish are also important for activities such as Nalukataq, Christian holidays, regular meals, and as a source of warmth necessary for other subsistence gathering ventures (Brewster et al. 2008).

Although subsistence practices have remained largely intact through generations, the timing of fish runs and environmental cues have changed within living memory (Krupnik and Jolly 2002). Warmer temperatures are causing permafrost thawing, a reduction in summer sea ice extent and sea ice thickness, glacial retreat, increases in precipitation, and decreases in the length and thickness of snow cover (Arctic Climate Impact Assessment 2005, Kerr 2012, National Snow and Ice Data Center 2012). Increasing water temperatures and freshwater inputs have also been observed in Arctic Ocean marine environments (Wassmann et al. 2011). The Beaufort and Chukchi seas have shown a 2 to 3°C increase in mean fall sea surface temperature over the past few decades (Steele et al.

2010). Thus, the effects of climate change on fisheries in the Arctic can be numerous (Schrank 2007). Warmer ocean conditions and increases in nutrient availability for marine species are predicted to extend the range of habitat suitable for fish species, such as walleye pollock (*Theragra chalcogramma*) and Pacific salmon (*Oncorhynchus* spp.) northward, but large oceanic weather patterns and cycles may also create unfavorable conditions during some years (Morita et al. 2001, Ruggerone et al. 2007, Moss et al. 2009). Higher nutrient availablity generated by increasing temperatures and photoperiod may result in a trophic feedback loop in which there is competition among salmon and other species for favorable food sources such as zooplankton (Ruggerone et al. 2007). Recent research (e.g., Benner et al. 2005, Holmes et al. 2008, Dunton et al. 2012) has suggested that climate change impacts that increase the transport of terrestrial dissolved organic matter into marine environments may have negative consequences for higher trophic levels of Arctic food webs. Development and extractive projects and a regime shift in the Bering Sea are factors hypothesized to have created disturbances that may be pushing or allowing salmon to colonize the Arctic in greater numbers since the 1970s (Luton 1985, Ruggerone et al. 2007).

The current state of salmon catch and distribution in the Arctic is not well understood. Fisheries studies have been conducted, but have tended to focus on various whitefish species (*Coregonus* spp.) that are more abundant and have higher harvest numbers than salmon in the North Slope region (McElderry and Craig 1981, Nelson 1982, Schneider and Arundale 1982, Stephen R. Braund and Associates 1993, Georgette and Sheidt 2005, Fechhelm et al. 2007, Fechhelm et al. 2009, Pedersen unpublished work). Traditional knowledge regarding the environment, biota, and flora is especially important to help assess current changes in a historical context because it is accumulated over multiple generations as a group of people inhabit an area over an extended period of time (Reidlinger 1999, Bowers 2005, Berkes 2008).

There are many definitions of traditional knowledge (including a variety of nomenclatures, e.g., traditional ecological knowledge, local knowledge, indigenous knowledge) and approaches to the study of traditional knowledge. The basic principle is that people who inhabit and actively use a specified area have a deep-rooted relationship with the land and pass down their experiences through generations via oral history and experiential learning (Houde 2007). Berkes (2008), in defining traditional ecological knowledge, stressed that knowledge is best conceived of as an adaptive knowledge-practice-belief system. Generations of people with an intimate connection to a place create a spiritual connection and accrue knowledge and effective practices well-suited for the environments in which they live. In many ways, the people and the land are connected. Although each culture is unique and it is difficult to make generalizations about various knowledge-practice-belief systems, there are major themes that are commonly shared. Subsistence-based communities pass down information, such as location and timing of migration or prime harvest, methods for harvest and preparation, safe environmental conditions for travel, navigation techniques, etc. This information and these practices are always encoded in culture and worldview (Berkes 2008).

As described in similar studies of traditional knowledge of fisheries (e.g., Georgette and Sheidt 2005, Brewster et al. 2008, Moerlein and Carothers 2012), local elders and active fishermen are among the most knowledgeable sources of information concerning changes in fish catch and distribution. This chapter documents the historic and current importance of salmon as a subsistence resource and also contextualizes salmon among the suite of subsistence resources, practices, and culture on the Arctic North Slope. The specific objectives of this study were to:

(1) establish strong rapport with local community residents and regional experts;
(2) document the current subsistence use of Beaufort Sea salmon populations in Barrow and Nuiqsut, Alaska;
(3) document the local and traditional ecological knowledge of historic and recent trends in salmon use and distribution in the North Slope region;
(4) better understand the Iñupiat context for ecological observations and appropriate uses of such knowledge;

(5) use spatial and ethnographic data to identify streams and coastal areas where salmon have been harvested or observed.

2.2 Methods

Prior to conducting ethnographic research, we conducted a literature review on current knowledge about the use and distribution of salmon in the Beaufort Sea region. This review summarized literature on: 1) climate change in the Arctic, 2) the Beaufort Sea marine environment, 3) salmon distribution and catch in the Beaufort Sea region, 4) subsistence salmon fisheries in Barrow, and 5) subsistence salmon fisheries in Nuiqsut. As part of this review, we compiled and annotated over 70 sources and synthesized a literature overview (Chapter 1).

Also, in advance of ethnographic research in Barrow and Nuiqsut, Alaska (Figure 1.1), we developed cooperative relationships with the following organizations: the Alaska Department of Fish and Game, the Iñupiat History, Language and Culture division of the North Slope Borough, the Kuukpik Subsistence Oversight Panel, the Native Village of Barrow, the Native Village of Nuiqsut, and the North Slope Borough Department of Wildlife Management (NSB DWM). We received formal endorsements from the Kuukpik Subsistence Oversight Panel, the Native Village of Barrow, the Native Village of Nuiqsut, and the North Slope Borough Fish and Game Management Committee for our study.

We conducted fieldwork in Barrow from 1-4 June 2010, 6-27 July 2010, and 14 July-17 August 2011. Nuiqsut fieldwork was conducted during: 13-16 December 2010, 14-18 March 2011, and 20-26 June 2011. We also presented our partial findings to the NSB FGMC Committee and in multiple public community meetings in Barrow and Nuiqsut. These meetings, including the participation of many of our interviewees, provided an opportunity to clarify and refine our findings.

Key informants in each community were identified using purposive, snowball sampling methods (Bernard 2006). We wanted to identify those individuals in each community considered most knowledgeable about fishing and who have had long-time experience and thus are most likely to have observed changes over time (purposive sampling). Community leaders first recommended knowledgeable, active, and long-time fishermen, then those individuals recommended other knowledgeable and active fishermen (snowball sampling). In total, we conducted 41 interviews. In Barrow, we interviewed 22 key respondents (17 men and 5 women). In Nuiqsut, we interviewed 19 key respondents (15 men and 4 women). In both communities, the ages of our key informants generally ranged from mid-40s to mid-80s. We used an open-ended, semi-directed interview protocol (Spradley 1979, Huntington 1998; see Appendix A), which enabled us to individually tailor each interview to capture the experiences of every fisherman. During interviews, we utilized local and regional maps to allow informants to discuss spatial references if they desired to do so.

With permission, interviews with key informants were digitally recorded and fully transcribed (UAF IRB 09-38). Three interviews were conducted in Iñupiaq with the assistance of a translator present during the interviews. A translator also translated and transcribed these interviews into English. Audio-recordings and transcripts of interviews conducted with elders were archived with their permission at the Iñupiat History, Language, and Culture Commission in April 2012.

As part of our ethnographic research, we were also able to use participant observation to gather details about the subsistence fisheries in this region. Participant observation is a qualitative research method in which a researcher becomes immersed in a community or activity he or she is studying in order to gain a deeper level of understanding (Bernard 2006). We conducted participant observation of fishing activity, community gatherings, meals, and other local events and activities. Fishermen in Elson Lagoon were observed at their nets and while launching boats. During participant observation, detailed notes were taken, discussion about catches occurred, and help was provided to pull in nets and pick fish. We were able to visit gill net sites in Elson Lagoon to observe the summer subsistence fishery in 2010 and 2011. While we were not able to visit fishing locations in

Nuiqsut during the open water season, we were able to view several fish camps from the seasonal ice road along the Nigliq Channel in 2011, and also participate in Nalukataq celebrations in Nuiqsut in June 2011.

The qualitative data analysis program, Atlas.ti, was utilized to thematically code interviews, produce code count tables, explore code co-occurrence, and generate lists of specific quotes for each code (Muhr and Friese 2004). All verbatim transcripts of interviews were uploaded into Atlas.ti. Each interview was assigned a community code (i.e., Barrow or Nuiqsut). Community-level coding enabled a comparison of code counts by community. Next, the interview content was coded in segments ranging in length from several words to several paragraphs based on the type of information contained in the responses. A hierarchical thematic code list of primary and secondary codes was developed from Moerlein and Carothers (2012) (Table 2.1). Open coding was utilized in which the code list was refined as coding was completed to allow for community- and context-specific codes to be developed. Code counts (Table 2.1) show the number of times a certain theme appeared in the transcripts of the 41 interviews.

2.3 Results and Discussion

Table 2.1 presents the codebook used to analyze qualitative interview data as well as the total number of times each of the 46 secondary codes were identified in the interview data (n=2,125 individual coded excerpts from interview data). For example, the secondary code "abundance" was identified a total of 98 times in the interview data. Of the seven primary code groups, subsistence fishing was discussed most frequently in interviews (27% of code occurrences). Figure 2.1 presents the proportion of coded interview data by primary code. Code occurrences were generally similar between both Barrow and Nuiqsut informants. Of particular interest to this project, Nuiqsut informants tended to talk less about salmon species (7% of total codes in Nuiqsut interview data) compared to Barrow informants (13% of total codes in Barrow interview data). The most frequently discussed specific code in both communities was "non-salmon species" (9% of total codes) (see Section 2.3.3 Non-Salmon Species).

Table 2.1: Code list, count of occurrences, and percentage of interviews containing code for salmon knowledge and use interviews conducted in Barrow and Nuiqsut, Alaska.

Primary Code	**Secondary Code**	**Count of Occurrences (n=2,125)**	**Percentage of Interviews Containing Code (n= 41)**
Salmon Knowledge	Abundance	98	76%
Salmon Knowledge	Run Timing	68	71%
Salmon Knowledge	Name/ID	67	66%
Salmon Knowledge	Distribution	60	49%
Salmon Knowledge	Spawning	41	49%
Salmon Knowledge	Species Interactions	2	5%
Salmon Use	Fishing Locations	151	78%
Salmon Use	Gear	75	78%
Salmon Use	Sharing	69	68%
Salmon Use	Preferences	67	68%
Salmon Use	Preparation	51	71%
Salmon Use	Fish Processing	36	41%
Salmon Use	Selling	25	37%
Salmon Use	Cultural Transmission	19	22%
Salmon Species	Chum Salmon	90	83%
Salmon Species	Pink Salmon	80	78%
Salmon Species	Chinook Salmon	69	73%
Salmon Species	"Silver" Salmon	32	44%
Salmon Species	Sockeye Salmon	24	44%
Subsistence Fishing	Non-Salmon Species	200	93%
Subsistence Fishing	History	127	85%
Subsistence Fishing	Motivation	120	88%
Subsistence Fishing	Fish Camp	67	56%
Subsistence Fishing	Unusual Species	28	46%
Subsistence Fishing	Learning	20	32%
Subsistence Fishing	Fish Quality	16	27%
Environmental Change	Erosion	16	29%
Environmental Change	Weather Change	35	59%
Environmental Change	Water Levels	21	44%
Environmental Change	Access to Resources	21	34%
Environmental Change	Break-up	19	44%
Environmental Change	Erosion	16	29%
Environmental Change	Ice Conditions	16	29%
Environmental Change	Freeze-up	16	34%
Environmental Change	Travel	15	22%
Environmental Change	Change Normal/No Change	12	20%
Environmental Change	Outside information	7	17%
Socioeconomic factors	Development	42	51%
Socioeconomic factors	High Cost of Subsistence	13	32%
Socioeconomic factors	Jobs/Employment	12	27%
Cultural dimensions	Elders	47	66%
Cultural dimensions	Lifestyle Change	43	51%
Cultural dimensions	Youth	39	63%
Cultural dimensions	Iñupiat Culture	17	29%
Cultural dimensions	Spirituality/Prophesy	8	12%
Cultural dimensions	Gender	8	15%

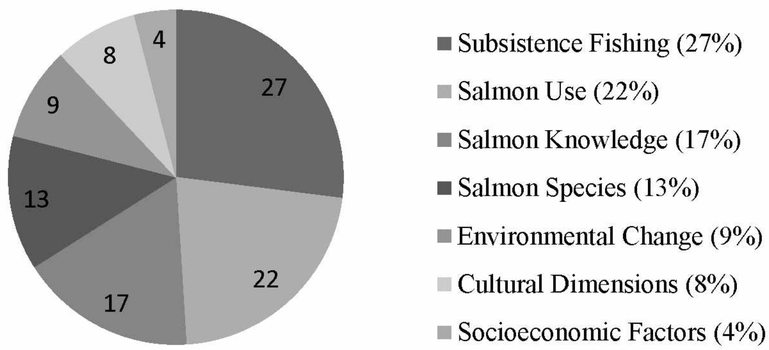


Figure 2.1: Proportion of coded interview data by primary code.

2.3.1 Salmon Knowledge

Key informants in Barrow and Nuiqsut were familiar with salmon and were knowledgeable about trends that have not yet been documented in the scientific literature. However, due to timing of subsistence fishing, locations visited, gear used, and the extent of personal fishing activity, individual fishermen's knowledge of salmon varied considerably. We comment below on general trends of agreement and make note of instances of contradictory observations.

Salmon Abundance

Informants in Barrow and Nuiqsut, Alaska, generally agreed that salmon catches have increased over the last 10 to 15 years, but perceptions of changing salmon abundance over time were mixed. Salmon abundance was specifically discussed by 28 of the 41 interviewees. The results from interview coding (Table 2.2) show that about half of active fishermen and elders who discussed salmon abundance perceived salmon abundance to be increasing, while others perceived abundance trends to be cyclical, not changing, or even decreasing. One third of both elders and active fishermen characterized salmon abundance as cyclical and stated that there has been no overall pattern of increase or decrease. Some informants noted no change in salmon abundance. Several Nuiqsut fishermen expressed their perception of decreasing salmon abundance, and related fish declines to oil and gas development encroaching on their subsistence lifestyle.

Table 2.2: Summary of perceptions of salmon abundance during salmon knowledge and use interviews by active fishermen and elders in Barrow and Nuiqsut, Alaska.

Perception of salmon abundance	**Fishermen (n=21)**	**Elders (n=7)**	**Total (n=28)**
Increased	48%	43%	46%
Decreased	14%	0%	11%
Cyclical	29%	29%	29%
No Change	10%	29%	14%

Our ethnographic data did not enable us to say whether increasing salmon catches corresponded with an increase in salmon abundance or increased effort and attention. Several elders in both Barrow and Nuiqsut remembered catching salmon when they were young and stressed that we cannot conclude that salmon populations on the North Slope are a new occurrence or even increasing. However, other elders stated that salmon are relatively novel to the North Slope region and are increasing in both abundance and geographic distribution. Some elders in our interviews, who suggested that salmon abundance is increasing, remembered the specific year they first began catching salmon. The timing of these first salmon catches ranged from the 1950s to the 1970s in our interview data. Several elders in Nuiqsut mentioned not knowing what to call salmon, because neither they nor their parents had experienced seeing, catching, or eating salmon. Two active fishermen in Barrow said that they do not remember catching salmon in the 1970s when they first started setting gill nets in the Elson Lagoon area near Barrow (Figure 1.1); however, these fishermen noted that they were not paying close attention to species differentiation in those days. As one informant stated, “I wasn’t up on fish.” Another informant stressed that salmon have always been plentiful in some of the river systems in the region and cautioned against the conclusion that salmon abundance is increasing.

Brewster et al. (2008) discussed observations of increasing salmon abundance by respondents from Barrow over the past several decades. As early as 1982, Raymond Neakok reported to have noticed salmon increasing. In 1988, Robert Aiken (1988) noted:

> Salmon, they never used to come up here. In summertime, by our cabin, I got a net. And it started getting some salmon. Dog salmon. Real big toothed ones. Not very many of them. We never used to get them, but now we do, so maybe they start moving from someplace.

In another interview conducted in 1988, Sadie Neakok (1988) indicated that there are silver-colored salmon in the Ikpikpuk River (Figure 1.1). She stated that “We’re not used to fishing for salmon up here, but we found out there is a run in the fall.”

Pink Salmon

While several elders stated that catching pink salmon (*Oncorhynchus gorbuscha*) is not a new occurrence in the North Slope region, fishing effort and catches of pink salmon have been relatively high in recent years compared to past years, particularly in the Elson Lagoon gill net fishery near Barrow (Chapter 4). During our interviews in 2010, several informants who set nets in Elson Lagoon stated that there have been years recently where pink salmon have been so abundant that they clogged up their fishing nets. One fisherman detailed that in these years, fishing conditions have “… gotten to the point where there’s too many pink salmon to deal with.” Another fishermen commented, “We get more of the humpies (pink salmon), a lot of the humpies, and last two years (2008 and 2009) there’s been mostly humpies.” Some fishermen noted that they do not set their nets when pink salmon runs are at their maximum. One informant, who did not set his net in 2009, was told by an active fisherman during that year, “You ain’t missing nothing. I ain’t getting much, it’s a bunch of pinks.” He replied, “Yeah, somebody needs to shoot them things.” Pink salmon catches were also high in the 1980s when the gill net fishery was developing in Elson Lagoon (Chapter 4).

Decades earlier, elders also confirmed catching pink salmon, but explained that they did not prefer to eat them (Brewster et al. 2008). These authors also reported that Warren Matumeak and Martha Aiken from Barrow stated that these salmon did not used to be preferred, were not targeted, and were not consumed. After the 1970s, Warren Matumeak indicated pink salmon (locally called *amaqtuuq*) catches began to increase:

> We used to get lots of those *amaqtuuq*. Still get them out in the rivers. They are noticeable when we get them in our nets. We just throw them away. Leave for the animals to feed on. Maybe after the 1970s we saw more of them. Before 1980s. *Amaqtuuq* are not good at all. Although people do eat them. Take the hump off and eat them. Catch at Pigniq. I used to leave the *amaqtuuq* and get the *aanaakliq* (broad whitefish). I had heard that someone had planted them. They're a nuisance – are no good at all. Iñupiat used to take that hump off and use it. I heard a tannik (white) guy planted the pink salmon in rivers around here. I don't know what year or what his name was. He said he planted them because they are hardy fish. I spoke to that guy or somebody who knew him told me about it.

William Leavitt, also from Barrow, fished on the Miguakiaq River and in 1978 caught more pink salmon in his net than he could harvest, but took as much of them as his family would use. The rest went back into the river to be consumed by other animals.

> Those *amaqtuuqs*. Pinks. They're good eating. We don't get them every year. But there was this one year that they were just piling up in our gill net. We had to return them – most of them were dead. It was in about 1978. Every now and then, from that day on, there's two or three, they'll get caught (Brewster et al. 2008).

Several of our Barrow informants confirmed that the increase in pink salmon catches appear to have occurred in the 1970s or 1980s. Many fishermen interviewed in 2010 and 2011 in Nuiqsut and Barrow, Alaska, noted that pink salmon are often utilized earlier in the season to avoid waste as many pink salmon are unpalatable later during their spawning months. When males form a dramatic dorsal hump, they "stink" later in the season, so fishermen attempt to avoid catching these fish by pulling their nets or changing the gill net gear size (see Section 2.3.2 Salmon Use for more information about gear used to harvest salmon).

In Nuiqsut, informants observed high abundance of pink salmon every other year reflecting a pattern consistent with the scientific literature and common throughout Alaska (Craig 1989b). Several interviewees stated that there are thousands of pink salmon during the years when they are running. Some fishermen caught pink salmon on a regular basis, while others reported only an occasional catch (often dependent on the timing of when fishing nets are set). One Nuiqsut elder remembered that in the 1950s, when he was young, pink salmon were driven from the Itkillik River (Figure 2.2; tributary of Colville River, south of Nuiqsut) due to petroleum extraction in that region. This coincided with accounts of another fisherman about the same river system. He stated that there are now "…beginning to be a lot of pinks, especially on the Itkillik River," suggesting the fish may be returning to an area in which they have been seen regularly. One informant with a fish camp at the mouth of the Itkillik River recalled that thousands of pink salmon started showing up in the Itkillik River only about five years ago (2006).

Chum Salmon

Chum salmon (*Oncorhynchus keta*) are an important source of protein and many fish are caught throughout the summer and fall in Barrow. According to fishermen in Barrow, approximately 30 chum salmon per net per day can be caught in gill nets in Elson Lagoon during the peak of the run (Chapter 4). In Nuiqsut, however, the presence and abundance of chum salmon is less certain (see also Salmon Identification below). An elder informant, for instance, did not recall catching chum salmon when he was young fishing at fish camps along the Colville River. Several other informants confirmed that chum salmon are a relatively recent migrant to the Colville and Itkillik rivers (Figure 2.3). One fisherman stated that he used to catch a lot of chum salmon when he was younger in the 1970s and 1980s, but he considered them to be less abundant in 2011. A young fisherman in his twenties recollected catching more salmon today than when he was younger. These observations suggest that catches of chum salmon in the Colville River have been variable over the past three decades.

Chinook Salmon

In Barrow, there has been a lot of discussion about increasing catches of Chinook salmon (*Oncorhynchus tshawytscha)*. Our informants generally agreed that documented catches of Chinook salmon began in Barrow 10 to 20 years ago. One informant remembered catching his first two Chinook salmon in 1992, and estimated them both to be over 122 cm (4 ft) long. One active informant stated that he caught his first Chinook salmon in 2002 or 2003, and he has only caught one other Chinook salmon since. He recalled that he mistook his first Chinook salmon for a seal before he pulled in his net. He used a harpoon to get the large Chinook salmon out of his net and into his boat. Some fishermen use larger mesh gill nets during the month of July to specifically target Chinook salmon. One informant stated that a fisherman from Southeast Alaska was the first to catch a Chinook salmon on a fishing rod around 2003. Some locals have also begun fishing for Chinook salmon with fishing rods. These changes in fishing practice (e.g., using larger nets and fishing with poles) indicate that although Chinook salmon might not have been a predictable species previously, they have become a desired species for many Beaufort Sea fishermen.

Informants in both Barrow and Nuiqsut stated that they usually catch few Chinook salmon. During most seasons, informants reported that fishermen who catch one or two Chinook salmon are considered lucky. However, in 2003, fishermen consistently caught Chinook salmon in their gill nets every two to three days. The NSB DWM catch data confirmed that 2003 was a notably high year for Chinook salmon catches (Bacon et al.

2009). Bacon et al. (2009) reported that 229 Chinook salmon were caught in Barrow during that year. High catches of Chinook salmon in 2003 corresponded to low annual sea ice in the Bering Sea that same year (Rayner et al. 2003).

During a good Chinook salmon year, a Barrow informant estimated that a fisherman may catch about a dozen Chinook salmon over the entire summer season. However, as discussed below, species misidentification is widespread in both Barrow and Nuiqsut. During our observation of local fisheries, we confirmed several large chum salmon, approximately 76.2 cm (30 in) or longer, being called "king" salmon (Chinook salmon) by local fishermen (see Salmon Identification below).

Sockeye Salmon and Coho Salmon

Because of the species identification issues described below, we are not able to generate any conclusive information about sockeye salmon (*O. nerka*) and coho salmon (*O. kisutch*) species from our interviews. George et al. (2009) reported that sockeye salmon are uncommon in Barrow, but appear to be increasing in numbers in the last 10 years.

Coho salmon are the rarest of all Pacific salmon in Arctic waters (Stephenson 2006). Stephenson (2006) reported catching one coho salmon in October 1998. The only other confirmed catch in the Canadian Arctic occurred in 1987, as reported by Babaluk et al. (2000). Because coho salmon are rarely caught in the Canadian Arctic, these specimens are considered strays. George et al. (2009) recorded a small number of coho salmon catches in Barrow. Similarly, Craig and Haldorson (1986) documented occasional coho salmon presence near Prudhoe Bay.

During our participant observation in summer 2011 in Barrow, many fishermen exhibited their catches when returning from picking their nets. Many of the fish labeled "silver" salmon were in fact large chum salmon. Thus, care should be taken with interpretation of salmon abundance when species identification cannot be confirmed and previous reports listing "silver" salmon harvests should be revised and recorded as "unidentified salmon species." Holder and Hamner (1998) stated that on the Yukon River, misidentification of coho salmon and chum salmon is common, but suggested utilizing familiar local names to aide with taxonomy issues. Often photo identification cards do not resemble salmon from the stock of interest or salmon are shown ocean bright rather than during their spawning migration, so these aids may or may not be helpful. Utilizing local sources for pictures and specimens to create identification handouts, websites, and presentations enables a better understanding of the particulars of identification because Pacific salmon exhibit such high anatomical plasticity between regions (see Salmon Identification below). For example, salmon caught by Nuiqsut fishermen have different coloration than those caught in Elson Lagoon by Barrow fishermen. A majority of Nuiqsut fishermen harvest salmon in freshwater systems while Barrow fishermen utilize brackish water in Elson Lagoon to harvest salmon species. A photo identification card with salmon exhibiting spawning coloration should be used in Nuiqsut whereas a photo identification card of ocean-bright salmon should be utilized in Barrow.

Geographic Distribution

Information about the current geographic distribution of salmon in the Arctic in the scientific literature is limited. Chinook salmon, chum salmon, pink salmon, and sockeye salmon have been described in the Mackenzie River drainage (Babaluk et al. 2000) and along the Chukchi Sea (Alaska Department of Fish and Game 2011). Chum salmon and pink salmon are the only species thought to be spawning in Beaufort Sea tributaries, but other species have been documented in low numbers and are assumed to be strays (Stephenson 2006). Craig and Haldorson (1986) provided a detailed description of why chum salmon and pink salmon may be successfully spawning in Beaufort Sea systems. First, males and females require a stream with groundwater input. Spawning needs to occur within these thermal pockets, so that eggs can overwinter in water that does not freeze. Groundwater-fed streams are usually many degrees warmer than other streams on the North Slope, thus the eggs may be able to survive. Water temperatures average between 0 and 0.5°C, but pockets of groundwater provide shelter with temperatures between 2 and 5°C throughout winter months. Degree days are defined as the sum of °C from spawning through hatching (Boyd et al. 2010). Pink salmon eggs need 1000°C days to be successful, and chum salmon eggs need between 700-900°C days (Craig and Haldorson 1986). The degree-day requirements may be a limiting factor in salmon spawning stream selection (Craig and Haldorson 1986).

The location where chum salmon spend their winter is debated. Irvine et al. (2009) summarized three current hypotheses regarding adult chum salmon survival in the Arctic: 1) chum salmon migrate from the Beaufort Sea to the Bering Sea to feed and live in the ice-free zone; 2) chum salmon migrate to the Arctic Ocean and live at a depth greater than 200 m, where the temperature is usually above 0°C, while other water masses are less than 0°C during winter months; 3) chum salmon overwinter in freshwater or brackish habitats such as river mouths, spring-fed streams, and pockets of flowing water in large rivers that stay fluid throughout winter, or beaver ponds, which are warm-water refugia (relative to the surrounding habitats). The chemical composition of otoliths collected from chum salmon in the Beaufort Sea was found to be similar to the profile of Yukon River chum salmon, where chum salmon migrate to the Bering Sea to feed for three years. These results indicated support for the first hypothesis, that chum salmon from the Beaufort Sea may travel hundreds of miles to live and feed in the Bering Sea and then return to Arctic habitats to spawn. Pink salmon likely follow a similar migratory pattern (Irvine et al. 2009).

Sockeye salmon, coho salmon, and Chinook salmon all require time spent in freshwater to feed and grow before entering the marine system. It is therefore hypothesized that these species do not have suitable winter habitat north of Point Hope (Craig and Haldorson 1986, Stephenson 2006). Due to changing habitats in the Alaskan Arctic, as a result of warming conditions observed by scientific and local communities, the previously described distribution and spawning habitats characterized in the 1970s and 1980s need further exploration. Although there are no specific temperature records for many of the systems across the North Slope, warming conditions have created a situation in which habitat may be suitable for salmon that have not occurred in these areas previously.

Pink Salmon

East of Barrow, the Ikpikpuk River, Fish and Judy creeks, and the Colville, Itkillik, Sagavanirktok (including West Channel), Staines, West Canning, and Canning rivers are confirmed to have a pink salmon presence in the Alaska Department of Fish and Game (ADF&G) Anadromous Waters Catalog (Alaska Department of Fish and Game 2011; Figure 2.2). The Chipp, Ikpikpuk, Kuparuk, Sagavanirktok, and Kavik rivers are identified as spawning rivers for pink salmon (Alaska Department of Fish and Game 2011). Nuiqsut informants confirmed the presence and potential spawning of pink salmon in the Itkillik River. One informant with a fish camp at the mouth of the Itkillik River stated that thousands of pink salmon started showing up in the Itkillik only about five years ago. He stated that they congregated in one spot and remained there (4.8-6.4 km (3-4 mi) up the Itkillik River) (Figure 2.2). One Nuiqsut informant commented that he has seen pink salmon in the Chandler and Anaktuvuk rivers, which are tributaries of the Colville River.

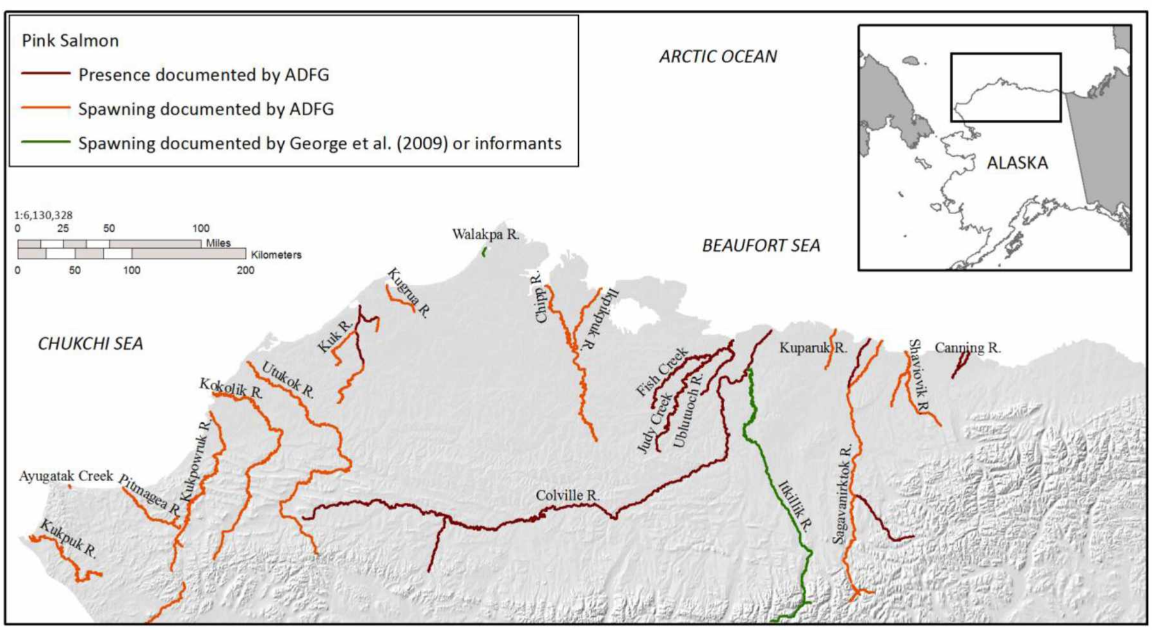


Figure 2.2: Map of the North Slope region showing stream systems with presence and spawning of pink salmon (*Oncorhynchus gorbuscha*). Map produced by Christine Woll, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

Chum Salmon

East of Barrow and North of the Brooks Range, the Chipp River, Ikpikpuk River, Fish and Judy creeks, and the Colville, Itkillik, Sagavanirktok (including West Channel), Canning, and Kongakut (and an additional unnamed stream west of Kongakut) rivers are confirmed to have a chum salmon presence in the ADF&G Anadromous Waters Catalog (Figure 2.2). Additionally, it has been established that chum salmon spawn in the Meade, Itkillik, and Colville rivers (Alaska Department of Fish and Game 2011). George et al. (2009) noted that chum salmon "likely spawn" in the Ikpikpuk River (Figure 2.2). Nuiqsut informants confirmed the presence and potential spawning of chum salmon in the Itkillik River and the presence of chum salmon in Fish Creek. Chum salmon rearing areas in river or estuarine systems have not yet been identified.

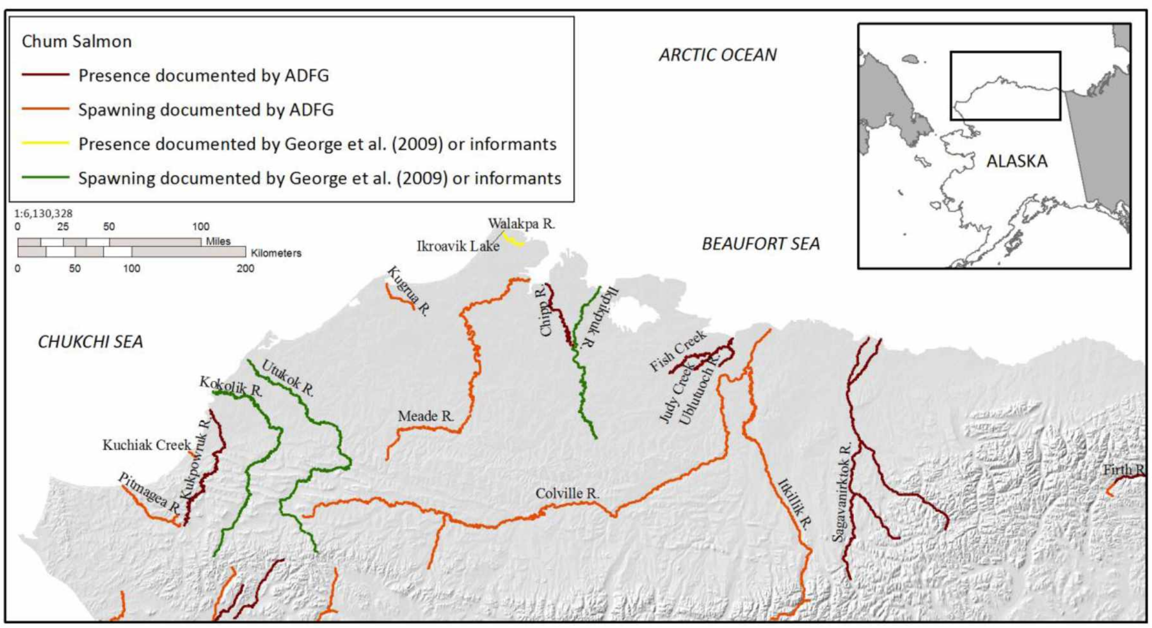


Figure 2.3: Map of the North Slope region showing stream systems with presence and spawning of chum salmon (*Oncorhynchus keta)*. Map produced by Christine Woll, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

Chinook Salmon

East of Barrow and north of the Brooks Range, Chinook salmon have been confirmed to be present in Fish Creek by the ADF&G Anadromous Waters Catalog (Figure 2.3). No stream systems in this region have been recorded on the catalog as spawning or rearing areas for Chinook salmon. George et al. (2009) reported a potential spawning population in the Kugrua River (Near Kuk River, Figure 2.3). Several of our informants confirmed that Chinook salmon pass through Peard Bay. One informant recalled harvesting two Chinook salmon at the elbow point at Nuvuk. Another informant stated that he caught a 98 pound (44.5 kg) Chinook salmon in Elson Lagoon. Nuiqsut informants noted that Chinook salmon are rarely caught in the Colville River.

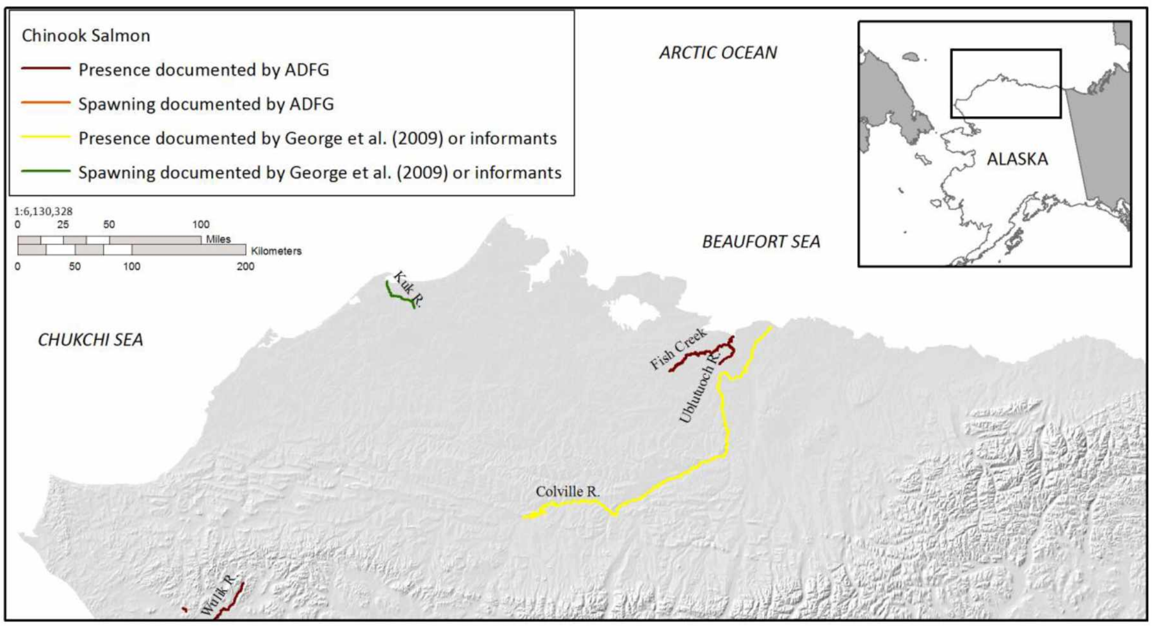


Figure 2.4: Map of the North Slope region showing stream systems with presence and spawning of Chinook salmon (*Oncorhynchus tshawytscha)*. Map produced by Christine Woll, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

Sockeye Salmon and Coho Salmon

The ADF&G Anadromous Waters Catalog reported that no streams in this region have confirmed sockeye salmon presence for either spawning or rearing (Alaska Department of Fish and Game 2011). George et al. (2009) indicated that sockeye salmon spawn in the Colville River (Figure 2.5). Several of our informants also indicated that they have occasionally caught sockeye salmon in the Colville River. One informant remarked that he had heard about sockeye salmon smolts in the Colville River area. One of our expert informants stated that he caught a sockeye salmon in 2009 at Cape Simpson in Smith Bay. Given the widespread misidentification of salmon species in the region, this informant was careful to noted that this fish was not a chum salmon as it was "totally different" than any other fish he had ever caught. He stated that "the meat was very red." Several Nuiqsut informants noted that they have caught "red" salmon in conversations about occasional catches of "king" or "silver" salmon. One young Nuiqsut informant reported that he caught a sockeye salmon on a rod and reel on the Colville River near Ocean Point. The ADF&G Anadromous Waters Catalog reported that no streams in this region have a confirmed coho salmon presence for neither spawning nor rearing. Similarly, no stream systems west of Barrow and north of Point Hope are currently labeled as containing this species at any life stage, with the exception of Kuchiak Creek near Point Lay, which is identified as a coho salmon spawning stream (Alaska Department of Fish and Game 2011; Figure 2.6).

Salmon: Unidentified Species

Informants in Barrow and Nuiqsut, Alaska, often discussed salmon generally without differentiating among species (see Salmon Identification below). Occasionally in Barrow, and often in Nuiqsut, informants also group salmon and Dolly Varden (*Salvelinus malma*) together in their discussion of geographic distributions. One informant stated that salmon and Dolly Varden (locally called char) migrate up the Singaruak River (south along the coast from the Will Rogers and Wiley Post Memorial). Nuiqsut informants catch salmon and Dolly Varden near Umiat, which is a six to eight hour boat ride up the Colville River from Nuiqsut.

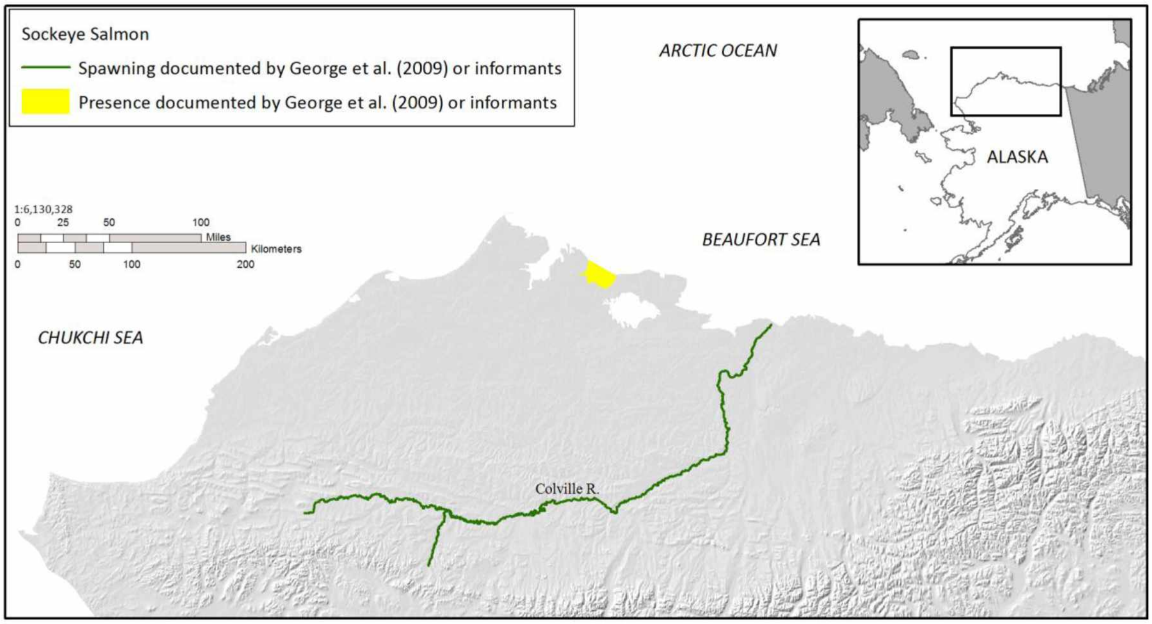


Figure 2.5: Map of the North Slope region showing stream systems with presence and spawning of sockeye salmon (*Oncorhynchus nerka)*. Map produced by Christine Woll, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

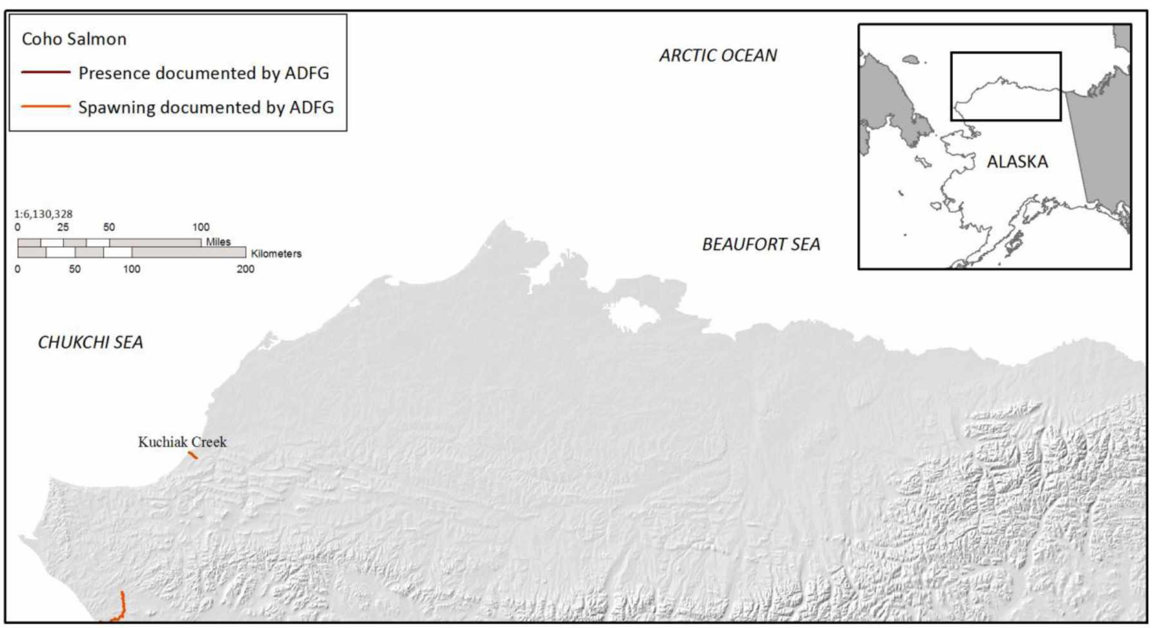


Figure 2.6: Map of the North Slope region showing stream systems with presence and spawning of coho salmon (*Oncorhynchus kisutch)*. Map produced by Christine Woll, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

Salmon Identification

According to George et al. (2009), there are 22 common fish species harvested in the Barrow region and 27 fishes captured in the Colville River. The primary species harvested include: broad whitefish (*Coregonus nasus*), Arctic cisco (*C. autumnalis*), least cisco (*C. sardinella*), Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), lake trout (*Salvelinus namaycush*), and Dolly Varden (see Appendix C for full list of species names, including Iñupiaq names).Various species of Pacific salmon are utilized as subsistence resources in Barrow and Nuiqsut, but are harvested in much smaller numbers and are relatively less important fisheries (Brewster et al. 2008; Table 2.3). Stephen R. Braund and Associates (2010) estimated that salmon comprise only 0.7% of the total usable pounds of subsistence harvest in Barrow. Because salmon are relatively less important informants tended to know less about these species than about other highly valued subsistence fish species.

Table 2.3: Variety of nomenclature for Pacific Salmon species. See Appendix C for list of additional species.

Common	**Iñupiaq**	**Scientific**
Pink, Humpy	*Amaqtuuq*[1]	*Oncorhynchus gorbuscha*
Chum, Dog	*Iqalugruaq*[2]	*Oncorhynchus keta*
Chinook, King	*Iqalugruaq*[2]	*Oncorhynchus tshawytscha*
Sockeye, Red	None	*Oncorhynchus nerka*
Silver, Coho	None	*Oncorhynchus kisutch*

[1]Translation: *amaqtuuq* – big dorsal fin; amaq - dorsal fin, tuuq - big or lots of.
[2]*iqalugruaq* – big fish; iqaluk – fish, gruaq – big (MacLean 2011).

In both study communities, we found that active and knowledgeable fishermen consistently misidentified salmon at the species level and in Nuiqsut in particular there was conflation of salmon species and Dolly Varden. Recently, some fishermen in Barrow have become interested in salmon identification. Prior to our study, several fishermen communicated with the NSB DWM to help them identify salmon species. Through our participant observation of the subsistence gill net fishery, we were able to examine several salmon in person at fishing sites or view pictures taken of fish that could not be identified. One common identification error was the use of the common name “silver” (usually a common name for coho salmon in other regions) to refer to chum salmon or pink salmon. Barrow fishermen catch their fish in brackish water while the salmon are still a brilliant silver color ("ocean bright"). The calico appearance of chum salmon in spawning colors is usually faint when Barrow fishermen harvest them. Several informants also tended to refer to large chum salmon as "king" (Chinook) salmon. We found that pink salmon, especially in spawning condition, tended to be identified correctly more often than chum salmon, due to the differences in size, texture of flesh, prominence of the dorsal hump, as well as large spots on their lateral surface and caudal fin. Although some fishermen correctly identified salmon to the level of species, some fishermen did commonly misidentify both pink salmon and chum salmon. One local informant stated that "all (fishermen) were making errors initially," but estimated that over half now correctly identify salmon to species level.

During our participant observation we noticed that some fishermen used identification keys and kept personal logbooks with their catches so that the appearance of species may be recorded. Fishermen were often proud of the range of species identification that they can provide. During an interview, one fisherman stated, "We've officially recorded every species incoming. I think all of them do get here." As a collective fishing community, the fishermen have worked with the biologists at the NSB DWM, the Native Village of Barrow, and Alaska Department of Fish and Game to learn to distinguish between the species of salmon using pictures and by collecting age, sex, weight, length, and genetics samples. Not all Barrow fishermen are concerned with species identification. One of our informants who is locally identified as an expert fisherman stated, "if they're not humpies I call 'em silvers, because they're silver… they all look the same to me." This fisherman was interested in harvesting as many fish as he needs to feed his family and to share with the rest of the community, and did not care to differentiate among salmon species.

Consistent with Iñupiaq nomenclature Barrow elders and knowledgeable fishermen tended to use two Iñupiaq names for salmon – *iqalugruaq* and *amaqtuuq* (see Table 2.3 and Appendix C). Our Barrow informants tended to use *iqalugruaq* to refer to bigger chum salmon and Chinook salmon and *amaqtuuq* to refer to the smaller pink salmon. It is unclear if Iñupiat elders differentiated between chum salmon and Chinook salmon. Other Alaska Native groups have five (or more) names for different salmon species (e.g., in the Bristol Bay Yup'ik language all five species of Pacific salmon are named, with additional names used for salmon species in various life stages and sizes [Sophie Woods, Dillingham resident, personal communication, 2011)]. The occurrence of only two names for salmon in this region illustrates that the Iñupiat have not had much historical experience with the other three species that are now being caught in the region.

In Nuiqsut, during a presentation to the Kuukpik Subsistence Oversight Panel, one of the members cautioned us that fishermen in Nuiqsut refer to Dolly Varden and salmon species with one name – *iqalukpik* (translated in George et al. 2009 as Dolly Varden char). This fact prompted us to identify the species being discussed during interviews. Species level identification was problematic in our interviews. When asking a translator in Nuiqsut about the Iñupiaq names for pink salmon (*amaqtuuq*) and chum salmon (*iqalugruaq*), he stated, "these are not the names that we normally hear in Colville region." Rather *iqalukpik*, meaning a "big salmon or fish", is normally used to refer to salmon species. The majority of elders and fishermen in Nuiqsut who we interviewed used the name "*iqalukpik*" to refer to salmon. Only two elder interviewees used the name "*iqalugruaq*," one specifically to refer to chum salmon, "these got teeth. We call them *iqalugruaq*." When discussing pink salmon, one elder in Nuiqsut stated, "They call it the *iqalukpik*. My grandfather would call them *iqalukpik*. He called them that because he did not know what else to call them…*iqalukpik* and *iqalugruaq*." One elder used the Iñupiaq term "*amaqtuuq*" to refer to pink salmon in Nuiqsut, discussing specifically the hump characteristic of this species.

One Nuiqsut informant emphasized that many of these species collectively called *iqalukpik* in this community migrate at the same time during the summer. During some years, many salmon arrive and, during other years, they do not. An elder informant in Barrow put it best, "Every year is different for the salmon migrations. Sometimes they come and sometimes they don't. It's different every year." While Nuiqsut informants often discussed salmon species and Dolly Varden interchangeably, many offered general species-specific information on presence and distribution of pink salmon and chum salmon in river and stream systems.

Bacon et al. (2009) summarized subsistence survey data collected by the NSB DWM over the past 20 years. Each community had a different history with salmon fisheries, different individuals conducting the surveys, and the results show the diversity of experiences. For example, salmon are a more abundant resource in Point Hope and Wainwright. The common names used in regional subsistence surveys in those communities are: Chinook salmon, chum salmon, coho salmon, pink salmon, sockeye salmon, and a general "salmon species." In Barrow, where there has been less exposure to a variety of salmon species, the following common names (and several of these are duplicate names for the salmon species that appear in the same surveys) are used: dog salmon, chum salmon, humpback salmon, pink salmon, and silver salmon, along with "salmon species." Bacon et al. (2009) noted that salmon identification by fishermen is problematic in many North Slope communities.

Salmon Run Timing

In the communities of Barrow and Nuiqsut, Alaska, salmon runs occur between June and August (Chapter 4). The short summer season does not allow much variation in run timing (Craig 1989a) as in other systems in Alaska where various Pacific salmon species may have multiple peak runs throughout the summer months (Fillatre et al. 2003). The fishing season in the Beaufort Sea is highly dependent upon ice conditions and begins when the ice leaves river or nearshore areas. One informant stated that salmon do not enter Elson Lagoon unless there is an ice-free zone north of Point Barrow. This observation may indicate that salmon are moving from the Chukchi Sea into the Beaufort Sea.

The season length and timing are also heavily dependent on wind patterns. Westward currents created by an east wind provide adequate water level in Elson Lagoon for fishermen to set their nets, and may also push the fish into the lagoon on their migration eastward (Craig 1989a). East winds are important to the Colville River system. Years with prevailing winds from the east are positively correlated with high recruitment of Arctic cisco, which are important to the diet of the Iñupiat (Fechhelm et al. 2007). Fishing is also successful when the water level in the Colville River is high enough to travel to fishing locations upriver in these conditions.

Pink salmon catches occur from June to August. An elder in Barrow stated that the fishermen can really start catching salmon "in August when it starts getting dark." Chum salmon are caught throughout the month of August after pink salmon catches peak (Craig 1989b), and fishing activities near Barrow and Nuiqsut follow this timeline.

Fishermen gave consistent answers when asked about the timing of the salmon runs. In general, the length of the fishing season has not changed much. However, the ice is unpredictable and the season is heavily dependent upon the prevalent winds. One major difference between the two communities is that Nuiqsut is situated close to hydrocarbon extraction fields. The people subsisting in Nuiqsut have noticed a large number of changes since the Alpine oil field and related infrastructure was developed near their village in 2000 (Stephen R. Braund and Associates 2009). There are roads that cross the river and may hinder the break-up of the river, thus changing the length of their fishing season. One fisherman remembers setting nets in early June when he was younger, but now usually sets the nets in late June because the ice has not gone out or the Colville River sediments have not subsided.

Walruses (*Odobenus rosmarus divergens*), bearded seals (*Erignathus barbatus*), and ringed seals (*Pusa hispida*) are harvested offshore during June, July, and August when the fishing nets are out. In August, many families also travel inland to hunt caribou (*Rangifer tarandus*), and take their fishing nets to catch fish in the rivers. These activities are flanked on either side by spring and fall whaling. Whaling is the most important subsistence activity for these two communities and determines when the subsistence users will be available.

The observed length of winter was noted in our interviews to be decreasing as break-up tends to happen earlier and freeze-up tends to occurs later. An increase in summer duration means a longer open-water fishing and hunting season, but the important fall whaling and fishing seasons happen later. One fisherman in Barrow is concerned that the fish may be passing when the ice is too thin to set nets on the ice for whitefish. A Nuiqsut respondent observed that later fall freeze-up timing affects his ability to catch the fish runs under the ice. As a result, the timing of when fishermen trade the summer gill net for an umiak and harpoon may be changing.

2.3.2 Salmon Use

There are many forms of fish preservation and preparation which our informants spoke about with much enjoyment. Fish species, including salmon, are served at regular family gatherings, holiday and celebration feasts, and are shared in vast networks within communities and throughout Alaska.

Salmon Harvest

Salmon are harvested mainly by set gill net near Barrow in Elson Lagoon (Chapter 4) or within the Colville River delta and drainage, Itkillik River, and Fish Creek regions near Nuiqsut. Local subsistence harvesters in these communities travel throughout the North Slope to gather fish and often take gill nets or rods and reels to harvest salmon for consumption and to share. A Barrow elder remembered gill nets in Elson Lagoon when he first moved to Barrow in 1938. Gill nets in the lagoon in the early 1900s targeted young seals, not fish as they are intended for today. Today, between 20 and 30 fishermen set gill nets in the lagoon to catch whitefish, salmon, and Dolly Varden (Chapter 4). Fishermen utilize a variety of mesh sizes, ranging from 7.6 cm (3 in), for smaller species such as whitefish to 20.3 cm (8 in) to target large fish such as Chinook salmon. Today, gill nets used in this fishery are made of monofilament fibers, but elders recall nets being made of cotton twine in the past. According to a Barrow fisherman, monofilament gill net mesh is more difficult for the fish to see and is more effective at catching fish when the wind is calm and the water turbidity is low. Before cotton or monofilament was introduced, one elder remembered his grandparents using sinew from caribou, whales, and pinnipeds braided into rope and used for gill nets.

The lengths of the nets vary from 5.5 m (18 ft) to over 137.2 m (450 ft), depending on the conditions and the amount of fish sought. Fishermen in Barrow and Nuiqsut set their gill nets and return daily or every other day, depending on the distance required to travel, the weather, and the amount of gas they can afford for the trip. Barrow residents drive to their nets with a truck or an all-terrain vehicle (ATV). Nuiqsut fishermen usually travel by boat, as many nets are set along the Nigliq channel of the Colville River and this area is not accessible by truck or ATV. Generally, the gill nets are attached to a heavy item and a buoy that keeps the net afloat in a stationary position, and staked to shore to keep the net perpendicular from shore to maximize the interception of fish passing by the shoreline. If the area is shallow enough, fishermen can pick the fish from their net in chest waders; otherwise, they use small boats. In Barrow, a few of the fishermen have learned a method employed by Point Hope fishermen in which a gill net is attached to a single line connected at both the seaward and shore ends of the net. There is a pulley system so the net can be pulled ashore without having to use a boat or chest waders to remove fish from the net. This system is less expensive because the net comes to fishermen and they do not have to go out into the water using a boat or other gear, and also less dangerous when waves are high or water is deep. The Point Hope method requires the use of a boat to deploy and remove (see Chapter 4).

Salmon Processing and Preparation

As with any other food, salmon are processed and prepared in a multitude of ways, depending on family and individual preferences. Traditionally, the Iñupiat did not cook much of their food. Most fish was eaten frozen, cut up and dipped in whale or seal oil. Some fish was dried, called *pipsi*, and was to be eaten later with whale or seal oil. In Barrow, many people choose to make their *pipsi* outside of town, however, because dust from traffic can ruin entire batches of drying fish. One elder in Barrow remembered that drying fish in town became difficult when the Navy Arctic Research Laboratory (NARL) became a hub of research activity in the 1950s and 1960s.

Traditionally, whitefish and other fish species were harvested, frozen whole, or cut up and frozen in ice cellars. Traditional practices are active in both Barrow and Nuiqsut, and many people still eat frozen fish with oil. According to several informants, this method of preparation was noted to provide people with warmth that store-bought foods cannot provide. Many fishermen and elders stated that traditional foods keep hunters and fishermen warm, while store-bought foods do not contain enough fats and nutrients to maintain the endurance needed for subsistence activities on the North Slope.

Thawing of permafrost has led to changes in the water levels and dynamics of rivers and lakes and increased erosion. As a result, these changes have prevented many people from using traditional ice cellars for storage. In our interviews, informants reported several accounts of their cabins and homes being relocated due to erosion and food spoilage in warm ice cellars. One of our key informants in Barrow explained his battle with erosion and warming at his fish camp located along the Beaufort Sea coast north of Teshekpuk Lake (Figure 1.1). Between the 1980s and 1995, he related that three separate ice cellars each became exposed by erosion and rendered unusable. After the third cellar failed due to the bank eroding away, he started to preserve fish by drying them and using freezers and vacuum sealers.

In Nuiqsut, there are also fish camps and ice cellars that have been impacted by erosion. A prominent Nuiqsut fisher explained to us that she has used the same ice cellar for her entire life. Ten years ago, this cellar eroded and she has now resorted to using generators and freezers to preserve her harvest at fish camp. In 2010, a family preparing for a Nalukataq in Nuiqsut stored a large amount of salmon for the festival. The next summer when they went to pull the salmon and other meat out of the cellar to prepare for the guests and the community of Nuiqsut, the salmon and some bowhead whale meat and muktuk were too spoiled to serve because the ice cellar thawed due to a lack of permafrost cover. A prominent Nuiqsut fisherwoman has observed that increased rainfall also impacted her ability to dry fish at camp.

Several interviewees stated that they are learning new methods for preserving and preparing salmon as subsistence practices are impacted by development and environmental change. "We're learning how to preserve. This year we smoked some of them (in a friend's electric smoker)…the smoked salmon is really good now that we can preserve it." Store-bought smoke chips are usually used, as wood is scarce and limited to drift wood collected along the North Slope or manufactured wood (e.g., pallets) imported to the region.

Pink salmon are usually eaten fresh, as some consider them unappetizing after they have been frozen and thawed to cook. However, several informants showed us their freezers stocked with frozen pink salmon. Several fishermen prefer their pink salmon prepared "tempura-style" by being dredged in batter and deep fried. Chum salmon and Chinook salmon are sought for baking, boiling, frying, grilling, and smoking.

Fish Preference

Many of our informants stated their preference for non-salmon species, especially broad whitefish, Arctic cisco, Dolly Varden, and burbot. Many research participants expressed their preferences for particular kinds of fish, from particular regions, prepared in particular ways. One respondent called highly prized subsistence goods "Iñupiaq gold." Some local delicacies include smelts from Wainwright, Arctic cisco from Nuiqsut, broad whitefish from Barrow (one informant observes a "tundra taste" compared to fish from Nuiqsut), and perfectly dried broad whitefish *pipsi* made by one particular expert who has a fish camp on the Nigliq Channel.

In both Barrow and Nuiqsut, residents expressed a wide range of preferences for salmon. There were some elders and younger people who stated explicitly that they especially enjoyed eating salmon, while others described their aversion to salmon. Some fishermen viewed pink salmon negatively for their perceived overabundance in certain years, as well as for their taste and consistency. Several informants referred to pink salmon as a nuisance species that clogs gill nets. One informant noted that families who fish for broad whitefish in the Chipp River consider pink salmon to be a nuisance species (Figure 1.1). Fishermen in the Elson Lagoon fishery (Figure 2.6), who often do not target any species in particular, stated that pink salmon can be a nuisance species. One informant said about his 2009 season, "I didn't set my nets last year, because they kept getting clogged up with pinks." Similarly, another interviewee reported, "In years when there are a lot of pinks, I'll pull my nets because I don't want to have to deal with too many fish." During these years, such as in 2008 when there were 1,551 pink salmon harvested in Elson Lagoon fisheries (Lemke et al. 2011), some fishermen pulled their nets when pink salmon were migrating through their fishing areas. Pink salmon have large humps on their backs that can become oily and have a foul smell when they near spawning condition. They can also be hard to preserve successfully. One Nuiqsut informant stated, "*Amaqtuuq*, once in a while we get these, but we don't eat them." When asked why, she said, "On this broad part they are stink. You have to take it out, that part, to cook it."

Although many informants stated that they choose not to catch large numbers of pink salmon, some fishermen will keep a net out throughout the season and harvest whatever the net brings. One fisherman relatively new to the Elson Lagoon fishery outside Barrow worked to sustain consistent fishing effort throughout the season and brought home all the fish his net catches. He often shared his catch, but took pride in feeding his extended family and neighbors by utilizing the pink salmon that others would rather not catch.

Evident in many of our interviews are the evolving taste preferences for salmon in the Barrow and Nuiqsut region. An elder in Nuiqsut said that when she was growing up, people did not eat chum salmon. She stated, "When I was growing up we feed the dogs with it, i*qalugruaq*. But nowadays they [people] sure like it." One young fisherman in Nuiqsut stated, "I love our salmon. That's basically why I go fishing in the summertime." A fisherman in Barrow commented that he did not eat salmon until he was older and went into the military. He stated, "(We) never did have much salmon when I was growing up.

Once I got out of high school and went into the military that's where most of us started eating salmon. Now it's a big thing, everybody wants salmon."

A Barrow elder remembered that people began to eat salmon, and more cooked food in general, when NARL began operating in Barrow and when oil development started to spread across the North Slope. One man who currently fishes in Barrow remembered that when he was younger they would spend about three months at fish camp. He recalled eating fish for three meals per day, but today he does not have a taste for fish. Although this fisherman did not prefer to eat fish, he still fished every summer to provide for his extended family and others in the community (Chapter 3).

2.3.3 Non-Salmon Species

Our thematic content analysis of interview data yielded a surprising finding. In our interviews about salmon use and knowledge, the most frequently coded theme was "non-salmon species." This finding emphasized the great importance of other fish species that are a food staple in the Iñupiat diet and the relatively marginal role salmon play in subsistence fisheries in this region. Extensive knowledge exists about the anatomy and morphological differences between whitefish species. Interview respondents showed no difficulty describing whitefish species and providing a description of when they are caught, where they spawn, and what time of the year they are caught. Salmon identification and description was more difficult, attesting to the long history of non-salmon species use and the relatively recent rise of salmon fishing.

A variety of whitefish species are harvested from different areas. Respondents often described their preferences for fish from certain areas, or from certain types of habitat. One fisherman used to buy fish for his father from a certain area. He noted:

> …you notice the ones I would buy I would buy from a friend of mine. They're a little more fattier and they had eggs in 'em. You know, just different from wherever you go… I know next to Atqasuk they're different. They're not fat but they taste like seaweed. And Dad always

> told me they were different. Like the one we caught from over where we used to have our cabin… fishes from different places on the Slope all taste different.

Many of our interviews included a discussion of the subsistence harvest seasons and which species are caught during particular times of the year. The summer salmon runs can overlap with migrating whitefish and Dolly Varden traveling during that time period. During winter ice fishing, whitefish and burbot are targeted without interruption from species such as salmon. Although non-salmon species are often the targeted species in Barrow and Nuiqsut, emphasis is placed on eating what is caught and not wasting any subsistence catch. The gill net fishermen see an opportunity to feed their family and the community with any fish they catch in their net. If fishermen are not willing to target a certain species, such as pink salmon during high run years, they will pull their nets to avoid wasting or having to process more fish than they and their extended sharing network can handle.

2.4 Summary

This chapter explored the use of salmon as a subsistence resource in North Slope of Alaska, knowledge about salmon, and perceptions of change in the abundance and distribution of salmon species over time. Table 2.4 presents a summary of the major findings reported in this chapter.

In our study, salmon catches were observed to be increasing, but perceptions about changing salmon abundance varied. Whether increasing catches are a result of increased abundance, increased effort, or an artifact of increased research attention are topics that need further exploration. The species composition of catches of fishermen in Barrow and Nuiqsut has changed over time (Chapter 4). Pink salmon and chum salmon have been common for many generations, whereas Chinook salmon and to a lesser extent sockeye salmon are considered new species regularly caught in this region within the last decade. Salmon are caught using gill nets in summer months when they are heading to spawning locations along the Beaufort Sea. Gill net locations are scattered throughout the North Slope, but many Barrow residents fish in Elson Lagoon, located about 16.1 km (10 mi) from Barrow (Chapter 4). Nuiqsut fishermen utilize the Nigliq Channel, north of Nuiqsut, to harvest most of their annual whitefish and salmon catches. Salmon is eaten fresh, preserved by drying or freezing whole, and is often an important part of annual holiday or ceremonial celebrations.

Table 2.4: Summary of observations of salmon knowledge and use, and related findings

Salmon Knowledge	• Salmon catches are generally perceived to be increasing, while perceptions about changing salmon abundance are mixed • Pink salmon and chum salmon have been caught for many years and have Iñupiaq names • Inconsistent usage of Iñupiaq and common English names for salmon and char species indicates under-differentiation and/or misidentification • Chinook salmon and sockeye salmon occur in the fisheries near Barrow and Nuiqsut, although the catch is relatively small compared to chum salmon and pink salmon • Sockeye salmon and Chinook salmon do not have Iñupiaq names, suggesting they are new migrants to the region • Informants have identified tributaries along the Beaufort Sea and streams near Nuiqsut where salmon are known to spawn, which may be useful information for future salmon research
Salmon Use	• Salmon are caught and processed by elders, adults, and youth primarily using gill nets • Salmon are part of the array of subsistence activities sustaining the Iñupiat throughout the winter and during other subsistence activities • Fishermen are learning about salmon and have tailored their gear toward catching certain species that their families and sharing networks prefer • Salmon is prepared and eaten in many ways, including baked, boiled, fried, grilled and smoked • Salmon preference is varied, but many enjoy catching and consuming salmon • Erosion and permafrost thaw have limited use of ice cellars to preserve fish • Dramatic cultural and environmental change has resulted in alteration of the timing, location, and technique of subsistence practice

Although salmon were the focus of this chapter, non-salmon species were the most frequently occurring secondary code item in our interview transcripts. Various species of whitefish, Dolly Varden, burbot, and other species are the primary targets of many fishermen. Most of the literature regarding fisheries research and the status of fish species along the North Slope has focused on whitefish species because those are the most abundant and directly targeted fish species in this region. Increasing salmon catches will hopefully provide more opportunities to answer many questions that we have begun to probe in this chapter. The use of traditional knowledge, in collaboration with scientific research, may provide insights about how environmental and social systems have changed over time and might help prepare for a future full of unknowns.

Chapter 3

Cultural and Economic Motivations for Participating in Elson Lagoon Fisheries

3.1 Introduction

During interviews seeking to understand knowledge and use of salmon (*Oncorhynchus* spp.) in Barrow and Nuiqsut (Chapter 2), I became interested in understanding the motivations for subsistence fishing in this region. I wanted an opportunity to explore in more detail some unexpected findings. For example, one active Barrow fisherman who used a 91.4 m (300 ft) subsistence net to fish in Elson Lagoon during summer stated in an interview that he did not like to eat fish. He did not eat fish, nor did he sell any of his catch. I wondered, what motivated this fisherman to spend so much time fishing? Similarly, I was surprised that many of those participating in ethnographic interviews described in Chapter 2 expressed a strong aversion to commercial fishing activity.

In this chapter, I focus on understanding what motivates people in the North Slope region to fish, particularly focusing on the Elson Lagoon fishery near Barrow (Figure 3.1). It is important to describe motivations for Elson Lagoon subsistence fisheries because there are currently no large-scale commercial or recreational fisheries in the region. Other regions in Alaska have had commercial salmon harvests for over a century. For example, the Bristol Bay salmon fisheries, for example, were primarily subsistence fisheries which became heavily utilized by commercial canneries in the late 19th century (Troll 2011). The Beaufort Sea is devoid of this level of commercial fishing activity, although there have been commercial fisheries for whitefish species (*Coregonus* spp.) which make its fisheries different from others in the state. Because subsistence is a deep spiritual connection to the land, along with a way to offset the cost of modern lifestyles, specific motivations for subsistence fisheries are multi-faceted and difficult to parse out (Condon et al. 1995).

Commercial fisheries can be defined as the harvest of fish resources to maximize profits. Recreational fisheries can be loosely defined as engaging in fishing activity for entertainment. Subsistence fisheries provide food, along with a multitude of social and cultural services. Subsistence, as defined by the Inuit Circumpolar Council (1992), is:

> A highly complex notion that includes vital economic, social, cultural and spiritual dimensions. The harvesting of renewable resources provides Inuit with food, nutrition, clothing, fuel, harvesting equipment and income. Subsistence means much more than mere survival or minimum living standards. … It enriches and sustains Inuit communities in a manner that promotes cohesiveness, pride and sharing. It also provides an essential link to, and communication with, the natural world of which Inuit are an integral part.

Although commercial fisheries do not currently occur in the Elson Lagoon region on a large scale, during local resource management meetings local leaders expressed a desire to understand local perceptions of potential future commercial fisheries development. Understanding the variety of reasons why Elson Lagoon fishermen participate in fishing is essential to understand the importance of fish to the families and communities who depend upon these resources, and also to assess future changes to fisheries.

The primary goal for the research described in this chapter is to better understand the motivations for fishing activity in Elson Lagoon. Motivation studies (e.g., Stairs and Wenzel 1992, Fedler and Ditton 1994, Condon et al. 1995) have illustrated that resource harvest activities have complex drivers. For example, Iñupiat subsistence practices reflect close spiritual connections with the land, animals, and the community. The act of becoming a mature Inuit, according to Stairs and Wenzel (1992), necessitates that a person is connected with the land and the community through subsistence. It is through being a conduit between the environment and a human community that an individual becomes a “whole” person. Jolles (2002) suggested that it is within cultures that harvest large marine mammals that this view of individual-community-environment personhood is strongest, as cooperation is a central requirement of such activity. In order to understand how Iñupiat values are expressed in subsistence fishing and to better understand the role of fishing in this region, I conducted ethnographic research exploring values motivate fishing activity. I also investigated the economic importance of fish and how economic factors influence fishing activity. Furthermore, I examined local opinions about potential future commercial fisheries development in this region.

Figure 3.1: Map of the Barrow area and Elson Lagoon. Map source: Google Maps 2012.

3.2 Methods

As described in Chapter 2, key informants were identified using a purposive, snowball sampling method (Bernard 2006). Snowball sampling is a process whereby community leaders recommended active, knowledgeable, and long-time fishermen who then recommended other knowledgeable and active fishermen. The subsequent interviews were open-ended and semi-directed. Using the semi-directed approached enabled me to individually tailor each interview to capture the experiences of individual fishermen (Spradley 1979, Huntington 1998).

Nine interviews were conducted with Elson Lagoon fishermen to specifically explore the topic of motivations for fishing in more detail (UAF IRB 09-38). These interviews were conducted in Barrow from 14 July - 17 August 2011. For these interviews, I did not develop a separate interview protocol (e.g., as in Appendix A), but rather generated a few questions to guide the discussions of this topic. As subsistence practices are so common in everyday life in Barrow, I did not ask direct questions, such as "why do you fish?", but indirect questions such as "when are fish eaten?" and "why should young people learn to fish?". These questions helped to reveal the importance of fishing in everyday life without asking people to analytically reflect upon these commonplace practices (e.g., Fedler and Ditton 1994, Condon et al. 1995).

Each interview was transcribed and coded using a code list in Atlas.ti (Muhr and Friese 2004). While the secondary code "motivation" identified interview data pertinent to the topic, as well as related codes, e.g., "sharing" and "learning," fully exploring this topic also required a thorough analysis of the many stories and anecdotes that interviewees shared to provide lessons pertinent to this theme.

Although only nine interviews focused on understanding motivation in more detail, all additional interviews described in Chapter 2 were also analyzed for material relevant to this topic. In total, 120 specific quotes from 23 interviews were analyzed.

Participant observation was also conducted in 2011 focusing on the Elson Lagoon set gill net fishery, community gatherings, meals, and other local events and activities. This technique allowed a deeper understanding of the activities, customs, and language of the informants and helps build community rapport (Bernard 2006).

3.3 Results and Discussion

Overall, I found that cultural and economic factors largely motivated fishing in Elson Lagoon. Fishing activity in Elson Lagoon provided Barrow residents an opportunity to engage with each other and their environment close to town. While out on the land with friends and family, youth and those recently introduced to a subsistence way of life are provided the opportunity to learn cultural practices and feed themselves and others fresh seafood. Respondents also indicated that fishing in Elson Lagoon was helpful to relieve economic pressure that increases as the cost of living rises in Barrow. Fishing helped to balance food costs, transportation needs, and provided a relatively low cost subsistence activity in which a wide array of Barrow residents participated.

3.3.1 Sharing and Barter

A primary motivating factor for participating in the Elson Lagoon fishery is harvesting fish to share. My interview and participant observation data demonstrated that the people of Barrow share much of their catch with other people in the community. One of the most active fishermen in Barrow, who is noted previously for his personal aversion to fish, gives away every fish he catches. Catching fish to share is mentioned by many informants as a core Iñupiat value, and our respondents observed this sharing in a variety of ways as illustrated by four fishermen below:

> Last year we gave away 75 percent of our catch. Our neighbors and everybody wanted fish, so I keep supplying.

> Fishing, it helps when people are having hardship. I mostly give away whatever I can depending on my catch…I only fish for what I handle and the rest I give away.

> I keep gunnysacks of fish that we caught in the fall outside so when people ask for food or when a family is hungry we get a couple of them and supplement it with caribou to feed the family. We do this year-round… (we) catch more than we need. We're fortunate enough, we're working and have snowmachines.

> It's part of our culture, sharing. Whatever you catch you share. The thought is that if you share you get more next time. That's just how

> my mom and dad raised me. When you catch something share with family, share with elders.

Fishing in Elson Lagoon requires cooperation and often many family members are needed to set nets, pick fish from gill nets, and to process the catch. Many families have extensive sharing networks that extend beyond these cooperation networks. Generally, a sharing network outside immediate family receives the excess after a family has stored enough for the winter. One fisherman recalled his sharing patterns, which is representative of many fishermen in Barrow:

> I usually feed the elders first, with the whitefish. And then the widows who don't have any hunters or somebody that's going to provide for 'em. They're getting fewer and fewer every year but I still go around and take them over to the senior center, to the assisted living so they'll have fresh fish and whatever. Then when I get to salmon I let people come and get 'em.

Many individuals are included in sharing networks: family members, neighbors, business partners, and friends that live outside the North Slope region. One fisherman who has fished in both Barrow and Nuiqsut stated, "…we don't trade. If we got it, we'll give it to our neighbors." Several interviewees mentioned giving fish away en masse at the fire station, airport, senior center, or a softball game when they caught more fish than they could distribute or store. Fish are not wasted and are a widely shared resource in North Slope communities.

As I learned during my interviews and participant observation, sharing extended past food for Iñupiat people. When someone is traveling out on the tundra, ocean, or ice, people keep in constant VHF radio contact with each other and with the North Slope Borough Search and Rescue Department. If someone has captured a large animal such as a walrus (*Odobenus rosmarus divergens*) or needs assistance, willing responders will come to their aid with no questions asked. During an interview in Barrow, an elder was spreading the word about a family in Wainwright (west of Barrow along the Chukchi Sea) who was in need of clothing, supplies, and food after a house fire. Through the interview process and participant observation, we experienced many accounts of the people of the North Slope taking care of one another.

Trading has been an Iñupiat activity for thousands of years (Jensen 2012). One Barrow elder remembered his family members meeting with interior Athabaskan groups to trade in the mountains south of the Barrow region. As he recalled, Athabaskans would bring smoked salmon and moose (*Alces alces*) to trade, and the Iñupiat would have whitefish and marine mammal products to trade in return. Younger people, and some elders, have created trading networks for their particular fish. One of our Barrow informants stated that he trades Barrow salmon for Atqasuk whitefish with relatives because he preferred the flavor of the whitefish found in the lakes in that region (Figure 1.1). Along with other Iñupiat, Barrow residents often trade with Filipino community members who live in Barrow, many of whom enjoyed eating salmon soup.

During my time in Barrow I observed infrequent and small-scale sales of individual fish, packaged fish, or plate meals. Flyers on bulletin boards advertise fish for sale. Salmon plate lunches are announced for sale on the VHF radio. A plate of salmon, rice and an “Eskimo donut” sold for $10 in 2010, a relatively cheap price compared to the cost of an average restaurant meal in Barrow (roughly $20). The local sale of subsistence- caught fish is minimal and is not a regulated commercial activity, but a form of local barter. Individuals who, during interviews, described trading or selling fish products stated that they did not make a living off the sale of fish but viewed these practices as consistent with a customary barter system. Some elders frowned upon the commodification of subsistence fish in my interview data.

Several fishermen openly discussed their traditional bartering practices. Others, however, did not provide information openly and stated that they did not participate in any barter or sale of their subsistence goods. Recently, there has been increased attention paid to the barter and sale of subsistence goods. Elders and fishermen who harvested salmon along the Yukon River have been investigated by the U.S. Fish and Wildlife Service for the sale of Chinook salmon (*Oncorhynchus tshawytscha*) that were allegedly harvested illegally (Mowry 2010). Although trade and barter is a customary practice, interview respondents were often reluctant to share information.

Barter and trade practices may also be influenced by species shifts. When I was younger, my family had a sharing relationship, through family ties, between Bristol Bay and Barrow. We would often send up boxes of smoked salmon in return for bags full of various waterfowl and a variety of marine mammal muktuk. These items were scarce in our communities so it was advantageous to make use of modern technology to acquire subsistence goods from another region. In recent years, however, the need for salmon on the North Slope has decreased. This has resulted in the sharing relationship breaking down so waterfowl and marine mammal muktuk is no longer traded in large quantities for smoked salmon between our particular family groups.

3.3.2 Commercial Fishing

Given our focus on salmon, some local leaders showed concern at meetings that because salmon are commercially valuable in other regions of the state, growing numbers and catches of salmon in the North Slope may result in development of commercial fisheries in the future. Federal fisheries managers in the U.S. have also begun to assess Arctic waters for potential commercial fisheries (North Pacific Fishery Management Council 2009, 2011). In 2009, the North Pacific Fishery Management Council put a hold on developing commercial Arctic fisheries until adequate information has been gathered for finfish and shellfish species (North Pacific Fishery Management Council 2011). This precautionary approach was implemented in an attempt to develop fisheries in a sustainable manner. I explored the topic of potential future commercial fisheries development in many of my interviews.

Commercial fishing is virtually absent in the North Slope region. Beginning in 1964, one family has operated a small-scale commercial fishing operation in the coastal Colville

River delta region that supplied a regional market for whitefish in Barrow and other villages. However, this commercial fishery has recently stopped its production due to economic constraints (Marine Biological Consultants, Inc 2003). Only a handful of residents have ever held commercial fishing permits (Alaska Department of Fish and Game 2012a). One of our informants mentioned that there has been some local interest in a commercial whitefish fishery in the Ikpikpuk River delta for local sale. Only one Barrow fisherman has ever purchased a commercial permit for whitefish harvest in the Ikpikpuk River fishery (Alaska Department of Fish and Game 2012a).

The majority of interviewees expressed concern about future commercial fisheries development. Subsistence is consistently defined as the primary focus of their activities, and many respondents stated that they do not want commercial activities to influence their lifestyle. During one of our interviews, a Barrow elder gave an account of a discussion regarding commercial harvest of resources. He remembered that it was promised during the planning stages of the North Slope Borough in the 1970s that commercial harvest of subsistence resources would not be allowed in the Borough boundaries.

Two respondents in Barrow, however, felt if salmon, halibut (*Hippoglossus stenolepis*), or king and snow crab (*Paralithodes* and *Chionoecetes* spp., respectively) were to become sufficiently abundant in the Chukchi and Beaufort seas to support commercial harvests, developing local commercial or recreational fisheries might be appropriate. Individuals who showed interest in developing commercial fisheries stated that the local economy would benefit from other opportunities for development. Specifically, one respondent cited Homer, which has a tourism-based economy and benefits from fishermen passing through the community. The individuals who were opposed to developing commercial fisheries expressed concerns regarding the effect current development has on subsistence patterns.

3.3.3 Economic Savings

In many ways, subsistence fishing in Elson Lagoon complements the mixed economy in Barrow where many individuals have salaried jobs and also engage in subsistence as a key part of their daily lives. Local informants and previous research have indicated that the price of store-bought food has increased greatly in recent years (Magdanz et al. 2010, Moerlein and Carothers 2012). Supplementing their diet with locally caught fish helps keep the annual cost of food low. One fisherman stated, "All the high prices of food up here, we rely on the fish for food." Another fisherman noted, "More and more, they want to fill their freezers locally." The price of food is high in Barrow as it is off the road system and requires food to be barged in around the coast of Alaska, or flown in with several flights which span the state.

The technology required to participate in most subsistence activities is expensive (Moerlein 2012, Moerlein and Carothers 2012). Fishing in Elson Lagoon, however, is a less-expensive alternative to traveling far outside of town to set nets in river and lake systems. Elson Lagoon is located 16.1 km (10 mi) outside Barrow near Pigniq (Figure 3.1) and fishing locations are accessible with trucks and all-terrain vehicles (ATVs). Many residents do not require a boat with a motor to pick fish from their nets (see also Section 2.3.2 Salmon Use). There are many techniques used to harvest the fish from gill nets, but most fishermen interviewed use chest waders, small dinghies, or a pulley system to bring the fish to shore (Chapter 4). Using a truck or ATV to travel to fishing sites is cheaper than using a boat and motor, which may often be more expensive to purchase and maintain. Another benefit to a low technology method, according to several Elson Lagoon fishermen, is that inclement weather does not often interfere with the ability to fish, as methods that keep fishermen close to shore in shallow water are safe in windy conditions.

Another cost-saving measure that one respondent in Barrow utilized was a dog team to travel during winter subsistence activities. Below, he emphasized how important it is to be less dependent upon outside sources of food and fuel for survival:

> Interviewer: Do you think it's important for young people to learn how to fish out there (Elson Lagoon) and in the lakes?
>
> Respondent: Yeah, you know, oil isn't going to last forever. When you live in a place like this, when you subsist you can live a good life. There's always plenty to eat and you're never going hungry. Once you get completely dependent on money, the high priced food at the store ruins your life. I think, you know, subsistence economics is really cool with catching the fish for the dogs. I can feed the dogs about 10 fish per day for fuel. We go out there and catch 300 or 400. In a little over a week, with a pretty minimal investment you can catch enough fish to feed them all winter. Everyone is so dependent upon buying gas it has made subsistence pretty expensive. (It's) neat to be engaged in something that you can turn a profit on.
>
> Interviewer: I wonder if you added up how much you have saved over the years it would probably be phenomenal.
>
> Respondent: When I do order dog food I order 1,000 lbs and it costs $1,000. With using fish, I usually have two orders per year. If I had to use only dog food, I would have to order six orders per year. I save thousands of dollars.

Not only are the methods in which Elson Lagoon fishermen traveling to their fishing sites more economically sound, but the gear used to harvest fisheries resources are less expensive than snowmachines, guns, and boats used for hunting and whaling. A fisherman can buy a net for several hundred dollars and have the means to provide a versatile protein source for his or her family and extended network for years to come.

According to informants, the upkeep on a gill net is relatively low compared to maintenance and shipping costs of boats and guns, and many fishermen mend their own nets and have many nets to use to ensure steady fishing when necessary. Furthermore, many respondents have several mesh sizes in order to capture a variety of species for their sharing network. By utilizing these strategies, fishermen provide a wide range of protein sources with a relatively small monetary input. Nets are also gifted to those that are entering the fishery. Young people or those who are not local are often given nets and mentored by another fisherman so they can feed their families and enter the subsistence lifeway (see Section 3.3.5 Learning).

3.3.4 Subsistence as Recreation

Elson Lagoon fishermen discussed their experiences subsistence fishing with fondness and smiles on their faces. Many often share stories about taking their family members and friends to the net. One fisherman recalled his experience fishing in Elson Lagoon, "(Fishing) gives us a reason to go out and just get outside, better than staying home. We sure don't need all the fish we catch. We just enjoy doing something."

Participant observation conducted at the Elson Lagoon net sites offered a glimpse into the importance of the fishery. Often three generations of a family were working together and the air was filled with laughter even when the weather was dreary. Smaller children played in the water and sometimes observed strange species, while older children helped clean the net and brought fish to the vehicle.

Along with recreational subsistence fishing in Elson Lagoon, there were others who go to Elson Lagoon to try their luck at rod and reel fishing. Casting is often a catch-and-release activity in other parts of the United States, but is another form of subsistence harvest for those who are lucky enough to catch a salmon or trout on the North Slope. Often elders and young people can be seen parked along the side of the road in Elson Lagoon casting for whatever may come across their hook. On warm days there are many people gathered by the Lagoon's calm water to enjoy the relative warm weather, generally 10°C and above, and attempt to bring home a fresh meal of fish.

Although fishermen in Elson Lagoon enjoy fishing, they do not consider themselves sport or "recreational" fishermen. One fisherman stated that it is unethical to "play with your food", as sport fishermen do when they practice catch-and-release methods. This observation draws into focus cultural relativism – what is ethical from one perspective is considered unethical from another. Fish caught with rod and reel in Elson Lagoon or other local waters are taken home to be utilized in the same way as fish caught in gill nets.

3.3.5 Learning

Culturally, subsistence fishing is more than harvesting food from the ocean, rivers, and lakes to feed a community. As expressed in interviews, subsistence provides teaching tools to ensure survival, develops appropriate behaviors and relationships, and fosters the well-being of the next generation. Many lessons are taught picking nets and spending time at fish camp along rivers, lakes, and beaches on the North Slope. While food is being gathered, young people are mentored. They learn not to waste fish, to work hard, and to share what they catch. The community sustains and reproduces itself through harvesting a sustainable resource. Furthermore, there is a healthy exchange between individuals and their land that is important for physical and spiritual well-being of those that live near Elson Lagoon. One fisherman emphasized the importance of fishing:

> It's one of those things that you feel you're doing things right. You're harvesting a local, replenishable resource… it's a real good family thing to do because everybody can be involved with it. It would be a good skill for them to have so they could feed themselves in the future.

While fishing, one learns how to read the weather, survive on the land and water, speak Iñupiaq words for plants and animals, and carry on traditions of hunting and gathering. Many of the respondents who we interviewed stated that they willingly take young boys and girls out fishing with them so that they could benefit from these experiences.

Oftentimes, they go fishing for the main purpose of showing young people how to harvest fish and to serve as mentors. Many of the elder men and women I interviewed opined that young people spend too much time indoors and do not value being on the land and learning about being Iñupiat.

One Barrow fisherman noted that he consistently brings young people fishing and hunting and allow them to bring back part of the catch and give it to their immediate family, other relatives, and neighbors. Fishing and sharing generate a strong sense of accomplishment and pride in the young subsistence users. One elder expresses that he tries to take young children out fishing or hunting if they do not have a person in their family that goes out hunting. Also, if a young person is having trouble adjusting to the Western lifestyle of school, work, and electronics, it often is a healing experience to spend time with a mentor on the land and to take something home to share (Condon et al. 1995).

There is agreement among elders interviewed in Barrow that too few young people are engaging in subsistence fishing. One elder woman stated that it was upsetting to her that no young people or fishermen were utilizing the large pieces of ice stranded on the beach to jig for Arctic cod (*Arctogadus glacialis*). She emphasized that when she was younger, everyone in Barrow would have been out on the ice harvesting the oily fish. She said that fishing is an important tool for survival, and young people should know how to gather food throughout the year in case of a scarcity of resources. As discussed below, fishermen voiced their frustrations that many young people know how to play fishing games on their electronic video game consoles, but lack the skills to participate in subsistence fishing. Many of these fishermen take young people with them to encourage the next generation to be interested in, and skilled at, subsistence fishing.

Fishermen discussed learning how to fish at camps located throughout the North Slope. Many fishermen also pass down those skills in Elson Lagoon and at fishing and hunting camps. Today, fish camps are used for shorter durations (usually weekend trips) than 20 to 30 years ago due to salary jobs and various obligations in Barrow (see Chapter 2 for a discussion of Nuiqsut fish camp usage). Often weekend trips are embarked upon to escape town and daily distractions. Adults take time away from the stressors of work to spend quality time with family (Knopf et al. 1973), and children often learn how to survive and harvest food at locations used by many generations. The winters in school classrooms are often spent telling fish tales from time spent at fish camp. Camps are also used during winter months for hunting and ice fishing, which is also an important time to harvest fish for the sharing network and family. Interview respondents discussed harvesting whitefish and burbot through the ice at camps to have fresh fish to share throughout winter months.

Those individuals interested in participating in subsistence, but who are not originally from the North Slope, are often allowed to enter into the world of subsistence through engaging in Elson Lagoon fishing activities. Several of the respondents we interviewed were from outside of Barrow, or outside of Alaska, and had made Barrow their home later in life. They learned from friends about fishing and utilized methods passed down from those that allowed them to enter their realm. Because Elson Lagoon is a common property fishery, the entrance of "outsiders" is granted by those who already possess knowledge of the fishery. Non-local people who are welcomed into the resident fishery are often those who have morals and values that parallel those of current fishermen (Miller and Van Maanen 1979, Acheson 1981, Miller and Van Maanen 1982). Interviews with respondents introduced to fishing by local people were littered with many stories about sharing fish selflessly and teaching others, which exhibits the Iñupiat values of sharing subsistence harvest and teaching others.

Interview data contained stories about people learning to fish quite recently, both long-time residents and newcomers to the region. One informant shared this story:

> Last year I talked to a 40-year old man that had never fished before, from here. I told him about all the fish we were catching. We're not serious, we don't put out more than one net, that's just unusual for us.

> This is just fun for us, we don't want to make it work, too hard. I told that young guy how we do it up here and got him all excited. I saw him out in a boat when we were checking our net. I flagged him down and asked him what he was doing. He said he was looking for a place to set his net and he found a net under somebody's house and was given permission to use it. So I showed him how to set it. The next morning he had his first fish ever as a local man. His dad gave up on him because when he took him out hunting he would always fall asleep on the sled and didn't pay attention. The dad just stopped taking him. It ended up being that guy was so excited he started fishing very seriously.

One non-Native fisherman who moved to Barrow several years ago has fed his family and shares catches with friends and neighbors with the catch from one net. He never participated in a subsistence lifestyle before moving to Barrow from the continental United States. A friend who he worked with showed him where to fish, gave him a net, and has been part of his sharing network in which he shares information about the conditions of the weather and fishery. For this fisherman he has felt like a part of the community now that he can participate in an activity which many residents are engaged.

3.3.6 Well-Being

Several interviewees stressed the point that subsistence practices, including fishing, are part of on-going healing processes for many indigenous peoples. A diversity of challenges confronts North Slope residents such as environmental change, development, and living on a border between a Western and Iñupiaq lifestyle (Chapter 2). Passing down knowledge and seeing a young person fish makes a fisherman feel fulfilled in his or her duty to be a knowledge bearer. The strong value of sharing is embraced and the way one was taught is the way he or she teaches the next generation. One whaling captain stated that his crew is responsible for working hard to ensure people do not go hungry. Also, those with jobs, vehicles, and boats also feel obligated to share the wealth they have in material goods by keeping sacks of fish and stores of caribou (*Rangifer tarandus*) on hand to give to those that are hungry in winter months. Interviewees stated that following teachings by their elders and family members creates a person who feels good about providing for others, feels fulfilled, and will lead a long, prosperous life. On the topic of the personal benefit of sharing fish, one fisherman shared, “It’s a bit of prestige to be able to catch a little bit more and give some away. You know, provide for a few people. Which makes you a fully functional male adult in this society.”

Many elders expressed concern that young people need to get outside and get adequate exercise to maintain physical fitness. One fisherman in Barrow stated that his younger nephews and nieces only know how to catch fish on a video game system. These simulated situations cannot be shared with others, but interview respondents stated that if these young people were instead brought out to Elson Lagoon to go fishing they could bring something tangible home to share. Furthermore, elders stressed they need to learn important skills which may increase their current and future well-being.

3.4 Summary

Overall, in this chapter we see that cultural, economic, and social values motivate subsistence fishing in Barrow. Core Iñupiat values, such as sharing and connection with the land are key motivators. Further, we see that subsistence fishermen are generally concerned about future large-scale commercial fisheries development of species such as cod, halibut, and crab, which may compete with these cultural values.

Sharing subsistence catch motivates fishing activities in Elson Lagoon. The drive to harvest for sharing is strong and may consume the short summer season for many fishermen. Many fishermen are blessed with jobs and vehicles that are capable of harvesting fish and sharing and they see those goods as a blessing. Sharing is as much a help to those who receive fish as to the well-being of the ones who do the sharing. Furthermore, individuals who share with the community by providing food and teaching others how to utilize resources are said to “never be without.” In this way, respondents feel they are ensuring they will receive future subsistence catches, help future generations feed themselves, and ensure the continuation of their community.

Sharing comes in many forms. Young people and non-local people who wish to fish are taken on as apprentices by those who possess the knowledge to pass on. Information is often shared freely with willing young people. The cultural importance of subsistence practices for well-being is an important motivating factor for many people. Many interviewees described fishing as a positive activity, binding generations, providing an outdoor activity for mental and physical well-being, and an escape from town-related stresses. This aspect of subsistence, and in this case motivating factors for fishing, are often overlooked and should be made more central to other research endeavors.

Economic factors also motivate people to fish in Elson Lagoon. Food is expensive on the North Slope and store-bought fresh seafood is exceptionally expensive. Locally caught fish lessens a family's dependence upon store bought food. Also, the method of harvest is relatively inexpensive so many families can afford to fish in Elson Lagoon. Decreasing the amount of fossil fuel input and bringing families outdoors together increases the current and future well-being of residents of Barrow. The cost of living is high in Barrow, so wage employment is usually required, but time away at fish camp provided families with important time away from the city while being connected to their land and family members.

Another key finding of this research was the sense of changing conditions that many informants discussed in their interviews. Although other cultural groups in Alaska are experiencing the restriction of their fisheries and barter systems, the fishermen of Elson Lagoon are adapting to an increase of fish caught (Chapter 2). This "salmon fever" already exists in other areas of Alaska, while Barrow residents have a more recent exposure. Small-scale barter and sale of salmon and other fish on a local level is small compared to large commercial enterprises that often distribute fish nationally or internationally. Local fisheries, however small, provide an important income for some. Elders and traditional fishermen talk about the sale of fish with disgust, but the fish are being sold locally so other residents are able to consume a relatively inexpensive, fresh, local seafood source. As the social and physical environments shift, so do the practices of fishermen and fisheries in Elson Lagoon. Fisheries practices and values are not static, but change over time. Evident in our interviews was the vital importance of subsistence fishing, for personal, cultural, social, and economic reasons.

Chapter 4
The 2011 Elson Lagoon Subsistence Gill Net Fishery

4.1 Introduction

The Iñupiat who live along the Beaufort Sea have been highly dependent on migratory resources for thousands of years. Traditionally, families were semi-nomadic, living in large settlements and traveling between outlying camps throughout the year targeting migrations of subsistence animals. A large settlement at Nuvuk was located at Point Barrow and was occupied from 300-400 AD to the present (Jensen 2012). Nuvuk was one of about two dozen villages located between the Colville River and the Seward Peninsula before Euro-American contact (Fogel-Chance 2002). The location of Nuvuk was advantageous for many reasons, one of which was the close proximity to migrating marine mammals, waterfowl, and fishes. The contemporary community of Barrow is located about 16.1 km (10 mi) southwest of the prehistoric village of Nuvuk (Figure 4.1). Families in Barrow continue to rely on the seasonal migrations of animals and fishes that pass near Point Barrow. While many families in Barrow still maintain active seasonal hunting and fishing camps distributed across the region, camps at nearby Pigniq (Figure 4.1) served as convenient seasonal camps for hunting, fishing, and recreation.

The earliest written accounts of gill net fisheries in Elson Lagoon, specifically harvest of salmon species, occur in Murdoch (1892). This account lists pink salmon (*Oncorhynchus gorbuscha*) and sockeye salmon (*O. nerka*) catches in Elson Lagoon during an expedition between 1881 and 1883. Elson Lagoon was historically, and is currently, utilized for harvesting fishes passing through the area on their seasonal migrations. In our ethnographic interviews (Chapter 2), Barrow elders remember the lagoon being used for seal hunting. One elder in his 80s gave an account of fishing activity in Elson Lagoon from when he was young:

> I did not see anyone using nets to harvest any fish out there (Elson Lagoon). People would use nets to catch fish, but at Arilivmik they

> would put out nets for catching seals. They would be catching the seal pups on their nets. They would catch the young seals at Nuvuk in the inlet. They had always caught the young seals there by using nets. They would net for the seals in the summer and around August and September.

Another elder remembered his first fishing experience in Elson Lagoon in his father's *qayaq* in the early 1950s. His father set a gill net there during the summer months to catch whitefish species (*Coregonus* spp.). According to Barrow fishermen, gill net fishing in Elson Lagoon increased in the late 1980s. The close proximity of Elson Lagoon to town enables individuals with full-time employment to easily access their fishing nets after work and on weekends (Brewster et al. 2008). Between July and September, Elson Lagoon supports a thriving subsistence gill net fishery, and over 30 fishermen have been setting nets in recent years.

Ethnographic interviews exploring changes in salmon use and knowledge (Chapter 2) and the North Slope Borough Department of Wildlife Management (NSB DWM) net survey project identified a need to better understand the current status of the Elson Lagoon subsistence gill net fishery. In collaboration with North Slope Borough, I helped to collect and analyze fisheries catch and effort data during the 2011 season. The data from the 2011 Elson Lagoon net survey and catch logbooks, along with NSB DWM fisheries surveys from 2006 to 2010 (Lemke et al. 2011), provided a baseline to compare to future seasons. The objectives of this chapter were to: 1) use 2011 net survey and logbook data to provide an estimate for fishing effort, catch composition, and salmon catch rates, and 2) to provide a baseline to assess potential fisheries changes linked to environmental change and increased marine development.

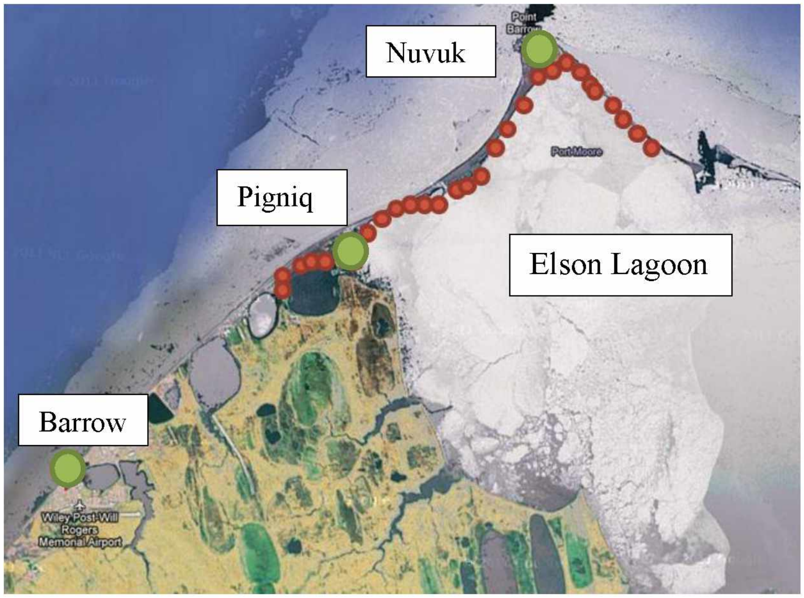


Figure 4.1: Map of the Barrow area and nearby points of reference (large green circles) and subsistence gill net locations recorded in 2011 (small red circles). The nets are set in the western portion of the Elson Lagoon shoreline from the North Salt Lagoon to Plover Point. Map source: Google Maps 2012.

4.2 Methods

As described in greater detail in Chapters 2 and 3, 41 key informant interviews were conducted with elders and active fishermen in Barrow. Participation observation was also conducted at net sites in Elson Lagoon in 2010 and 2011 (Bernard 2006, Chapter 2).

The Elson Lagoon fishery was assessed in 2011 as part of a summer internship with the NSB DWM monitoring project. Harvest effort and catch rates were calculated using daily net observations and fishermen's logbook data of recorded catches. Data collected during daily net surveys of each net set in Elson Lagoon included GPS location, net length, net mesh size, a unique identifier if present (or a net description), and the name of the fisherman (if known). Net length and mesh size were provided by local fishermen or measured using a range finder and tape measure. Raw data recorded in the field were transferred to data sheets created by NSB DWM biologists, and data sheets were then entered into a spreadsheet and also scanned for digital archives.

The aforementioned net count data described were used to estimate fishing effort. “Daily net effort” was defined as the number of nets fishing per day. Net length for the net surveys was standardized to 18.3 m (60 ft) (Lemke et al. 2011). A “net-day” was a 24-hour period soaking a 18.3 m (60 ft) net. “Total effort” was the sum of the net effort for all days in the fishery period.

Net effort was recorded over a 92-day period near Barrow, Alaska, by NSB DWM interns, and staff biologist Dr. T. Sformo, and me during summer 2011. Another aspect of catch monitoring by the NSB DWM was a logbook program. At the start of the 2011 season, 12 active fishermen were given logbooks to record their daily catches (Figure 4.2). These fishermen were selected based on their regular contact with the NSB DWM. In 2011, 12 logbooks were returned to the NSB DWM to be analyzed. One entire logbook was completed while the fisherman was at fish camp on an inland river. The fish camp catches were outside the study area so the logbook was not considered in the analyses of the Elson Lagoon fishery.

Logbook data provided details about species composition and total catch numbers for 11 Elson Lagoon fishermen. Net length and net mesh size were often included only in the first entry, unless fishermen use different nets. The general notes section mainly included information about weather, distribution of the catch (kept or given away), and other unusual observations such as an influx of jellyfish or a seal entanglement. Catches were recorded as the total number of fish caught in a gill net per day, and the unit of effort was net days. The results of the logbook fish species compositions and total catches were not used to provide extrapolated estimates of the total fishery because the logbooks were not distributed randomly, which could lead to biased estimates (Arce-Ibarra and Charles 2008).

Name of Net Checker: ______________________

Camp or Cabin Name: ______________________

Specific Net Location: ______________________

Net Number	Date Net Checked	Net Length	Mesh Size	Fish Species	Number Caught

General Comments:

Fish Species	Number Caught

Figure 4.2: North Slope Borough Department of Wildlife Management subsistence fishing logbook example.

4.3 Results and Discussion

4.3.1 Species Targeted

During ethnographic interviews, fishermen stated that fish caught in Elson Lagoon were harvested with gill nets when fish were at peak quality during spawning or overwintering migrations (Chapter 2). At this time, their lipid reserves are high and roe are in a preferable condition. Many Elson Lagoon fishermen stated that they do not target particular species, but rather they set their nets hoping to catch whatever species they can. Other fishermen stated that they avoided certain species by removing their nets during peak their migrations (such as pink salmon, see Chapter 2). Section 4.3.3 Survey and Logbook Data below describes the composition of the Elson Lagoon catch for 2011. These data presented only represent the Elson Lagoon fishery and do not take into account fish camp harvests, which are primarily whitefish.

4.3.2 Harvest Methods

There are a variety of harvest methods used by Elson Lagoon fishermen. Many fishermen described learning their techniques from family and mentors, or people with experience in other regions of Alaska. The dominant method is to set a gill net such that each end is anchored and the net is oriented perpendicular to the shoreline. These nets come in a variety of mesh sizes and materials, but the range of mesh sizes used in Elson Lagoon is between 6.35 and 20.3 cm (2.5 to 8.5 in). Materials used for gill net mesh include both monofilament and nylon. Today, many fishermen use monofilament as it entangles fish more effectively than nylon. Two ropes on the top and bottom of the gill net are used to keep the net afloat and anchored, respectively. The top rope (float line) has floating corks that keep the net floating at the surface, and the lower rope (lead line) is a lead line weighting the net to the lagoon bottom (Figure 4.3). The majority of Elson Lagoon fishermen keep nets submerged throughout the span of their fishing activity, while others have employed a pulley system to make cleaning and picking the net easier.

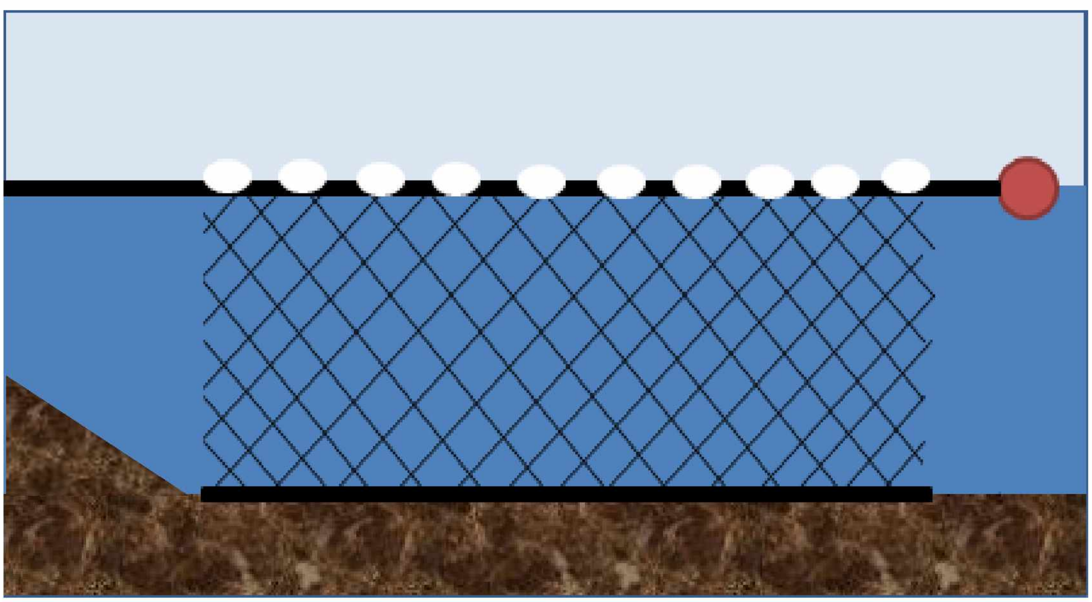


Figure 4.3: Example of a set gill net used in Elson Lagoon. Shown is the line connecting the net to shore (long black line, top), gill net mesh, small cork floats (white circles), buoy (red circle), and a lead line along the sediment (short black line, bottom).

One of our study respondents, who moved to the North Slope and started fishing in the 1970s, described learning his gill net technique in Point Hope. He anchors a ring offshore below the buoy and connects a line from the outer end of his net, through the ring, to shore where he ties that section of rope to an anchor at shore (Figure 4.4). This enables the fisherman to pull the net in using a loop of line connecting the outside of the net to the shore. This fisherman preferred not to use a boat or chest waders to harvest fish because these methods are not effective in adverse weather. Other fishermen utilize small boats, chest waders, hip waders, or completely pull their nets inshore when they pick the fish.

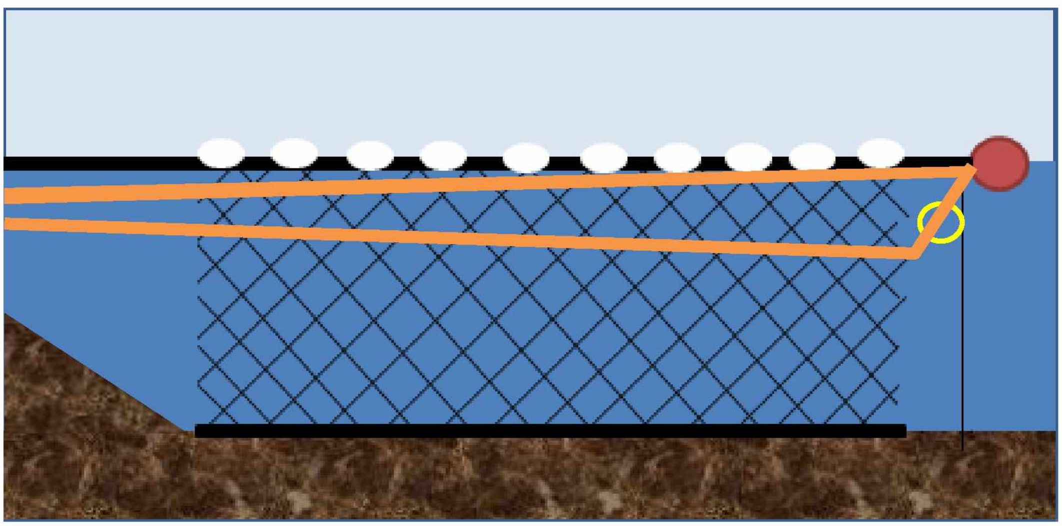


Figure 4.4: Example of the Point Hope style set gill net used in Elson Lagoon. Shown is the line which connects the net to the shore (long black line), a ring which allows fisherman to pull in the net with ease (yellow circle), and a loop of line (orange lines) connected to the outer end of the net which allows the fisherman to pull the outer portion to shore.

According to respondents, fishing occurs during summer months when northeast winds prevail and there are ice-free conditions. The gill nets in Elson Lagoon are generally set on the west side of the lagoon which has somewhat less wave action and can easily be accessed from the road connecting Nuvuk to Barrow (Figure 4.1).

Some fishermen also use rod and reel to cast for fish in this area. During our interviews in Barrow and Nuiqsut, this method was described as a fun activity, rather than a preferred method for subsistence fishing (Chapter 3). Many fishermen discussed going inland and casting for Arctic grayling (*Thymallus arcticus*), Pacific salmon (*Oncorhynchus* spp.), and Dolly Varden (*Salvelinus malma*) where angling success is higher. Fishermen stated that they prefer to use nets or jig because such methods provide a higher catch per unit effort (CPUE). Many of the fishermen that we interviewed have fulltime jobs or are retired and still active in the community. These fishermen stated that they appreciate being able to provide fish for the community, which gives them freedom to be active fishermen but still contribute to the community (Chapter 3).

4.3.3 Survey and Logbook Data

The following subsections describe and summarize 2011 Elson Lagoon fishery data from net counts and fisherman logbooks.

Fishing Effort

The total estimated net effort for the Elson Lagoon fishery in 2011 was 1,569 net days. Beginning on 26 June 2011, effort steadily increased until fishing activity peaked at the beginning of August. Effort began to decrease in September, ending on 19 September 2011 (Figure 4.5). Many factors likely influenced when fishermen decided to set or pull their nets. A large increase in the numbers of nets set indicated that fishermen targeted specific runs. Furthermore, adverse weather, ice presence, or personal travel may have caused fluctuations of up to 10 nets between days (Figure 4.5).

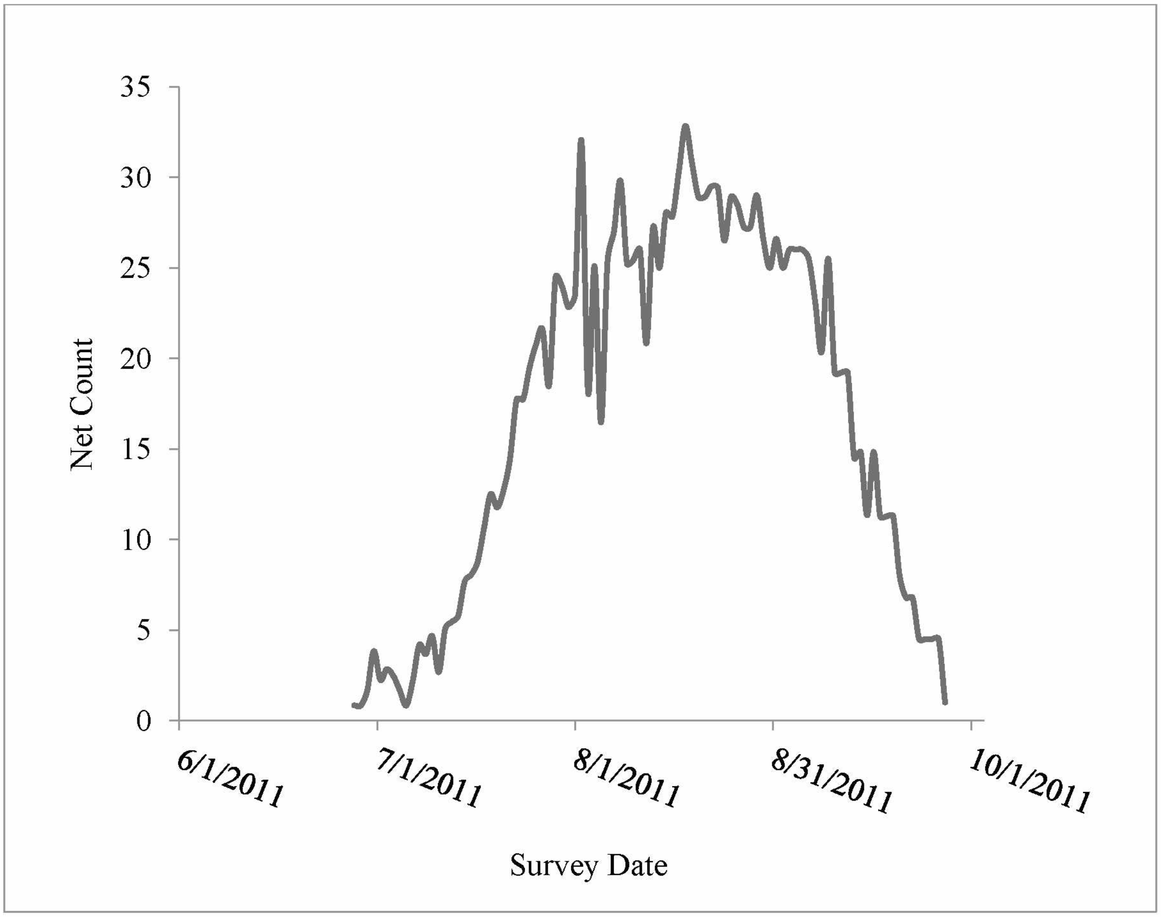


Figure 4.5: Total daily counts of gill nets in the 2011 Elson Lagoon fishery. Data collected by the North Slope Borough Department of Wildlife Management, Barrow, Alaska.

Catch Logbooks

Data consistently entered in logbooks include date, species name (generally recorded in Iñupiaq), and count. Entries were recorded after an average net soak time of 23 hours. Fishermen recorded net soak times from 0.3 hours to 72 hours. Figure 4.6 summarizes the total catch over time for the 11 Elson Lagoon logbook fishermen. A peak of 241 fish was caught in week 34 (mid-August; Appendix B), double the total catch of the next highest week (week 32).

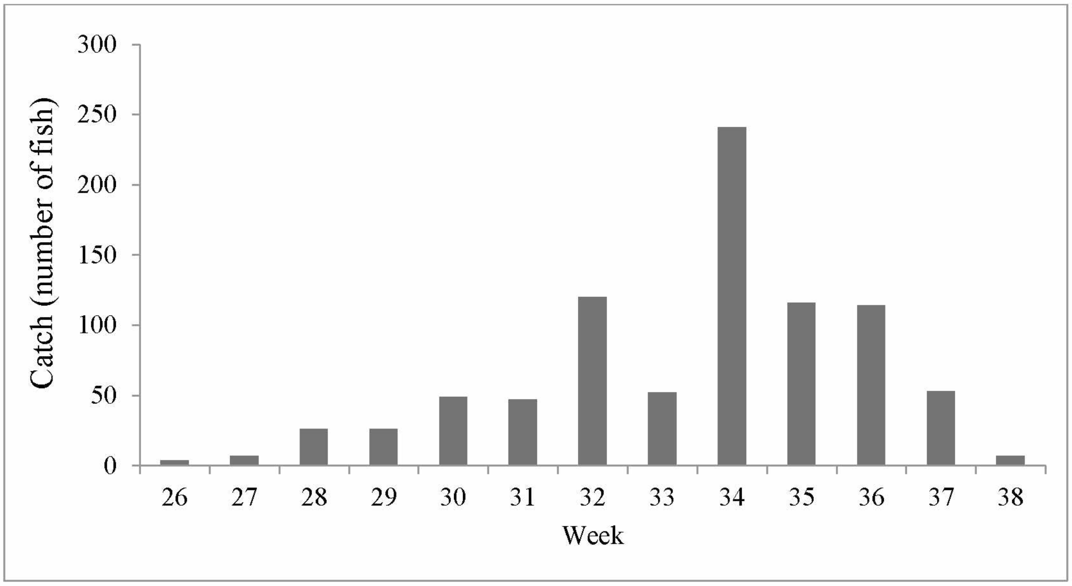


Figure 4.6: 2011 Elson Lagoon total catch for all species per statistical week for 11 Barrow fishermen. Data gathered by the North Slope Borough Department of Wildlife Management, Barrow, Alaska.

Catch Composition

Species composition of fish harvests recorded in 11 logbooks in 2011 is summarized in Table 4.1. Chum salmon (*O. keta*) and pink salmon comprised more than half the catch in Elson Lagoon in 2011. This outcome is consistent with recent years in which pink salmon were often the dominant species in catch surveys (Lemke et al. 2011). Biomass estimates, utilizing Alaska Department of Fish and Game (2012b) subsistence conversion factors, were multiplied by the total species harvested and reported by 11 Elson Lagoon fishermen. Species with highest estimated biomass were chum salmon, pink salmon, broad whitefish (*Coregonus nasus*), and Dolly Varden (*Salvelinus malma*). Based on the number of fish caught, the top species caught in 2011 were chum salmon, pink salmon, least cisco (*C. sardinella*), and fourhorn sculpin (*Myoxocephalus quadricornis*). Least cisco and fourhorn sculpin were caught incidentally and did not represent a large portion of the estimated biomass harvested in Elson Lagoon. This is consistent with interview data stating that least cisco and fourhorn sculpin are not culturally important subsistence species (Chapter 2).

Table 4.2 illustrated total catch by mesh size. Nearly all of the salmon were taken with larger gill net mesh nets, while the fourhorn sculpin and least cisco were taken in small mesh gill nets. The mesh size which had the lowest catch was 8.9 cm (3.5 in) with a catch of four fish; the mesh size with the greatest catch was 14.0 cm (5.5 in) with a catch of 159 fish. Larger chum salmon were primarily caught in 15.2 cm (6 in) mesh. Pink salmon were primarily caught in 10.2 cm (4 in) mesh. The gill net mesh size of 14.0 cm (5.5 in) caught the greatest variety of species, 14 of 17 species represented in the logbook data. This data is consistent with interview data; fishermen who aimed at catching high numbers of fish deployed smaller gill net mesh nets. Individuals who sought to catch the larger salmon species, but did not prefer to catch smaller species such as pink salmon, deployed nets with larger mesh size such as 15.2 cm (6 in) mesh.

Based on numbers of fish harvested, chum salmon comprised 42% of total Elson Lagoon logbook catches and the estimated catch weight comprised approximately 70% of the total estimated catch weight. Ten of 11 logbook fishermen reported catching chum salmon in their entries, and approximately 54% of all recorded entries in the logbooks included chum salmon. Of those recorded entries that include chum salmon, the average catch of chum salmon was 2.5 fish per entry (range was 1-20, with only three entries reporting a catch higher than six fish caught per net set). Averaged over all entries, the mean catch per net per day was 1.4 chum salmon.

Pink salmon were the second most harvested species (23% of total number of fish). All 11 logbook fishermen reported catching pink salmon and 35% of all recorded entries in the logbooks included pink salmon. Of those recorded entries that included pink salmon, the average catch was 2.1 fish per entry (range was 1-10 fish, with only two sets reporting a catch greater than six pink salmon). Averaged over all logbook catch entries, the mean catch per net per day was 0.75 pink salmon.

Table 4.1: Species composition of 2011 Elson Lagoon catches based on logbook data from 11 fishermen. Note that salmon species, broad whitefish, and Dolly Varden dominated by weight. Data source: North Slope Borough Department of Wildlife Management, Barrow, Alaska, and Alaska Department of Fish and Game (2012b). See Appendix C for scientific and Iñupiaq species names.

Species	**Catch (No. of fish)**	**Average Weight (lbs)[3]**	**Catch weight (lbs)**
Chum Salmon	362	6.1	2208.0
Pink Salmon	196	1.7	333.0
Least Cisco[1]	74	1.0	74.0
Fourhorn Sculpin[2]	71	0.6	42.6
Broad Whitefish	65	3.4	221.0
Dolly Varden	49	3.0	147.0
Arctic Cisco	12	1.0	12.0
Sockeye Salmon	11	4.2	46.4
Arctic Flounder	6	0.5	3.0
Unidentified Salmon	5	3.9	19.2
Rainbow Smelt	4	0.1	0.6
Chinook Salmon	2	18.0	36.0
Pacific Herring	2	0.2	0.4
Humpback Whitefish	1	2.5	2.5
Capelin	1	0.1	0.1
Saffron Cod	1	1.0	1.0
Total	862		3146.8

[1]In this fishery least cisco (*Coregonus sardinella*) were mostly caught during a one-week period, by one fisherman with small mesh gill nets, who targeted both Arctic cisco (*C. autumnali*) and Bering cisco (*C. laurettae*)

[2]Fourhorn sculpin are not a targeted species and are considered incidentally caught in small mesh nets during a one-week period

[3]Average round weight taken from Alaska Department of Fish and Game (2012b), from subsistence research conducted in the Arctic region (reflecting nearest location, Point Lay, North Slope, or Seward Peninsula)

Table 4.2: Total seasonal catch by mesh size in the 2011 Elson lagoon gill net fishery. Data summarized from 11 subsistence fishery logbooks for North Slope Borough Department of Wildlife Management, Barrow, Alaska. See Appendix C for scientific and Iñupiaq species names.

	Catch (number of fish)											
Mesh Size	**2.5**	**3**	**3.5**	**4**	**4.25**	**4.5**	**5**	**5.25**	**5.5**	**5.875**	**6**	**Total**
Effort (net days)	**4**	**14**	**1**	**49**	**17**	**28**	**39**	**6**	**35**	**26**	**37**	**257**
Arctic Cisco	11		1									12
Arctic Flounder				2			1		3			6
Broad Whitefish		11		6		14	8		22	1	3	65
Capelin				1								1
Chum Salmon	1			47	28	6	30	2	41	85	122	362
Dolly Varden		2		11	2	24	4		5		1	49
Fourhorn Sculpin	39	4							28			71
Humpback Whitefish							1					1
Pacific Herring									2			2
Chinook Salmon						1			1			2
Least Cisco	50			1					22		1	74
Pink Salmon		13	3	74	2	33	26	9	28	2	6	196
Rainbow Smelt						1	1		2			4
Unidentified Salmon						1			4			5
Saffron Cod									1			1
Sockeye Salmon				7			2	1			1	11
Total	101	30	4	149	32	80	73	12	159	88	134	862

Least cisco were caught using a small-mesh gill net, mostly by one individual trying to catch both Arctic cisco and Bering cisco during a one-week period. Fourhorn sculpin were incidentally caught nearly all by one individual during a one-week period. Broad whitefish and Dolly Varden were species harvested in moderate numbers in the Elson Lagoon fishery. Eleven sockeye salmon (all caught between August 17 and August 30) and two Chinook salmon (*O. tshawytscha*) were also recorded in the logbook data. Dolly Varden comprised the third highest caught species by weight and was typically an important component of this gill net fishery. The rest of the species were caught in relatively small numbers and are not specifically targeted by Elson Lagoon fishermen.

The temporal distribution of pink salmon and chum salmon harvested in the Elson Lagoon fishery is shown in Figure 4.7. Interviews with local experts indicated similar peak run timing for pink salmon and chum salmon throughout the summer months. Both chum salmon and pink salmon catches slowly increased with some small overlap in peak run timing between the two species. In the logbook data, the first pink salmon was caught on 21 July 2011 and the last on 7 September 2011. The first chum salmon was caught on 19 July 2011 and the last on 19 September 2011. These trends correspond with the weekly net count shown in Figure 4.7. Effort increases in relation to pink salmon catches. The peak of the weekly net effort occurs prior to high catches of chum salmon, indicating that fishermen are increasing fishery participation prior to the chum run.

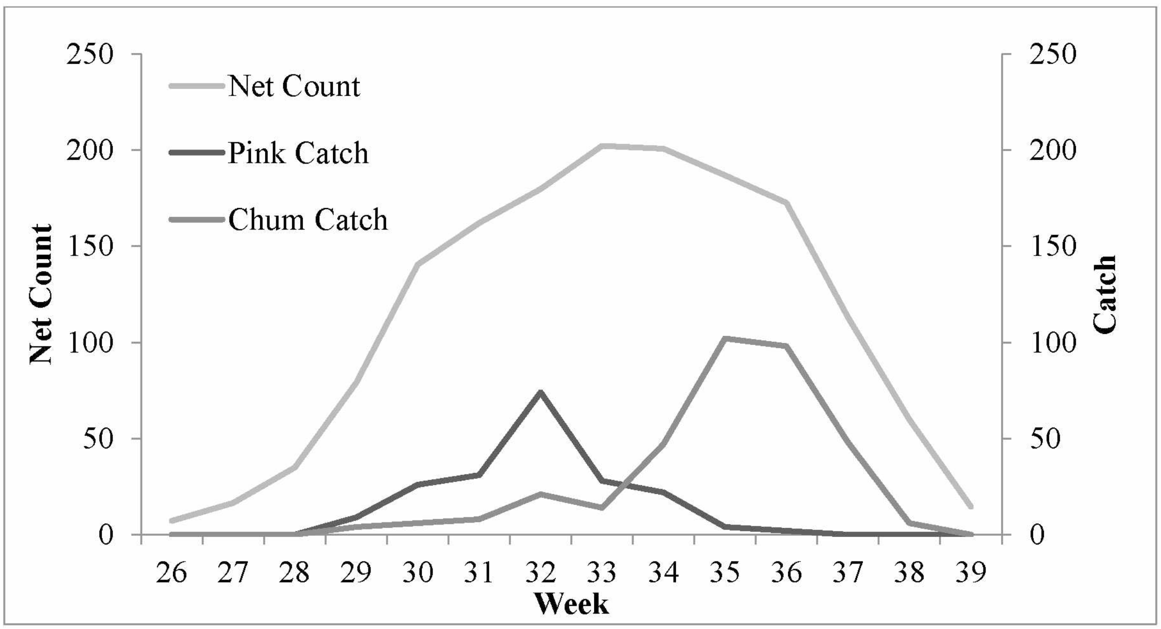


Figure 4.7: Weekly net count and catch of pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) by week in the 2011 Elson Lagoon fishery based on 11 catch logbooks. Data collected by the North Slope Borough Department of Wildlife Management, Barrow, Alaska.

4.4 Discussion and Summary

The data presented herein are a partial analysis of NSB DWM net survey and logbook data to illustrate a pattern of harvest within the three-month window of opportunity for Elson Lagoon fishermen. These data showed that in 2011, Elson Lagoon fishermen primarily harvested chum salmon and pink salmon in this fishery, both in terms of harvest by numbers and weight. While both chum salmon and pink salmon catches were evident in the catch data, the preference for these species, as discussed in Chapter 2, varies considerably. Least cisco, broad whitefish, Dolly Varden, Arctic cisco, and sockeye salmon are also species caught to a lesser extent in the Elson Lagoon fishery.

Based on the logbook data and net effort survey in 2011, there were multiple findings:

- fishing effort steadily increased from late June through July, peaking in August, and then decreasing during September;
- total net effort for the 2011 Elson Lagoon fishery was 1,569 net days, standardized to 18.3 m (60 ft), during a 92-day season between late June and mid-September;
- in 2011, chum salmon (42%) and pink salmon (23%) comprised the majority of the catch based on numbers of fish caught
- the estimated biomass of the 2011 Elson Lagoon catch was also dominated by chum salmon (70%), followed by pink salmon (11%).

These results provide a one-year snapshot of catch and effort in the Elson Lagoon fishery. Effort in this fishery began in late June and steadily increased until fishing activity peaked at the beginning of August. Effort began to decrease in September and ended at the middle of that month. Many factors likely influenced when fishermen decided to set or pull their nets. A large increase in the numbers of nets set indicated that fishermen targeted specific runs. Furthermore, adverse weather, ice presence, or personal travel may have caused fluctuations of up to 10 nets between days.

In 2011, pink salmon and chum salmon dominated the harvest in the Elson Lagoon fishery; however, Lemke et al. (2011) showed that catch composition varies considerably year-to-year in this fishery. Figure 4.8 lists the top four species harvested by total number in Elson Lagoon fisheries surveys from 2006 through 2010 (Lemke et al. 2011). Chum salmon and pink salmon are among the top species harvested most years in both catch and weight, but there is considerable annual variation (Lemke et al. 2011). Pink salmon have represented either the most harvested species, by count, or the second highest within the study years. Pink salmon may be harvested in high numbers during years of higher abundance, especially by fishermen with smaller mesh gill nets. During interviews, fishermen stated they pull their gill nets if they do not want to harvest more pink salmon than they are capable of processing or sharing (Chapter 2). These catch numbers may reflect lower numbers of pink salmon harvest because of this practice. These data are also in agreement with interviews conducted in Barrow which indicated that pink salmon catches occurred earlier in the season, while chum salmon were harvested later (Chapter 2). Some other species, such as fourhorn sculpin, were caught in some years, but represent bycatch and are not eaten. The absence of sculpin in some years suggests that small-mesh nets (used to target Arctic cisco and Bering cisco) are not used every year.

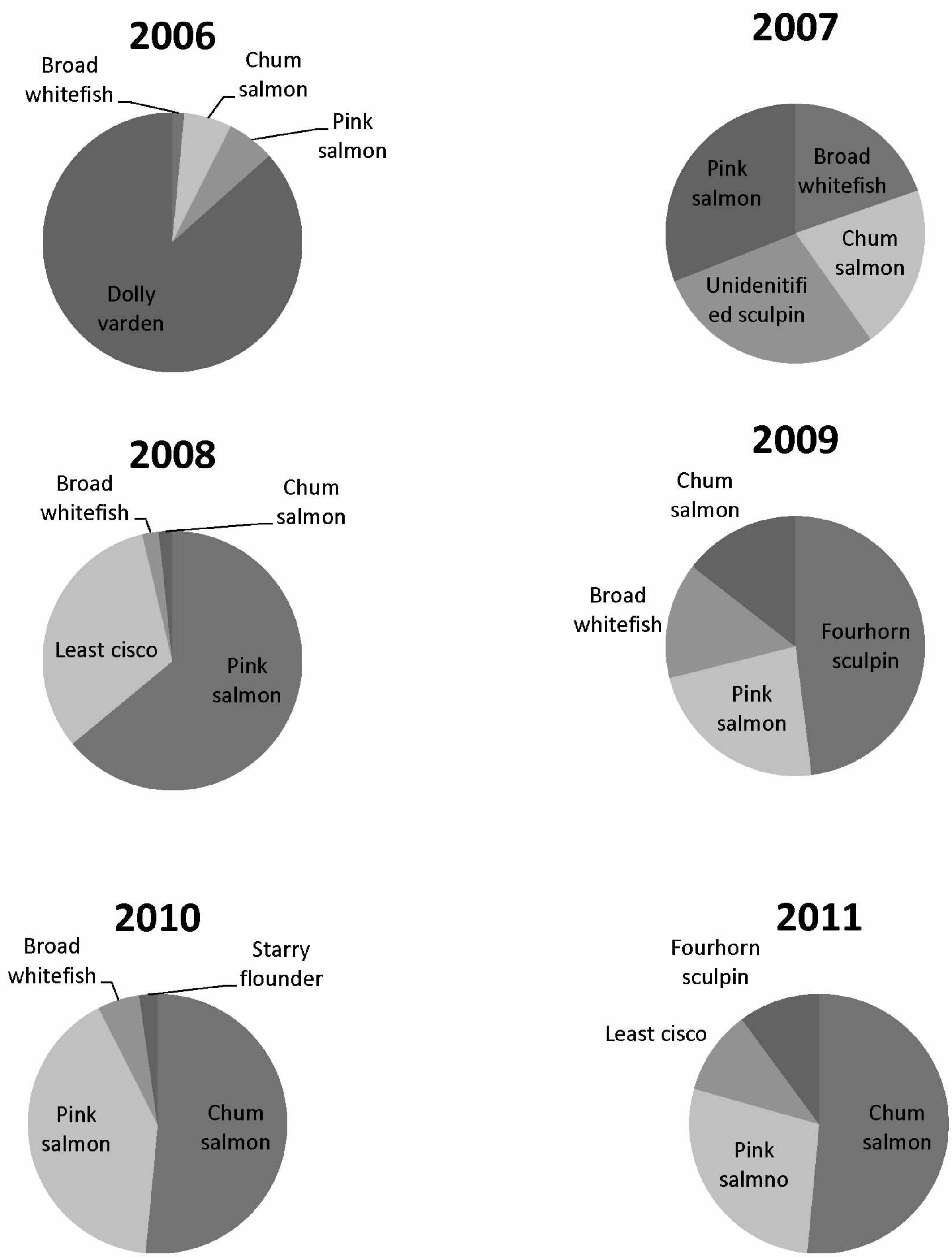
It is important to note that harvest estimates presented in Lemke et al. (2011) are based on total recorded catch in a voluntary logbook program. These total catches varied greatly from 135 and 2,502 fish. Harvest logbooks were distributed to various fishermen and return rates also varied by year. Fishermen only recorded instances of fish caught and did not distinguish between periods of nets soaking with no catch and periods when they have pulled their nets and no fishing occurred. Thus, catch statistics such as CPUE were difficult to calculate from the available data. At least 11 Elson Lagoon fishermen demonstrated that they were interested in sustainable management of the fishery by participating in a logbook program and by allowing NSB DWM biologists to track their catches in 2011. In future years, steps could be taken to randomize logbook distribution program to enable total catch estimates. Alternatively, willing participants might be placed in a lottery to decide who will be given a logbook in any given year (Murphy and Willis 1996).

In general, the results of the net survey, logbook program, and interviews with key informants have produced findings that complement each other. First, from interviews, we learned that sharing is extremely important and integral part of Iñupiat culture and that fishing is an important activity to the annual subsistence cycle on the North Slope (Chapter 3). We learned from the net survey and logbook data that a relatively small number of fishermen provide salmon to the community of Barrow and the North Slope region. Second, in our interviews we learned that while whitefish are a preferred species and are widely harvested in inland fisheries, salmon comprised the majority of the species caught in the Elson Lagoon fishery. Logbook information showed that chum salmon comprised the highest catch, approximately 70% by weight in 2011, followed by pink salmon. Sockeye salmon and Chinook salmon were also present in low numbers in Elson Lagoon catches.

It is further important to note that many Elson Lagoon fishermen and other local fishermen also embark on trips to fish camp in other marine and freshwater systems to target broad whitefish and other species of cultural importance (Stephen R. Braund and Associates 2010). Species of great cultural importance such as *aanaakliq*, or broad whitefish, are harvested in large numbers in these regions and were absent from this analysis. For instance, Stephen R. Braund and Associates (1993) reported a three-year average harvest of whitefish of 28,683 fish (61,149 useable lbs) annually for Barrow from 1987-1989. Broad whitefish form at least half of the catch in the late 1980s (Stephen R. Braund and Associates 1993). By comparison, the three-year average for salmon in the same study was 788 fish, or 4,638 lbs. Salmon harvest reported by logbook fishermen in Elson Lagoon in 2011 is 576 fish, totaling 2,643 lbs. While this harvest is lower than the average reported in the 1980s, it includes only one area of harvest for Barrow fishermen (Elson Lagoon). As noted in our interviews, salmon are also harvested in other lagoons and marine environments and in some freshwater systems (Chapter 2).

As stated above, total harvest estimates were not calculated for the entire Elson Lagoon fishery because logbook data are insufficient for this extrapolation. However, it is likely that several thousand chum salmon and pink salmon were harvested from Elson Lagoon in 2011 considering that a) total estimated effort is about 1,500 net days, and b) the catches for pink salmon and chum salmon average about one to two fish per net per day.

Figure 4.8: Top four species harvested by total number in Elson Lagoon fisheries surveys from 2006 through 2011. Data for 2006-2010 summarized in Lemke et al. (2011). See Appendix C for scientific and Iñupiaq species names.



Chapter 5
Conclusions

5.1 Synthesis of Findings

Arctic ecosystems are experiencing unprecedented changes. The scientific literature about whether the distribution and abundance of salmon (*Oncorhynchus* spp.) in the Arctic is changing is currently inconclusive. While increased attention to this topic is likely to yield new information, active Arctic fishermen and elders are among the most knowledgeable about long-term changes observed in their environments over time. This thesis provides an interdisciplinary approach using multiple methods to understand this knowledge about salmon in the Arctic, as well as to explore historic and current harvest and use of salmon species. This research adds to the state of knowledge about salmon and other fisheries in the region in a time of climate change and also contributes to the broader context of subsistence fisheries in Iñupiat culture. Synthesized herein are several overall findings.

First, while perceptions about overall abundance patterns vary, the weight of evidence suggests that salmon catches in Barrow and Nuiqsut are increasing. Our ethnographic research and historical accounts indicate that pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) have been observed in subsistence fisheries in the central North Slope region for multiple generations; however, only recently has local use of these resources begun to increase. Chum salmon and pink salmon are consistently harvested in Elson Lagoon near Barrow. These species comprised approximately 65% of total numbers of recorded fish caught in 2011.

Second, fishermen in Barrow, and to a lesser extent in Nuiqsut, are actively learning about salmon fishing, processing, and preparation. Salmon are harvested primarily using set gill nets, although some local fishermen are also starting to use rod and reel techniques to cast for salmon. Methods for harvesting, processing, and preparing salmon are passed down vertically through generations and horizontally among regions of

Alaska. Fishermen in Barrow and Nuiqsut often have a variety of sources of recipes and techniques for salmon harvest and use. The preference and use of salmon species varies greatly among individual families. Many elders and fishermen do not prefer pink salmon or chum salmon, but fish caught are not wasted. Catching fish, including salmon, to share is a primary motivator for many subsistence fishermen in both Barrow and Nuiqsut. Fish are commonly distributed to family, neighbors, elders, and anyone who needs or wants fish.

Third, cultural and economic motivations for participation in fishing activities are often overlooked, but are central to understanding the importance of local fisheries and assessing potential threats. For example, "community" as a whole unit is the focus of most conversations regarding subsistence fisheries in this region. Many fishermen feel a cultural obligation to harvest fish for their family and sharing network. Others enjoy spending time outdoors and keep detailed logbooks of their ventures and catches to share information with local managers. Some view subsistence fishing as a necessity in hard economic times. Subsistence fishermen and elders express concerns about potential future commercial activities currently under discussion.

Fourth, overall, salmon are still a relatively unimportant subsistence resource. Salmon catches are very important, however, to a few non-native Elson Lagoon fishermen who primarily harvest salmon. Although interviews are focused on salmon use and knowledge the most frequently coded theme in our qualitative data analysis of the interviews in Barrow and Nuiqsut was "non-salmon species," reflecting the cultural importance of other fish species in this region. Elders and fishermen have a deeper understanding of morphology, run timing, harvest techniques, and a tighter cultural connection to whitefish species (*Coregonus* spp.). For example, some salmon species such as sockeye salmon (*O. nerka*) and Chinook salmon (*O. tshawytscha*) do not have a distinct name in the Iñupiaq language. Knowledge of these species is increasing, but there is still widespread misidentification of salmon species, even among expert fishermen. The fact that fishermen expend so much effort (over 1,500 net days) for a relatively low catch (averaging just a few fish per day) compared to other regions in Alaska makes a clear statement about the cultural importance of this activity.

Lastly, increased salmon catches are perceived to be one among a suite of environmental and social changes currently being experienced in Arctic Alaska. Perceptions of environmental changes are a common theme throughout our interviews. Environmental change is dramatic, increasing, and impacting local resource harvest. Informants noted that winter freeze-up occurs later in the year and the spring thaw earlier, resulting in a shorter winter season and a longer ice-free summer. Localized weather patterns are variable and unpredictable. Warmer winter and summer conditions are generally observed in Barrow and Nuiqsut, Alaska, and affected harvesting, processing, and storage practices.

Along with environmental change, we saw evidence of dramatic social and economic change in our ethnographic data. Our interviews revealed the effects of development on fishing practices, particularly in Nuiqsut. Confounded with environmental change, recent development projects have created concern in Nuiqsut about resource access, safety, and quality. Several Nuiqsut fishermen who have fish camps along the Nigliq Channel expressed their discomfort caused by the close proximity of their fish camps to development infrastructure of the Alpine oil field. Many activities at fish camp are important to subsistence users' physical, mental, and spiritual health. Family traditions and subsistence lessons are learned during time spent at these outlying fish camps. Fishermen in Nuiqsut recalled spending months at fish camp, but today might only spend a night or two multiple times per summer to harvest the fish they need.

Subsistence is a vital part of being Iñupiat, but does not come without a price. The equipment necessary to conduct modern subsistence is expensive and includes boats, trucks, all-terrain vehicles, freezers, maintenance for machinery, and petroleum products (Moerlein 2012). Barrow residents are concerned that there may be a time when they will have to rely solely on subsistence harvest and their own resources for food and survival.

These broad environmental and social changes provide an important context with which to assess changing salmon fisheries.

5.2 Future Research Directions and Personal Reflection

Given the ambiguity about salmon abundance and distribution in the Arctic, it is clear that biological studies should be conducted more extensively in rivers along the Chukchi and Beaufort seas, in conjunction with Canadian and Russian researchers. Examples of questions that may further the understanding of changes to salmon assemblages in the Arctic include:

- where are the current distributions of the various species?
- where are salmon spawning?
- where are they overwintering?
- are the eggs and juveniles surviving?
- what migration patterns do they follow?

Genetics in particular may lead to interesting developments in determining what salmon populations are extending their ranges. Traditional ecological knowledge studies like this one are helpful to assist such efforts. For example, Nuiqsut residents who travel seasonally to hunting and fishing camps on the Itkillik River would be valuable research partners in locating potential spawning sites in this system. Local hunters and fishermen can use GPS units, which are already incorporated into subsistence harvest, to pinpoint locations of open water or salmon occurrence. In the Yukon River, subsistence users have been gathering genetic samples throughout the salmon fishing season. Community members are hired and paid an hourly wage to harvest samples which would be difficult to gather throughout the large expanse of the Yukon River (Drobny and Stark 2011). Similar types of cooperation would lead to an increase in samples available for analysis and increased accounts of salmon observations. Furthermore, gathering genetic samples from subsistence catches within river systems would aid in identify salmon to the species level, along with adding to genetic databases. Currently genetic information for salmon in the Arctic is not readily available. Subsistence catches in the region would be a convenient source of samples and could supplement directed sampling at spawning grounds.

To understand species level changes in Barrow and Nuiqsut, my original research design included a participatory mapping component. While I was able to collect information about salmon presence in certain river systems, the communities in general showed an aversion to the detailed mapping I had proposed. Information about the location of species harvests and changes over time is revered and elders and fishermen often do not want to share this information in a public arena. The Iñupiat Heritage and Language Center (IHLC) is the appropriate location for this type of information as this institution is charged with housing traditional knowledge appropriately so that the information can be passed to future generations. Fortunately, elder interviews for our salmon use and knowledge project are archived with IHLC to allow the community to be keepers of their own information.

Cultural context and correct use of data is, of course, highly important when conducting community research. Similar to planning a detailed mapping project, in depth discussion of salmon with Nuiqsut fishermen and elders was not always appropriate. Nuiqsut fishermen do not put a high importance on salmon, but value other fish species. A study focused on salmon may not be a topic of interest to the community and may be viewed suspiciously (e.g., fear of outside interest in developing commercial fisheries).

I come from a traditional Alaska Native background in a rural Alaska coastal community, so I came into this project with my own biases and preconceived perceptions. I also engaged in courses to learn more about Alaska Native cultures. Often when I read about Alaska Natives, we are all perceived as having similar issues and our paths are discussed as being interconnected going into the future. I disagree with this type of generalization. The people of Dillingham, where I grew up, have been in seasonal contact with all five Pacific salmon species since recorded history. My people have a similar value system, but engage in subsistence and commercial fishing simultaneously. We might pull a few fish from a net to take home and process to sustain the family for winter, while the rest get delivered to an industrial cannery to provide wage income. As revealed in our interviews, fishermen in Barrow tended to be opposed to commercial fishing activity. On the same note, a majority of the residents in Dillingham oppose mineral extraction for multiple reasons. One of the salient reasons is that it will interfere with subsistence lifestyles and income practices. North Slope residents, however, live next to non-renewable resource extraction sites. Many of the services the borough and local governments provide are funded by tax revenues and dividend royalties from these large-scale, non-renewable resource extraction activities. Alaska Native cultures which thrive in Dillingham and Barrow share similar value systems, with sharing and subsistence comprising core values; however, these values are expressed in different ways.

I would emphasize that throughout Alaska, indigenous groups experience similar struggles integrating Western and traditional practices, yet there are a variety of ways in which our similar values are expressed. There are many threats to the subsistence way of life, but different regions accept these threats and manage the outcomes differently. In the 21^{st} century, a cash income is necessary to participate in the Western society that has been introduced to Alaska over the last two centuries. In the Bristol Bay region and many other areas of Alaska, we choose to utilize a portion of our fishery resources to provide income for our families. In Barrow and Nuiqsut, however, these subsistence goods are highly coveted and large-scale commercialization of subsistence resources is not acceptable for many residents.

While my thesis provides an initial investigation of the cultural and economic motivations for fisheries on the North Slope, this is an area of study that demands more attention. Generating the “right” set of questions could lead to a better understanding of how values drive subsistence activities or hinder other potential Western “opportunities.” Traditional values, like contemporary laws, have a degree of flexibility and many of the ways in which we interpret and conform to these laws depend on our personal background and community culture. As oil exploration and extraction in the Arctic Ocean progresses, the North Slope environment and communities are likely to experience many changes that may confound co-occurring rapid environmental changes. Changes in the Arctic are going to have positive and negative impacts for the people and their resources, whether it is the flora, fauna, or the physical environment. I hope that through reading this thesis, the voices of those who are the cultural bearers of this information ring loudly and their message is presented intact.

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Appendix A: Semi-Directed Interview Protocol

SALMON SUBSISTENCE (species-level when possible)

- Historic & current importance of salmon as a subsistence resource. Change over time. Relative to other fisheries, other subsistence resources
- Current subsistence uses of salmon
- Seasons for fishing
- Ways of processing
- Trade/exchange/sale

KNOWLEDGE ABOUT SALMON

- Distributions, migration routes and timing, changes
- Abundance, changes
- Juveniles, spawning areas, changes
- Effect of salmon on other fish species/environment

OBSERVATIONS OF CLIMATE CHANGE

<u>Break Up/Summer season</u>

- Summer weather & precipitation
- Water levels in rivers/lakes
- Water temperature
- Water quality (color, silt load
- Fish habitats
- Fish health
- Fish movements, abundance, and distribution
- Fish species (declines in expected species, increases in uncommon species)
- Fishing methods or activities (access, timing, gear)
- Fish processing (methods, timing, concerns)
- Fish camp (timing, duration)
- Resource importance (cultural values, sharing
- Other non-water/non-fish comments (forest fires, other flora and fauna changes)

<u>Freeze Up/Ice Season</u>

- Winter weather patterns and precipitation
- Ice thickness and snow depths
- Access and travel routes
- Winter fish movements and distribution
- Fish over-wintering habitats
- Health & quality of winter-caught fish
- Fish species (declines in expected species, increases in uncommon species)
- Winter fishing methods or activities (access, timing, gear)
- Other resources (fur bearers, bear denning, animal movements)

Appendix B: Statistical Weeks

Statistical Week	Starting Date
23	4 June 2011
24	11 June 2011
25	18 June 2011
26	25 June 2011
27	2 July 2011
28	9 July 2011
29	16 July 2011
30	23 July 2011
31	30 July 2011
32	6 August 2011
33	13 August 2011
34	20 August 2011
35	27 August 2011
36	3 September 2011
37	10 September 2011
38	17 September 2011
39	24 September 2011

Appendix C: Fish species' Common, Iñupiaq, and Scientific Names

Anadromous Fishes:			
Arctic cisco	ACIS	*Qaaktaq*	*Coregonus autumnalis*
Least cisco	LCIS	*Iqalusaaq*	*Coregonus sardinella*
Bering cisco	BCIS	*Tiipuq*	*Coregonus laurettae*
Broad whitefish	BDWF	*Aanaakliq*	*Coregonus nasus*
Humpback whitefish	HBWF	*Piquktuuq*	*Coregonus pidschian*
Dolly Varden	DCHR	*Iqalukpik*	*Salvelinus malma*
Rainbow smelt	RBSM	*Ilhaugniq*	*Osmerus mordax*
Chinook salmon	CHIN	*Iqalugruaq*	*Oncorhynchus tshawytscha*
Sockeye salmon	SOCK		*Oncorhynchus nerka*
Pink salmon	PINK	*Amaqtuuq*	*Oncorhynchus gorbuscha*
Chum salmon	CHUM	*Iqalugruaq*	*Oncorhynchus keta*
Unidentified salmon	SALM		*Oncorhynchus spp.*
Freshwater Fishes:			
Arctic grayling	GRAY	*Sulukpaugaq*	*Thymallus arcticus*
Lake trout	LKTR	*Iqaluaqpuk*	*Salvelinus namaycush*
Round whitefish	RDWF	*Savigunnaq*	*Prosopium cylindraceum*
Burbot	BURB	*Tittaaliq*	*Lota lota*
Longnose sucker	LNSK	*Milugiaq*	*Catostomus catostomus*
Northern pike	PIKE	*Siulik*	*Esox lucius*
Alaska blackfish	AKBF	*Iluuginiq*	*Dallia pectoralis*
Arctic lamprey	LAMP	*Nimigiaq*	*Lethenteron camtschaticum*
Ninespine stickleback	NSSB	*Kakalisauraq*	*Pungittius pungittius*
Threespine stickleback	TSSB		*Gasterosteus aculeatus*
Slimy sculpin			*Cottus cognatus*
Marine Fishes:			
Fourhorn sculpin	FHSC	*Kanayuq*	*Myoxocephalus quadricornis*
Arctic flounder	ARFL	*Nataagnaq*	*Liopsetta glacialis*
Arctic cod	ACOD	*Iqalugaq*	*Boreogadus saida*
Saffron cod	SCOD	*Uugaq*	*Eleginus gracilis*
Capelin	CAPE	*Pagmaksraq*	*Mallotus villosus*
Pacific herring	HERR	*Uqsruqtuuq*	*Clupea harengus*
Pacific sandlance	SAND		*Ammodytes hexapterus*
Snailfish	SNFS		*Liparis sp.*
Starry flounder			*Platichthys stellatus*