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Subsistence Use and Knowledge of Salmon in Barrow and Nuiqsut, Alaska

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ABSTRACT

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 was conducted in Barrow and Nuiqsut, Alaska, in 2010 and 2011 with 41 active fishermen and elders. Subsistence salmon harvests are generally perceived to be increasing; however, perceptions about changing salmon abundance are mixed. While pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) have been regularly documented in subsistence fisheries in the central North Slope region, only within the last 10 to 20 years has local use of these resources begun to increase. In this region, salmon are a minor subsistence resource compared to whitefish species (*Coregonus* spp.) and Dolly Varden (*Salvelinus malma*). However, fishermen participating in the growing Elson Lagoon subsistence gill net fishery near Barrow regularly harvest chum salmon and pink salmon. These species of salmon are described by some local fishermen as nuisance species; some avoid setting their gill nets during periods of high salmon abundance. Chinook salmon (*O. tshawytscha*) are increasingly targeted, but catches are generally low. While sockeye salmon (*O. nerka*) numbers are perceived to have increased on the North Slope, catches of this species are rare. Similarly, few coho salmon (*O. kisutch*) have been captured in this region. Research participants identified salmon as present or spawning in stream systems where salmon were previously not recorded, suggesting possible shifts in distribution. In both communities, we found that many active fishermen and elders did not differentiate between Pacific salmon species, and that Nuiqsut fishermen often did not differentiate salmon species from Dolly Varden. Fishermen in both communities reported developing new knowledge of salmon and increasing their use of salmon as a subsistence resource. Core Iñupiat cultural values, such as sharing, food gathering, and connection to the land, were found to be key motivators for subsistence fishing in this region.

INTRODUCTION AND BACKGROUND

Local observations of increasing numbers of salmon in subsistence fisheries in the North Slope region have generated interest in collecting more information about salmon use, abundance, and distribution in Arctic waters. This study explores the use of salmon as a subsistence resource in North Slope communities, local knowledge about salmon, and perceptions of change in the abundance and distribution of salmon species over time. Ethnographic research with local elders and active fishermen in Barrow and Nuiqsut, Alaska (Figures 1 and 2) contributes to the documentation of historic and current use of salmon as a subsistence resource, the perceptions of change related to salmon and other important fisheries, and the larger context of climate and ecological change in the North Slope region.

This study uses a traditional ecological knowledge framework to explore local perceptions of climate change with a particular focus on recent shifts in subsistence salmon fisheries. Traditional ecological knowledge of fish species in the North Slope region of Alaska has rarely been documented (Brewster et al. 2008) or, if documented, is not easily available (e.g., Schneider and Arundale 1982).

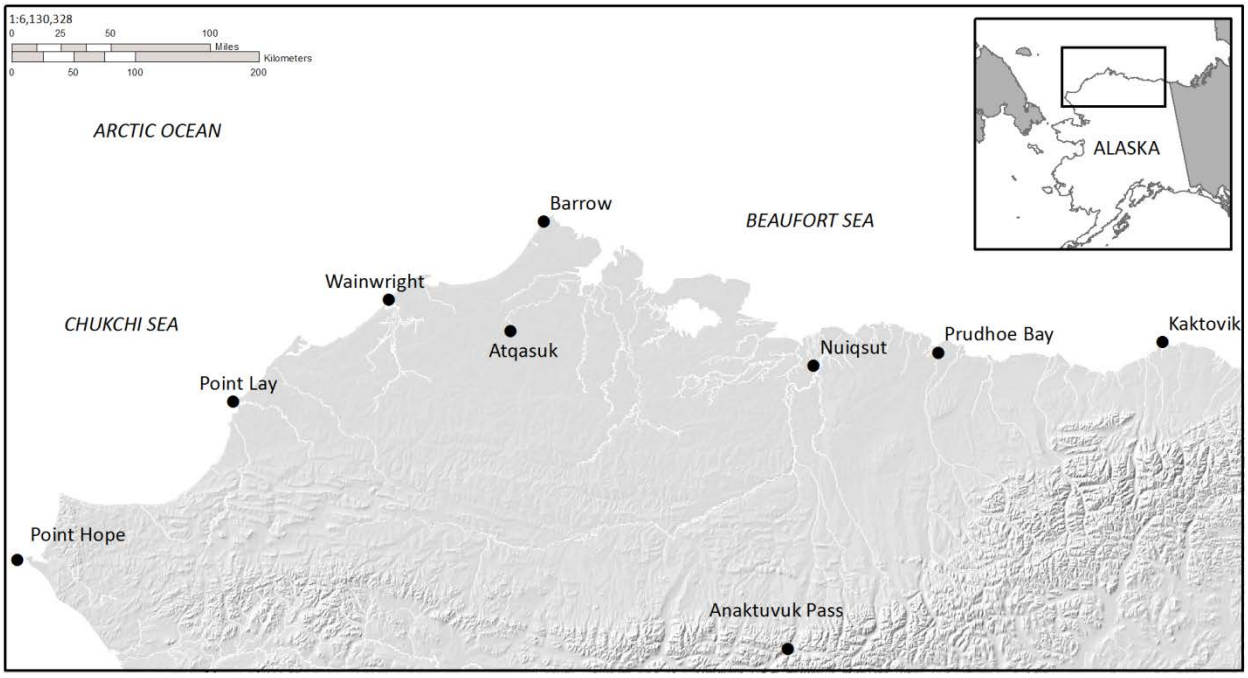

Figure 1. Map of the North Slope Region. Map by Christine Woll, University of Alaska Fairbanks.

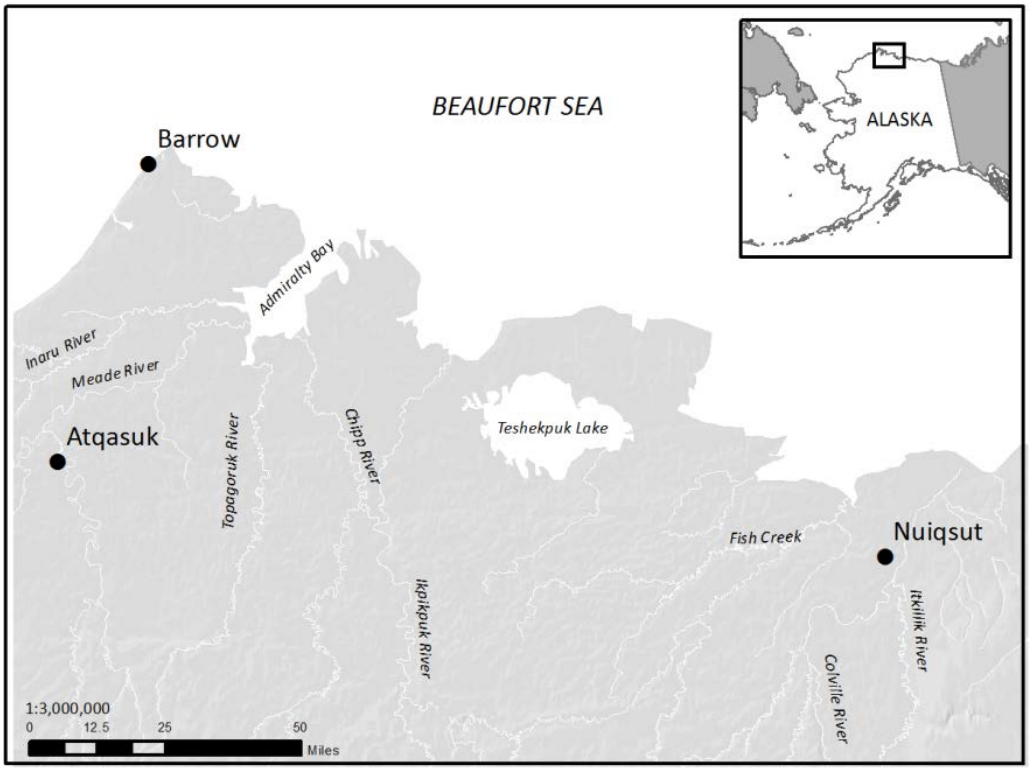

Figure 2. Map of the central North Slope region showing the primary study communities of Barrow and Nuiqsut and area waters. Map by Christine Woll, University of Alaska Fairbanks.

Biological data on anadromous fish species have been collected across the North Slope region, but focus primarily on whitefish (*Coregonus*) species, which are regionally more abundant and are harvested in greater numbers than salmon (Fechhelm et al. 2009). The continued documentation of traditional knowledge 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; Cotton 2012).

Traditional Ecological Knowledge Framework

There are various approaches to the study of traditional ecological knowledge (including a variety of nomenclatures, e.g., local and traditional knowledge, local ecological knowledge, indigenous knowledge, and place-based knowledge). Berkes (2008) conceptualizes traditional ecological knowledge (TEK) as an adaptive knowledge-practice-belief system. Adaptive knowledge systems develop from the deep-rooted relationships between human groups and the lands they inhabit. Detailed knowledge about the land, effective practices for resource harvesting and management, and cultural beliefs are accumulated and passed down through the generations often through oral transmission and experiential learning (Berkes 2008; Houde 2007).

Interest in traditional ecological knowledge systems has grown in recent years, in part due to a growing recognition within scientific disciplines that indigenous and other long-term, resource-engaged communities possess a deep understanding of complex systems based on close interactions with their surroundings over many generations (Berkes et al. 2000; Dowsley 2009). In the past several decades, scientists have increasingly recognized the inadequacy of ecological models that assume static or slowly changing parameters (Dowsley 2009). The integration of long-term, holistic environmental knowledge is increasingly viewed as essential in order to understand and respond to complex environmental problems (Dowsley 2009). There has also been a paradigm shift in ecological sciences towards viewing humans as being embedded in complex social-ecological systems (Berkes 2004; Holling 2001). The idea being that integration of the accumulated environmental knowledge of hunting, fishing and gathering peoples, who have spent much of their lives on the land, with that of scientific experts, will foster increased understanding of environmental processes, effective environmental impact assessment, and responsible and ethical resource management (Nadasdy 1999).

Scientists and managers are increasingly called upon to incorporate traditional, indigenous, and local knowledge systems into their studies and management practices. While generating new possibilities for engagement, the inclusion of multiple ways of knowing in science and management also produces challenges. Most scholars who study TEK systems view knowledge not as an end product that can be easily extracted from its context, but rather focus on the processes of knowledge production and practice. These processes and practices vary widely across cultural and ecological systems. Some researchers have attempted to homogenize and dichotomize TEK and western science systems in terms of their respective epistemological assumptions, values, worldviews, substantive content, methods, and context (e.g., Freeman 1992; Johnson 1992; Usher 2000). Usher (2000), for example, contrasts a scientific approach that places high value on empirical observation, rationality, and logic, with TEK systems that tend to place greater value on received or felt truths or "lived experience." Others, such as Agrawal (1995), find it inappropriate to view TEK and science knowledge systems as bounded and

separate and focus their attention on the social construction of all knowledge systems (e.g., Hackett et al. 2008).

Despite some challenges of integration, researchers have demonstrated the utility of combining TEK and ecological studies to examine Arctic climate change-related issues (Berkes et al. 2007; Hinzman et al. 2005). Traditional knowledge is increasingly seen as both a source of environmental expertise and a means to ensure that research is ethically conducted and socially relevant to communities (Riedlinger 2001). Several studies in the Arctic region have established that indigenous observations can benefit climate change research as a rich source of climate history and baseline data, as a framework for formulating research questions, and as a source of insights into impacts and adaptations (Ford and Furgal 2009; Krupnik and Jolly 2002; Riedlinger and Berkes 2001). Documentation of local knowledge of climate change in Arctic communities provides a valuable opportunity to develop frameworks and tools for reciprocal communication and partnerships between many different stakeholders (Fox 2002). Additionally, TEK projects have the potential to result in the creation of rich bodies of text which document cultural traditions and years of accumulated wisdom, for the benefit of both local communities and scholars (Oozeva et al. 2004). Because TEK embodies such a broad knowledge-practice-belief complex (Berkes 2008), the challenge is to identify and interpret the information of relevance to outside researchers without losing sight of the larger political, spiritual, and epistemological contexts in which that information is developed (Huntington et al. 2006).

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 [ACIA] 2005; Ford and Furgal 2009; Hansen et al. 2012). Since the 1950s, air temperatures in the Arctic have increased by 2 to 3°C during summer and 4°C in winter (ACIA 2005). It is anticipated that by 2100 air temperature will have risen by an additional 5 to 8°C (Leiserovitz et al. 2006). Warmer air temperatures contribute to a variety of changes including permafrost thawing, a reduction in summertime sea ice coverage and sea ice thickness, decreased snow cover, glacial retreat, increased precipitation, and increased riverine runoff which contributes to higher organic carbon inputs to the Arctic Ocean (ACIA 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).

Increasing water temperatures and freshwater inputs have been noted in Arctic Ocean marine environments (Wassmann et al. 2011). Mean sea surface temperatures in September 2007 in the Beaufort and Chukchi Seas were 2 to 3°C warmer than the mean sea surface temperature from the period 1982 to 2006 (Steele et al. 2010). Climate change has multiple effects on fisheries in the Arctic (Schrank 2007). Increasing freshwater inputs contribute to increased stratification in the Arctic Ocean marine environment, affecting stenohaline fish species (Wassmann et al. 2011). Warmer ocean conditions and increased food availability may extend the northern range of suitable habitat for fish species such as walleye pollock (*Theragra chalcogramma*) and Pacific salmon (*Oncorhynchus* spp.).

However, these changes may also result in conditions that inhibit salmon habitat expansion. Increasesd nutrient availability and primary productivity might lead to an overall biomass increase in the region forcing more competition for favorable food sources such as zooplankton (Ruggerone et al. 2007; Morita et al. 2001; Moss et al. 2009). Recent research (e.g., Benner et al. 2005; Dunton et al. 2012; Holmes et al. 2008) suggests that increases in the transport of terrestrial dissolved organic matter into Arctic marine environments due to climatic changes may negatively impact organisms at higher trophic levels. The impacts of climatic change on the distribution and abundance of salmon in Arctic waters remains inconclusive.

The effects of changing climatic conditions on the Actic marine environment may have pronounced impacts on subsistence users who depend upon Arctic fishes. In the Iñupiat communities of the Arctic Slope, people share a close physical, social, and cultural connection with the land and waters. Predictability of weather patterns and other natural trends such as ice conditions and resource distribution affect daily life and influence the success of hunting, fishing, and gathering. The shifts brought about by climate change have important implications for the persistance of subsistence practices in the Arctic (Eisner et al. 2009; Ford 2009; Leiserovitz et al. 2006; Reidlinger 1999; Schrank 2007).

Marine Environment

The oceanography of the Arctic is influenced by both the Pacific and Atlantic oceans. A strong current moves water through the Bering Strait, bringing Pacific Ocean water into the Arctic. This water is cold and comprises the upper layer of the Arctic Ocean, Chukchi, and Beaufort Seas. Warmer, more saline water comes from the Atlantic and exists at depths greater than 200 meters. Freshwater inputs include the large Mackenzie and Colville River systems and over 200 stream systems that flow from the North Slope region into the Beaufort and northeast Chukchi Seas (Craig 1989a). Winter temperatures of the upper layers are generally sub-zero, lethal for salmon. The warmer layer of water derived from the Atlantic generally has a temperature near 0°C. This water may produce a wintertime refuge for salmon. However, it is unclear if salmon utilize this zone of warm water, migrate long distances, or have adapted to overwinter in fresh or brackish water (Irvine et al. 2009; Figure 3).

The continental shelf of the Beaufort Sea is shallow, averaging a depth of only 37 meters. Except for a short period of time between late July and September, these shelf waters are covered by ice. The Beaufort Gyre circulates in a clockwise direction in offshore waters. Wind patterns in near shore waters tend to produce dominant westward currents (Craig 1989a). Northeasterly wind patterns predominate in the summer off the coast of Barrow (Fechhelm et al. 2009). The formation of a near-shore band of brackish water (usually between 2 and 10 km wide) during the summer creates an important feeding area for both anadromous and marine species of fish (Craig 1984).

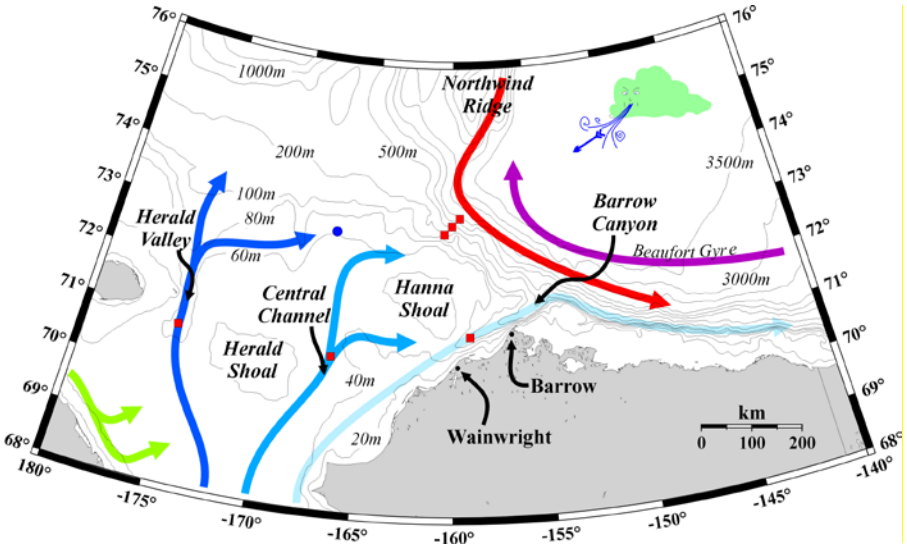

Figure 3. Major ocean currents of the Chukchi and Beaufort Seas. The Chukchi Sea is located west of Barrow, and the Beaufort Sea is located east of Barrow. Reproduced from Weingartner et al. (2001).

The most abundant fish of the Arctic region include: Arctic cod (*Boreogadus saida*), Arctic flounder (*Liopsetta glacialis)*, fourhorn sculpin (*Myoxocephalus quadricornis*), pacific herring (*Clupea harengus*), Arctic cisco (*Coregonus autumnalis*), Arctic char (*Salvelinus alpinus)*, least cisco (*Coregonus sardinella*), broad whitefish (*Coregonus nasus*), humpback whitefish (*Coregonus pidschian*), lake whitefish (*Coregonus clupeaformis*), inconnu (*Stenodus leucichthy*), rainbow smelt (*Osmerus mordax*), ninespine stickleback (*Pungittius pungittius*), Arctic grayling (*Thymallus arcticus*), round whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), northern pike (*Esox Lucius*), and burbot (*Lota lota*) (Craig 1989a). All five species of Pacific salmon have been observed in the Alaskan and Canadian Arctic but are relatively rare by contrast to these more abundant species. Pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) are the only two species that are currently noted in the literature to maintain natal streams between northwest Alaska and the Mackenzie River (Irvine et al. 2009).

Salmon Distribution and Abundance in the Beaufort Sea Region

To provide context for our ethnographic investigation of subsistence use and knowledge of salmon in Barrow and Nuiqsut, we reviewed what is known about North Slope salmon distribution and abundance and identified information needs and issues associated with existing data. The abundance and geographic extent of salmon species in the Arctic region is not well-understood and researchers and local fishermen often differ in their understanding of where salmon are present. Pink salmon and chum salmon are more numerous in Arctic waters than Chinook salmon, sockeye salmon, and coho salmon. Pink salmon and chum salmon are cold tolerant and complete the majority of their life cycles in marine waters, which may explain their relative success in Beaufort Sea waters (Craig and Haldorson 1986). These species 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 immediately after they

emerge from eggs and complete their growing phases outside of freshwater (Irvine et al. 2009; Babaluk et al. 2000).

Pink salmon are the most numerous salmon species in Beaufort Sea coastal waters off of Alaska (Craig and Haldorson 1986). As of 2011, eleven streams west of Barrow were confirmed to support small populations of pink salmon (Alaska Department of Fish and Game [ADFG] 2011; Craig and Haldorson 1986). Some sources note that streams east of Point Barrow are not known to support any self-sustaining runs (Craig and Haldorson 1986); however, locals in Barrow identified spawning populations of pink salmon in the Ikpikpuk and Itkillik rivers (Figure 2; George et al. 2009). Occurrences of spawned-out pink salmon have been noted in the Sagavanirktok River, but no spawning activity has been observed there (Fechhelm et al. 2009).

Chum salmon are distributed widely in Arctic waters but are less abundant than pink salmon, except in the Mackenzie River watershed where chum are endemic (Irvine et al. 2009; McLeod and O'Neil 1983). While chum have been observed to spawn in the Colville River (Bendock 1979; Craig and Haldorson 1986), some dispute that these spawning events sustain consistent runs of chum (Bendock and Burr 1984, cited in Craig and Haldorson 1986). Chum salmon in the Colville River drainage have been observed spawning in the lower reaches of the river from mid-August to mid-September (Moulton 2001). Smolts have also been caught in the lower Colville River (Fechhelm et al. 2009). Spawning populations have been reported in the Kokolik and Utukok Rivers near Point Lay (Craig and Haldorson 1986, cited in George et al. 2009), the Itkillik River (McElderry and Craig 1981), and are noted to "likely spawn" in the Ikpikpuk River (George et al. 2009). Stephenson (2006) reported an increasing frequency of high catches of chum salmon in the Mackenzie River.

As noted above, winter temperatures of Arctic marine waters are generally lethal for salmon. 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; 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. Groundwater-fed streams are usually many degrees warmer than other streams on the North Slope, thus the eggs may be able to survive. Typical Arctic stream temperatures average between 0 and 0.5°C in winter months, but pockets of groundwater provide shelter with temperatures between 2 and 5°C throughout winter months (Craig and Haldorson 1986). 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 support 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 may follow a similar migratory pattern (Irvine et al. 2009).

Chinook salmon, sockeye salmon, and coho salmon are relatively rare in the Chukchi and Beaufort Seas. Recent studies of the Arctic document catches of these salmon species in the Beaufort Sea region, but it remains inconclusive if these data indicate an increase in abundance, a shift in range, or increased attention and research in these systems (Babaluk et al. 2000;

Fechhelm and Griffiths 2001; Irvine et al. 2009; Stephenson 2006).Young Chinook salmon, sockeye salmon, and coho salmon all require freshwater to feed and grow before entering the marine system. It is hypothesized that there is no suitable winter habitat north of Point Hope for these species (Craig and Haldorson 1986; Stephenson 2006; Figure 1). Stephenson (2006) listed Kotzebue Sound as the northernmost spawning population of Chinook salmon; although George et al. (2009) reported that local fishers identify the Kugrua River (Peard Bay) as a likely spawning site for Chinook salmon. Researchers have indicated that Chinook salmon are relatively uncommon in coastal Chukchi and Beaufort Sea waters from Point Lay to Kaktovik. However, residents of Barrow regularly harvest this species (George et al. 2009). Sustained runs of sockeye salmon exist as far north as Kotzebue Sound. Stephenson (2006) noted sockeye catches have become more frequent in the western Canadian Arctic over the past 20 years, but he was careful to note that there is no evidence of a consistent increase, or a stable population presence. Coho salmon are the rarest of all Pacific salmon in Arctic waters and only a handful of captures have been documented (George et al. 2009; Stephenson 2006).

Recent evidence suggests that catches of Pacific salmon species by North Slope residents have increased. In 2008, for example, subsistence harvesters using gillnets in Elson Lagoon near Barrow (Figure 4) recorded a catch of 1,551 pink salmon in their logbooks, with an estimated total 2008 harvest of pink salmon of 4,895 to 10,475 fish (Lemke et al. 2011). In the same year, Fechhelm et al. (2009) reported that 284 pink salmon were caught in fyke nets at Endicott, an oil field located about 16 km northeast of Prudhoe Bay (Figure 5)[1]. Fechhelm et al. also indicate that catches of pink salmon are increasing in Itkillik River during the fall subsistence fisheries (2009). The pink salmon caught in 2008 were noted to be 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 (Fechhelm et al. 2009; Irvine et al. 2009; Stephenson 2006). The presence and abundance of pink salmon is cyclical in the region around Barrow, with pink salmon runs peaking in even-numbered years. This trend is consistent throughout western Alaska (Craig 1989b).

Kassam et al. (2001) state that salmon catches near Wainwright (Figure 1) have increased and that new species of salmon, not previously characterized in the fishery, are becoming more 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 have not been previously caught. While high catch years are more common now than in the past, Stephenson (2006: 44) states 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 has made it appear that there is now a greater abundance of salmon. He concludes 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." In contrast, a recent study by Moss et al. (2009) suggests that there is an increase in the abundance of pink and chum salmon in the Bering and Chukchi Seas and this increase is linked to favorable oceanic conditions for salmon. Due to

[1] Fechhelm et al. (2009) note that sampling nets used to study the long term effects of oil and gas development on fish populations were designed to catch the smaller-size species more abundant in Arctic waters. These nets likely excluded Chinook salmon and chum salmon from being sampled. During the 26-year period that this particular study took place, only 26 chum salmon and a single Chinook salmon were caught.

Figure 4. Map of the Barrow area and Elson Lagoon. Map source: Google Maps 2012.

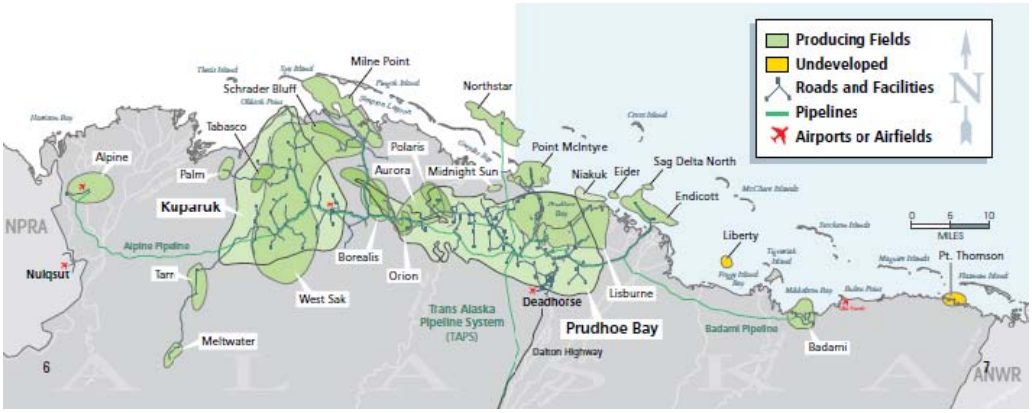

Figure 5. Map of North Slope oil and gas fields. Map source: British Petroleum 2012.

changing habitats in the Alaskan Arctic as a result of warming conditions observed by researchers and local residents alike, we must reassess our understanding of the distribution and spawning habitats of the Pacific salmon species in the Arctic. Warming conditions may be producing more suitable habitat for salmon in the Arctic.

Study Communities and Subsistence Fisheries

While whaling often dominates representations of North Slope Iñupiat subsistence practices, fishing has historically been, and continues to be, an important part of the subsistence economy and culture. In the past, when the indigenous peoples of the region were primarily nomadic, camps or settlements were often selected based on the availability of good fishing spots (Burch 1998). Fish were an especially important resource utilized in times of scarcity (Schneider et al. 1980). Today, fish remains a major part of the modern diet. Fishing is viewed by North Slope residents as a vitally important subsistence activity that fosters family cooperation and sharing

(Brewster et al. 2008). Below, we discuss the subsistence patterns and practices of Barrow and Nuiqsut. We highlight what is known about salmon use and also describe the use of other local resources.

Barrow

Barrow is located on the coast of the Chukchi Sea, approximately 16 km south of Point Barrow, the northernmost point of the United States (Figure 2). Barrow is the administrative and economic hub of the North Slope region. As such, it is a diverse community and has a relatively large population of approximately 4,300 people. According to the 2010 US Census, approximately 61 percent of Barrow residents identify as Alaska Native or American Indian (primarily Iñupiat), 17 percent as white, nine percent as Asian, two percent as Pacific Islander, one percent as black, three percent identify as Hispanic, and roughly nine percent identify with multiple racial backgrounds (State of Alaska 2012a).

Subsistence Salmon Fishing in Barrow

Important fishing locations for Barrow residents range from coastal areas near Wainwright to Teshepuk Lake and inland to the headwaters of the Chipp River (Figure 2). The primary fish species harvested include: broad whitefish, least cisco, Arctic grayling, burbot, and lake trout. Pink salmon, chum salmon, and Chinook salmon are utilized by people in the Barrow area, but are harvested in much smaller numbers (Brewster et al. 2008; Cotton 2012).

The earliest written accounts of salmon harvest near Barrow occur in Murdoch (1892). This account lists pink salmon (*Oncorhynchus gorbuscha*) and sockeye salmon (*O. nerka*) catches in Elson Lagoon (Figure 4) 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. Between the months of July and September, Elson Lagoon supports a growing subsistence gill net fishery (Figure 4). Brewster et al. (2008) link the relatively recent development of the Elson Lagoon gill net fishery to the increase in full-time wage employment available to Barrow residents, which makes travel to fish camps far from town more difficult. Participation in this fishery is convenient for many Barrow residents, who are able to access the lagoon with vehicles after work and on weekends. During fall, residents travel to fish camps along the Chipp, Ikpikpuk, and other local river and stream systems to catch spawning whitefish with gillnets (Figure 2). Salmon may also be caught incidentally. However, the majority of salmon caught by Barrow residents are harvested in Elson Lagoon (Brewster et al. 2008; Cotton 2012).

Stephen R. Braund and Associates (2010) estimate that only about 12 percent of Barrow households harvest salmon; on average, each household in Barrow consumes only about 0.5 to 1 kg of salmon per year; however, there are a small number of households that harvest and consume large amounts of salmon. For these households, salmon may be a particularly important and valued resource (Cotton 2012).

Subsistence salmon harvests vary significantly from year to year in the Barrow area (Figure 6). Figure 6 shows reported catch numbers of all salmon species combined, and does not display extrapolated total catch numbers. Data collection efforts of reported catch have varied over the

years, making annual comparisons problematic. Species composition of the reported catch of salmon species also shows marked annual variation, but is generally dominated by pink salmon and chum salmon. In certain years, Barrow residents have also caught Chinook salmon in appreciable numbers. In 2003, for example, approximately 44 percent of the total salmon catch was reported to be Chinook salmon (but see *Species Identification* below). Fuller and George (1997) noted that 178 Chinook salmon were harvested in Barrow in 1993. Bacon et al. (2009) reported that only 27 and 19 Chinook salmon were harvested in 2000 and 2001, respectively, but in 2003 Chinook salmon harvests rose sharply to 229 fish. Stephenson (2006) also noted that catches of chum salmon and sockeye salmon were high in the Mackenzie River in 2003.

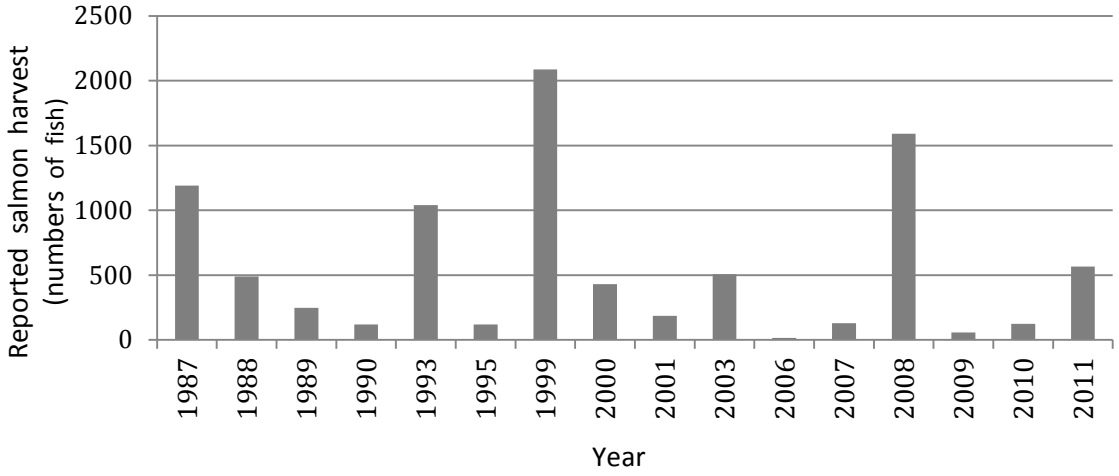

Figure 6. Reported salmon catches (not extrapolated) for all salmon species in Barrow subsistence fisheries from 1987 through 2011. Data sources: Bacon et al. 2009; Cotton 2012; Lemke et al. 2011; Fuller and George 1997; Stephen R. Braund and Associates 1993.

Due to the growing interest in the Elson Lagoon salmon fishery, researchers have begun monitoring harvest levels for this fishery. Lemke et al. (2011) and Cotton (2012) describe the findings from the North Slope Borough, Department of Wildlife Management monitoring project that recorded catches for the subsistence gill net fishery in Elson Lagoon from 2006 to 2011. During this time period, fishermen recorded their net effort daily from June through September in logbooks (between two and twelve fishermen have participated annually). Results indicate that the fishery tends to begin in late June or early July and ends in late August through mid-September. In 2011 effort steadily increased in the fishery and peaked at over 30 gill net fishermen participating in the fishery in August (Cotton 2012). Figure 7 shows the species composition of the Elson Lagoon subsistence fishery between the years of 2006 and 2011, based on reported harvest. It remains unclear if numbers of salmon have increased in this region, or if more fishermen are targeting them more now than in the past (Bacon, personal communication, 2010).

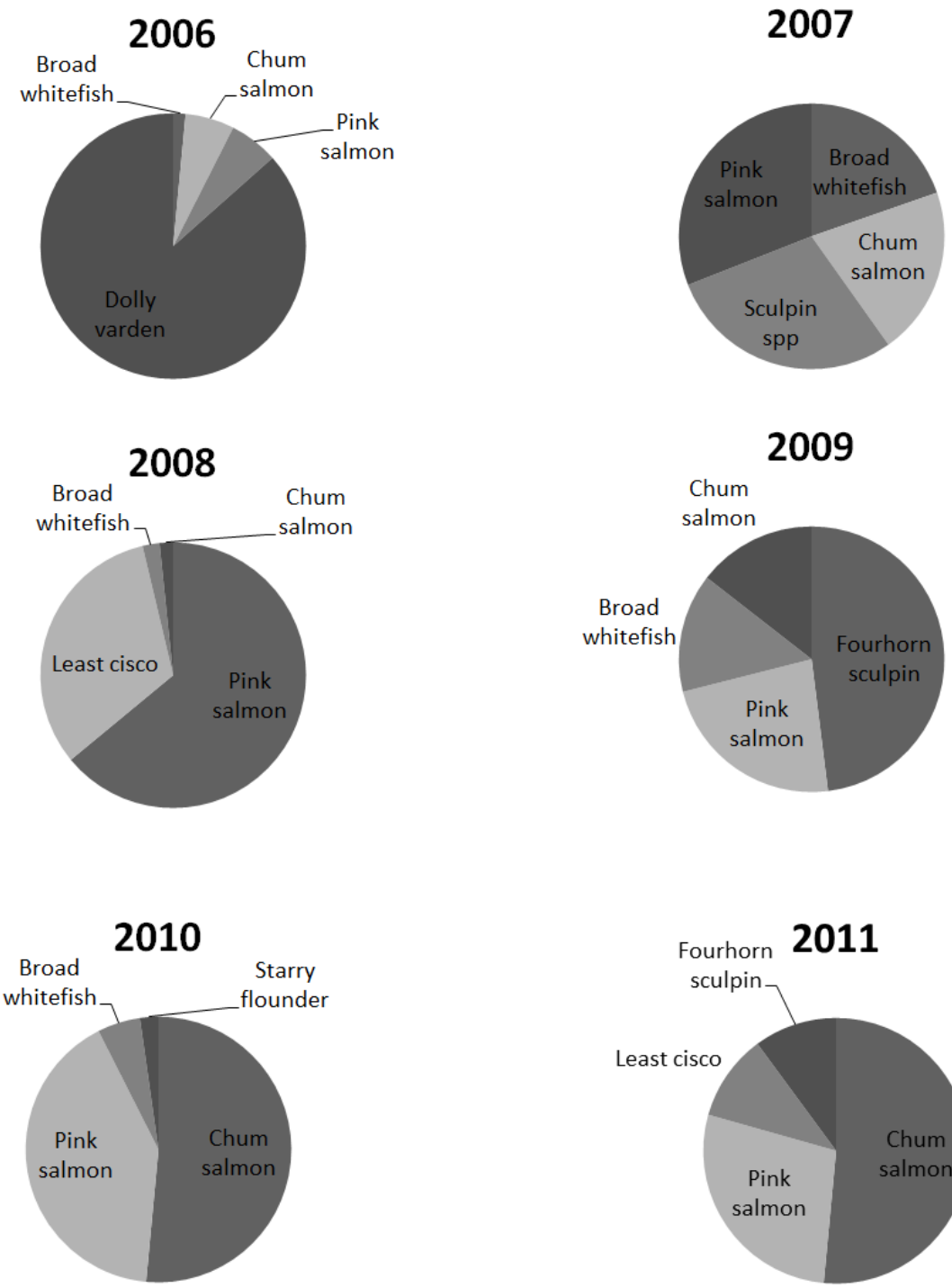

Figure 7. Top four species harvested in Elson Lagoon subsistence gill net fishery from 2006 through 2011, based on reported harvest. Data sources: Cotton 2012 and Lemke et al. 2011

Nuiqsut

Nuiqsut is a small village of about 434 residents located approximately 56 kilometers from the Beaufort Sea coast (243 kilometers from Barrow), situated on the west bank of the Nechelik

(Nigliq) Channel of the Colville River (Figure 2). The community, which is located in the homeland of the *Kukpikmiut* (the People of the Lower Colville River), was resettled by 27 families in 1973 and formally incorporated as a 2nd class city in 1975 (Brogan 1979). According to the 2010 US Census, about 87 percent of Nuiqsut residents identify as Alaska Native or American Indian (primarily Iñupiat), 10 percent as white, 0.3 percent as black, and 2.7 percent of multiple racial backgrounds (State of Alaska 2012a).

Subsistence Salmon Fishing in Nuiqsut

As in Barrow, fish are an important subsistence resource for the community of Nuiqsut. In the early 1990s, fish comprised over 30 percent of the subsistence harvest of Nuiqsut households (second to caribou, which accounted for 58 percent of harvested pounds) (Brower and Opie 1998, citing Pedersen, unpublished data). Nuiqsut fishermen use set nets as their primary mode of catching fish. They primarily harvest Arctic cisco, Dolly Varden, and broad whitefish in their nets (Stephen R. Braund and Associates 2010). During a study conducted in 1994 and 1995, Brower and Opie (1998) found that 11 types of fish were harvested by Nuiqsut households. It was reported that the total number of fish harvested in 1994-1995 was 14,650.

Arctic cisco are primarily harvested between September and January. Broad whitefish are harvested during summer and fall months. These two species are the most commonly harvested fish in Nuiqsut. Salmon historically comprise a very minor portion of the subsistence fish catch in this community. Fechhelm et al. (2009) states that pink salmon are not targeted by Nuiqsut fishermen. Some pink salmon are incidentally caught on the Colville River. Chum salmon are caught somewhat frequently in the fall, but only comprise a small portion of the fall subsistence catch in Nuiqsut (Fechhelm et al. 2009). It was estimated that Nuiqsut residents harvested 438 salmon in 1985 and 1986 (Craig 1989b, citing Pedersen and Shishido 1988), 35 salmon in 1995 (Bacon et al. 2009), and seven salmon in 2000 (Bacon et al. 2009). Stephen R. Braund and Associates (2010) report that some residents use rod and reels to catch salmon at the mouth of the Chandler River; however, they do not provide any quantitative estimate of salmon catch in Nuiqsut.

Study Objectives

Changing ecological conditions and increasing interest in salmon harvesting on the North Slope warrant an investigation of current knowledge and use of salmon. Local elders and active fishermen are among the most knowledgeable sources of information concerning changes in salmon abundance and distribution and related ecological shifts. This study documents the historic and current use of salmon as a subsistence resource and also contextualizes salmon among the suite of subsistence resources in this region. The specific tasks and objectives of this project 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.
(3) Document the local and traditional ecological knowledge of historic and recent trends in salmon use, abundance, and distribution in the North Slope region.

(4) Better understand the Iñupiaq 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.

METHODS

Data Collection

Literature Review

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) Beaufort Sea marine environment, 3) salmon distribution and abundance 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 70 sources and developed a literature synthesis presented in the introduction of this report.

Ethnographic Research

Prior to conducting ethnographic research in Barrow and Nuiqsut, we developed relationships with the Native Village of Barrow, the Native Village of Nuiqsut, the Kuukpik Subsistence Oversight Panel, the North Slope Borough Department of Wildlife Management, the Alaska Department of Fish and Game, the Iñupiat Heritage Center, Iñupiat History, Language and Culture Division, and the Iñupiat Community of the Arctic Slope. We received formal project endorsement from the Fish and Game Management Committee of the North Slope Borough (June 2010), the Native Village of Barrow (July 2010), the Native Village of Nuiqsut (December 2010), and the Kuukpik Subsistence Oversight Panel (March 2011). We conducted fieldwork in Barrow during: 1-4 June 2010, 6-27 July 2010, and 3-16 August 2011, and in Nuiqsut during: 13-16 December 2010, 14-18 March 2011, and 20-26 June 2011. We presented our research results and a draft of this report to the North Slope Borough Fish and Game Advisory Committee meeting in Barrow on 22 February 2012 and in public community meetings in Barrow on 21-22 February 2012 and 7 April 2012 and Nuiqsut on 23-24 February 2012. These meetings, including the participation of many of our interviewees, provided an opportunity to clarify and refine our findings. In total we spent 43 days in Barrow (and additional time for a graduate student participating in a Barrow-based internship at the North Slope Borough, Department of Wildlife Management; see Cotton 2012) and 18 days in Nuiqsut.

Local experts in each community were identified using purposive, snowball sampling methods (Bernard 2006). Community leaders recommended knowledgeable, active, and long-time fishermen. Those individuals then recommended other knowledgeable and active fishermen. In Barrow we interviewed 23 local experts, 18 men and 5 women. In Nuiqsut, we interviewed 18 local experts, 14 men and 4 women. In both communities the ages of our key informants ranged from mid-40s to mid-80s, with the exception of one interview with a group of three young fishermen, aged 23 to 40, in Nuiqsut. We conducted a total of 24 interviews in Barrow. We interviewed one elderly couple together and interviewed two informants twice. In Nuiqsut, we

conducted a total of 16 interviews. We conducted one group interview involving three young fishermen. The remaining interviews in Nuiqsut involved only one informant.

We conducted open-ended ethnographic interviews with these local experts (Huntington 1998; Spradley 1979). During the interviews, we guided the discussion but did not ask a set list of questions. Broadly, interviews focused on subsistence fishing and changing environmental conditions that impact subsistence fishing. Specifically, we focused discussions on the current and historic importance of salmon compared to other species, current subsistence fisheries for salmon, uses of salmon, and knowledge about salmon abundance, distribution, and life history. We provided local and regional maps during the ethnographic interviews so that informants could point out places of interest as appropriate. With permission, interviews with key informants were audio-taped and fully transcribed (UAF IRB 09-38). Three interviews were conducted in the Iñupiaq language with the assistance of a translator. These interviews were translated and transcribed 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.

In addition to ethnographic interviews, we utilized participant observation to gather details about subsistence fisheries in this region. Participant observation is a signature method of anthropological study, where researchers learn by doing (Bernard 2006). We joined alongside community members in fishing activities, community gatherings, meals, and other local events and activities. Fishermen in Elson Lagoon were observed tending 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. We were unable to visit fishing locations in Nuiqsut during the open water season. However, we did observe several fish camps from the seasonal ice road along the Nigliq Channel in 2011, and also participated in Nalukataq, or spring whaling celebrations, in Nuiqsut in June 2011.

Data Analysis

After transcribing interview data, we thematically coded the text using the qualitative data analysis program, *Atlas.ti*. 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). Open coding was utilized, meaning that we refined the code list as we analyzed the text to allow for community- and context-specific codes to be developed. Once coding was completed, we produced code count tables, explored code co-occurrences, and generated lists of specific quotes for each code for further analysis (Muhr and Friese 2004). Geographic data collected during interviews was combined with available spatial data to generate a series of maps in *ArcGIS*.

Collaboration

The research team collaborated with the Alaska Department of Fish and Game (ADFG) in the development of this study. ADFG researchers are conducting a project of similar scope in the communities of Wainwright and Point Lay. We have collaborated during data collection and data analysis. We plan to incorporate the research findings of both projects to provide an overall assessment of knowledge about, and use of, salmon species across the North Slope for publication.

RESULTS AND DISCUSSION

Over the course of this ethnographic investigation we amassed a large body of information regarding subsistence fishing, changing ecological conditions, salmon on the North Slope, and impacts of changing conditions on subsistence practices. Here, we summarize our findings. Largely descriptive, the following analysis presents residents' understandings and perceptions of salmon in this region and observations of the environmental changes that they are currently experiencing. In order to present informants' observations as accurately as possible, we use many direct quotes from interviews. It is not possible to record the totality of what we learned within this report; rather, we focus the discussion on the growing importance of salmon in these communities, the perceptions of changing salmon numbers, and the role of salmon harvesting among the entire suite of subsistence gathering activities.

Table 1 presents the lists of primary and secondary codes developed during the analysis of qualitative interview data, and the occurrence count for each code. We found that some topics were discussed more frequently in interviews than others. For example, the secondary code "abundance" was identified a total of 98 times in the interview data, while "fishing locations" was found to occur 151 times. Figure 8 presents the proportion of coded interview data by primary code for all the interviews combined as well as the subset of Barrow and Nuiqsut interviews. Of the seven primary code groups, subsistence fishing was discussed most frequently in interviews (25% of code occurrences). Code occurrences were generally similar between both Barrow and Nuiqsut informants. Nuiqsut informants tended to talk less about salmon species (10% of total codes in Nuiqsut interview data) compared to Barrow informants (16% of total codes in Barrow interview data) (see *Species Identification* below) and more about environmental and socioeconomic changes (17% of total codes in Nuiqsut and 11% of total codes in Barrow). The most frequently discussed specific code in both communities was "non-salmon species" (coded in interview data 200 times).

Table 1. List of thematic codes and counts of occurrences in qualitative interview data.

Primary Code	Secondary Code	Occurrences Nuiqsut	Occurrences Barrow	Combined Count of Occurrences
Salmon Knowledge	Abundance	43	55	98
Salmon Knowledge	Distribution	43	17	60
Salmon Knowledge	Name/ID	34	33	67
Salmon Knowledge	Run Timing	31	37	68
Salmon Knowledge	Spawn	18	23	41
Salmon Knowledge	Species Interactions	0	2	2
Salmon Use	Cultural Transmission	1	18	19
Salmon Use	Fishing Locations	81	70	151
Salmon Use	Fish Processing	9	27	36
Salmon Use	Gear	24	51	75
Salmon Use	Preferences	35	32	67
Salmon Use	Preparation	23	28	51
Salmon Use	Selling	9	16	25
Salmon Use	Sharing	18	51	69
Salmon Species	Chum	33	57	90
Salmon Species	Chinook	22	47	69
Salmon Species	Pink	27	53	80
Salmon Species	"Silver"	7	25	32
Salmon Species	Sockeye	7	17	24
Subsistence Fishing	Fish Camp	33	34	67
Subsistence Fishing	Fish Quality	6	10	16
Subsistence Fishing	History	70	57	127
Subsistence Fishing	Learning	7	13	20
Subsistence Fishing	Motivation	41	79	120
Subsistence Fishing	Non-salmon Species	83	117	200
Environmental Change	Access To Resources	14	7	21
Environmental Change	Break-Up	8	14	22
Environmental Change	Erosion	9	8	17
Environmental Change	Freeze-Up	9	9	18
Environmental Change	Ice Conditions	9	8	17
Environmental Change	Normal /No Change	8	4	12
Environmental Change	Outside Info-Climate	4	3	7
Environmental Change	Permafrost	2	2	4
Environmental Change	Travel	5	10	15
Environmental Change	Unusual species	9	19	28
Environmental Change	Water Levels	17	5	22
Environmental Change	Weather Change	18	20	38
Socioeconomic Factors	Development	29	16	45
Socioeconomic Factors	High Cost Of Subsistence	9	7	16
Socioeconomic Factors	Jobs/Employment	6	7	13
Cultural Dimensions	Elders	29	28	57
Cultural Dimensions	Gender	2	7	9
Cultural Dimensions	Iñupiaq	3	16	19
Cultural Dimensions	Lifestyle Change	23	25	48
Cultural Dimensions	Spirituality/Prophesy	5	3	8
Cultural Dimensions	Youth	25	25	50
	TOTALS:	948	1,212	2,160

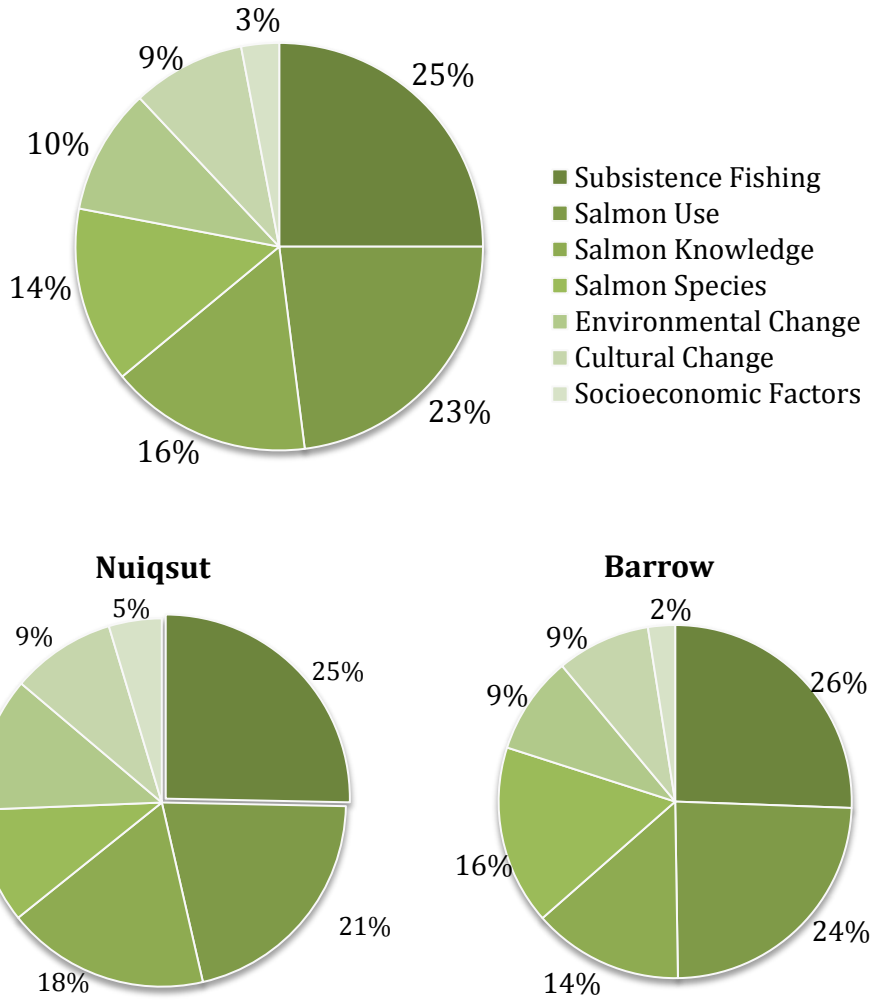

Figure 8. Proportional occurrence of each primary code in qualitative interview data.

Salmon Knowledge

Generally, local experts 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 differences in the timing of subsistence fishing, locations visited, gear used, and the extent of personal fishing activity, individual fisherman's knowledge of salmon varied considerably.

Salmon Abundance

While the experiences and observations of fishermen we interviewed varied, informants in both Barrow and Nuiqsut generally agreed that salmon catches have increased over the past 10 to 15 years. Whether these increases in salmon harvest are indicative of an increase in salmon abundance is not clear. Some elders stated that they have observed or caught salmon for a long

time and cautioned against any generalization that salmon populations are new, or increasing in numbers. Others considered salmon species to be relatively new migrants to the region, and ones that are increasing in abundance and distribution. One elder stated that her family "first saw that salmon come up this far" (referring to an area east of Barrow) in the late 1940s. She noted that her parents had no knowledge about these kinds of fish, but they made use of this new resource. Several elders in Nuiqsut noted that they were unsure about what names to use to describe salmon because neither they nor their parents previously had experience seeing, catching, or eating salmon. Two active fishermen in Barrow reported that they did not remember catching salmon in the 1970's when they first began setting gill nets in the Elson Lagoon area. However, both of these fishermen noted that they were not paying close attention to species differentiation in those days.

Other researchers have documented observations by North Slope fishers that salmon numbers have increased over the past several decades (Brewster et al. 2008). As early as 1982, Raymond Neakok stated that he began noticing an increase in salmon. In 1988, Robert Aiken stated:

> Salmon, they never used to come up here. In summertime, by our cabin, I got a net. And it started getting some salmon. Dog [chum] 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 indicated that there were silver-colored salmon in the Ikpikpuk River. She stated that "we're not used to fishing for salmon up here. But we found out there is a run in the fall" (Neakok 1988). In 1982, one fisherman stated that he had noticed salmon numbers increasing (Bureau of Land Management 1982, Appendix II: 4).

Pink Salmon

While there are increasing observations of, and fisheries for, salmon, several elders noted in our interviews that pink salmon are not a new occurrence in the region. In the Elson Lagoon gill net fishery in Barrow, pink salmon catches appear to be increasing overall, with highest abundances following an even year cycle. During our interviews in 2010, several informants noted that over the past couple of years, pink salmon had been too abundant and clogged their fishing nets. One fisherman stated that fishing conditions have "… gotten to the point where there's too many pinks to deal with." Another noted: "we get more of the humpies (pink salmon), a lot of the humpies, and last two years there's been mostly humpies." For some fishermen, pink salmon is not a desirable fish to catch; therefore these increases are not viewed as a positive change. We discuss this matter in further detail later in this report. During interviews, several informants mentioned a notable increase in pink salmon abundance in the 1970s. This observation is confirmed by previous ethnographic investigation (Brewster et al. 2008).

In Nuiqsut, informants confirmed the cyclical abundance of pink salmon. Informants noted that there are thousands of pink salmon during the years when they are running. Some fishermen catch pink salmon on a regular basis while others note only an occasional catch (often dependent on the timing of setting the fishing nets). It appears that pink salmon are returning in significant numbers in some areas where they previously experienced a population decline. One elder

fisherman remembered that when he was young, in the 1950s, the pink salmon were driven from the Itkillik River due to development in that region (Figure 2). This coincides with what another fisherman said about the same river, that there is now "…beginning to be a lot of pinks, especially on the Itkillik River" and the fish may be returning to an area in which they used to be seen regularly. One informant with a fish camp at the mouth of the Itkillik River said that thousands of pink salmon started showing up in the Itkillik around 2005.

Chum Salmon

Chum salmon are caught throughout the summer and early fall in Barrow. Informants stated that approximately 30 chum salmon per net per day are caught Elson Lagoon near Barrow during the peak of the run (see also Cotton 2012). In Nuiqsut, however, the presence and abundance of chum salmon is less certain (see also *Salmon Identification*). For instance, one elder stated that he does not remember catching chum salmon when he was young at fish camps along the Colville River. Several other informants confirmed that chum salmon are a relatively recent migrant to the Colville and Itkillik systems. Whether or not chum salmon are increasing in abundance and expanding their distribution in this region remains inconclusive. We heard mixed comments about this subject. One middle-aged fisherman stated that he used to catch a lot of chum in the 1970s and 1980s, but he considered them to be less abundant in 2011. A young fisherman in his twenties noted that he catches 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, researchers and residents alike have paid increasing attention to recent high catches of Chinook salmon and what this means about the abundance and distribution of this species. During interviews, several informants noted that the first Chinook was caught in Barrow between 10 and 20 years ago. One informant stated that a fisherman from Southeast Alaska visiting Barrow was the first to catch a Chinook salmon on a fishing rod. Locals also began fishing for Chinook salmon with fishing rods around this time. Another informant noted that he caught two Chinook salmon in 1992 that were both longer than a meter (or four feet by his estimate). One informant who is a particularly active fisherman stated that he caught his first Chinook salmon in 2002 or 2003, and has only caught one other Chinook salmon since then. He noted 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 now use larger mesh gill nets during the month of July to specifically target Chinook salmon. These changes in fishing practice (e.g., using larger nets and fishing with poles) indicate that although Chinook salmon may be a relatively new species to the region, Beaufort Sea fishermen now recognize them as a desirable fish to catch.

Despite apparent increasing presence, informants in both Barrow and Nuiqsut stated that they usually harvest few Chinook salmon. Informants reported that generally fishermen who catch one or two Chinook salmon over the course of an entire fishing season are considered lucky. Together with data collected by the North Slope Borough, Department of Wildlife Management (Bacon et al. 2009), interview data for this project indicates that 2003 was a notable year for

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

Sockeye & Coho Salmon

Due to issues associated with species identification, as described below, we were not able to generalize about the presence of sockeye salmon and coho salmon species in this region from our interview data. George et al. (2009) report that sockeye salmon are uncommon in Barrow, but appear to be increasing in recent years.

Coho salmon are the rarest of all Pacific salmon in Arctic waters (Stephenson 2006). Stephenson (2006) reports only two confirmed coho captures in the Canadian Arctic waters (one reported by Babaluk et al. 2000 captured in 1987, and one captured as part of Stephenson's study in 1998), and concludes these to be strays. George et al. (2009) note only a few recorded catches of coho salmon in Barrow. Craig and Haldorson (1986) report occasional coho salmon presence near Prudhoe Bay.

Geographic Distribution

Scientific literature concerning the current geographic distribution of salmon in the Arctic remains 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 (ADFG 2011). Chum salmon and pink salmon are the only species thought to spawn in Beaufort Sea tributaries, as discussed previously. Other species have been documented in low numbers and are assumed to be strays (Stephenson 2006). In the following section, we provide a brief discussion of what is known about the geographic distribution of each salmon species, based on previously conducted biological research and interview data.

Pink Salmon

East of Barrow, ADFG lists the Ikpikpuk River, Fish Creek, Judy Creek, Colville River, Itkillik River, Sagavanirktok River (including West Channel), Staines River, West Canning River, and Canning River as having pink salmon (ADFG 2011; Figure 9). The Chipp, Ikpikpuk, Kuparuk, Sagavanirktok, and Kavik Rivers are identified as spawning rivers for pink salmon (ADFG 2011). Nuiqsut informants confirmed the presence and possible spawning activity of pink salmon in the Itkillik River. One informant with a fish camp at the mouth of the Itkillik River reported that thousands of pink salmon started showing up there around 2005. He stated that they congregated in one spot (4.8-6.4 km upriver) and remained there. One Nuiqsut informant commented that he has seen pink salmon in tributaries of the Colville, such as the Chandler and Anaktuvuk rivers.

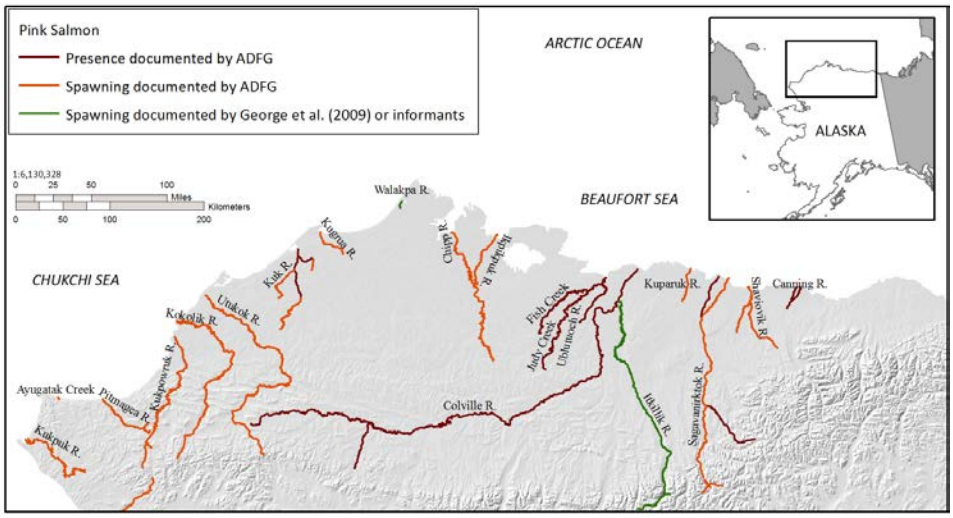

Figure 9. Map of North Slope Region showing stream systems with presence and spawning of pink salmon. Map by Christine Woll, University of Alaska Fairbanks.

Chum Salmon

East of Barrow and north of the Brooks Range, the Chipp River, Ikpikpuk River, Fish Creek, Judy Creek, Colville River, Itkillik River, Sagavanirktok River (including West Channel), Canning River, Kongakut River, and an unnamed stream west of Kongakut, are confirmed to have chum salmon presence and spawning is confirmed in the Meade, Itkillik, and Colville Rivers (ADFG 2011; Figure 10). George et al. (2009: 34) note that chum salmon "likely spawn" in the Ikpikpak River. One interviewee reported that he caught a chum salmon in Ikroavic Lake (connected to Iko Bay via Avak Creek) in mid to late October, just after the lake froze over. Nuiqsut informants confirmed the presence and potential spawning of chum salmon in the Itkillik River and the presence of chum in Fish Creek. Chum salmon rearing areas in river or estuarine systems have not yet been identified.

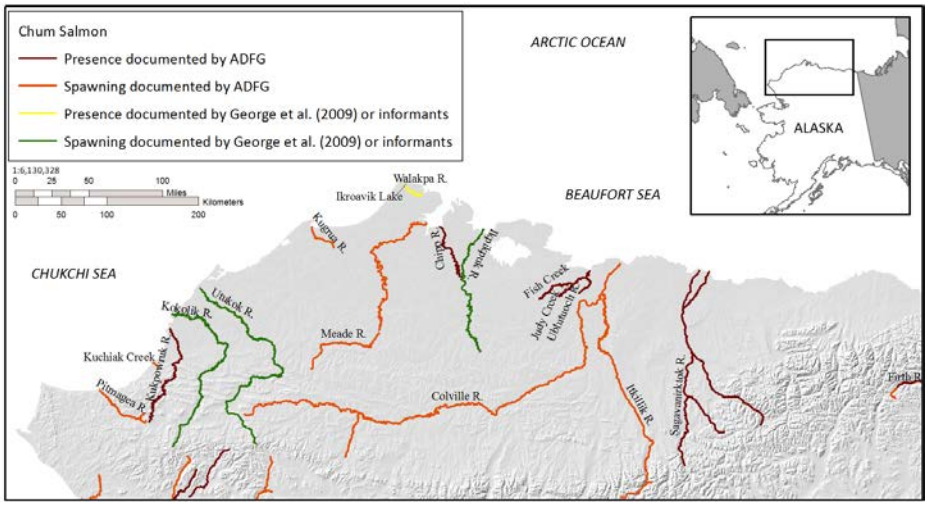

Figure 10. Map of North Slope Region showing stream systems with presence and spawning of chum salmon. Map by Christine Woll, University of Alaska Fairbanks.

Chinook Salmon

ADFG (2011) lists Chinook salmon as present in Fish Creek, which is east of Barrow and north of the Brooks Range (Figure 11). They do not identify spawning or rearing areas; however, George et al. (2009) report a potential spawning population in the Kugrua River (Peard Bay). Nuiqsut informants revealed that local knowledge suggests Chinook salmon are in Peard Bay and one described taking two Chinook salmon at the elbow point at Nuvuk. They also noted that Chinook salmon are rarely caught in the Colville River.

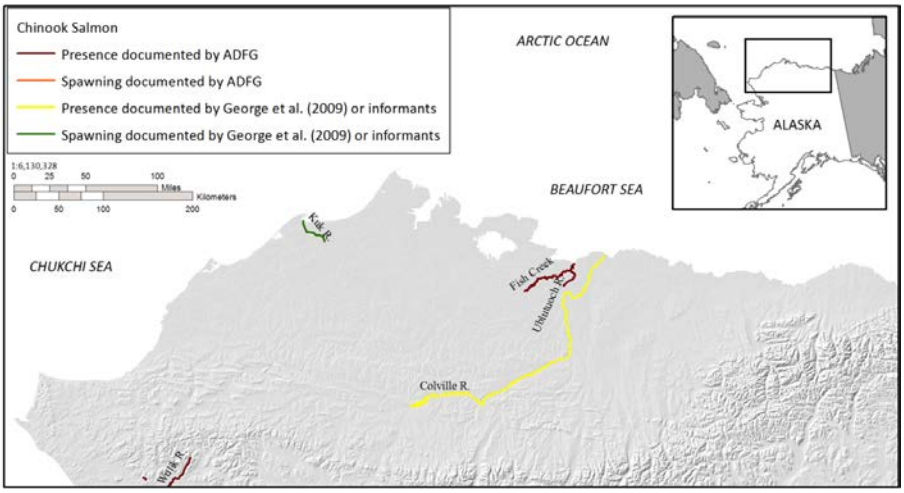

Figure 11. Map of North Slope Region showing stream systems with presence and spawning of Chinook salmon. Map by Christine Woll, University of Alaska Fairbanks.

Sockeye & Coho Salmon

No streams in this region are confirmed to have sockeye salmon presence, spawning, or rearing (ADFG 2011). George et al. (2009: 37) note that sockeye salmon are thought by local residents to spawn in the Colville River (Figure 12). Several interview informants noted that they had heard about occasional red salmon catches in the region. One informant noted that he had heard about the presence of red salmon smolts in the Colville River area and another noted that he caught a red salmon in 2009 at Cape Simpson in Smith Bay. Given the widespread misidentification of salmon species in the region, this informant was careful to note that this fish was not a chum salmon; he said this fish was "totally different" than any other fish he had ever caught. He noted that "the meat was very red." During interviews, several Nuiqsut informants mentioned catching red salmon. One young Nuiqsut informant noted that when fishing with a rod and reel on the Colville River near Ocean Point, he caught a red salmon.

No streams in this region are confirmed to have coho salmon presence, spawning, or rearing (ADFG 2011). Similarly, it is generally understood that no stream systems west of Barrow and north of Point Hope contain these species during any life stage except for Kuchiak Creek near Point Lay, which is noted as a coho spawning stream (Figure 13).

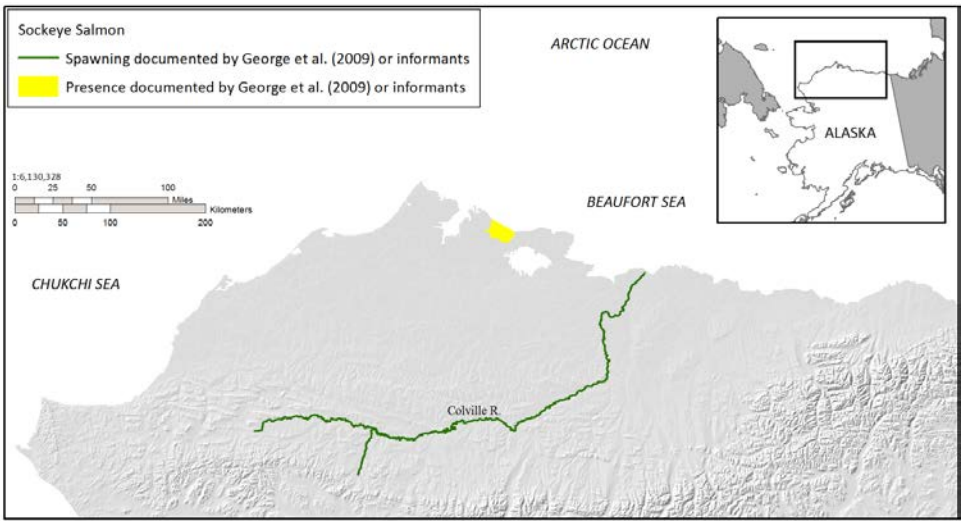

Figure 12. Map of North Slope Region showing stream systems with presence and spawning of sockeye salmon. Map by Christine Woll, University of Alaska Fairbanks.

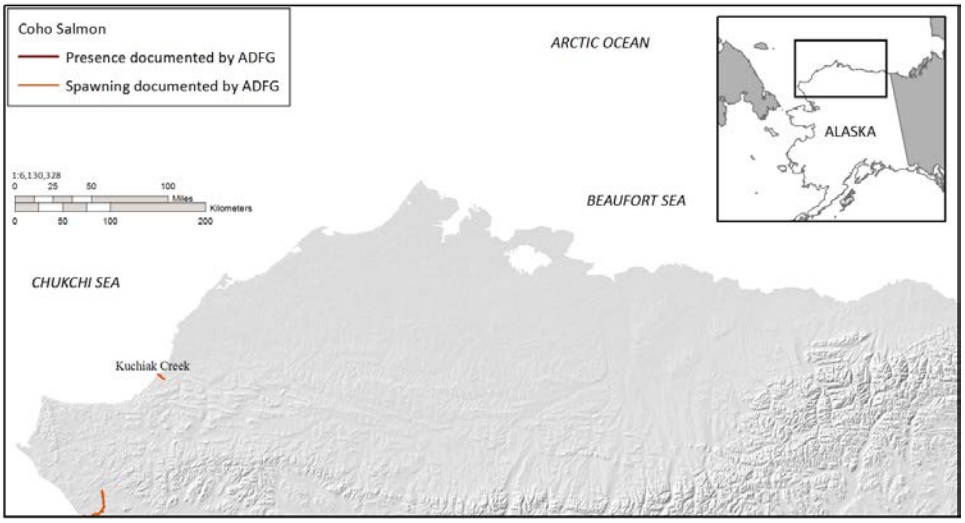

Figure 13. Map of North Slope Region showing stream systems with presence and spawning of coho salmon. Map by Christine Woll, University of Alaska Fairbanks.

Salmon, Undefined Species

Informants in both Barrow and Nuiqsut often discussed the general subject of salmon without differentiating between species (see *Salmon Identification*). Occasionally in Barrow, and often in Nuiqsut, informants also grouped salmon and Dolly Varden (locally called char) together in their discussions about geographic distributions. One informant noted that salmon and char will travel together up the Singaruak River near Barrow. Nuiqsut informants reported harvesting salmon

and char near Umiat, an important fishing spot that is a six to eight hour boat ride from Nuiqsut up the Colville River.

Salmon Identification

According to George et al. (2009) there are 22 common fish species harvested in the Barrow region and 27 in the Colville River and tributaries. The primary species harvested by local residents include: broad whitefish, Arctic cisco, least cisco, grayling, burbot, lake trout, and Dolly Varden. Various species of Pacific salmon are utilized as subsistence resources in Barrow and Nuiqsut, but are harvested in much smaller numbers and are less important fisheries (Brewster et al. 2008). Informants tended to know less about these species. We that found identification issues arose during our interviews and misidentification of salmon species contributes to inconsistent reporting of catch data. In both study communities, we found that active and knowledgeable fishermen consistently misidentified salmon at the species level. In Nuiqsut we found a high degree of a conflation of salmon species and Dolly Varden.

During our participant observation in summer 2011 in Barrow, many fishermen exhibited their catches while picking their nets. Chum salmon were often called "silver" salmon (another common name used for coho salmon in other regions). Barrow fishermen catch their fish in brackish water when salmon are still a brilliant silver color ("ocean bright"). The calico spawning appearance is usually faint when Barrow fishermen harvest chum salmon, and appears later in the year or after the fish has spent time in freshwater. The reporting of "silver" (or coho) salmon caught in subsistence fisheries in both the US and Canadian Arctic (e.g., NPFMC 2009) is problematic for this reason. We also found that several informants tended to refer to large chum salmon as "king" salmon (another common name for Chinook salmon). We found that pink salmon, especially in spawning condition, tended to be identified correctly more often than chum salmon. This is likely due to the differences in size, texture of flesh, prominence of the dorsal hump, and spotting patterns between the species. We found variability among fishermen in their knowledge of salmon species. Some fishermen correctly identified salmon to the level of species, while others commonly misidentified both pink and chum salmon. Recently, there has been increasing interest by local fishermen in learning to correctly identify salmon species.

Prior to our study, several fishermen asked the North Slope Borough, Department of Wildlife Management to help them identify the different species of salmon. During our participant observation we found that several fishermen used identification keys and kept personal logbooks of their harvests. Fishermen displayed pride in their ability to identify the different species of salmon. 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 North Slope Borough, Department of Wildlife Management, the Native Village of Barrow, and ADFG to learn species identification and by collecting age, sex, weight, length, and genetics samples. Despite these recent measures to improve the detail of harvest records, not all Barrow fishermen are interested in species-level identification. One informant who is locally identified as an expert fisherman stated, "if they're not humpies (pink salmon) I call 'em silvers, because they're silver… they all look the same to me." For some, catching fish to feed their family takes precedence over learning to differentiate among salmon species.

Consistent with the way fishermen used the common English name "silver" to refer to more than one species of salmon, Iñupiaq nomenclature in this region has only two names for salmon – *amaqtuuq* and *iqalugruaq* (Table 2; see also Appendix A). *Amaqtuuq* is used to refer to pink salmon. Barrow informants tended to use *iqalugruaq* to refer to bigger chum 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. For example, 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 were historically inexperienced with the other three species that now appear in the region.

In Nuiqsut, it appears that fishermen use one Iñupiaq name to refer to both salmon and Dolly Varden, *iqalukpik* (translated in George et al. 2009 as Dolly Varden char). During interviews with Nuiqsut informants, we found that species level identification was difficult. During a discussion with 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 the elders and fishermen we interviewed in Nuiqsut used the name "*iqalukpik*" to refer to salmon. Only two elder informants used the name "*iqalugruaq*." One specifically used the term "*iqalugruaq"* 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, and mentioned specifically the hump characteristic of this species.

Table 2. Variety of nomenclature for Pacific Salmon species in the study region.

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]Translation: *iqalugruaq* – big fish; iqaluk – fish, gruaq – big (MacLean 2011).

It appears that the different species of salmon display similar movement patterns, which may contribute to the confusion of identifying the separate species. A Nuiqsut informant emphasized that many of these species, collectively called *iqalukpik*, migrate at the same time during the summer and that populations vary greatly year to year. While Nuiqsut informants often discussed salmon species and Dolly Varden interchangeably, many offered species-specific information on the presence and distribution of pink salmon and chum salmon in river and stream systems. This research project is not the first to record misidentification issues. Bacon et al. (2009) found that

salmon identification by fishermen is problematic in many North Slope communities, even in Point Hope and Wainwright, where salmon are more commonly harvested.

Salmon Run Timing

In the waterways surrounding the communities of Barrow and Nuiqsut, most salmon are caught in July and August. The short summer season does not allow much variation in run timing 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 rivers or near shore areas. In 2008, pink salmon catches were highest between July 20 and August 31 (NSB et al. 2009). An elder in Barrow reported that fishermen catch salmon "in August when it starts getting dark." Chum salmon are caught throughout the month of August after the pink salmon catches peak (Cotton 2012; Craig 1989b). Fishing activity levels in and around both Barrow and Nuiqsut follow this timeline.

Vast numbers and kinds of resources are available in this region during a constrained time period; fishing is only one of many activities that consume people's time in the ice free months. Once waterways have cleared of ice, harvesters spend their summer and fall months hunting marine mammals in the open ocean, traveling along the coast and inland to hunt caribou, and harvesting a variety of fish with gill nets, rod and reel, and jigging poles (Stephen R. Braund and Associates 2010). In Barrow, these activities are flanked on either side by spring and fall whaling. The timing of fishing activities is related to when fish are available in the waterways, but is also closely tied to the accessibility of other resources. If a herd of caribou passes near town, fishermen may pull their nets for some time while hunting and processing caribou. Due to the inconsistency in salmon fishing effort over the course of a summer and from year to year, informants' observations of salmon movement timing varied.

The duration and timing of the salmon fishery in Elson Lagoon is tied to the sea ice conditions. One informant noted that salmon do not enter Elson Lagoon unless there is an ice-free zone above Point Barrow. This observation may indicate that the salmon are moving from the Chukchi Sea into the Beaufort Sea. Wind patterns also affect the season length and timing of this fishery. Westward currents created by an east wind provides 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, a highly valued subsistence food in Nuiqsut (Fechhelm et al. 2007; Murphy et al. 2007). Fishing is also successful when water levels in the Colville River are high enough to travel to fishing locations upriver in these conditions.

Fishermen gave consistent answers when asked about the timing of the salmon runs and it does not appear that the length of the season has not changed much over time. However, informants noted that the ice conditions are unpredictable. Since salmon migrations and fishing activities are both tied to ice conditions, the fishing season is heavily dependent upon the prevalent winds. An elder informant in Barrow mentioned that, "Every year is different for the salmon migrations. Sometimes they come and sometimes they don't. It's different every year."

Nuiqsut differs from Barrow in its close proximity to the Alpine oil field. Subsistence harvesters in Nuiqsut have noticed many changes since exploration and development was initiated near their village (Figure 5; Stephen R. Braund and Associates 2009). Local experts stated that ice roads built across the river hinder the break-up of the river, which affects 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. These changes may be linked to the presence of the ice roads.

Salmon Use

Subsistence Fishing and Salmon Harvest

Seasonal migrations to specific river systems for harvesting fish and hunting have occurred among the Iñupiat for many generations and are still an important part of life for many people in Barrow and Nuiqsut (Stephen R. Braund and Associates 2010; Burch 1998). Generally, families return to the same location or camp every year. Modern fish camps include cabins, generators, freezers, and motorized vehicles such as boats, all-terrain vehicles, and snow mobiles. During winter months, under-ice fishing occurs. Arctic cisco and burbot make up the primary catch during winter and are harvested with gill nets or by jigging. Salmon are primarily harvested by Barrow residents in Elson Lagoon and by Nuiqsut residents within the Colville River delta and drainage, Itkillik River, and Fish Creek regions. Local subsistence harvesters in these communities also travel throughout the North Slope region to gather fish. They often carry gill nets or rods and reels to harvest salmon for consumption and to share.

The Elson Lagoon gill net fishery, while gaining increasing attention in recent years, is not new. A Barrow elder remembers the presence of gill nets in Elson Lagoon when he first moved to Barrow in 1938. In the early 1900s people set gill nets in the lagoon to target young seals. Today between 20 and 30 fishermen set gill nets in the lagoon to catch whitefish, salmon, and Dolly Varden species. Fishermen use a variety of mesh sizes, ranging from 7.6 cm up to 20 cm. The smaller mesh sizes are used to target whitefish and small salmon, while the larger mesh sizes are used to catch large chum salmon and occasionally Chinook salmon (Cotton 2012). Today, gill nets used in Elson Lagoon are made of monofilament fibers, but nets were made of cotton twine in decades past. Monofilament is more difficult for the fish to see and is effective when the wind is calm and the water is not turbid, according to a Barrow fisherman. An elder noted that before cotton and monofilament were introduced, his grandparents used line made from caribou, whale, and seal sinew to construct gill nets. Murdoch (1892) noted that nets were also made of baleen.

The lengths of the nets vary from six meters to over 90 meters, depending on the conditions and the amount of fish sought. Fishermen in Barrow and Nuiqsut set their gill nets and return to check for fish 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 may also 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. Generally the gill nets are placed at a 90 degree angle from the shore. The offshore end of the net is attached to a heavy item sitting on bottom (an anchor) and to a buoy that both marks the position of the net and keeps that end of the net afloat. If the area is shallow enough, fishermen can pick the fish from their net in chest

waders, otherwise fishermen use small boats (Figure 14). In Barrow a few of the fishermen have developed a method for pulling in their net, a style that one fisherman said comes from the Point Hope area. A single line is attached to both the seaward and shore ends of the net. A pulley system is employed so that fishermen can pull their net ashore and pick fish without having to use a boat or chest waders. This system relies on fewer resources, since fishermen do not need a boat or other equipment to reach the seaward side of their net. Additionally, this setup is very valuable during inclement weather because fishermen are less exposed to dangerous water conditions.

Figure 14. Barrow fisherman using a small dingy to pick his gill net, summer 2011.

Salmon Processing and Preparation

As with any other food, fish are processed and prepared in a multitude of ways, depending on individual and family preferences and weather conditions. Traditionally, the Iñupiat did not cook much of their food. Fish were generally frozen or dried upon harvesting and eaten later with seal or whale oil. While fishing in the winter months, harvesters make use of the frigid weather and freeze their catch whole. This frozen fish is generally eaten raw throughout the year as a staple of the Iñupiaq diet. During the summer months, fish are hung to dry at fish camp. People also place fish in ice cellars during the ice free period. If ice cellars are not available, families bring generators and freezers to camp in order to freeze fish whole.

The advent of electricity allows for other preservation methods. Salmon and other fish can be gutted and filleted. These pieces of processed meat are placed in vacuum-sealed bags, or other plastic storage devices, and stored in electric freezers. Smoking fish, particularly salmon, has become more common in this region. “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." Residents purchase commercially produced wood chips for smoking from the store because wood is a scarce resource in this area and is generally limited to drift wood.

In addition to new methods of preservation, traditional practices are still in place. Frozen fish with oil remains a common treat in Iñupiat homes. According to several informants, this method of preparation provides people with warmth and energy that store-bought foods cannot provide. *Pipsi*, or dried fish, is still made in Barrow and Nuiqsut. All species of locally harvested fish are dried and their eggs harvested because of the high fat content. These foods are considered a delicacy by many Iñupiat peoples. 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 reported that producing quality dried fish in town became difficult around the 1950s and 60s, when the Navy Arctic Research Laboratory (NARL) became a hub of research activity. The development of roads and motorized vehicle traffic produced dust and affected air quality.

Pink salmon are usually eaten fresh, as many informants consider them unappetizing after they have been frozen and thawed to cook. Several fishermen prefer their pink salmon prepared "tempura-style," meaning they are dredged in batter and deep fried. Chum salmon and Chinook salmon are also often eaten fresh. Residents often eat these species raw as sushi or poke, grilled, baked, smoked, fried, or boiled. Several interviewees stated that they are learning new methods for preserving and preparing salmon.

Fish Preferences

Many informants stated early in our interviews their preference for non-salmon species, especially broad whitefish, Arctic cisco, Dolly Varden, and burbot. However, we found that residents expressed a wide range of preferences for salmon. Residents appeared to have a general negative view of pink salmon, which may be partly related to their perceived overabundance in certain years, as well as to their taste and the meat's soft consistency. Several informants referred to pink salmon as a pest species that clog their gill nets.

We learned that during periods of high pink abundance in the Elson Lagoon fishery, many fishermen take their nets out of the water to avoid catching large numbers of pink salmon. One informant said, "I didn't set my nets last year (2009), because they kept getting clogged up with pinks." Similarly, another interviewee said, "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." 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 (the hump), they are stink. You have to (take) it out, that part, to cook (it)." We spoke with one informant who said that he did not set his net in 2009 and was told by an active fisherman during that year: "You ain't missing nothing. I ain't getting much, or it's a bunch of pinks." He replied: "Yeah, somebody needs to shoot them things." In particular, families who fish for broad whitefish in the Chipp River noted that they consider pink salmon to be a nuisance. Earlier ethnographic research also found that North Slope residents do not prefer pink salmon.

> 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 (Brewster et al. 2008; quoting elder Warren Matumeak).

Evident in many of our interviews is 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 said, "When I was growing up we feed the dogs with it. *Iqalugruaq*. But nowadays they 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 noted 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."

Another Barrow elder reported that his grandmother had a name for salmon that meant "to vomit" in Iñupiaq, although none of our other informants confirmed this assertion, nor did local language experts. This same elder said that he remembers people beginning to eat salmon, and more cooked food in general, when the Naval Arctic Research Laboratory began operating in Barrow and when oil exploration and development began to spread across the North Slope.

Non-Salmon Species and Species Interactions

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 emphasizes the great importance of other fish species that are a food staple in the Iñupiaq 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 the time of the year when they are caught. Salmon identification and description, on the other hand, was more difficult. This attests to the long history of non-salmon species use and the relatively recent rise of salmon fishing.

Certain villages are known for producing particularly desirable kinds of fish. For example, in our interviews, several people stated their preference for: smelts from Wainwright, Arctic cisco from Nuiqsut, broad whitefish from Barrow and perfectly dried broad whitefish, *pipsi,* made by one particular expert. Fish caught in certain areas have particular tastes, which are either preferred or not, as noted in this interview excerpt:

> …you notice the ones 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.

When discussing broad whitefish harvested in Barrow, one informant described a "tundra taste" that is present in those fish, which is not detectable in fish from Nuiqsut.

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 generally overlap with migrating whitefish and Dolly Varden. During winter ice fishing, whitefish and burbot are targeted without incidental catches of salmon. Although salmon species are often not the targeted species in Barrow and Nuiqsut, emphasis is placed on eating what is caught and not wasting any subsistence catch. 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.

Subsistence Fishing and Cultural Dimensions

During one interview with a particularly active Barrow fisherman, we were surprised to learn that this fishermen fishes every day during the summer season, yet does not have a taste for fish. He does not consume a single fish he catches, nor does he sell any of his fish. We wondered what motivated this fisherman to spend so much time fishing. Similarly, we were surprised that many of those participating in ethnographic interviews expressed a strong aversion to commercial fishing activity. We wanted to better understand the factors that motivate people to devote resources to subsistence fishing so that we may appreciate the cultural significance of fish in this region.

Motivation studies (e.g., Condon et al. 1995; Fedler and Ditton 1994; Stairs and Wenzel 1992) 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. As we discuss below, we found that Iñupiat cultural practices of fishing for sharing, teaching, and well-being were strong motivating factors for many subsistence fishermen in Barrow and Nuiqsut. We also found that the economic benefits of providing fish as food was an additional but less important driver. Several fishermen mentioned that the high costs of store-bought food prompts many people to start fishing, or to catch more fish. One said: "All the high prices of food up here, we rely on the fish for food." Many fishermen also noted that fishing provides a healthy outdoor activity in a community where indoor pastimes have become increasingly common: "(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."

Cultural Transmission and Well-Being

Culturally, subsistence fishing represents much more than simply harvesting for food. Many lessons are taught while picking nets and spending time at fish camp on the North Slope. While

working alongside their elders at fish camp, a young person learns various types of traditional knowledge: how to read the weather, survival skills, Iñupiaq words for plants and animals, and traditional methods of hunting and gathering. Several informants expressed concern that fewer young people are learning how to hunt and fish. Many informants noted that they willingly take young boys and girls out fishing with them so that they may benefit from these experiences. Informants stated that they often go fishing primarily to show young people how to harvest fish. Subsistence practices are conceptualized as "healthy ways of living," as a Nuiqsut elder put it.

The young people who go fishing and hunting are allowed to bring some of the catch home to share with their family and friends. This act of sharing generates a strong sense of accomplishment and pride in young subsistence users. One elder expressed that he tries to take young children out fishing or hunting if they do not have a person in their family who goes out hunting. Others mentioned that spending time with a mentor on the land helps young people who are struggling to deal with the daily stresses of village life, particularly those stresses associated with living an increasingly western lifestyle. The healing power of participating in subsistence activities was emphasized by several informants.

A diverse set of challenges confronts residents of Barrow and Nuiqsut. In our interviews and observation many elders expressed a concern that that too few young people are engaging in subsistence practices. One elderly 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 prized 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.

Elders expressed that they hope to encourage young people to participate in subsistence activities, in order to preserve the cultural traditions of hunting and gathering. The healthy exchange between individuals and their land is important for physical and spiritual well-being of those that live on the North Slope. 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.

Learning subsistence fishing skills extends past the younger generation of Iñupiat peoples. Due to Barrow's diverse population base, many people who are not originally from the North Slope but now live in Barrow are interested in learning to harvest local resources. Such individuals often enter into the world of subsistence through the Elson Lagoon fishery, which is close to town and requires few resources. We met several very active fishermen who were not originally from Barrow. These individuals learned fishing methods from friends who were willing to share their knowledge. Non-local people who are welcomed into the resident fishery are often those

who have morals and values that parallel those of current fishermen (Acheson 1981; Miller and Van Maanen 1979; Miller and Van Maanen 1982) . Informants shared many stories about people learning to fish quite recently, both long-time residents and newcomers to the region, such as this one:

> 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.
>
> Fishing is a vital form of food source because of the fact that it's something you can go out and do, anybody can do it. I've never fished in my life, this way. I had someone show me briefly and I've talked to the Native elders that I've run into and you can find out how to do it.

With a relatively low-cost investment in equipment and the mentorship of other fishermen, a person can enter into the subsistence activities in Barrow and Nuiqsut. Fishing represents an important activity for many along the Beaufort Sea, not only in terms of economics but in terms of feeling "a part of the community." A new resident who meets others while out fishing can become involved in other activities once a connection is made through sharing fishing experiences.

Status

In some discussions we explored the topic of status related to the harvest of different subsistence foods. Some informants directly discussed fishing and sharing in terms of status: "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." In our observation of community dynamics in both Barrow and Nuiqsut, we noticed the high status role occupied by whaling captains, captains' wives, and their families. We were curious about how high harvesting fishermen were viewed in comparison to whaling captains. We explored this topic in some of our interviews, such as in this excerpt:

> *Interviewer:* Do fishermen that bring in a lot of fish have a high status like a whaler or a hunter?

> *Interviewee:* That's a really good question. My sense is no, never heard that. We haven't had a mayor of the North Slope Borough that hasn't been a whaling captain. It's almost a pre-requisite. It's not the same for, "well I catch fish." You know the guys, the salmon really isn't the thing but I think there's a lot of status associated with the heavy hitters in the broad whitefish/*anaakliq*, fishery. Like [one of the local elder men]. There was definitely status involved in that. That's the fish that's eaten at *Nalukataq* (spring whaling festival named for the blanket toss) and at Thanksgiving and Christmas. That's what people want to see in the bag when it's handed out for holidays and celebrations. There's quite a bit of status associated with that for sure. [One of the female elders] dries a lot of fish. Broad whitefish, air dried *pipsi*, and so did [a few other families]. That stuff is gold.

As the previous informant described, residents of Nuiqsut and Barrow have different preferences for various fish species. When fishermen share their catch, they often preferentially give the more desirable whitefish species to elders and give the salmon to a broader group of people. Some informants stated that they do give away salmon directly to elders, or supply them to the senior and assisted living centers. While asking about the status associated with each type of locally harvested food, we learned that it is often the whaling captains who are the ones also catching large amounts of fish; these individuals are expected to feed large numbers of people, even beyond the whaling season. Thus, a social high status is earned by those who feed their families and community, with whales, as well as fish, caribou, and other locally available resources.

> People who are fishing are, some of them are, whaling captains. They're getting ready to do their part in feeding the community. It's more or less their obligation to continue to gather food which they share to the community. Not only do they share whale but they share fish, most frequently. In our family that's the way it's been.

Sharing, Barter, and Sale

Catching food to share is a defining activity for the Iñupiat people. Sharing goes far beyond giving food. Harvesting local resources is generally a cooperative activity; people share equipment, money for gas, time, and knowledge. Often many family members and friends are needed to set nets, pick fish from gill nets, and process the catch. Informants in Barrow and Nuiqsut discussed the importance of sharing in a variety of ways:

> 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 snow machines.
>
> 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.

Many people maintain extensive sharing networks, which include family members, friends, neighbors, business associates, and individuals who live outside the North Slope. Several interviewees mentioned giving fish away *en masse* at the fire station, airport, or senior center when they caught more fish than expected in their nets. One Barrow fisherman described his sharing patterns in the following way:

> 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 salmon I let people come and get 'em.

Our ethnographic research shows that sharing extends beyond food for Iñupiat people. When someone is traveling out on the tundra, ocean, or ice, residents 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 or needs assistance, willing responders come to their aid without question. During our interviews in Barrow, one of our elder informants was collecting donations for a family in Wainwright who was in need of clothing, supplies, and food, after a house fire. We experienced many instances of the people of the North Slope taking care of each other.

Trading has been, and continues to be, an important Iñupiaq activity (Burch 1998). During an interview, one Barrow elder told a story about his family members meeting with interior Athabaskan groups to trade in the mountains south of the North Slope. As he recalled, Athabaskans would bring smoked fish and other items and the Iñupiat would have fish and marine mammals to trade. Fish continues to be bartered for *muktuk* (whale skin and blubber) across North Slope communities. As Nuiqsut only participates in fall whaling, residents of this community trade excess whitefish and other fish products for *muktuk*, whale meat, or whale oil if the supply of bowhead runs low. Generally, Nuiqsut is known regionally for its Arctic cisco. Residents of Nuiqsut travel to Barrow to trade their preserved Arctic cisco for other food items or for cash.

> The best area for Arctic cisco nowadays is Nuiqsut... We call it the Arctic Cisco Capital of the World… 'Cause they got the best and the fattest and so they tend to market their Arctic cisco into Barrow in the winter.

Younger people, and some elders, have created small-scale markets for their particular fish. In Nuiqsut, an elderly woman is known throughout Alaska for her highly prized *pipsi*. One Barrow informant noted that he trades salmon for whitefish with relatives in Atqasuk (Figure 1) because he prefers the flavor of the whitefish found in the lakes in that region.

Along with other Iñupiat, Barrow residents barter fish with members of the Filipino community who live in Barrow. Many informants noted that Filipino residents of Barrow enjoy eating salmon soup. While many fishermen exchange some of their catch for other items, others stress that they only give away fish, and do not expect anything in return: "We don't trade. If we got it, we'll give it to our neighbors."

The Fish and Game Management Committee of the North Slope Borough directed us to explore the topic of commercial fishing in our interviews about salmon. Some members of the committee suggested that, given the economic value of salmon in other regions of the state, increasing numbers and catches of salmon in the North Slope may prompt interest in commercial fisheries development. Many informants voiced concern about the potential effects commercial activities would have on subsistence activities for the same resources in this region and noted that they did not want commercial activities to influence their lifestyle. Two respondents in Barrow, however, expressed that if salmon, halibut (*Hippoglossus stenolepis*), or king and snow crab (*Paralithodes* and *Chionoecetes* spp., respectively) exist in the Chukchi and Beaufort Seas at commercially viable levels, developing commercial fisheries may be appropriate and they discussed the community-based motivations for local commercial harvest. For example, the income may aide the local economy. We found consistent support for local community needs from both groups – those who strongly opposed commercial fisheries development and those who discussed other future opportunities, such as fish hatcheries.

Commercial fishing is virtually absent in the North Slope region. Beginning in 1964, the Helmericks family operated a small-scale commercial fishing operation in the coastal Colville Delta region that supplied a regional market for whitefish in Barrow and other villages (Fechhelm et al. 2007; Helmericks 2012; MBC 2003). In 1978, one member of the Helmericks family and two residents of Nuiqsut held statewide interim-use freshwater fish, set gill net commercial fishery permits (ADFG 2012). Despite the lack of formal commercial fisheries, informal customary and traditional sale of fish and fish products occurs.

Fish Camp

Traditionally, people of the North Slope region lived a seasonally nomadic lifestyle, traveling from one fishing and hunting location to another, dependent upon resource availability (Burch 1998). While modern day residents of Barrow and Nuiqsut are primarily town-based, families continue to travel to seasonal fish camps. This social institution, fish camp, is vitally important for the modern Iñupiat people. Fish camp is an important place where knowledge transfer and cultural transmission from older to younger generations takes place. Many informants in Nuiqsut and Barrow stated that although still important, the act of going to fish camp has changed over their lifetime. Families used to spend several months at fish camp, harvesting and processing fish for the winter months. But today many families travel to fish camp only occasionally, and for short periods of time. The time spent at camp varies by family, but many North Slope families

spend less time at camp now compared to the past. This change is due in part to time constraints associated with wage earning jobs and various obligations in town.

Informants in Nuiqsut noted that the oil and gas infrastructure of the Alpine facilities has affected their camping patterns. One informant noted that his family stopped staying at their camp when the Alpine platforms came in 2001.

> That pad is so close to my grandma's camp. She's got a camp right there. CD-2 (Colville Delta 2) is closest to it. There's a road going to CD-2. It [camp] has been really impacted big time. CD-4 was the latest, that was about 2004. You don't see many people camping on that side anymore. Hardly anybody is camped on that side over there. It's hard to hunt when there's so much activity going on. I haven't spent the night in that area since like 10 to 15 years ago.

Another informant shared a similar story. His family has fished for Arctic cisco on the Colville River since the 1970s. They used to harvest a large amount of fish each year but noticed a decline in Arctic cisco catches after oil exploration began to expand westward from Prudhoe Bay toward the Colville River. Some people believe that the development of the Kuparuk facilities around the 1980s impacted the Arctic cisco population. Oil began flowing from the Alpine facility in 2000. Informants note that there are "no more fish in the middle channel." According to Murphy et al. (2007), while the effect of development on Arctic cisco abundance in the Colville River remains inconclusive, winter development activities in the Colville delta do have the potential to adversely affect Arctic cisco survival.

Broader Context of Change

Perceptions of Environmental Change Affecting Subsistence

In our interviews about changing salmon abundance and distribution, we also discussed with informants their perceptions of broader environmental and socioeconomic shifts in the region. In both communities, respondents shared mixed observations of environmental change. Some stated that the environment has always been in flux. Others note directional change. Local observations of climate change and weather patterns coincide with what the scientific literature has concluded about contemporary Arctic climatic shifts. Informants reported that they are observing higher temperatures in the summer and winter. In our interviews, informants often stated that weather is more unpredictable and variable than the past. Some local experts described the changing nature and timing of break-up and freeze-up of area waterways. Similar research in the Arctic suggests a shift in the nature of spring break-up and fall freeze-up that affects fishing access and processing (Moerlein and Carothers 2012).

The dramatic retreat of summer sea ice in the Beaufort Sea, and the decrease in the presence of multi-year ice and ice thickness are experienced in the North Slope region (ACIA 2005; Wassmann et al. 2011). A Barrow elder noted that in his lifetime the winter sea ice conditions have changed dramatically. In the past, multi-year ice would be present, which was strong and could be melted to produce potable water. Today, he concluded, much less multi-year ice is

present during the winter months. Informants also noted changes in the condition of river ice on the Colville River drainage during the winter months. Several informants noted that the river ice thickness is thinner now than in the past. One stated that the ice typically averaged between two and two and a half meters thick in the 1970s, whereas currently it may often be less than one meter thick. Due to thinner ice and less predictable ice conditions, travel and activities on ice are more dangerous now compared to the past. Informants in Nuiqsut also noted that spring break-up of ice on the Colville River has changed over the past couple of decades; the break-up event is less dramatic now compared to the past. An active fisher stated that the ice does not pile up when it goes out as it once did decades ago, which results in a less violent break-up. The changing nature of break-up may decrease the clearing of sediment and amplify the effects of increased erosion (discussed below).

Permafrost underlies much of the land mass of the North Slope. The tundra, lakes, and villages rest upon this solid layer of ice. Several of our informants have noticed changes in the permafrost over time. One Barrow informant, a former utilities company employee, placed power poles across the North Slope region during the 1970s to 1990s. He estimated that the permafrost layer in the 1970s was about 46 cm (18 inches) below the surface at the maximum extent of the thaw in October. In the mid-1990s, he estimated that the maximum extent of permafrost thaw was nearly 1.5 meters (5 feet) below the surface of the tundra. Thawing of permafrost has led to changes in the water levels and dynamics of rivers and lakes, increased erosion, and has prohibited many people from using traditional ice cellars for storage. In our interviews, we heard several accounts of cabins and homes needing to be relocated due to erosion and of food spoilage due to ineffective ice cellars. One of our key informants in Barrow explained his struggles with erosion and warming at his fish camp located along the Beaufort Sea coast north of Teshekpuk Lake. Between the 1980s and 1995, three separate ice cellars each became exposed and unusable. After the third cellar failed due to bank erosion, he started to preserve fish by drying and freezing with electric freezers. Erosion is not new to this region, but appears to be occurring at an increasing rate. The previously mentioned informant estimated that the bank near his fish camp has eroded about 300 meters every six or seven years. Eventually the family was forced to build a new cabin on skids so that they could periodically move it away from the eroding bank.

In Nuiqsut, residents have also experienced the negative effects of erosion on their fish camps and ice cellars. One informant explained that she has used the same ice cellar for her entire life; around 2000 this cellar eroded and became unusable. This person must now use a generator and electric freezer to preserve her harvest at fish camp. In 2010, a Nuiqsut family preparing for a *Nalukataq* put away large amounts of salmon for the festival. The next summer when they went to pull the salmon and other meat out of the cellar they discovered that the salmon and some bowhead whale meat and *muktuk* were spoiled and inedible. The ice cellar had thawed due to lack of permafrost cover. We learned from several Nuiqsut informants that cabins located along the Colville River have been moved several times in the last 30 years due to permafrost thawing and erosion. These are only some of many examples of the effects of thawing permafrost and erosion on North Slope subsistence practices.

Perceptions of Socioeconomic Change Affecting Subsistence

While our interviews in Barrow and Nuiqsut were focused on salmon use and knowledge, and perceptions of environmental changes, we heard much about the social, economic and cultural changes that are affecting all subsistence practices. In particular, informants focused on the effects of infrastructure and technological development and oil and gas exploration and production in the region. The impacts of oil and gas development on the Arctic Slope communities are multiple (NRC 2003). One obvious marker of change evident in the North Slope compared to other rural regions of the state is the influx of economic wealth. The average household income in North Slope communities was about $2,000 in 1970. By 1979 household income approached $75,000 (Klausner and Foulks 1982). Large-scale modernization processes followed the oil revenues, including vast amounts of infrastructural development Barrow and other North Slope villages. North Slope Borough oil-related property taxes totaled $271 million in 2010, which accounts for 98 percent of the Borough's total property tax revenue. In FY 2010, the State of Alaska noted revenues of $6.2 billion from oil and gas industries. On average, the State estimates that oil and gas revenues will supply more than 87% of the total state funds through FY 2020 (State of Alaska 2012b).

Nuiqsut lies in the heart of the Colville River delta, 80 km west of the Prudhoe Bay development, and has the distinction of being the Alaska Native village most proximate to an active oil field. In 2001, production began just a few miles from the village of Nuiqsut at the Alpine oil field, a 429-million-barrel field operated by ConocoPhillips, Alaska. Nuiqsut's village corporation, Kuukpik Corporation, was established in 1973 under the Alaska Native Claims Settlement Act. This local corporation negotiated a surface-use agreement with governing bodies and the industry that has produced strong earnings for the Kuukpik Corporation and its approximately 250 shareholders. In addition to revenue, the surface-use agreement provides education and training opportunities and hiring preferences for Nuiqsut residents.

This wealth has not been generated without costs, however. Several of our informants, particularly in Nuiqsut, noted specific threats to subsistence from oil and gas impacts, including: seismic activity, increased ground and air traffic, pipelines, roads, ice roads, oil wells, processing facilities, platforms, staging areas, airborne discharges (including, flaring exhaust, volatile organics, hazardous air pollutants), oil spills, contaminant spills, and a large flux of non-local employees into and out of the region. One young tribal leader noted at a public meeting:

> It's mind-blowing to see how much activity has developed since I was born. I wish I was born 50 years ago because I would have said no a long time ago. Because today I have to deal with all of this development impacting the way I eat my food on a daily basis. As of right now we can't stop it because of dollar signs. Because of oil and gas. Because of international oil companies. They are impacting real lives, my kids' lives.

Study participants in Nuiqsut, while vocalizing concerns, also expressed their close involvement and dependence on the oil and gas industry. As one local leader noted, "In Nuiqsut, we are in the heart of the industry. I've learned my ways to support the community – both for economics, jobs and for subsistence." About half of the village residents are shareholders in the Kuukpik

Corporation, and many informants noted corporation dividends enable them to more fully engage in subsistence-based ways of life.

This history of development also has important implications for ethnography. No matter how benign our questions about salmon and environmental change were intended, our informants' responses were made in the context of their lived experiences that are strongly influenced by oil and gas exploration and development. As one informant noted, our questions about fish and subsistence, caused "eruptions" inside of him. He pointed out that our study about salmon, climate change, and subsistence fishing draws in such larger issues like oil and gas development, environmental consequences of development, and social and personal impacts. This informant was visibly shaken as he explained his emotional response to our research in his community. He discussed personal examples of how oil and gas development has catalyzed social fracturing in the community through recent accusations and potential criminal charges. The seemingly narrow questions that we intended to ask regarding changing salmon populations were, in this informant's mind, linked to experiences and emotions generated over the past several decades of people interacting with companies, universities, federal agencies, all with external, non-local desires for information. We noticed tension about research across the region, and particularly in Nuiqsut. Several informants became emotional, or stated explicitly that discussions about subsistence and change produced strong emotions. These reactions revealed the ambivalence and disagreement that generates conflict within individuals, families, and communities specifically regarding oil and gas activities, and more generally, about modernization.

Given these tensions, we strived throughout our research process to maintain an ethical approach. Research itself became a topic of considerable discussion in our interviews and participant observation. Informants shared stories of company scientists acting unethically, state employees resigning because of results being reinterpreted inaccurately, and environmental nongovernmental organizations doing a poor job of representing the region and its communities. We presented this report in multiple community meetings and in hard copy throughout the communities of Nuiqsut and Barrow and welcomed local input regarding its content and delivery. In response, we received valuable insights about themes we had overlooked or underemphasized and have included many suggestions that have strengthened this final report.

SUMMARY AND CONCLUSIONS

Arctic social-ecological systems are experiencing unprecedented changes. This ethnographic research with active Arctic fishermen and elders adds to the state of knowledge about salmon and other subsistence fisheries in the region and in the context of Iñupiat culture and communities. Table 3 summarizes our major findings.

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 and chum salmon 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 percent of total numbers of recorded fish caught in 2011 (Cotton 2012).

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 over whitefish, but fish that are caught are not wasted. Catching fish to share, including salmon, 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.

Table 3. Summary of observations of salmon knowledge and use, and related findings.

Salmon Knowledge	• Salmon catches are 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 distinct Iñupiaq names • Inconsistent usage of Iñupiaq and common English names for salmon and Dolly Varden species indicates under-differentiation and/or misidentification • Chinook salmon and sockeye salmon are occasionally caught near Barrow and Nuiqsut, although the catch is small compared to chum salmon and pink salmon • Chinook salmon and sockeye 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
Salmon Use	• Salmon are a relatively unimportant fish resource compared to whitefish species • Salmon are part of the array of subsistence foods utilized by the Iñupiat and other local residents • Salmon preference is varied; some view salmon as a nuisance species, but many others enjoy catching, sharing, and eating salmon • Salmon are caught and processed by elders, adults, and youth • Salmon are caught primarily using gill net • Salmon are prepared and eaten in many ways, including dried, baked, boiled, fried, grilled and smoked • Fishermen are learning about salmon and have tailored their gear toward catching species that their families and sharing networks prefer • Erosion and permafrost thaw have caused the relocation of coastal camps and 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 fishing practices

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 and to teach youth how to catch and process fish. 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 fishing activities currently under discussion.

Overall, salmon are still a relatively minor subsistence resource in Barrow and Nuiqsut. However, a few Barrow fishermen intentionally target salmon for harvest. Although interviews were 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. In our interviews and participant observation, elders and fishermen demonstrated a deeper understanding of morphology, run timing, harvest techniques, and a tighter cultural connection to whitefish species. Knowledge of the salmon species is increasing, but there is still widespread misidentification, even among expert fishermen.

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 and spring thaw and break-up patterns have shifted. Some noted timing shifts of a later freeze-up, shortening the ice season. Localized weather patterns were noted to be variable and unpredictable. Warmer conditions are generally observed in Barrow and Nuiqsut and affect 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, cultural, 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. These broad environmental and social changes provide an important context with which to assess changing salmon fisheries.

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REFERENCES CITED

Acheson, J. M. 1981. Anthropology of fishing. Annual Review of Anthropology 10: 275-316.

Agrawal, A. 1995. Dismantling the divide between indigenous and scientific knowledge. Development and Change 26: 413-439.

Aiken, Martha. 2007. Oral history interview with Karen Brewster. March 14, 2007. Barrow, Alaska. Iñupiaq Knowledge of Whitefish Project. DVD Number: H2007-01-04, PTS, 1-2. Fairbanks, Alaska: Alaska and Polar Regions Collection, Elmer E. Rasmuson Library, University of Alaska Fairbanks.

Aiken, Robert Sr. 1988. Oral history interview with Jack Winters and Billy Adams. March 9, 1988, Barrow, Alaska. Recorded for "Fishes Utilized in Subsistence Fisheries in National Petroleum Reserve-Alaska Project." Barrow, Alaska: North Slope Borough Department of Wildlife Management.

Alaska Department of Fish and Game (ADFG). 2011. Anadromous waters catalog. http://www.adfg.alaska.gov/sf/SARR/AWC/. Accessed 15 May 2011.

Alaska Department of Fish and Game (ADFG). 2012. Commercial Fisheries Entry Commission data. http://www.cfec.state.ak.us/. Accessed 07 March 2012.

Arctic Climate Impact Assessment (ACIA). 2005. Arctic climate impact assessment. New York: Cambridge University Press.

Babaluk, J.A., J.D. Reist, J.D. Johnson, and L. Johnson. 2000. First records of sockeye (*Oncorhynchus nerka*) and pink salmon (*O. gorbuscha*) from Banks Island and other records of Pacific salmon in Northwest Territories, Canada. Arctic 53(2): 161.

Bacon, J.J. 2010. Personal communication. Barrow, Alaska: North Slope Borough, Department of Wildlife Management.

Bacon, J.J., T.R. Hepa, H.K. Brower Jr., M. Pederson, T.P. Olemaun, J.C. George, and B.G. Corrigan. 2009. Estimates of subsistence harvest for villages on the North Slope of Alaska, 1994-2003. Barrow, Alaska: North Slope Borough Department of Wildlife Management.

Bendock, T. 1979. Inventory and cataloging of Arctic area waters. Juneau: Alaska Department of Fish and Game Annual Report 20: 1-64.

Bendock, T. and J. Burr. 1984. Freshwater fish distributions in the central Arctic Coastal Plain (Ikpikpuk River to Colville River). Fairbanks, Alaska: Alaska Department of Fish and Game.

Benner, R., P. Louchouarn, R. M. W. Amon. 2005. Terrigenous dissolved organic matter in the Arctic Ocean and its transport to surface and deep waters of the North Atlantic. Global Biogeochemical Cycles 19: GB2025.

Berkes, F. 2004. Rethinking community-based conservation. Conservation Biology 18: 621-630.

Berkes, F. 2008. Sacred Ecology, Second Edition. Florence, Kentucky: Routledge.

Berkes, F., M. K. Berkes, and H. Fast. 2007. Collaborative integrated management in Canada's North: the role of local and traditional knowledge and community-based monitoring. Coastal Management 35: 143-162.

Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10: 1251-1262.

Bernard, H. R. 2006. Research methods in anthropology: qualitative and quantitative approaches. Lanham, Maryland: AltaMira Press.

Brewster, K., C. George, and Barrow elders: Martha Aiken, Arnold Brower, Sr., Mollie Itta, Noah Itta, Mary Lou Leavitt, Oliver Leavitt, and Warren Matumeak. 2008. Iñupiat knowledge of selected subsistence fish near Barrow, Alaska. Report prepared for the Bureau of Land Management through an assistance agreement to the North Slope Borough Department of Wildlife Management.

British Petroleum. 2012. http://www.bp.com. Accessed 07 March 2012.

Brogan, J. 1979. Nuiqsut Paisanich, Nuiqust heritage: a cultural plan. Prepared by the Arctic Environmental Data Center for the Village of Nuiqsut and the North Slope Borough Planning Commission and Commission on History and Culture.

Brower, H.K. and R.T. Opie. 1998. North Slope Borough subsistence harvest documentation project: data for Nuiqsut, Alaska for the period July 1, 1994, to June 30, 1995. Technical Report. Barrow, Alaska: Department of Wildlife Management. North Slope Borough. Revised version. [revised report from April 15, 1998, listed as H.K. Brower and R.T. Hepa]

Burch, E. S. 1998. The Iñupiaq Eskimo nations of northwest Alaska. Fairbanks, Alaska: Univserity of Alaska Press.

Bureau of Land Management. 1982. Record of testimony: National Petroleum Reserve, subsistence hearing, Barrow, Alaska, November 22, 1982. Anchorage, Alaska, US Department of the Interior, BLM, NPR-A Program, Alaska State Office.

Condon, R. G., P. Collings, and G. Wenzel. 1995. The best part of life - subsistence hunting, ethnicity, and economic adaptation among young-adult Inuit males. Arctic 48: 31-46.

Cotton, S. 2012. Subsistence salmon fishing in Beaufort Sea communities. Master's Thesis. University of Alaska Fairbanks, Fairbanks, Alaska.

Craig, P.C. 1984. Fish use of coastal waters of the Alaskan Beaufort Sea. Transactions of the American Fisheries Society 113: 265-282.

Craig, P.C. 1989a. An introduction to anadromous fishes in the Alaskan Arctic. Biology Papers of the University of Alaska. Fairbanks, Alaska, Institute of Arctic Biology. 24: 27-54.

Craig, P.C. 1989b. Subsistence fisheries at coastal villages in the Alaskan Arctic, 1970-1986. Biology Papers of the University of Alaska 24: 131-152.

Craig, P.C. and L. Haldorson 1986. Pacific salmon in the North American Arctic. Arctic 39 (1): 2-7.

Dowsley, M. 2009. Community clusters in wildlife and environmental management: using TEK and community involvement to improve co-management in an era of rapid environmental change. Polar Research 28: 43-59.

Dunton, K. H., S. V. Schonberg, L. W. Cooper. 2012. Food web structure of the Alaskan nearshore shelf and estuarine lagoons of the Beaufort Sea. Estuaries and Coasts 35: 416-435.

Eisner, W.R., C. J. Cuomo, K.M. Hinkel, B.M. Jones, and R.H. Brower Sr. 2009. Advancing landscape change research through the incorporation of Iñupiaq knowledge. Arctic 62(4): 429-442.

Fechhelm, R. G. and W. W. Griffiths. 2001. Status of the Pacific salmon in the Beaufort Sea, 2001: a synopsis. Anchorage, Alaska: LGL Alaska Research Associates, Inc.

Fechhelm, R.G., S.W. Raborn, and M.R. Link. 2009. Year 26 of the long-term monitoring of nearshore Beaufort Sea fisheries in the Prudhoe Bay region: 2008 annual report. Report for BP Exploration (Alaska) Inc. by LGL Research Associates, Inc. Anchorage, Alaska.

Fechhelm, R., B. Streever, and B. Gallaway. 2007. The Arctic cisco (*Coregonus autumnalis*) subsistence and commercial fisheries, Colville River, Alaska: a conceptual model. Arctic 60(4): 421-429.

Fedler, A. J. and R. B. Ditton. 1994. Understanding angler motivations in fisheries management. Fisheries 19: 6-13.

Fillatre, E., P. Etherton, and D. Heath. 2003. Bimodal run distribution in a northern population of sockeye salmon (*Oncorhynchus nerka*): life history and genetic analysis on a temporal scale. Molecular Ecology 12: 1793-1805.

Ford, J.D. 2009. Dangerous climate change and the importance of adaptation for the Arctic's Inuit population. Environmental Research Letters (ERL) 4(2): 9.

Ford, J.D. and C. Furgal. 2009. Foreword to the special issue: climate change impacts, adaptation and vulnerability in the Arctic. Polar Research 28(1): 1-9.

Fox, S. 2002. These are things that are really happening: Inuit perspectives on the evidence of climate change in Nunavut. Pages 13-53 *in* I. Krupnik and D. Jolly, editors. The earth is faster now: indigenous observations of arctic environmental change. Arctic Research Consortium of the United States, Fairbanks, Alaska.

Freeman, M. M. R. 1992. The nature and utility of traditional ecological knowledge. Northern Perspectives 20: 9-12.

Fuller, A.S., and John C. George. 1997. Evaluation of subsistence harvest data from the North Slope Borough 1993 census for eight North Slope villages: for the calendar year 1992. Barrow, Alaska: Department of Wildlife Management, North Slope Borough.

George, C., L. Moulton, and M. Johnson. 2009. A field guide to the common fishes of the North Slope of Alaska. Version 1.5. Barrow, Alaska: Department of Wildlife Management, North Slope Borough.

Google Maps. 2012. https://maps.google.com/. Accessed 07 March 2012.

Hackett, E.J., O. Amsterdamska, M. Lynch, and J. Wajcman. 2008. The handbook of science and technology studies, 3rd edition, Cambridge: Massachusetts Institute of Technology.

Hansen, J., M. Sato, and R. Ruedy. 2012. Perception of climate change. Proceedings of the National Academy of Sciences 109: E2415-E2423.

Helmericks. 2012. http://www.goldenplover.org/index.html. Accessed 07 March 2012.

Hinzman, L. D., N. D. Bettez, W. R. Bolton, F. S. Chapin, M. B. Dyurgerov, C. L. Fastie, B. Griffith, R. D. Hollister, A. Hope, H. P. Huntington, A. M. Jensen, G. J. Jia, T. Jorgenson, D. L. Kane, D. R. Klein, G. Kofinas, A. H. Lynch, A. H. Lloyd, A. D. McGuire, F. E. Nelson, W. C. Oechel, T. E. Osterkamp, C. H. Racine, V. E. Romanovsky, R. S. Stone, D. A. Stow, M. Sturm, C. E. Tweedie, G. L. Vourlitis, M. D. Walker, D. A. Walker, P. J. Webber, J. M. Welker, K. Winker, and K. Yoshikawa. 2005. Evidence and implications of recent climate change in northern Alaska and other arctic regions. Climatic Change 72: 251-298.

Holling, C. S. 2001. Understanding the complexity of economic, ecological, and social systems. Ecosystems 4: 1270-1274.

Holmes, R. M., J. W. McClelland, P. A. Raymond, B. B. Frazer, B. J. Peterson, M. Stieglitz. 2008. Liability of DOC transported by Alaskan rivers to the Arctic Ocean. Geophysical Research Letters 35: L03402.

Holmes, R. M., M. T. Coe, G. J. Fiske, T. Gurtovaya, J. W. McClelland, A. I. Shiklomanov, R. G. Spencer, S. E. Tank, and A. V. Zhulidov. 2013. Climate change impacts on the hydrology and biogeochemistry of Arctic Rivers, *in* C. R. Goldman, M. Kumagai, and R. D. Robarts. [eds.], Global impacts of climate change on inland waters, Somerset, New Jersey: Wiley.

Houde, N. 2007. The six faces of traditional ecological knowledge: challenges and opportunities for Canadian co-management arrangements. Ecology and Society 12: 34-51.

Huntington, H.P. 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51(3): 237-242.

Huntington, H. P., S. F. Trainor, D. C. Natcher, O. H. Huntington, L. DeWilde, and F. S. Chapin. 2006. The significance of context in community-based research: Understanding discussions about wildfire in Huslia, Alaska. Ecology and Society 11(1): 40.

Irvine, J. R., R.W. Macdonald, R.J. Brown, L. Godbout, J.D. Reist, and E.C. Carmack. 2009. Salmon in the Arctic and how they avoid lethal low temperatures. North Pacific Anadromous Fish Commission Bulletin No. 5: 39-50.

Johnson, M., editor. 1992. Lore: capturing traditional environmental knowledge. Ottawa: Dene Cultural Institute and International Development Research Centre.

Jolles, C. Z. 2002. Faith, food, and family in a Yupik whaling community. Seattle, Washington: University of Washington Press.

Kassam, K.A.S., Wainwright Tribal Council, and Arctic Institute of North America. 2001. Passing on the knowledge: mapping human ecology in Wainwright, Alaska. Calgary, Alberta: Arctic Institute of North America.

Klausner, S.Z. and E.F. Foulks. 1982. Eskimo capitalists: oil, politics, and alcohol. Totowa, New Jersey: Allanheld, Osmun & Co. Publishers.

Krupnik, I. and D. Jolly, editors. 2002. The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change. Arctic Research Consortium of the United States, Fairbanks, Alaska.

Leiserovitz, A., R. Gregory, and L. Failing. 2006. Climate change impacts, vulnerabilities, and adaptation in Northwest Alaska (No. 06-11). Kotzebue, Alaska, NW Arctic Borough.

Lemke, J. L., J. C. Seigle, L. L. Moulton, J. C. George, and J. J. Bacon. 2011. Fish harvest monitoring in two lagoon systems near Barrow, Alaska. Anchorage, Alaska: ABR, Ind. - Environmental Research & Services.

MacLean, E. A. 2011. Iñupiatun Uqaluit Taniktun Sivunniuġutiŋit North Slope Iñupiaq to English dictionary. Fairbanks, Alaska: University of Alaska Fairbanks.

Marine Biological Consultants, Inc. (MBC) Applied Environmental Sciences. 2003. Proceedings of a workshop on the variability of Arctic cisco (Qaaktaq) in the Colville River. Costa Mesa, California: MBC Applied Environmental Sciences.

McElderry, H.I. and P.C. Craig. 1981. A fish survey in the lower Colville River drainage with an analysis of spawning use by Arctic and least cisco. Appendix 2. (657-678) *in* Environmental assessment of the Alaskan continental shelf. Final reports of principal investigators. Volume 7. Biological studies. USDC; NOAA, OMPA; USDI; BLM.

McLeod, C. L. and J. P. O'Neil. 1983. Major range expansion of anadromous salmonids and first record of Chinook salmon in the Mackenzie River Drainage. Canadian Journal of Zoology 61: 2183-2184.

Miller, M. L. and J. Van Maanen. 1979. Boats don't fish, people do: some ethnographic notes on federal management of fisheries in Gloucester. Human Organization 38: 377-385.

Miller, M. L. and J. Van Maanen. 1982. Getting into fishing. Journal of Contemporary Ethnography 11: 27-54.

Moerlein, K. and C. Carothers. 2012. Total environment of change: impacts of climate change and social transitions on subsistence fisheries in Northwest Alaska. Ecology & Society. http://www.ecologyandsociety.org/vol17/iss1/art10/

Morita, S. H., K. Morita, and H. Sakano. 2001. Growth of chum salmon (*Oncorhynchus keta*) correlated with sea-surface salinity in the North Pacific. ICES Journal of Marine Science 58: 1335-1339.

Moss, J.H., J.M. Murphy, E.V. Farley Jr., L.B. Eisner, and A.G. Andrews. 2009. Juvenile pink and chum salmon distribution, diet, and growth in the northern Bering and Chukchi seas. North Pacific Anadromous Fish Commission Bulletin 5: 191-196.

Moulton, L.L. 2001. Harvest estimate and associated information for the 2000 Colville River fall fishery. Report to Phillips Alaska, Inc. and BP Exploration (Alaska) Inc., Anchorage, Alaska.

Muhr, T. and S. Friese. 2004. User's manual for ATLAS. ti 5.0. Berlin, Germany: ATLAS. ti Scientific Software Development.

Murdoch, J. 1892. Ethnological results of the Point Barrow expedition. The 9th Annual Report of the Bureau of American Ethnology. Government Printing Office, Washington D.C.

Murphy, S.M., F.J. Mueter, S.R. Braund. 2007. Variation in the abundance of Arctic cisco in the Colville River: analysis of existing data and local knowledge. OCS Study MMS 2007-042. ABR, Inc. Fairbanks, Alaska.

Nadasdy, P. 1999. The politics of TEK: power and the "integration" of knowledge. Arctic Anthropology 36: 1-18.

National Research Council (NRC). 2003. Cumulative environmental effects of oil and gas activities on Alaska's North Slope. Washington, DC: National Academies Press.

National Snow and Ice Data Center, editor. Vizcarra, N. 2012. Press release: Arctic sea ice shatters previous low records; Antarctic sea ice edges to record high. Boulder, Colorado: University of Colorado, Boulder, National Snow and Ice Data Center.

Neakok, Sadie and Nate. 1988. Oral history interview with John Burns. March 10, 1988, Barrow, Alaska. Recorded for "Fishes utilized in subsistence fisheries in National Petroleum Reserve-Alaska project." Barrow, Alaska: North Slope Borough Department of Wildlife Management.

North Pacific Fishery Management Council (NPFMC). 2009. Fishery management plan for the salmon fisheries in the EEZ off the Coast of Alaska. Anchorage, Alaska. Available at: http://www.fakr.noaa.gov/npfmc/PDFdocuments/fmp/Arctic/ArcticFMP.pdf. Accessed 13 December 2011.

North Pacific Fishery Management Council (NPFMC). 2011. Fishery management plan for fish resources of the Arctic management area. Anchorage, Alaska. Available at: http://www.fakr.noaa.gov/npfmc/PDFdocuments/fmp/Salmon/SalmonFMP311.pdf. Accessed 21 May 2012.

North Slope Borough (NSB) Department of Wildlife Management, MJM, ADF&G, BLM, and ABR, Inc. – Environmental Research & Services . 2009. 2008 harvest surveys in Elson Lagoon - summary preliminary findings. Barrow, Alaska: NSB Department of Wildlife Management.

Oozeva, C., C. Noongwook, G. Noongwook, C. Alowa, and I. Krupnik. 2004. Watching ice and weather our way. Arctic Studies Center, Smithsonian Institution, Washington D.C.
Pedersen, S. Unpublished data. Nuiqsut: wild resources harvests and uses in 1993. Alaska Department of Fish and Game, Division of Subsistence, Fairbanks Alaska.
Pedersen, S. and N.S. Shishido. 1988. Subsistence study at Nuiqsut. Fairbanks, Alaska: Alaska Department of Fish and Game, Division of Subsistence.
Rayner, N., D. Parker, E. Horton, C. Folland, L. Alexander, D. Rowell, E. Kent, and A. Kaplan. 2003. Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. Journal of Geophysical Research 108: 4407-4436.
Reidlinger, D. 1999. Climate change and the Inuvialuit of Banks Island, NWT: using traditional environmental knowledge to complement western science. Arctic 52: 430.
Riedlinger, D. and F. Berkes. 2001. Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. Polar Record 37: 315-328.
Ruggerone, G. T., J. L. Nielsen, and J. Bumgarner. 2007. Linkages between Alaskan sockeye salmon abundance, growth at sea, and climate, 1955–2002. Deep Sea Research Part II: Topical Studies in Oceanography 54(23-26): 2776-2793.
Schrank, W. 2007. The ACIA, climate change and fisheries. Marine Policy 31(1): 5-18.
Schneider, W. S. and W. Arundale. 1982. Chipp-Ikpikpuk and Upper Meade River oral history project. Fairbanks, Alaska: University of Alaska Fairbanks Oral History Program.
Schneider, W.S., S. Pedersen, and D. Libbey. 1980. Barrow-Atqasuk: land use values through time in Barrow-Atqasuk area. Fairbanks, Alaska: Cooperative Park Studies Unit, University of Alaska Fairbanks
Spradley, J. 1979. The ethnographic interview. New York: Holt, Rinehart, & Winston.
Stairs, A. and G. Wenzel. 1992. "I Am I and the environment": Inuit hunting, community, and identity. Journal of Indigenous Studies 3: 1-12.
State of Alaska. 2012a. Alaska community database, community information summaries. http://commerce.alaska.gov/dca/commdb/CF_CIS.htm. Accessed 16 February 2012.
State of Alaska. 2012b. Fall 2010. Revenue source book. Juneau, Alaska: State of Alaska, Department of Revenue, Tax Division. http://www.tax.alaska.gov/programs/documentviewer/viewer.aspx?2136f. Accessed 21 May 2012.
Stephen R. Braund and Associates. 1993. North Slope subsistence study: Barrow, 1987, 1988, 1999. Anchorage, Alaska: Stephen R. Braund & Associates.
Stephen R. Braund and Associates. 2009. Impacts of oil and gas development to Barrow, Nuiqsut, Wainwright, and Atqasuk harvesters. Report prepared for North Slope Borough, Department of Wildlife Management. Anchorage, Alaska: Stephen R. Braund & Associates.
Stephen R. Braund and Associates. 2010. Subsistence mapping of Nuiqsut, Kaktovik, and Barrow. OCS Study MMS 2009-003. Anchorage, Alaska: USDOI, MMS, Alaska OCS Region.
Steele, M. A., J. Zhang, and W. Ermold. 2010. Mechanisms of summertime upper Arctic Ocean warming and the effect on sea ice melt. Journal of Geophysical Research 115 (C11004): 1-12.
Stephenson, S.A. 2006. A review of the occurrence of Pacific salmon (*Oncorhynchus* spp.) in the Canadian western Arctic. Arctic 59(1): 37-46.

Usher, P. J. 2000. Traditional ecological knowledge in environmental assessment and management. Arctic 53: 183-193.
Wassmann, P. C.M. Duarte, S. Agusti, and M.K. Sejr. 2011. Footprints of climate change in the Arctic marine ecosystem. Global Change Biology 17(2): 1235-1249.
Weingartner, T., K. Aagaard, K. Shimada, D. Cavalieri, and A. Roach. 2001. Circulation on the Central Chukchi Sea shelf. San Antonio, Texas: AGU 2000 Ocean Science Meeting.
Woods, S. 2011. Personal communication, Dillingham, Alaska.

APPENDIX A.

Table A1. Common, Iñupiaq, and scientific names for fish species in the study region.

Common name	Iñupiaq name	Scientific name
Anadromous Fishes**:**		
Arctic cisco	*Qaaktaq*	*Coregonus autumnalis*
Least cisco	*Iqalusaaq*	*Coregonus sardinella*
Bering cisco	*Tiipuq*	*Coregonus laurettae*
Broad whitefish	*Aanaakliq*	*Coregonus nasus*
Humpback whitefish	*Piquktuuq*	*Coregonus pidschian*
Dolly Varden	*Iqalukpik*	*Salvelinus malma*
Rainbow smelt	*Ilhaugniq*	*Osmerus mordax*
Chinook salmon	*Iqalugruaq*	*Oncorhynchus tshawytscha*
Sockeye salmon		*Oncorhynchus nerka*
Pink salmon	*Amaqtuuq*	*Oncorhynchus gorbuscha*
Chum salmon	*Iqalugruaq*	*Oncorhynchus keta*
Unidentified salmon		*Oncorhynchus spp.*
Freshwater Fishes:		
Arctic grayling	*Sulukpaugaq*	*Thymallus arcticus*
Lake trout	*Iqaluaqpuk*	*Salvelinus namaycush*
Round whitefish	*Savigunnaq*	*Prosopium cylindraceum*
Burbot	*Tittaaliq*	*Lota lota*
Longnose sucker	*Milugiaq*	*Catostomus catostomus*
Northern pike	*Siulik*	*Esox lucius*
Alaska blackfish	*Iluuginiq*	*Dallia pectoralis*
Arctic lamprey	*Nimigiaq*	*Lethenteron camtschaticum*
Ninespine stickleback	*Kakalisauraq*	*Pungittius pungittius*
Threespine stickleback		*Gasterosteus aculeatus*
Slimy sculpin		*Cottus cognatus*
Marine Fishes:		
Fourhorn sculpin	*Kanayuq*	*Myoxocephalus quadricornis*
Arctic flounder	*Nataagnaq*	*Liopsetta glacialis*
Arctic cod	*Iqalugaq*	*Boreogadus saida*
Saffron cod	*Uugaq*	*Eleginus gracilis*
Capelin	*Pagmaksraq*	*Mallotus villosus*
Pacific herring	*Uqsruqtuuq*	*Clupea harengus*
Pacific sandlance		*Ammodytes hexapterus*
Snailfish		*Liparis sp.*
Starry flounder		*Platichthys stellatus*