Natural Indicators of Salmon Run Timing and Abundance

Yukon River

by

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ABSTRACT

Fishers' specialized and adaptive local knowledge can provide long-term observational data to fisheries managers and scientists and aid in understanding environmental variability that influences fluctuations in populations of Pacific salmon. Alaska Native fishermen and women from the Yukon River have long relied on their elders to guide them in preparation for the salmon arrival. This knowledge, often referred to as local knowledge or traditional ecological knowledge, is a critical aspect of successful fishing.

Principal investigators sought to understand the historical abundance, distribution, and health of salmon populations in several subsistence communities in the middle and lower Yukon River watershed through the documentation and analysis of local and traditional knowledge (LTK). Ethnographic research focused on natural indicators of salmon run characteristics in order to explore patterns in Chinook *Onchorhynchus tshawytscha* and summer and fall chum *O. keta* salmon runs. For the purposes of this project, natural indicators are defined as empirical observations that correlate with specific ecological phenomena. This research primarily addressed the question of how LTK can inform our understanding of the changes in the abundance, distribution, and health of salmon populations.

Results of this study suggested that fishermen implicitly separate their observations of natural phenomena into either causal or correlative indicators. Causal indicators are those events that make something happen with the fish run: they are directly tied to how the salmon run develops. For example, wind direction and intensity at specific times of the year affects when fish run and which mouth of the Yukon River they enter. Correlative indicators, on the other hand, are observations that occur with the salmon run. Indicators that correlate observations of natural phenomena to the salmon runs are useful as they provide information to the fishers about the salmon run, but do not have any effect on the run. Examples of these indicators are migrating birds and the appearance of certain flora and fauna.

Throughout this study, participants expressed concern about environmental changes that make natural indicators less predictable or reliable. The changes include weather shifts, warmer winter air temperatures, an increase in sandbars, and reduced salmon abundance. Most residents believe that these changes affect both how people fish and the fish themselves.

Finally, respondents discussed the conflicts between natural indicators and the windowed subsistence fishing schedule. Put in place to conserve salmon, the windows schedule nonetheless ignores the environmental relationships recognized by natural indicators and sets fishing times on a different schedule than natural indicators dictate. Often the windows schedule stands in direct conflict to when people recognize the most efficient times to harvest.

Key Words: Yukon River, salmon, Chinook, chum, Alaska Native, fishermen, local and traditional knowledge, traditional ecological knowledge, TEK, LTK

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

NOAA FUNDING STATEMENT

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INTRODUCTION

> *"Technology is all what they wanna use. And if you wanna learn something, you have to come to the old people in the small village... Technology terms are used for the big cities. Not for the small villages, and how we live on the fish and animals."*
>
> LAURENCE SAUNDERS, KALTAG

The Yukon River is the largest river in Alaska (Figure 1). It drains approximately thirty-five percent of the state and is the fifth largest watershed in North America, originating in British Columbia and flowing over 2,300 miles to its mouth at the Bering Sea (Vania et al. 2002). In late May and early June, the Chinook salmon *Onchorhynchus tshawytscha* arrive in the lower Yukon River and salmon fishing begins. Chum salmon *O. keta* follow in two distinct runs – summer and fall chum. These are the primary species harvested during the salmon fishing season (Fienup-Riordan 1986:125) rounded out by generally smaller numbers of pink salmon *O. gorbusha* in the lower river and coho salmon *O. kisutch*. The size of each summer's returning salmon run varies by year and species and the prediction of run size remains a critical question for the state and federal managers' allocations between escapement, subsistence, sport, and commercial fisheries. Unlike many marine or coastal fisheries where commercial harvests predominate, Yukon River subsistence salmon harvests often exceed commercial, sport and other personal uses of salmon (Fall et al. 2007:37).

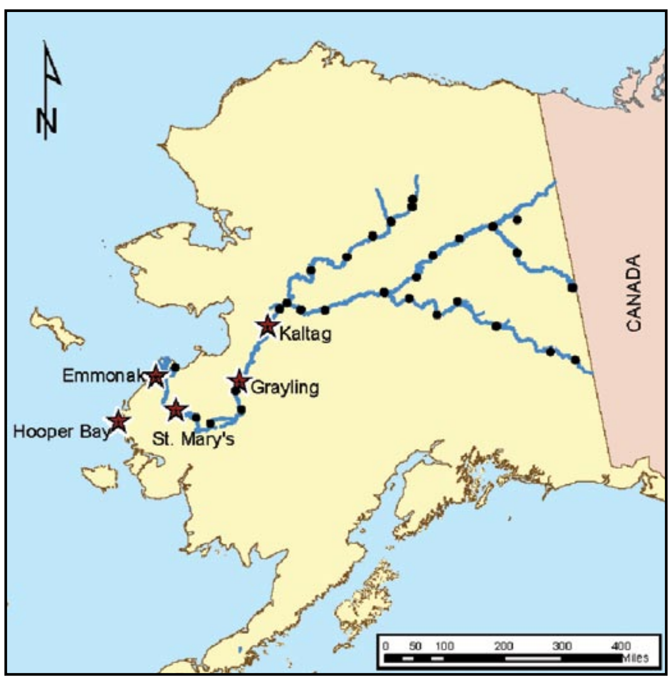
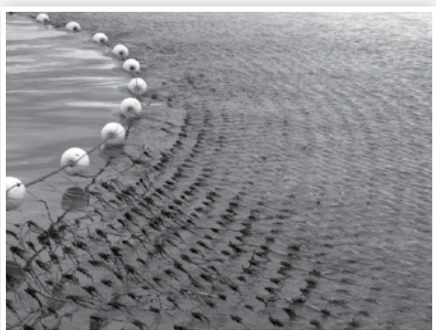


Figure 1. *Yukon River Drainage with 5 study communities.*

Problems of assessment, management and allocation of salmon for Yukon River fisheries currently dominate State and Federal regulatory actions. Between 1997 and 2002, sharp declines in salmon abundance caused severe hardship for fishery-dependent communities on the Yukon River. In the Yukon River watershed, state economic fish disasters were declared in 1997, 1998, 2000, 2001, and 2002, and a federal fisheries disaster was declared in 2000. Sustainable salmon management during this period was made more difficult in part from a lack of knowledge about the underlying causes of the declines. In March 2000, the State of Alaska Board of Fisheries adopted the Policy for the Management of Sustainable Salmon Fisheries that established a process for the identification of specific "stocks of concern" (5AAC 39.222). On the Yukon River, the Chinook salmon stock was designated as a yield concern because it failed to produce expected returns. Summer and fall chum salmon in the Yukon River drainage were designated as stocks of concern, but no longer meet that criteria based on their recent return to near average production levels (Clark et al. 2006; Bue et al. 2006, AYK Scientific Technical Committee 2005).



Fish net

Technological and statistical advances in fish and wildlife enumeration have largely shaped the contemporary practices of fish and wildlife management. With these advances, biologists and managers have been able to expand their understandings of animal populations from a small segment to the entirety in order to design and implement sustainable management systems. However, as the above quote indicates, for some of the people most affected by those management systems, technological advances and statistical constructions are not the only ways to understand or evaluate fish and wildlife populations. Rather, residents of local communities along the Yukon River continue to suggest that understanding fish requires more than simply counting them or decoding their genetic sequences. Understanding the relationship between humans and fish, as well as fish and the other aspects of their environment, remains a critical component of management, but is largely absent from existing management systems.

Alaska Native fishermen and women from the Yukon River have long relied on their elders' observations of the weather, environmental conditions, and the behavior of other animals to guide them in preparation for the arrival of the salmon. These "natural indicators," or empirical observations, such as wind direction, bird migrations, or the development of various flora that correlate with specific ecological phenomena, such as the return of the salmon, are culturally important aspects of salmon fishing in the Yukon River drainage. Since territorial days, however, salmon fishing has been increasingly regulated by federal or state agencies in order to allow for a variety of protections and uses including escapement and subsistence, commercial, and sport fisheries (Wheeler 1987).

This research project addresses two of the research questions described in the AYK SSI Research and Restoration Plan (AYKSSI 2006). This research primarily focuses on the first and fourth questions in the research theme entitled "Linking Traditional/Local Ecological

Knowledge and Conventional Approaches to Fisheries Research" (#18). Specifically, this project sought to compile long-term LTK data about natural indicators and other methods used by subsistence fishers to characterize a given salmon run in order to inform our understanding of the changes in abundance, distribution, and health of salmon populations.

The Role of Local and Traditional Knowledge (LTK)

The documentation of local and traditional knowledge (LTK) is important for social, cultural, and biological reasons, and can lend important ecological insights to resource management, conservation education, and environmental assessment (Inglis 1993). The incorporation of LTK is often cited as an effective method for involving resource users in fisheries research and cooperative management (Huntington 2000). In general, however, because of the qualitative nature of LTK and the unfamiliarity of most natural science researchers with social science methods, this human experience and knowledge are often ignored (Huntington 2000).

A greater emphasis on the value of local and traditional knowledge within resource management regimes appears to have begun in the late 1980s with the increased role of social scientists in management-based or problem-oriented research. However, the kinds of information garnered through a lifetime of observation and practice does not always lend itself easily to direct questions, nor can it be easily "formulated as a set of rules" (Cruikshank 2004). Rather local knowledge studies continue to raise questions about how different kinds of information can be incorporated into different settings, including management, and what is meant by local knowledge more generally. Nonetheless, LTK can provide long-term observational data along with unique local perspectives to fisheries managers and scientists and aid in understanding the environmental variability that influences fluctuations in populations of Pacific salmon.

The ethnographic documentation of subsistence fisheries in the Yukon River drainage dates back at least to missionary accounts in the early 1900s (e.g., Jette 1911). Since then, several researchers have documented the subsistence salmon fishing practices of Yukon River drainage residents (Osgood 1958; Loyens 1966; Clark 1981; Nelson 1983; Fienup-Riordan 1986). The Alaska Department of Fish and Game (ADF&G) Subsistence Division has provided comprehensive information on use patterns and harvest estimates to state and federal management agencies for the Arctic-Yukon-Kuskokwim (AYK) region. Several studies of subsistence salmon and non-salmon fisheries have documented LTK in Alaska, including information about the role of run timing, abundance, and other aspects of fish life history within the social structure of fishing harvest areas and practices (e.g., Wolfe 1981, Andrews 1986; Andrews and Coffing 1986; Case and Halpin 1990; Brown et al. 2002; Andersen et al. 2004; Brown et al. 2005). While the above referenced studies contribute to the LTK literature in the Yukon River area, none of them took an in-depth look at natural indicators in the middle and lower Yukon River. In researching LTK of Yukon River Chinook salmon, Moncrieff and Klein (2003) found that customary and traditional practices associated with this fishery entail particular attention to a variety of natural indicators to determine salmon arrival time, run strength, and other characteristics of salmon runs. The current study focuses on the natural indicators mentioned in Moncrieff and Klein (2003) and investigates their depth and spread. This topic was selected for further investigation due to its potential application in contributing new ways of knowing to improving management of salmon on the Yukon River.

Through semi-structured ethnographic interviews and three summers of participant-observation, it became apparent during this research project that these environmental observations remain critically important to successful fishing practices and in maintaining strong relationships with the land and animals. However, LTK holders had little influence over the larger processes of fishery regulation, which adds layers of planning and complexity to subsistence fishing efforts of Yukon River community residents.

Alaska Native Communities and Salmon

This study was conducted between 2006 and 2009 in the Yup'ik communities of Hooper Bay, Emmonak, and St. Mary's and the Athabascan communities of Grayling and Kaltag—five Alaska Native communities in the lower reaches of the Yukon River. These two large and internally diverse cultural groups, Yup'ik Eskimo and Athabascan Indian, have long inhabited the Yukon River area, drawing seasonally on the rich marine and terrestrial resources it supports. Primary among these resources is salmon, which have been traditionally harvested for human consumption, dog food, and other uses from early summer through late fall, depending on the species and run timing. While the historic reliance on salmon unites the subsistence practices of these formerly semi-nomadic communities, the details of their harvest, use, and knowledge of salmon differs depending on seasonality, species, and the particular geography of specific locales. The more recent history of commercial fishing throughout the river also varies depending on location. In the past decade, much of the commercial harvesting of salmon in the Yukon River has occurred in the lower reaches of the river (see Appendix 1 for commercial and subsistence catch histories). Because of their historic reliance on fishing, Yukon River residents have had to fine-tune their knowledge of salmon runs to ensure harvest success, developing a sensitivity to a rich body of environmental signals or natural indicators used to adapt their fishing practices year-to-year.

The Yukon River is inhabited by predominantly Yup'ik communities in the lower portions of the river near its mouth at the Bering Sea while Athabascan communities reside on the banks of its middle and upper reaches and into Canada at its headwaters. Though culturally distinct, Yup'ik and Athabascan communities share many similarities in their subsistence pursuits. Both groups historically formed into smaller, kinship-based units traveling around the land in seasonal subsistence pursuits (Fienup-Riordan 1986, VanStone 1974).[1] Today, Yup'ik and Athabascan people live in larger, sedentary villages, though many still practice seasonal subsistence activities.

[1] For more information on Yup'ik culture see Andrews, Elizabeth F.1989, 1996., Fienup-Riordan, Ann 1984, 1986, 1990., Hensel, Chase 1992, 1996,. Kawagley, Oscar 1995, Oswalt, Wendall 1990, Vanstone, James 1984., Wolfe, Robert 1981. For additional information on Athabascan culture see Nelson, Richard 1983, VanStone, James 1974, 1978, 1979.

Understanding the importance of salmon to the people of the Yukon River as well as the various activities and roles of individuals in fish camp and their beliefs regarding salmon are important to understanding the role of local knowledge in preparation for the salmon runs. Prior to the introduction of western institutions, fishing on the Yukon River was structured around the informal rules and institutions of community and culture, or the customary and traditional practices of subsistence. The return to summer fish camps to fish for salmon along the Yukon River or one of its tributaries remains an important tradition to the people of western coastal and interior Alaska alike. While all Yukon River communities harvest salmon species, they do so in differing amounts depending on community size and composition, presence of dog teams, use patterns, salmon availability, and environmental conditions, among other factors. Generally however, Chinook salmon harvests have remained relatively stable at least since the mid-1980s, while chum harvests have varied in response to abundance and changing use patterns. The estimated harvests of each community in the study area varies broadly, ranging between 3,000 to 16,000 fish per year, depending on various factors such as community population size, access to fish, harvesting techniques, and use needs, among others (see annual Regional Information Reports for the Yukon River, Division of Commercial Fisheries, ADF&G). The Yup'ik coastal and Athabascan interior communities remain the highest harvesters in the state (Wolfe 2000).

Drying nets

Harvest methods have evolved through time, usually in response to changing uses and technology. Historically, fishermen in the lower portions of the Yukon River have used a variety of methods to harvest salmon, including large wooden basket traps with weirs and willow root set nets, but have adopted more efficient technologies as they have become available - twine and nylon nets and later drift nets from a motorized skiff used in the 1950s and popularized in the 1970s (Wolfe 1982, 1984). Similar technologies are found in the upper portions of the river, with some exceptions. Fishwheels were introduced and became popular throughout much of the Yukon River around 1910 (Loyens 1966:151-152), greatly increasing harvest efficiency. Today, in addition to fishwheels, set and drift gill nets remain the primary methods for harvesting salmon. Both require detailed knowledge of the salmon runs (e.g. where in the river do specific species swim?) and gear deployment (e.g. selection of a good site). Methods of processing fish have remained largely unchanged with few improvements. Methods usually include smoking and drying strips or split fish for human consumption and drying or cribbing fish (freezing whole) for dogs. The added cost of electricity to run a freezer can be significant.

Subsistence production remains an activity of the extended family unit. Most commonly, several families or one extended family might occupy a single fish camp, with other relatives or fishing partners also staying at camp and helping with the work. While the responsibilities of most jobs at fish camp are relatively fluid, there are some generalized gender and age-related roles associated with fishing, according to study participants. In most cases, fishermen bring their catch back to camp where the experienced women lead the processing tasks and direct younger, less experienced family members in these tasks such as washing the fish, hauling water, or hanging strips. Younger women are taught to cut fish at varying ages depending on their interest and need at the fish camp (Moncrieff and Klein 2003).

In most rural Alaskan communities, wild foods including salmon are harvested and processed within small, kinship-based groups and redistributed throughout larger multi-household groups following rules of kinship and alliance (Wolfe 1987). Families on the Yukon River fish for themselves but also for their extended family or other community members with which they maintain significant social ties, even including some members outside the community. Complex, although unwritten, rules surround the patterns and levels of sharing. Fishers attempt to harvest enough salmon to meet these needs and may share more than half of their total catch (Moncrieff 2007). As one Yup'ik fishermen in Alakanuk states, "Usually up and down in Alakanuk there are certain families who put up a lot of fish, I guess for all their relations and stuff...there might be about one [smokehouse], for every five or 10 families there might be one smokehouse" (Moncrieff 2007).

The Regulatory Arena and Subsistence Fishing

Historically, Alaska Natives made their living solely from the land. With contact and associated commercial and governmental activities, wage labor and other commercial opportunities were introduced to the growing villages. Today, most villages maintain what is termed a mixed-cash, or mixed subsistence-based economy—the combination of seasonal wage labor and subsistence (Wolfe et al. 1983). Both subsistence and wage labor inputs are required to support the community, but while cash influxes are important, subsistence inputs are far more stable as central features of the traditional economy and it is through those inputs that most commercial opportunities, such as trapping and commercial fishing, are expressed (Loyens 1966, Wolfe 1984). Thus, a mixed-cash economy on the Yukon River translates to a situation where families rely on a combination of wage earnings and subsistence products to support the household throughout the year. In addition to employment wages, household members sometimes sell any excess fish or game to provide limited amounts of cash to purchase heat, clothing, store-bought food, and other regular expenses.

As a result, the relationship between commercial and subsistence fishing on the Yukon River is complex. In fact, in his comparison between subsistence fishing activity and commercial production for lower river families, Wolfe (1984) argues that, "Households with the largest overall volume of subsistence productivity were those most heavily engaged in the market sector." (Wolfe 1984:176). In the lower river, commercial fishing is one of the few opportunities available to obtain capital needed to purchase the supplies (gas, net, boat, etc.) necessary to subsistence fish. As a result, many fishers in the lower river balance their time between commercial fishing and subsistence fishing to maximize their limited opportunities to earn cash while still being able to harvest enough salmon to meet their annual subsistence needs. However, accommodating the commercialization of salmon into a sustainable management regime has over time resulted in a relatively complex and often inflexible system that regulates fishing times, gear, and fishing areas for subsistence fishing (Wolfe 1982).

The management of Yukon River salmon is complicated by several factors. The Alaska portion of the river is divided into six fishing districts (Figure 2). At least three different species (Chinook salmon, chum salmon, and coho salmon) with different life histories, run timing, and population dynamics travel the length of the river in overlapping runs, creating a mixed-stock fishery where subsistence fishers deploy different gear and fishing techniques depending on their target harvest. Currently, salmon runs are managed using scientific metrics to understand run size and species composition in order to allow for escapements and harvests using maximum sustained yield principles. According to these principles, as well as laws governing subsistence priorities, escapements—or putting salmon on the spawning grounds to ensure for adequate reproduction—are the highest priority.

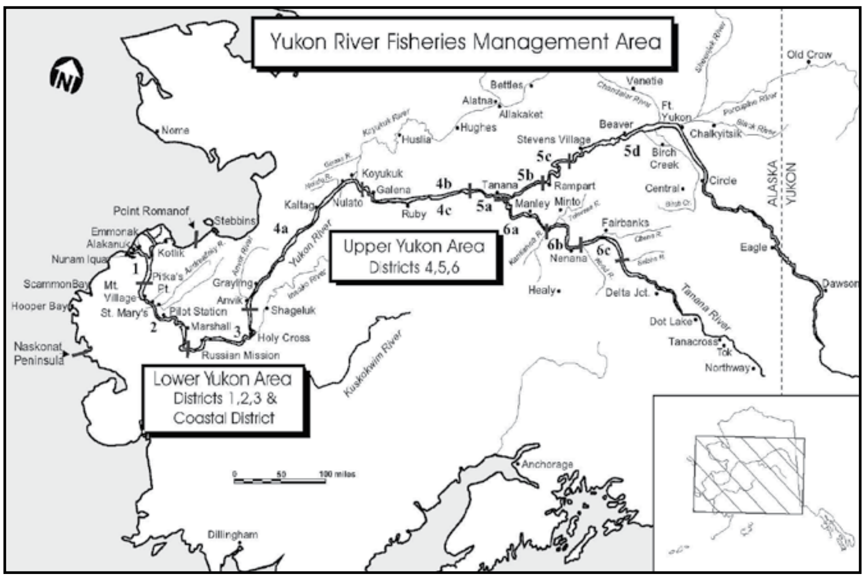


Figure 2. *Yukon River fishing districts.*

The state subsistence law (AS 16.05.258) requires that salmon regulations provide reasonable opportunity for Alaskan residents to fish for customary and traditional uses as determined by the Alaska Board of Fisheries (BOF). In recognition of the customary and traditional uses of salmon which include widespread patterns of sharing, subsistence salmon regulations along the Yukon River do not generally limit the amount of salmon an individual fisherman can harvest during the season. Only in cases when a salmon run is estimated to be insufficient to provide for subsistence uses and non-subsistence uses are commercial, sport and personal use opportunities reduced or eliminated (AS 16.05258). Additionally, under Title VIII of the Alaska National Interest Lands Conservation Act (ANILCA), the Federal Subsistence Board (FSB) can impose restrictions in subsistence fishing regulations in waters adjacent to federal lands in the form of a rural priority.

Declining salmon returns beginning in 1997 led to restrictions on subsistence fishing, with a complete closure in 2000 to protect Chinook and summer chum salmon populations. In 2001, because of crashing salmon stocks, the BOF instituted a "windows" schedule to regulate fishing on the Yukon River. The windows schedule would dictate, in the pre-season, periods of time where subsistence fishing would be open or closed by fishing district. This schedule was designed to increase the quality of escapement, distribute the subsistence opportunity among the users up and down the river, and reduce the impact of harvest on any one stock by spreading the harvest throughout the run, allowing closed periods when the salmon could migrate upriver with reduced exploitation. Managers and the BOF argued that this schedule was based on the earlier pattern of subsistence fishing closures around commercial fisheries and so provided opportunity for families and communities along the river to get their subsistence fish.

While the stated purposes of the windows schedule have not changed, state and federal managers have relaxed the schedule in recent years when they have determined that there are enough fish to meet escapement goals, subsistence needs, and provide for a commercial fishery. However, in years of poor returns, the subsistence fishing windows are further reduced to provide for increased escapement. Nonetheless, the political conflict and resulting incompatibility between state and federal laws over management and the biologically justified increase in regulatory frameworks for Yukon River salmon management have created a complicated, dual system of subsistence management by federal and state managers.[2] Increased legislation and regulatory complication can limit the flexibility and adaptability characteristic of and necessary for subsistence.

This project examines the important role of LTK and natural indicators in contemporary fishing on the Yukon River. The investigators explore the use of natural indicators in five communities in the lower Yukon River and the changes seen over the respondents' lifetimes.

OBJECTIVES

1. Document local and traditional ecological knowledge of Chinook, summer chum, and fall chum salmon in five Yukon River communities.
    a. Conduct LTK interviews with local experts to collect information on natural indicators and other methods used by subsistence fishery communities for anticipating salmon run returns. Researchers also will collect information about current and historical harvest and use patterns, and relative abundance and population trends of salmon species, as understood locally.
    b. Create maps with interview respondents to identify important salmon habitat areas and resource use sites.
    c. Compile maps and spatial data into a geographic information system

Objective 1(a) was met in full. Investigators exceeded interview goals of 30 – 48 key respondents by conducting interviews with 61 key respondents, approximately 9 – 16 interviews per

[2] For more information on and a discussion of state subsistence law and its history with the Alaska National Interest Lands Conservation Act (ANILCA), see: Bryner 1995; Shapiro 1997; Thornton and Wheeler 2005; ADF&G 1993; David 1998; Hull and Leask 2000.

community. Participants were asked about their personal fishing histories documenting historical and contemporary fishing patterns, any personal observations of salmon abundance through time, and observations of natural indicators. Objective 1(b) was met in four of five communities. In St. Mary's the respondents chose not to participate in the mapping activities. Mapped data was compiled into a geographic information system (GIS) and included in the Results section, meeting Objective 1(c).

2. Promote capacity building in local communities, tribal organizations, and non-profit organizations.
    a. Consult with local village assemblies in developing the research plan, designing interview questions, and collecting, reviewing, and analyzing data.
    b. Train local tribal entities in the use and applications of research results and maps.
    c. Train Yukon River Drainage Fisheries Association (YRDFA) and ADF&G staff in the use of GIS for presenting research results.

Objective 2(a) was met. Investigators consulted with tribal councils to guide the research and worked with councils to select and hire local research assistants who participated in identifying key respondents and collecting data. Due to time constraints, community presentations were conducted in four of the five study communities to present and discuss the results and maps. All tribal councils were given the opportunity to review the final report to address Objective 2(b). Finally, with Objective 2(c), YRDFA staff and ADF&G staff did train with ArcMap to collect and present fish camp and fishing site data and build maps for all communities except St. Mary's. The ArcMap GIS program has been updated to 9.2 and is available for YRDFA staff use to increase the organization's capacity.

METHODS

Community Consultation and Research Approval

This project is a partnership between the Yukon River Drainage Fisheries Association (YRDFA) and the Subsistence Division of the Alaska Department of Fish and Game (ADF&G), working with five individual tribal councils to address questions about the use of natural indicators in long-term fishing practices.

Communities for this study were selected based on their fishing histories and harvest level patterns, as well as their location within the lower reaches of the Yukon River. With the exception of Hooper Bay, each community is composed of a combination of subsistence and commercial fishers, representing a breadth of experience in the fishery. Additionally, investigators had existing relationships in each community which were expected to have facilitated the research. The communities represent one coastal location, one location at the mouth, one lower in-river community, and two more communities further up-river. Together, it was hypothesized that these communities would offer a good representative sample of experiences and observations that may differ by community location. Alternatively, investigators were interested in which experiences and observations might be consonant regardless of location.

Finally, this sample represents both Yup'ik and Athabascan communities in order to consider possible cultural differences in perspectives on salmon and salmon-related knowledge.

Both during the project design phase and the first year of the project, investigators contacted each study community to explain the project objectives and to ask for support and project approval. Tribal councils or tribal administrators in each community reviewed the project description and ultimately provided their support to the project. Tribal councils, their staff, and other community members proved invaluable sources of advice about potential key respondents, in addition to providing information about the research topic more generally.

Throughout the length of the project, several individuals from the two cooperating organizations participated in the research and analysis. Moncrieff (YRDFA) and Brown (ADF&G) remain as two of the original three investigators. The third PI, the biologist from YRDFA, was originally Kristin Mull, then later replaced by Bob Dubey, and finally replaced by historian Lauren Sill. Brown participated in all three field seasons (2006-2008), Moncrieff in field seasons 2 and 3 (2007-2008), Mull in field season 1 (2006), and Sill and Dubey in field season 3 (2008). The project also benefited from the assistance of Amy Russell (ADFG Subsistence) during field season 3 (2008), Casey Peavy and Victoria Evans (YRDFA intern) in field season 2 (2007). Moncrieff, Brown, and Sill have had the primary responsibilities in analysis and writing. Field research was mostly conducted on the community level in groups of two or three researchers. Investigators visited three communities in each field season, spending approximately a week in each place during the summer. Trips to each community were timed so that researchers would have the opportunity to visit each community once right before the salmon arrived, and once during the fishing season. Specific field methods are outlined below.

Qualitative Research Methods

As organizations that specialize in applied science research, both YRDFA and the Subsistence Division investigators utilized primarily qualitative research methods to fulfill the objectives of this research. Local and traditional ecological knowledge (LTK) interviews constituted the primary means of collecting data, in addition to mapping, participant observation, and limited literature reviews.

Key Respondent Interviews: Investigators worked with tribal councils and others in the community to identify key respondents, who were selected based largely on their knowledge of natural indicators of salmon. Several factors were considered in selecting key respondents, including age, fishing experience, kinship, and gender. Selecting the sample for key respondent interviews is critical for addressing the project goals; depending on the research question, selecting a sample that represents a cross-section of the population will often allow for a greater breadth of information to be documented.

Investigators focused on interviewing both elders and younger active fishers. The interviews with elders in each community were conducted in order to best document the long-term knowledge passed down generationally about natural indicators, the primary subject of the interviews. It was believed that this type of information would be most available from elders who learned a variety of indicators from their parents and grandparents. At the same time, younger, more active fishers are a critical part of the sample because they tend to be more aware of contemporary conditions, observations, and concerns as compared to the elders who are often no longer fishing.

Gender also plays an important role in selecting a sample of key respondents as women and men often serve different roles in this fishery and make different kinds of observations. Women play a stronger role in the processing of the fish and observe more closely details about the condition of the internal parts of fish while the men tend to be the primary fishers and are able to observe more details about the conditions in the river. Finally, investigators attempted to interview individuals representing different family lines in each community. Attention to kinship can be an important factor in documenting the breadth of information across a community as different family lines tend to fish in different places and pass information generationally through family lines.

In total, we interviewed 61 individuals for this project, exceeding our original goal of 30 – 48 key respondents. Our interview goal was six to eight individuals per community; we accomplished 9 – 16 interviews per community. Participants ranged in age from 39 to 92 years old, representing individuals who still fished and processed fish to elders who no longer actively engaged in the fishery directly. However, many participants in their 60s still actively fished and processed fish. Of our total 61 participants, 22 (36%) were women and 39 (64%) were men.

Table 1. *Key Respondents by Community*

Village	Names	Years of birth	Interview dates
Hooper Bay	Helen Smith, Neva Rivers	1923/ not provided	5.18.06/5.28.08
	George Moses, Gabe Moses	1930/1965	5.19.06
	James Gump	1924	5.19.06
	Nicholas Smith	1960	5.21.06/5.30.08
	Carl and Catherine Smith	1926/1935	5.20.06/5.29.08
	Silas Tomaganuk, Evan Tomaganuk	1930/not provided	5.20.06
	David Simon, Sr.	1929	5.30.08
	James Smith	1964	5.30.08
	Nathan Fisher	1931	5.30.08
	Peter Seton, Sr.	1930	5.29.08
Emmonak	Mary Ann Andrews, Michael Andrews	1933/1928	5.23.06/6.09.08
	Peter Moore	not provided	5.23.06
	Benedict Tucker	1917	5.24.06/6.09.08
	William Trader	1923	5.24.06
	Mary Ann Immamak	1938	5.25.06/6.09.08
	Peter Jones	1950	5.25.06/6.09.08
	John Bird	1969	6.09.08
	Simon & Josephine Harpak	1935/1939	6.10.08
	John Thompson	1923	6.10.08

St. Mary's	Cecilia Sipary	1932	6.18.07
	Clarence Johnson, Lillian Johnson	not provided	6.18.07
	Dan Stevens, Theresa Stevens	1916/1931	6.18.07
	Hilda Alstrom	1950	6.18.07
	Marcia Thompson	1926	6.18.07
	Mike Joe, Liz Joe	1948/1942	6.18.07
	Mary Paukan	1943	6.19.07
	Pat Beans, Jr., Sophie Beans	1943/1944	6.19.07
	Charlie Paukan, Maggie Paukan	1944/1954	6.20.07
	Evan Kozevnikoff	1937	6.20.07
	Mary Patsy	1924	6.20.07
Grayling	Joe Maillelle, Rose Maillelle	1941/1933	6.26.07
	Edna Deacon, Tiny Deacon	1938/1925	6.16.06
	Gabe Nicholi	1952	6.14.06
	Herman Deacon	not provided	6.16.06/ 6.08.08
	Rose Golilie	1933	6.14.06
	Mary Mountain	1939	6.07.08
	Freddie Howard	1939	6.07.08
Kaltag	Franklin Madros, Sr.	not provided	6.18.06
	Lawrence Saunders	not provided	6.18.06
	Goodwin Semaken	1920	6.19.06
	Austin Esmailka	1931	6.18.06
	Robert Dentler	1942	6.18.06
	Mary Rose Agnes	not provided	6.26.08
	Richard Burnham, Justin Esmailka	not provided	6.26.08
	Barb & Dale Arquell	1949/?	6.25.08
	Albert (Al-boy) Nickolai	1946	6.25.08

The semi-structured interview format allowed investigators a measure of consistency and comparability in data collected while providing enough flexibility to allow respondents to share their different experiences and knowledge bases (Bernard 1995). The average interview length was between one and two hours. The interview protocol consisted of a list of questions and topics that highlighted participants' perceptions and knowledge about natural indicators used through time, historical and contemporary fishing practices, and concerns (Appendix 2). The interviews began with a discussion of each respondent's personal or family fishing history which included his or her birth date, where he or she grew up, participation in a seasonal round and how salmon fishing fit into that cycle, who taught him or her to fish, contemporary fishing practices, how he or she would describe a good year, and recollections of years as they compared to one another. The second part of each interview focused on natural indicators, or the environmental cues respondents used or knew about to predict salmon arrival timing and abundance, as well as in-season indicators that may be used to develop expectations of how the run may progress. Investigators also asked about the relationship of one salmon run (or other fish species) to another. Finally, investigators asked about changes in the land, environment, or other social factors that may affect the salmon runs or fishing practices. At this point in the interview, if the respondent had not already described any concerns they often discussed them here. Follow-up interviews were conducted with the majority of participants. This provided an opportunity for the researchers to clarify parts of the original interviews as well as for the participants to add any additional comments.

Mapping: In addition to semi-structured interviews, investigators also employed anthropological methods of resource use mapping and participant-observation as part of data collection. The mapping largely took place during the second or follow-up interviews. Investigators used topographic maps (at 1:63,360 or 1:250,000 scale, whichever was more appropriate to the mapping in a given community) from the U.S. Geological Survey (USGS) to document harvest locations as well as to ensure systematic mapping data collection from respondents. Participants pointed out harvest areas and, when possible, indicated whether they fished with set nets, drift nets or fish wheels. Also, investigators attempted to document the locations of historical and contemporary fish camps. As part of this report, maps for each community are included, except for St. Mary's where participants did not participate in the mapping component. It is important to keep in mind that these maps do not represent a complete picture of all harvest areas and fishing camps/locations, but rather represent the most comprehensive picture that could be obtained from those individuals interviewed.

Participant Observation: Finally, participant observation was an important part of the methods used in this project. The team of researchers was able to assist with and observe drift net and set net fishing, cleaning, cutting and drying the salmon, and travel by boat to fishing sites and camps. Participant observation allows a much deeper understanding of the effort and knowledge required in salmon fishing and provided opportunities to approach the subject from different angles as people were engaged in fishing related practices. Often, fishers are able to communicate additional layers of knowledge and experience while engaged in the activity itself rather than through the recall required by in-depth interviews. It also provides researchers more insight into the research topic through direct observation, allowing for additional lines of questioning. For instance, while cutting fish in St. Mary's our teachers elaborated on the plant locally referred to as "fish perfume" which they used to use to scent the nets to attract salmon. They searched and found the plant and explained the methods used to apply its scent to the fishing nets. When the opportunity arose they showed the researchers scars from lamprey on the skin of the salmon they were cutting and discussed the frequency of this occurrence along with other kinds of information they glean from their work.

This research benefited from an inter-disciplinary team of anthropologists, biologists, and a historian with a northern studies focus to provide a diverse set of perspectives and approaches that benefited the project in various ways. During the interviews this was helpful in understanding information provided from various backgrounds. Our different educational backgrounds allowed us to ask probing questions of our participants from different angles until we felt we understood the discussion fully. Each discipline has a unique perspective and multiple participants bring a full range of questions and multi-faceted understanding of what participants say.

RESULTS

Hooper Bay

The most coastal of the participant communities, Hooper Bay is located on the western coast of Alaska, south of the mouth of the Yukon River in the Yukon-Kuskokwim Delta about 25 miles south of Scammon Bay. It is a Yup'ik Eskimo community of 1,160 (2007 DDCED certified population), located within the Yukon River coastal fishing district and the Yukon Delta National Wildlife Refuge.

Hooper Bay is a large, shallow tidal bay surrounded by sand dunes. Nuok Spit emerges on the northeast side of the bay. Nearby there are three knolls where the community of Hooper Bay sits today between the Napayaraq slough (or river) and the Akulakutug Slough (Stickney 1984).

Prior to sustained contact with westerners, the people of the Hooper Bay area lived a nomadic lifestyle following the fish and game. They spent time in a semi-permanent winter settlement and had seasonal camps during the spring, summer and fall. When E. W. Nelson traveled through the Hooper Bay area during the winter of 1878 and 1879, he encountered a community of about 200 people at the present day site of Hooper Bay (Stickney 1984). In 1891 two "qasgiq" or men's community houses in the Hooper Bay area were recorded in a census (Stickney 1984). Remains of these can be found at the beach in Hooper Bay.

The two winter villages of Naparyaarmiut and Qissunamiut were close allies and became the modern-day villages of Hooper Bay and Chevak (Woodbury 1984). Over time, smaller communities consolidated into Hooper Bay due to school and medical facilities. Hooper Bay residents have roots in previous settlements in the area such as Paimiut, Kashunuk, and Napayarak (Stickney 1984).

Reviewing data

The city has two sections: an old, built-up townsite on two hills, and a newer section in the lowlands. Most of the land surrounding the community of Hooper Bay is swampy and wet; as a result, many of the houses are connected by boardwalks. The historical changes witnessed by the community are apparent to even the newest visitor. The contemporary community is set just inland from the beach, with a large, modern grocery store, a new school, and other contemporary facilities, while the remnants of the old sod houses remain along the coast. Early Eskimo names for Hooper Bay were "Askinuk" and "Askinaghamiut", and its present-day Eskimo name is "Naparyarmiut". Members of Paimiut village (a seasonally-occupied subsistence area, just south of Scammon Bay) also live in Hooper Bay.

During two separate field trips in 2006 and 2008, investigators interviewed 14 participants in Hooper Bay. Of these 14 key respondents, 10 elders were interviewed -- seven men and three women -- who were born between 1923 and 1935, ranging in age from 71 to 85. Our younger group of key respondents, or active fishers, was four men who were born between 1960 and 1965. All of our participants spent all or the majority of their lives in Hooper Bay and started fishing as early as 5 or 6 and as late as 17. The older men who were born in sod houses were taught to fish in a kayak by their fathers or other male relatives. These elders remember moving from the sod houses to wooden houses when they were still young. Some served in the Alaska National Guard and World War II. One participant worked in a cannery in Bristol Bay for 8 years when he was 14 years old in the 1940s. Almost all of the Hooper Bay participants were born in Hooper Bay.

From early June through July, salmon are present in the bay, beginning with summer chum and king salmon, then pink salmon, and finally fall chum (locally called "silver salmon") (Stickney 1984). Because chum and king salmon arrive at the same time, nets with different mesh sizes are set simultaneously. Residents target king salmon by setting 7-inch mesh nets. However, most of the nets are 5.5-6 inches, with a length of 50-60 feet or 100 feet. The complete range of net lengths ranges between 30 and 300 feet. Residents of Hooper Bay use 20-24-foot long homemade wooden skiffs to set their nets. Common fishing locations are the tidal flats inshore of Nuok Spit and east of Napayaraq Slough's channel, where residents set their nets perpendicular to the shoreline (Figure 3) (Stickney 1984). Coastal Villages Seafood Inc. processes salmon and halibut harvested commercially in a small boat fishery just offshore from the village (DCRA 2006).

There are fish camps on the Napayaraq Slough stretching from the community to the bay. While most salmon fishing takes place in the bay at either the shallow (north) end or the deeper (south) end, Gabe Moses, one of the key respondents in Hooper Bay, explains how new technology is allowing Hooper Bay fishers to expand their range to outside of the bay:

> *We really don't see people fishing out in the sea. Just in the bay itself. But nowadays when you have conveniences of modern [outboard] motor and floats and buoys, some people start floating them now, drifting them, just recently.*

Many Hooper Bay families maintain fish camps for summer fishing. Camps can be up to a quarter of a mile from Hooper Bay and may have only a tent for shelter. They also have fish camps at Nuok Point, another popular historic and contemporary fishing area. The participants interviewed for this project mostly fish in family groups, sharing the responsibility of fishing and cutting. For example, a young male participant fishes with his brother and nephew while his sister cuts the fish for drying and smoking. A few participants in this study fished commercially for herring at Cape Romanzof. Some Hooper Bay residents also have winter trapping camps between Hooper Bay and Bethel.

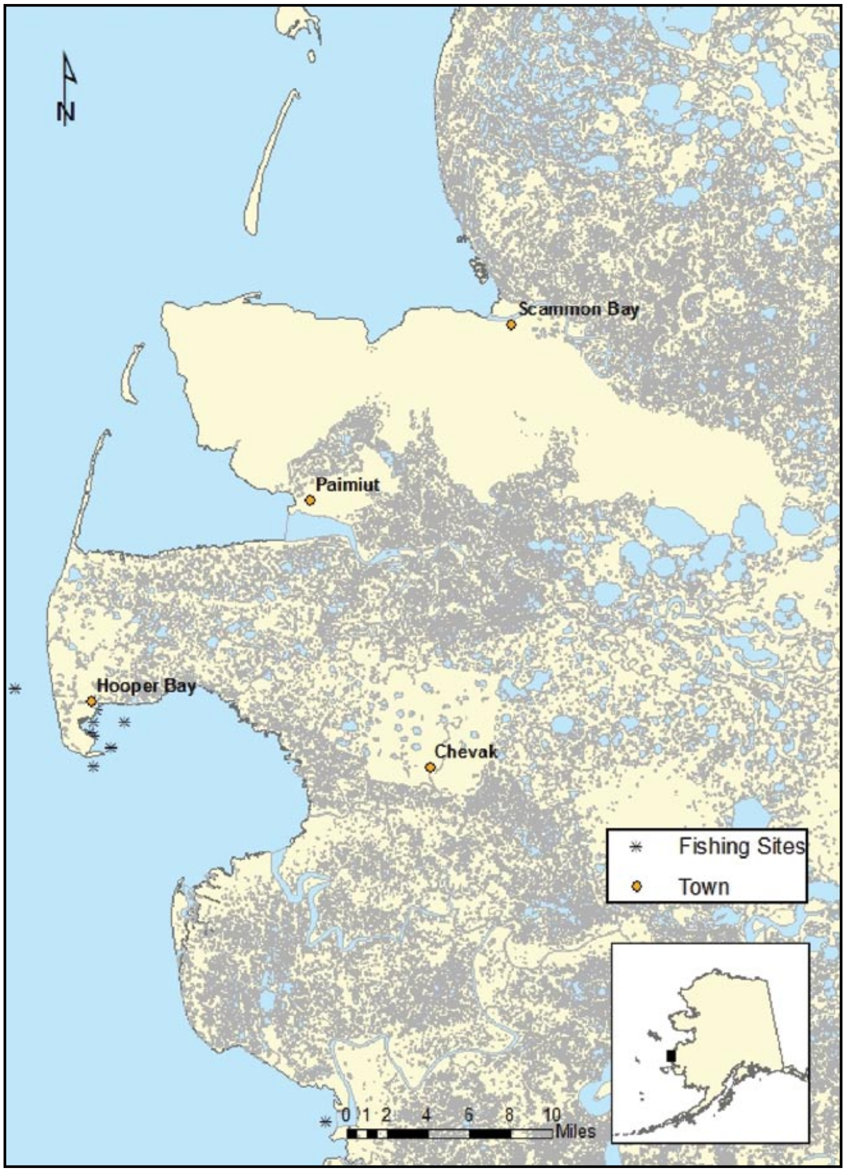


Figure 3. *Location of fishing sites obtained through key respondent interviews in Hooper Bay.*

In addition to salmon, residents of Hooper Bay fish for various whitefish species, blackfish, "flat fish", devil fish, "hump fish", tomcod and herring. They hunt for seal (spring), sea lion, walrus, beluga whale, swan, geese, ducks, ptarmigan and other waterfowl (Stickney 1984; DCRA 2006). In the fall they harvest blackberries, blueberries, cranberries and salmon berries from the surrounding tundra. Residents also trap and sell fox, otter, mink and muskrat pelts for income, in addition to selling grass baskets and ivory handicrafts (DCRA 1979).

Hooper Bay fishers expressed several concerns about changes they've witnessed over their lives in the land and water. Mostly, these changes relate to the weather. Fishers mentioned how in the past the weather was warmer and calmer, with fewer clouds and less wind. Participants also spoke about how there appears to be less snow now than in the past. Other changes include less abundant salmon and erosion on the south side of the river at Hooper Bay.

Natural Indicators – Hooper Bay

In Hooper Bay, investigators learned about natural indicators of salmon run timing and abundance used by respondents as they relate to weather (such as high tides, water temperature, clouds, winds, El Niño years, snow, and storms) and other animals and plants.

The most important and prevalent indicator we heard about in Hooper Bay was the wind and its effect on the fish runs.[3] The right winds with a high tide bring the salmon into the bay where fishers can catch them in their nets. As elders explained, the combination is important: "When there's wind - too much wind from the north, northwest - low water, very low water, until that high tide, higher tide come in. They [salmon] can come into the bay, only when the water is high." (James Gump, Hooper Bay). Fishers further explained that north and northwest winds, combined with a high tide, are the best for fishing as they bring salmon and herring into Hooper Bay and keep them there, close to the shore, where nets can be set to harvest them. When the weather is calm, fish tend to swim farther out in the deeper water: "More fish come in when the north wind blows. And when the south or any other - south, west, east or west - hardly any fish come in. They [salmon] like north wind and the cold water." (Nicholas Smith, Hooper Bay).

Gabe Moses further describes the effect of wind on their salmon catch and their usual harvest locations, "We rarely, don't fish out in the sea, 'cause we know where the fish usually hit. They usually come in through the bay when there's a north wind." A northwest wind clears the ice from Hooper Bay and pushes it out from the spit and away from the community. The northwest wind moves the ice out towards the south, and fish are more likely to come up and circulate through the bay. With clear and calm weather, the fish are out farther in the bay, not concentrating as much in the shallow end of Hooper Bay, thereby eluding most fishermen.

While a northwest wind brings fish into the usual harvest locations of Hooper Bay fishermen, fishers also reported that stormy, cloudy, windy weather is good for fishing in Hooper Bay because the fish cannot see the net and therefore inadvertently swim into it:

> *The weather is a significant factor. [when it is bad weather] we catch fish. More fish. Yeah, when the north wind- It churns up the water. Churns up the water. When the water's churned we catch a lot more fish. Usually, basically, it's just mostly the wind that they use. 'Cause if there was no wind, there's no storm. There'll be no storm. You know how it churns out the water and gets it murky, the fish really they can't see the net and they just swim right in. They usually hope for big storm.*
>
> Gabe Moses, translating for George Moses, Hooper Bay

[3] Also see Salomone 2005. The Alaska Department of Fish and Game, conducting a test fishery in Hooper Bay, heard from residents how prevailing winds affected salmon harvests. Ultimately, ADF&G did not find a way to incorporate this information into their inseason management tools.

Water temperature also plays an important role and participants in Hooper Bay observe less salmon when the water is warm, more when it is colder: "Just when it's colder there's more fish, when its warmer there's less fish...The colder the water is, the more fish they'll get." (Nicolas Smith, Hooper Bay)

For most Hooper Bay respondents, snow levels seem to be positively related to salmon. Fishers observed that heavy snow loads usually meant more salmon the following summer and the opposite was also true – that low snow winters led to summers with less abundant salmon.

El Niño years also have a significant impact on salmon fishing. During El Niño years, participants reported that the weather was warmer and that salmon were less abundant. Additionally, the salmon they did see had more sores and scrapes on them. In contrast to salmon abundance, eels were more prevalent during El Niño years.

In addition to weather indicators, the behavior of other animals also indicates important aspects of the salmon run. For example, the arrival of swallows and geese tells fishers that the salmon will be arriving soon. The presence of the mud swallows in town alert Hooper Bay residents that the herring are in the bay, which in turn acts as an indication to fishers that salmon will be arriving shortly. David Simon, Sr. discussed this in his interview when he said, "Birds, even the swallows, the mud birds, they start flying when they hit, the herring fish. You can see them out there now, the mud birds, signs of the fish." Gabe Moses had a similar comment, "They say in our tradition, whenever these mud swallows come flying, you know you see swallows flying around, they say, our ancestors used to say that whenever the swallows are here, the king salmon's here."

Knowing the species run order of salmon and other fish species is important because it allows fishers to know and prepare for what will be arriving next. The herring arrival indicates for fishers that salmon will be arriving next. Carl Smith discussed this in his second interview, "Herring fish right now, pretty soon and then after that it's the salmon." The herring come in four pulses each of which varies in oil content, "They're - herrings hitting right now, the first batch. [Next] second batch, third batch and fourth batch... The first ones are very fat and very rich, too oily. Dry longer. Maybe the third batch [are the ones I will fish]." (James Smith, Hooper Bay)

Hooper Bay fishers discussed local distinctions observed as the king salmon run progresses. Fishers from the coastal and lower reaches of the river have long observed what they consider to be distinctions within particular salmon species (Moncrieff et al. 2005). Hooper Bay fishers report harvesting two distinct phenotypic groups of king salmon. The black nose king salmon arrive first and have a black nose and good, red meat. This first group of king salmon is fatter and oilier. The northwest winds are said to bring these desirable black noses to the fishers' nets. The second type of king salmon is the white nose, which is a bigger king salmon, has a white nose and lighter colored meat. "The last [ones]...[arriving]somewhere around end of June or in the first part of July. Different nose than the first one[s], white" (James Gump, Hooper Bay). "Black nose hit first, and the white nose later...Black nose, they're a little smaller than white nose." (David Simon, Sr. Hooper Bay)

Fishers who have a preference for one fish over the other will tailor their harvest accordingly. Those that prefer more oily fish will try to catch the black noses and those who want a less oily fish will wait for the white noses to arrive:

> *When the salmon comes in, the first one, some people, when they hear there are salmon out there, some people set their net right away, the same day or within 24 hours, 48 hours. They'll set their net. And then those that want to catch the other run, they wouldn't tell and they'd just wait about a week then they'll set their net. We wait about a week.*
>
> James Smith, Hooper Bay

After the king salmon arrive in Hooper Bay, the chum salmon come next, in two distinct runs. The regular ones (the pink or less desirable ones) arrive first followed by the silvers, which are the more desirable eating fish. Nicolas Smith (Hooper Bay) reported that the two runs look similar but arrived at different times.

Many key respondents interviewed for this project suggested a link between abundance and size of Chinook salmon – primarily that Chinook salmon appear to be smaller in size when "crowded" or abundant in the water. In Hooper Bay, as well as some of the other study communities, this was true. Hooper Bay fishers observed that Chinook salmon appeared smaller when abundance was high. Thus, small salmon size can sometimes be an indicator of abundance. As James Gump describes, "the elders used to tell us, if there's smaller king salmon, that means crowded, too many, crowded."

Emmonak

One of the three larger coastal or lower river Yup'ik communities participating in this study, Emmonak currently has a population of 794 (2007 DDCED certified population). It is located on the middle mouth of the Yukon River or the north bank of the Kwiguk pass. The village of Emmonak lies within the Y-1 fishing district and the Yukon Delta National Wildlife Refuge (DCRA 2006).

The land surrounding the village in the Yukon River delta is flat tundra and muskeg, covered with willows, alders, and connected by an integrated system of lakes and sloughs (Benedict 1969). This lowland coastal plain extends inland with swampy mud flats (Vanstone 1984). Moving downriver within the Yukon River delta, the river splits into numerous channels, ending in three mouths as it drains in a north and northwestern direction into the Bering Sea - North Mouth, Middle Mouth, and South Mouth. The community itself sprawls out along Kwiguk Pass just before it meets the mainstem Yukon River, with access to the coast, all three mouths of the Yukon, and numerous sloughs and creeks that connect various habitats and harvest areas of important subsistence resources. Comprised of approximately 180 households, the community also houses a large community center, city and tribal government buildings, a large health clinic, two grocery stores, a small restaurant, and a fish processing plant (Kwik'pak).

In Emmonak, investigators interviewed 11 key respondents (three women and eight men). The nine elders in this group were born between 1917 and 1939, and ranged in ages from 67 to 89 at the time of their interviews. Two active fishermen also were interviewed. They were born in 1950 and 1969. The majority of the older respondents were not born in the community of Emmonak, which was not established until the 1950s when a school was built, but moved here as children or young adults from the Black River area, Pilot Station, Mountain Village and other nearby camps or historic settlements, such as Hamilton and Fish Village. Most of the Emmonak respondents learned to fish from their parents. Many of the older group went away to boarding school either at St. Mary's or Akulurak (a mission and boarding school established by the Jesuits in 1903 on an island in between two sloughs of the Yukon. The area silted in and in 1967 they moved to what is now St. Mary's.) and participated in the salmon harvest at the school. In Emmonak, people still fish in family groups; for instance, a man fishing with his son while his wife and sister cut and process the fish.

While there has been a settlement near the present day site of Emmonak since the turn of the 20th century, it wasn't until the 1960s that Emmonak was officially established as an incorporated city. The original settlement was called "Kwiguk," meaning "big stream" in Yup'ik, and the residents called themselves "Kuigpagmuit" or people from the Yukon River (DCRA, 2006). After the post office was established in 1920, the commercial fishery grew in importance and a cannery was built by the Northern Commercial Company. The cannery lasted until 1964 when it was flooded and washed away. The village was relocated to its present location in 1964-65 due to flooding and erosion problems. The new location was 1.4 miles north of Kwiguk and was renamed Emmonak or "blackfish" (DCRA 2006). Members of the Native Village of Chuloonawick, a historic village on the north bank of Kwikpak pass, now abandoned, live in Emmonak.

Prep for drying

Emmonak has long been a commercial fishing community that also maintains an active subsistence fishery. Indeed, many have commented on the interrelated nature of these two activities, both in terms of financial resources and gear availability (Wolfe 1981). Commercial fishing is a way for fishers to earn cash income, which can then be used to participate in the subsistence fishery. Commercial salmon processors and exporters for the village include Kwik'pak Fisheries, a subsidiary of the Yukon Delta Fisheries Development Association, a native-owned community development quota (CDQ) non-profit. Fishing areas are largely shared between the commercial and subsistence fisheries for both Chinook salmon and chum salmon harvests. Salmon are usually found just downriver from Emmonak on Kwiguk Pass and a few miles upriver and downriver of where Kwiguk branches off from the mainstem Yukon River. "Bering Sea," just downriver from the entrance to Kwiguk and a popular area for set nets, was an earlier cannery site which is no longer functioning. There are abundant fish camps in the larger delta region, immediately across from the community on Kwiguk Pass, in the Akulurak area, up the main stem Yukon beyond Fish Village, and even stretching up into the North and Middle Mouth areas of Hamilton and Kotlik.

The majority of Emmonak residents travel to fish camps for at least some part of the summer, although a few families live at fish camp for the entire summer (Figure 4). The Chinook salmon usually arrive between the beginning and the middle of June. The fishers who grew up at Black River remember fishing with shorter nets than are used in Emmonak today. They also remember fishing with dip nets when the tide would bring the salmon in to their coastal fishing areas. Today fishers primarily use set nets and drift nets for fishing.

In the lower river, summer chum is often the most desired salmon species for local consumption; the Yukon River summer chum have less oil and dry more quickly. While Chinook salmon are also highly valued, near the mouth of the river Chinook have a much higher oil content, making it difficult to process effectively. In 2007, for example, Emmonak fishers reported harvesting approximately four times as much summer chum salmon (9,256 fish) than Chinook salmon (2,326 fish). Processing time in the lower river (fishing, cutting, drying and smoking on outside racks and in smokehouses) requires cooperative weather in the early summer. As a result, much of the processing in the lower river is accomplished early on before the weather begins to deteriorate.

In addition to salmon, Emmonak residents fish for whitefish, blackfish, loche (burbot), sheefish, pike, smelt and tomcod, among other species. They also hunt moose, beluga whale, bearded and ringed seal, ptarmigan, snowshoe hare and migratory waterfowl. In the fall, families travel upriver and north and south of the community near the Black River area, for example, to harvest large quantities of cranberries, blueberries, crowberries (locally referred to as blackberries) and salmon berries. Residents also trap and sell local mink, otter, lynx, red and arctic fox pelts for income (DCRA 1979). As part of the seasonal round of subsistence activities, folks from the Emmonak and Black River area used to go muskrat hunting in the spring before the fish arrived. These fishers would set up camp along the south mouth of the Yukon River to prepare for the salmon arrival.

As in Hooper Bay, fisheries in Emmonak have witnessed many changes over their lifetimes to the land and water around them. Again, many of the observed changes are in the weather. In general, the weather is more stormy and unpredictable today than it used to be. The rainy season used to have a pattern that was predictable. In spite of increased storminess, there is less snow today and the ice doesn't get as thick as it once did. Erosion is being witnessed on both banks of the Yukon River, which is overall wider today than in the past.

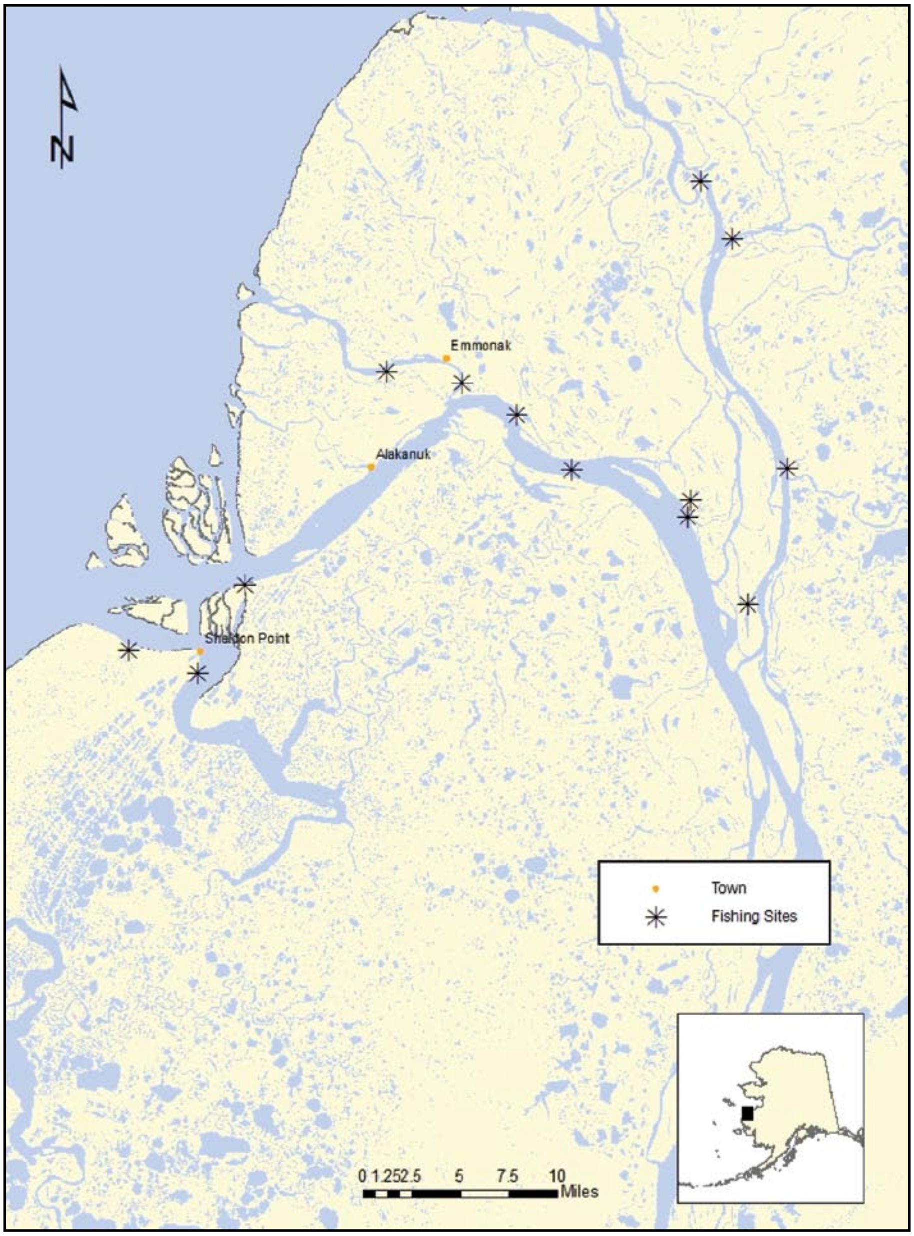


Figure 4. *Location of fishing areas and camps as obtained through key respondent interviews in Emmonak.*

Emmonak residents have also observed that while many migratory birds arrive in the community every spring, several species such as the snow goose no longer come around. Elders note that they appear to have changed their migratory routes in ways that circumvent the village. Some respondents also reported that the smaller birds are not as abundant.

> *These little birds, makes us, the wife and I when we first got here there were all kinds of little birds, in the morning. Today, they don't show up anymore. How come? When I work with the nets, they used to be around me eating mosquitoes. No more today.*
>
> John Thompson, Emmonak

Natural Indicators – Emmonak

Emmonak fishers at the mouth of the Yukon River use a variety of natural indicators of salmon run timing and abundance. Participants discussed the importance of weather indicators, such as wind, water levels and snow; animal indicators such as birds, black flies, and mosquitoes; as well as knowledge of species run order. Some participants also told of the different types of Chinook salmon and how wind can affect which type arrives in Emmonak.

The main indicator Emmonak fishers discussed was the relationship between winds and fish behavior. According to Emmonak residents, winds can affect which mouth the salmon enter in their upstream migration. This is important for area fishers because if the salmon enter the north mouth, near Kotlik, they would bypass the nets of the Emmonak fishers at the middle and south mouths. With north and west winds during the wintertime, the salmon will most likely enter the south mouth. With south winds over the winter, the salmon will enter the middle and north mouths:

> *Old people used to say, when it's north wind and west wind in the wintertime that means, they tell us south mouth, and there'll be more fish, lots of fish on the south mouth, including Black River, all around. And then, when they see, in the wintertime, south wind blowing mostly winter, and east wind, now the fish will be on the north mouth.*
>
> Michael Andrews, Emmonak

A west wind after a south wind can push (or draw) the salmon into the middle mouth. Paul Jones was raised upriver of Emmonak in the community of Mountain Village. Since moving to Emmonak when he was 18 years old, he has learned that a west wind can push the salmon into Kwiguk Pass or the middle mouth and that a southwest wind will bring the salmon to the south mouth near Emmonak fishing grounds, "Down here it's the wind that's coming, the westerly wind they come through Kwiguk, or the southwesterly wind they come through the south mouth" (Paul Jones, Emmonak). An east wind can push the salmon away from the Yukon River and some will go into Norton Sound instead. Frequent or heavy north winds will push the salmon south to the south mouth and Black River which is good for Hooper Bay fishers. As a result, Emmonak fishers pay close attention to the wind prior to the salmon run to predict where to set their nets.

Respondents indicated that years where there is heavy snowfall correlate with years of a lot of fish. We also heard that with low water in the Yukon River the salmon have trouble traveling upriver. "If the Yukon River is low, pretty low, there's hardly any fish. The fish gotta have water to come in with the wind" (William Trader, Emmonak).

Birds were another indicator mentioned during our interviews as important to observe when preparing for the salmon arrival. Emmonak participants suggested that the birds' behavior correlates with the salmon behavior. For example, when the migrating birds arrive late the salmon will arrive late. When the birds show up in a large group, the salmon will show up in large groups. One elder noted that when you find three snipe eggs in a nest that is an indicator that salmon will be abundant. "When they have three eggs, they got only two, every time when you eat (see?) something they'll have only two. When there's three in one nest that means that there'll be lots of fish. That's what my mom used to tell me" (Mary Ann Andrews, Emmonak).

Participants observed that years that have a lot of black flies or mosquitoes are also years with greater salmon abundance:

> *And one of the traditions was that – I don't know if it's real, or…but what I observe and seen, by the mosquitoes. How the mosquitoes are. Like last year, they were sort of, well how many years in a row there were sort of lots of mosquitoes, seemed like more mosquitoes than usual and they [salmon] were more abundant.*
>
> Paul Jones, Emmonak

As in Hooper Bay, fish species run order also helps Emmonak fishermen and women know when to prepare for the salmon arrival:

> *Well, one of the indications were when they [salmon] were coming, they'd know that the fish were coming by the first little run of smelts. Those were the first indication that I know…And then the herring, and then the kings. Pretty much the same cycle every year at the beginning of the springtime.*
>
> Paul Jones, Emmonak

As Mr. Jones describes, fishers expect smelts to arrive first followed by herring and Chinook salmon.

Emmonak participants reported that there are two kinds of Chinook salmon and the direction of the winter wind determines which kind arrives. Although Emmonak participants in this study reported only two phenotypes of Chinook salmon, a previous study which took place in Alakanuk, Emmonak, and Holy Cross (Moncrieff et. al. 2005) found greater variation in the locally described groups. Moncrieff et al. found that "whitenose" is the name used to describe Chinook salmon with lighter-colored noses and greenish sides while the darker-colored Chinook salmon with blue or black backs were called "blueback," "blackhead," or "blacknose." The two kinds of Chinook salmon described by Benedict Tucker in this current study are black backs, which come with the north wind and are a smaller Chinook salmon, and white noses, which come with south winds, are larger or fatter, silver in color and more oily. The larger white nose Chinook arrive later than the darker ones.

> *Last year was north, north side, northwest [wind]. The wind was blowing mostly all the winter from the north. And we noticed it in the backs of them [Chinook salmon] were dark. It's what you call north Chinook [?], dark back. Southside [south wind], [bring Chinook salmon] silver in color.*
>
> Benedict Tucker, Emmonak

St. Mary's

On the north bank of the Andreafsky River, five miles from its confluence with the Yukon River, lies the city of St. Mary's, also known as Algaaciq. The city encompasses the Yup'ik villages of St. Mary's and Andreafsky, with a total population of about 549 people (2007 DDCED certified population). It lies within the Y-2 fishing district.

The Andreafsky hills are near St. Mary's, but the geography along the river is low-lying land (Moncrieff 2004). The Andreafsky River provides the only deep-water dock in the Yukon Delta. Today, St. Mary's is a large and spread-out town with two general stores, a school, a health clinic and a year-round airstrip. It is connected by road to Pitka's Point and Mountain Village.

In St. Mary's, 16 participants, born between 1916 and 1954, participated in the interviews. There were 10 women and 6 men. This group is unique in that the people come from all over the lower river area. Many of them live in St. Mary's today because they went to school here. Many moved here for school when they were as young as four or five. They all grew up living the subsistence lifestyle moving from camp to camp with the seasons.

The village of Andreafsky got its name from the Andrea family, which settled on the river at the turn of the 19th century and opened a Russian Orthodox Church. The area began as a supply depot and winter headquarters for the Northern Commercial Company's riverboat fleet. The village of St. Mary's began in 1951 when residents of Akulurak relocated to its present-day location on the Andreafsky River. Akulurak, which means "in between place," was the site of a Jesuit mission set up in 1903. The mission school flourished and eventually became a boarding school. However, it was located on an island in between two sloughs of the Yukon, and over time the area silted in. In the late 1940s, the mission, and families from around Akulurak, decided to move to higher ground and chose the current site. In 1967, the area near the mission incorporated into the city of St. Mary's, although Andreafsky remained independent until 1980. The Catholic Church closed the boarding school in 1987.

Dependent on a seasonal economy, subsistence activities are important to the people of St. Mary's. Residents fish for salmon, sheefish, blackfish, whitefish, grayling, trout and pike. They hunt for moose, bear, duck, geese, swan and ptarmigan. In the fall season, they gather blueberries, blackberries, high and low bush cranberries, and salmonberries. Salmon plays an important role in St. Mary's, both for commercial and subsistence uses. The region has the first gravel beds (spawning grounds) for salmon (king and chum) as one moves upriver.

Fishing for salmon begins in the early summer. The Yukon River at St. Mary's is clear of ice three to four weeks before the mouth of the river melts, and the Yukon is ice-free from June through October (DCRA 2006; McLaughlin 1969). Most fishermen in St. Mary's harvest king salmon with drift nets (Moncrieff and Klein 2003). Fishing locations for residents include Old Andreafsky, below Pitka's Point, near Boreal Fisheries (a fish processing plant), and between Pilot Station and Mountain Village. Boreal Fisheries processes salmon just outside of town.

St. Mary's residents have observed many changes throughout their lifetimes in the salmon and other fish species, the river itself and the weather. In Alstrom Slough, which goes right through town, respondents observed that there used to be lots of grayling and whitefish, but now winters have hardly any fish except pike. Similarly, respondents noted that salmon are getting smaller and less abundant and the run order is not as predictable as it used to be. Some participants recall sheefish coming in before any salmon in their youth. Other participants recount that chum salmon used to come in first, and then the kings, whereas now the kings come in, then the chum and sometimes they come in together.

The Yukon River itself is physically changing, according to residents. Erosion is evident and the river is wider than it used to be. There are also more sandbars in the river now which sometimes cause fishers to change their fishing location. In terms of weather, there is less snow and rain now, winters are warmer with more winter thaws and the hot summer weather is drying up berries.

Natural Indicators – St. Mary's

A diverse set of observations are used by St. Mary's fishers as indicators of the salmon run. Participants spoke about their observations of the weather, non-salmon fish species, plant growth, and behavior of animals as ways of predicting how the salmon run may develop.

St. Mary's fishers and elders watch the weather throughout the year to gain insight into the upcoming salmon run. Wind plays a very important role in the natural indicators of salmon in St. Mary's. The direction of the wind is observed throughout the year and can affect the salmon in a variety of ways. One participant stated that a strong west wind at St. Mary's indicates salmon arrival. Winter winds can affect king salmon size; north winds in the winter bring shorter or smaller Chinook salmon while south winter winds bring longer Chinook salmon. The following quote describes what one participant learned from his father:

> *One of the factors Dad talk[s] about - He still talk[s] about. He's 91. He still talks about it. - What they used to do is watch the kind of weather we have wintertime you know, where the wind blowing from most of the time, what direction. If the wind had been blowing from the north most of the time, they used to predict that the kings will be smaller. Smaller fish. Due to the wind, you know. I don't know what- Keep 'em offshore I guess. I don't know what it is. If we had south wind quite often during the winter, we'd have bigger fish.*
>
> Pat Beans, St. Mary's

Another participant describes what he learned from his elders about how the wind direction in the winter determines the size of the Chinook salmon:

> *I used to hear from elders, my parents and other elders, when we have wind direction in wintertime, like north wind, the kings are really small. That's what I used to hear. North wind, west wind. And when we have south wind my mom used to say there's gonna be some big kings. And sure enough they'd be humongous. And those indicators*

of six, seven year olds, that's what's coming back right now, six, seven year olds. So the wind is an indicator of if they'll be a lot of fish, or if the size will be big, small.

Charlie Paukan, St. Mary's

The winds also play a role in determining which of the three mouths of the Yukon River the salmon will enter. Entering through the middle mouth is favorable for the community of St. Mary's. Another participant explained that a north wind bring salmon to the middle mouth around Emmonak and then a south wind will brings the salmon to St. Mary's.

In addition to winds, thunderstorms were also watched as an indicator of salmon arrival in St. Mary's. Participants related that thunder was thought to wake up the salmon, which would then come in to spawn. Thunder storms are also indicators of salmon run timing and abundance. The following quote describes what one participant learned from her grandfather:

[My grandpa] used to say when we get thunder clouds in the spring, depending on how much thunder clouds or lightning, whether or not they'd use that for - what do you call it? - They'd use that as a way to tell how much and whether or not the fish were coming. And he used to say depending on how much thunder, he goes, they're waking the fish and getting them ready to come in to spawn.

Mary Patsy, St. Mary's

Two participants reported that when there are a lot of "eels" (arctic lamprey) in the fall there will be a lot of Chinook salmon the following summer. The presence or absence of eels in a given year can also reflect upon community events, possibly foretelling negative future events as the following quote describes:

Lots of eels, they'll say gonna be lots of fish. We have eels during the fall time. Only fall time. So that's for next summer's fish. And the eels are real- Some years some people can't catch any in one place. Like one year we didn't catch any right around freeze-up time. When a family gonna lose a person to drowning, they won't come by the village. They'll go I don't know, maybe by the main river. When they gonna have anything in that village, in the family, even if some people are catching, if somebody come around, they'll stop coming around and they'll pass you or whatever. Bypass. And they won't catch any. They sense everything, the eels.

Mary Paukan, St. Mary's

Species run order is an indicator for knowledgeable fishers in the St. Mary's area, as knowing the expected run order allows them to anticipate the harvests of different fish species. The Chinook salmon arrive in St. Mary's after the smelt arrive. According to St. Mary's participants, sheefish can come either before or after the Chinook salmon run, but generally, they are said to arrive at the end of the Chinook salmon run. Some fishers use the appearance of sheefish in their nets as an indicator that the run of Chinook salmon is ending. If there are sheefish in the river at the same time as the Chinook salmon, that is taken as an indication of low salmon abundance. In general, sheefish and salmon were said to have an inverse relationship. When there are many salmon in the river, there would be few sheefish but if there are many sheefish there would be few salmon.

> *When we're fishing for kings, when we get sheefish, that means that that run end. You know, we're at the tail end of that run. Sheefish for some reason seem to come up or they start mingling with the kings, toward the end of the run. Like if we were fishing for king salmon right now, and then we start getting one or two sheefish, that means that that run had passed. When we're fishing for kings, if we get sheefish, that means that run's really slack. Just a pulse. For some reason, the sheefish seem to come up or, maybe they stay way down. I don't know what they do. But that's always been the case. When we're fishing for kings, if we get sheefish, that means that run's really slack.*
>
> Pat Beans, St. Mary's

Fishers also rely on certain plants as indicators of the fishing season. Key respondents suggested that the growth of some plants can indicate that the salmon season is beginning, or plants can indicate an abundance or scarcity of salmon. Mary Patsy, one of the elders interviewed, related how her grandfather taught her to watch plants to know when to get ready for salmon fishing. When the grass got to just below the knee, he knew it was time to get ready. Once the willow leaves got big enough to cover the salmon as shade, that was also a sign the salmon would be arriving. The willow leaves were used during her grandfather's days to build shade for the salmon drying on the racks on the banks of the river. Her grandfather and other elders also told her to watch the alder trees; when they started budding, that meant the salmon were there.

Elders also looked at grass height as indicators of salmon abundance. Grass height at the end of the summer indicates to the elders the amount of snow they will receive in the coming winter, and the abundance of salmon in the following summer's salmon run. Some plants are used to enhance fishing techniques such as fish perfume which is used to scent a net to attract fish to it.

Wild rhubarb (Rheum rhabarbarum) and cotton from trees are two other plant indicators used by St. Mary's residents. Pat Beans explains that rhubarb usually starts to grow when salmon start coming in. Years where the salmon arrive early, the rhubarb also begins growing early. Maggie Paukan described how the cotton falling from the trees in St. Mary's indicates to them that the fish will start to slack off or thin out in the river. This happens at the end of June or the beginning of July. "When there's cotton drop, fish will slack off. They go with these cotton that start falling off the trees." (Mary Paukan, St. Mary's)

Fauna plays a pertinent role in residents' knowledge of the salmon run. Geese, in particular, are important, as their arrival correlates with king salmon arrival.[4] Fishers in St. Mary's watch the geese arrival and collect information from their timing, pattern and abundance because the king salmon will follow the same pattern.

[4] Respondents did not name the species of geese but it is most likely White Fronted or Taverner Canadian geese (A. Nick, personal communication, 2009).

We thought they [king salmon]were gonna be early. But I learned this before too from the [old] folks. When the geese come in springtime, you know, trickling in, they said the first run of the kings would be like that. Fish would be like that, trickling in. Which happened this summer too (2007). They were just trickling in for awhile. Now they're just starting to hit pretty good.

Pat Beans, St. Mary's

Another participant explained that when the birds come in late, the fish will also arrive late. "They [geese] come in, they fly in late, that's when the fish are gonna be late too. So the birds come in first and then the fish. That's the way I understand it." (Marcia Thompson, St. Mary's)

Grayling

Moving upriver from St. Mary's, communities shift from a primarily Yup'ik composition to a predominately Athabascan population beginning around Holy Cross, 75 miles downriver of Grayling. Approximately 350 river miles from the mouth of the Yukon River is the community of Grayling, located in fishing district Y-4. Grayling is a Holikachuk Athabascan village located in Interior Alaska on the west bank of the Yukon River, east of the Nulato Hills (DCRA 1984). With a year-round population of approximately 174 residents (DCRA 2006), Grayling is one of the two smaller communities participating in this study. Interior Athabascan communities tend to be smaller than the Yup'ik communities of the lower river and coastal areas, largely due to the kinds and amounts of subsistence resources available for harvest, average annual incomes,[5] and historical settlement patterns. Grayling is made up of two main roads, cross-cut by several shorter roads that house the community's 51 households. With the airstrip and Grayling Creek on one end of the community and a gravel pit on the far other end, one small store, a church, a school, the tribal council building, city office building, and community hall, or *kashim*, sit in the center of town, all within view of the river.

At Grayling, the Yukon River is relatively wide and dotted with several islands, sand bars, and tributaries that influence primary fishing methods and locations for Grayling fishers. Grayling residents' fishing locations range from Eagle Island and the Fox Point area all the way upstream to the mouth of Thompson Creek (see Figure 5). Primary contemporary salmon drift net spots are just upriver from the community. In this stretch of the Yukon, the bottom is alternatively muddy or gravel-bottomed, of varying depths, and more recently, affected by ever-shifting sandy deposits that sometimes cause dramatic changes in the waterways. These changes can have significant impacts on fish movements and as a result, harvest locations.

[5] According to DCRA 2006, Grayling has the lowest median household income and highest unemployment rate of all five study communities. Kaltag has the second lowest median income and second highest unemployment rate.

The residents of Grayling moved to this contemporary location in the early 1950s from the historic community of Holikachuk on the Innoko River, located upriver from Shageluk (Brown et al. 2005). Holikachuk and Shageluk residents regularly traveled to the Yukon River during the summer months for fish camps to take advantage of the larger runs of salmon there. Initially these Holikachuk speakers used the Grayling site solely for summer camps, but by 1962 had settled in Grayling permanently (DCRA 1984). Grayling residents return regularly to the Holikachuk area to harvest a variety of subsistence resources, including moose, birds, and non-salmon fish species and also to attend a nearby spirit camp in June (Brown et al. 2005).

The population of Grayling now includes both Holikachuk and Deg Hit'an Athabascan people who have intermarried or settled in Grayling from Holy Cross, Anvik, and Shageluk. These four communities remain closely tied through kinship and family ties, as well as overlapping subsistence harvest areas, communicating regularly over CB radios. Residents of Grayling harvest wild foods by fishing, hunting, trapping, and gathering. Several families also maintain large gardens, where they grow potatoes, turnips, lettuce, cabbage and carrots for family consumption. Residents fish for salmon as well as whitefish, sheefish, pike, arctic lamprey and many other non-salmon fish species. They hunt for moose, black bear, small game, and waterfowl. They also trap and sell the fur of river otter, marten, mink, beaver, wolf, lynx and wolverine. Residents also make and sell handicrafts such as root and grass baskets, beadwork, and sleds (DCED 2006).

Nine individuals were interviewed for this project in seven separate interviews over three summers. Interviews varied in length but averaged about 1 – 1.5 hours each. Depending upon experience, key respondents also mapped fish camp or fishing areas. Investigators accompanied Grayling fishers on two separate trips: the first was to visit an old fish camp site with an old birch bark smoke house, upriver from the village; the second trip was a participant-observational trip where one investigator went drift gillnet fishing with two Grayling fishers (aged approximately 55 and 13) to harvest salmon during a subsistence opening in District Y-3. Of the key respondents interviewed, eight were elders and three still actively fished. Investigators interviewed two married couples, five men and four women.

Salmon fishing occurred throughout this stretch of the Yukon, adjacent to fish camps that were both permanent and temporary (Figure 5). As with other communities, fish camps were populated by multiple generations and/or related family members and friends working together to cut and store enough fish for winter. The youngest respondent interviewed, an active fisherman who moved to Grayling from Holikachuk when he was a boy, remembered that there were usually about eight families at his family's summer camp every year, working together. The camp is currently shared by four families. When he was young, there were approximately 15-20 kids at the camp every summer, helping to check the fish wheel, haul water, and clean and hang fish. He stayed there

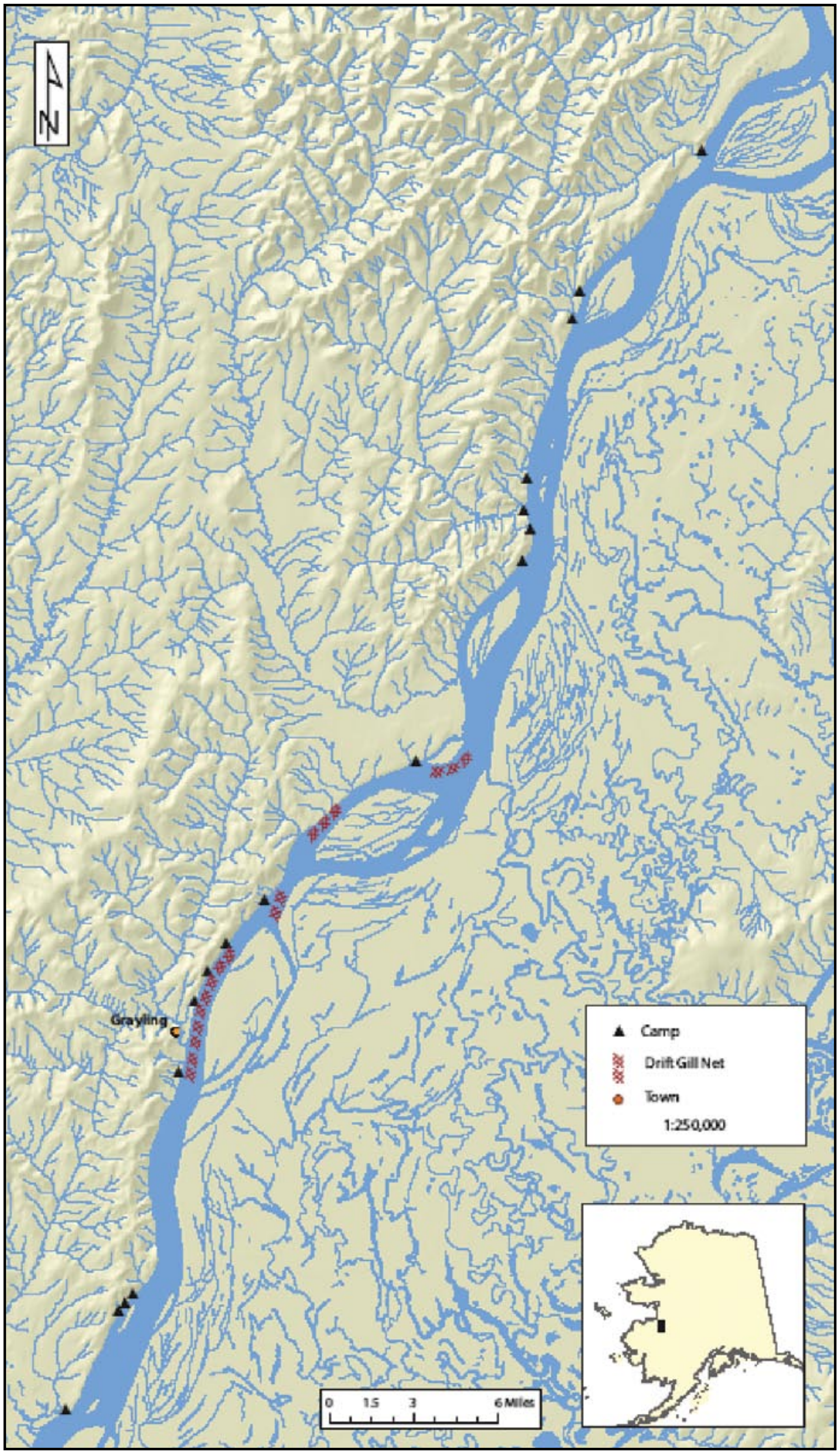


Figure 5. *Location of camps and driftnet sets as obtained through key respondent interviews in Grayling.*

with his family until the late 1960s or early 1970s when his family started fishing from town. According to one elder,

> *When I moved to Grayling in 1968, I started going to fish camp with my cousin Virginia. She had a fish camp above the village. There's Joe's fish camp, then Fred, then Walter Maillelle's – that's where we went, the third fish camp. I went out all summer with my cousins, we helped each other. As soon as we got there we started the fire in the smokehouse, we carried lots of wood. And then we went out and checked the fish net and cut fish.*
>
> Edna Deacon, Shageluk/Grayling

The composite fishing history for the community of Grayling reflects its historical connections to the Innoko River area. While most of the respondents were originally from the Holikachuk area and moved to Grayling in the 1950s and 1960s (one respondent was originally from Shageluk and married into the Grayling community), they maintained summer fish camps along the Yukon River to take advantage of more abundant and better quality salmon fishing. Elders describe traveling to the Yukon River through the Yukon Slough which connects the Innoko River to the Yukon River near Fox Point. According to most respondents who fished during that time, families mostly used fishwheels and homemade set nets near their camps. "At the camp we used a fish wheel and a long set net too. I made a fish net out of twine for the silver salmon [fall chum]. The meshes were measured by a stick." (Rose Golilie, Grayling). As a result, they harvested primarily chum salmon for themselves and their dogs with relatively few Chinook salmon. "People caught very few kings in their fish wheels. They are further out in deep water. They'd catch 1 or 2 once in a while. There were a few people who fished in the eddies and caught kings, but most people didn't drift" (Gabe Nicholi, Grayling).

> *I was almost 10 years old and I went out here to Rapids. Before my mother and father died, we had a fish camp way up at Simon Creek, off the Yukon. It's past Rapids, and past Thompson's Creek. We got dog fish. Those years, they never caught two to three king salmon. They caught one once in a while in the fish wheel. There were lots of king salmon, but it wasn't the right place. We were using a fish wheel. We didn't use a net to fish for king salmon until about 10-15 years ago. Nowadays you have to have a lot of money to buy a boat, motor, net.*
>
> Tiny Deacon, Grayling

In one mapping session, an elder pointed out approximately 10-15 camps along the Yukon River that were maintained by Grayling families, though most are not used regularly anymore. He also noted that many more temporary camps existed in this area over time, but their owners did little more than pitch a wall tent and construct racks and a basic smoke house and then move on the next year in search of a better spot.

Historically, when fewer king salmon were harvested by Grayling fishers, the women cut and dried chum salmon as "flat fish" rather than in strips, as is often done with Chinook salmon in contemporary times.

Back then, they never made strips. They made fancy fish. They were like flat fish. They cut it so the meat is hanging over, and then they take it off the backbone. Then from the middle of the fins, they cut it so the other side will be hanging down, and then they take a stick to stretch it. It's hanging on the pole from the middle fin on the belly. I still cut them like that, and I take the backbone out.

Edna Deacon, Grayling

The smokehouse that my mother and my two aunts used at Rapids was something like 40x30 feet, and we had something like four tiers – vertical rows of fish. We had at least two or three stoves in there made from 55-gallon barrels. They took about the same amount of time to dry as now, one week or 10 days.

Gabe Nicholi, Grayling

Interior communities have long maintained large dog teams and continue to keep more dogs than lower river communities. Several respondents recall the work required in cutting quantities of fish for all those dogs. "We had lots of dogs – 14. We had to cut a lot of fish for them. We were fishing for dog fish in the summer time and fall time. The silvers (fall chum) came around August. I never counted how many fish we used to cut for the dogs" (Rose Golilie, Grayling). According to another fisherman who was raised in a summer fish camp,

We were cutting that number of fish for six or seven dogs for each family. On our side of the creek there were about 30 dogs, and we had to cut fish for them for the whole winter. When the summers were hotter, the fish dried faster...To store them afterwards we would bale them for dogs. The eating fish were different – we put them in boxes for people to eat. An average bale was 50 pounds, anywhere from 50-55 fish. It was about one pound per fish. The bales were about two to three feet in diameter.

Gabe Nicholi, Grayling

Drift gill netting became the predominant form of fishing in Grayling in the late 1970s; prior to that, most families used set nets and fish wheels. Today, Grayling fishermen use primarily 8 ¼ to 8 ½ mesh nets that are approximately 28-45 meshes deep and up to 150 feet in length in order to harvest the Chinook salmon that most Grayling fishermen observe swimming in the center or east side of the river, deep near the bottom. "The kings are all deep. When the water is too low and you're drifting, the current is different, and it's hard to catch fish...Kings tend to stay on the east side of the river." (Gabe Nicholi, Grayling)

Grayling fishers expressed several concerns about how fishing is changing in their area. Primarily, fishers complain about the weather, suggesting that winters are not as cold and that they no longer see the 60-70F below temperatures that used to characterize the area. The summers are also not as hot or dry and both seasons seem marked by increased precipitation.

The river is also changing, according to most of the respondents. "We're getting lower water. It's not like it used to be when we had high water all spring. We had high water when the ice went out, up to the bank on the east side." (Gabe Nicholi, Grayling). Additionally, several fishers noted that the sandbars are shifting, affecting harvest locations.

> *Sandbars are filling up. That's the place we like to drift, at the sandbars. Some of them are under water...They are good places because that's where the current is going. The sandbars build kind of like a whirlpool. The sandbars are 10 or 20 feet deep. Every time we fish a whirlpool, we catch at least one or two kings. At Rapids, probably about 400 feet from shore, there are two big sandbars and a lot of whirlpools. We call it far out drift. When Rapids is busy down below us, we go way up and far out.*
>
> Gabe Nicholi, Grayling

Finally, Grayling fishers expressed concern about the declining size of salmon they observe in their nets. "We don't catch grandpas anymore – four feet. We caught a 55-pounder 4 foot long and 13" girth king salmon. The last time we caught one that size was about 10 years ago. The average size we catch now is about 20 pounds." (Gabe Nicholi Grayling)

Natural Indicators – Grayling

In Grayling, most of the fishers we spoke with indicated that flora and fauna were their primary indicators of the upcoming salmon run. "Fish birds" were discussed by a majority of the participants. They observed that the fish bird arrival correlates with salmon arrival. They sing a song that means that the fish are coming up the river to Grayling. In the Holikachuk dialect, the fish bird sings "slocknay" or "slackyach,"

> *I don't know what the name of it is. It says "slackyach"- that means "it's fish time" or "the fish are coming" in Dekanaag [Athabascan language]. When the fish are coming you'll hear it from way back here, but if the fish are very close, it will go near the bank. That's when everybody gets excited.*
>
> Edna Deacon, Grayling

This bird can also act as an indicator for sheefish, which in turn act as an indicator for the king salmon arrival. Based on pictures provided, it is likely a dark-eyed junco. While we were not able to make a positive identification of the bird by species from its description, it was described as grey and white like a sparrow, about 6 inches long.

Residents usually hear the bird several days before they see cotton flying around in the air. Just after the fish bird arrives, the cotton begins to blow and the salmon arrive. If there is a lot of cotton then there will be a lot of salmon.

Grayling residents also observed a relationship between water level and salmon abundance. While water levels in the Yukon vary throughout the summer in response to a variety of factors, Grayling fishers, just like Kaltag fishers (described below) observe a rise in water levels just before the Chinook salmon begin to arrive.

Grayling fishermen also observe phenotypical differences within Chinook salmon species, referred to as "bluebacks" and "whitenoses." Bluebacks are described as the first fish, generally smaller, but much fatter and richer, while whitenoses come later, are larger, but less oily.

> *There are some they call bluebacks. They are huge and they are really fat. I study fish all the time when I'm cutting it. They are harder to dry because they're too fat. You have to make your strips kind of thin. If you make it the regular width then they spoil. I like to get them because they're so nice and fat. I'll just jar it.*
>
> Edna Deacon, Grayling

Finally, Grayling fishers note that generally Chinook salmon are smaller at the beginning of the season and people expect them to get bigger if the run is going to develop well. During the summer of 2008 when investigators were visiting Grayling, fishers were evaluating the run timing and strength based on their observations of salmon size. Even though the first and second pulses were small and erratic, Grayling fishers were confident that it would improve, despite established patterns of a weaker third pulse, based on their observations of fish size. Indeed the third pulse was the largest, though the overall run remained below average.

Kaltag

Also located in District Y-4, Kaltag is a Koyukon Athabascan village located on the west bank of the Yukon River. The village sits on a 35-foot bluff at the base of the Nulato Hills, west of the Innoko National Wildlife Refuge. Kaltag's current population is approximately 199 (DCRA 2006). Located 430 miles from the mouth of the Yukon River (Wheeler, 1987), Kaltag sits in a landscape characterized by boreal forest and flat marshlands connected by complicated slough and lake systems. They share much in common with their upriver neighbors in Nulato, including resource use areas, kinship ties, and cultural practices such as the Stickdance, an annual memorial potlatch for individuals who had passed away up to several years prior.

Eleven individuals were interviewed from Kaltag for this project during two summer field trips. Of these 10 key respondents, seven were elders. There were nine men and two women in the group and of those, seven were active fishers. Four of the respondents were fluent in Athabascan and one elder woman in particular was able to provide a great deal of information about placenames, described below.

The contemporary community of Kaltag is at one end of the Portage Trail, an early trade route that links the Yukon River westward to Unalakleet on the Bering Sea. Until more recently in the 1950s and 1960s, the numbers of full-time residents of Kaltag remained relatively low as most families still traveled a seasonal subsistence round in the vicinity of the Kaiyuh Flats and downriver of Kaltag all the way to Khotolkaket, 25 miles downriver of the village.

The historical settlements that precede the contemporary community of Kaltag indicate its long-term relationship to salmon resources. Kaltag residents reported that many of their ancestors lived at *Tloge kkayeh*, or "fish village," during the 1800s, which was located on the Kaiyuh Slough. When a war between neighboring Koyukon groups killed many of the residents of *Tloge kkayeh*, those who survived scattered to surrounding settlements. Another historical village site was *Ggaal doh*, a Koyukon phrase literally meaning "before the king salmon," and from which, they said, the name of the contemporary community of Kaltag was derived. According to Kaltag residents, this site was across the river from the current village location and was where residents used to dip net from canoes and maintain a community smokehouse. Residents also said that a settlement was located at *Rodokaket*, a few miles downstream of the contemporary community; *Rodokaket* is now referred to as "Old Village." Respondents noted that residents moved to Kaltag around 1935 after excessive flooding in the *Rodokaket* area (see also Wheeler 1987 for an alternate description).

Kaltag residents have long harvested a combination of subsistence resources, including moose, bear, migratory birds, berries and other plants, small land animals, non-salmon fish species, and salmon. While still practiced today by some residents, trapping used to be a primary means of income for Kaltag people until the 1980s when fur prices declined (Robert 1984). In the 1930s-1960s, many families traveled a seasonal round supported by trapping activities. Despite this varied resource base, the most stable resource available to Kaltag residents has always been fish (Wheeler 1987).

Residents of Kaltag mostly subsistence fish from the village in locations relatively close to town, where they harvest Chinook salmon and summer chum in the early summer, and fall chum and coho salmon in the late summer. Several middle Yukon River communities, including Kaltag, used to maintain large commercial summer chum roe fisheries until the late 1990s when the markets were flooded by farmed salmon roe (Fall et al 2009). This effort has only recently been revitalized in Kaltag, beginning in 2008, though hampered by poor returns. Commercial harvests of summer chum roe used to take place primarily from fish camps. However, the use of fish camps has decreased over time due to a variety of socioeconomic factors including shifting employment opportunities that keep residents in the village for longer stretches of time and changing fishing schedules that make travel to fish camps or staying at them for periods of inactivity inconvenient and inefficient. According to one elder born in 1935, "You know, back when I was a young man, I seen a lot of fish. I traveled up around the river. There used to be fish camp every five, six miles. And there was fish racks all along the beach. I never see that again. Ever." Summer chum harvests have also decreased as travel by snowmobiles and bush planes replace dog sleds, thus requiring less summer chum for dog food (Wheeler 1987).

Fish table

The personal fishing histories of Kaltag residents that make up a community composite of salmon fishing in Kaltag vary depending on the age of the respondent. The elders interviewed for this study, regardless of whether they still actively fish or not, all remember traveling a seasonal round as children with their families until they were young adults themselves, around the 1960s. Beginning in the spring, most families trapped muskrat and other furbearers until March when they returned to Kaltag to sell their furs. After break-up, families traveled to their summer fish camps where they stayed all summer harvesting various salmon species before moving on to fall camp for moose hunting and wood gathering, usually through December. Most families then spent the dark winter months in the village where their children might take advantage of the mission school. Younger fishers who were born after the 1960s generally stayed in the village all year long, with longer camping trips out onto the land or to fish camp to pursue the same activities, but from a village base.


Salmon drying

Fish camp sites were dotted along a long stretch of the Yukon River around Kaltag (Figure 6). One elder's family fish camp was located approximately 15-20 miles upriver, half-way to Nulato, where Nulato families also maintained camps. Other fish camps were located closer to the contemporary village or several miles below. Travel to these camps was made by small motor boat (called a gas boat) or by human powered boat. According to one elder, she rowed between her family's fish camp, about 3 miles below the village, and Kaltag several times a summer to deliver dried salmon bundles to store for winter use to her family's cache in the village, "Rowboat! No motor, arm power!" (Mary Rose Agnes, Kaltag)

During fish camp days, most families used fishwheels and sometimes set nets, harvesting primarily summer chum (locally called silvers) and fall chum, with smaller numbers of Chinook salmon mixed in. Large quantities of chum salmon were necessary to feed multiple families working a camp and also the multitude of dogs used for winter travel, especially to trap lines. One elder described the make-up of his childhood fish camp: the camp regularly housed his immediate family of two parents and four siblings, his mother's parents, his maternal aunt and her family, and his maternal grandfather's brother and family. His family maintained anywhere from 30-50 dogs throughout the years for which they tried to cut 2,000 chum salmon for winter dog food, which would usually run out by late spring, before the next salmon run.

Historically, large in-river funnel traps, gill nets, and dip nets were the primary gear types used until the introduction of the fish wheel at the turn of the century (Clark 1981,

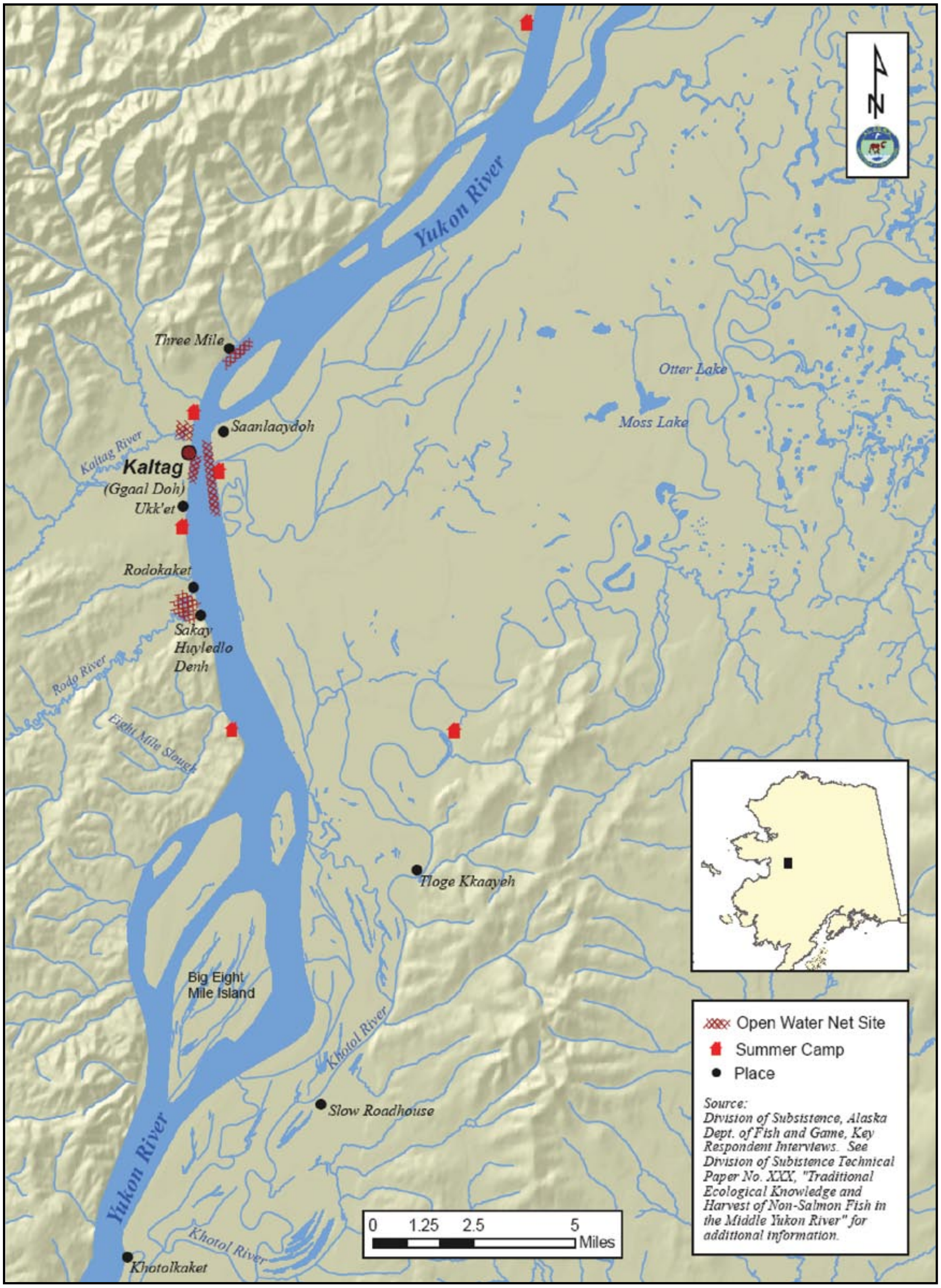


Figure 6. *Locations of summer camps as obtained through key respondent interviews in Kaltag.*

Loyens 1966, Wheeler 1987). Drift and set nets were historically constructed with rabbit babiche (strips of rawhide, sinew, or gut used for sewing, lacing, or fastening) (Loyens 1966), then with burlap after sacks became more readily available with trading, then with cotton twine when it became available. Now, nets are usually commercially made of monofilament line. Fishwheels continued to be a favored gear type while families maintained dog teams and while there was an active commercial roe fishery, both of which required a steady supply of chum salmon. Positioned along the banks, fishwheels and set nets targeted primarily chum salmon in this stretch of the river while Chinook salmon primarily migrate in the deep center channels, harvestable most effectively by drift gill nets, according to Kaltag fishermen. However, drift gillnetting was prohibited in this stretch of the river between 1974 and 1981 (Marcotte 1982).

Today, Chinook nets used by Kaltag fishermen are usually 7" to 8" mesh, approximately 100 feet long and around 20 feet deep, though some fishermen prefer to use a 6" mesh to harvest more fish. Chum nets are smaller, usually 5" to 6" mesh. Many fishermen fish for chums in the same locations they harvest Chinook salmon but also in additional spots that are historically good spots, such as "3 Mile" and "2 Mile" creeks just above Kaltag. Household harvests range broadly, depending on the size of the family, the time they have to spend on fishing, other resources available to them, and their social obligations to provide fish for other families or households. Far fewer Kaltag households maintain working dog teams than in earlier times. According to a recent study, there were 11 mushing households in Kaltag and 113 sled dogs. In 2008, there were no active mushers and no working dogs, though a number of sled dogs were still owned as pets (Andersen, personal communication, 2009). One fisherman noted that he tries to harvest approximately 120-130 Chinook salmon every year to meet the needs of his own family and other families he provides for, as well as about 30 silvers, that he fillets or half-dries. Another fisherman attempts to harvest approximately 300-350 king salmon but few to no chums. While many families still harvest large numbers of summer chum, Chinook salmon have comprised a larger proportion of the subsistence harvest since the early to mid 1990s.

Salmon are processed in a variety of ways. Chinook salmon are made into strips and frozen whole or in fillets. Kaltag residents continue their historical practices of drying or fermenting Chinook fish heads with roe, storing them either in buckets under the ground, in freezers, or drying them in a smokehouse. Historically, elders would also tie fish heads together and leave them in the water to ferment for a few days before cooking them. When there were more dogs in Kaltag, people also kept the Chinook backbones and dried them on large, flat rocks, and stored them in gunnysacks to feed to dogs in the winter.

Subsistence fishing has occurred alongside opportunities to sell salmon through the years. Many Kaltag fishers baled dried chum salmon to sell or trade to store owners who traveled up and down the river during the fish camps days, around the 1940s (Moncrieff 2007). One elder remembered his father selling up to 30 bales each fall at 23 cents a pound (each bale contained 50 chum salmon), which was on top of the 2,000 fish he cut for his own dogs each winter. Salmon was sold for cash or traded for grubstake goods such as flour, coffee, sugar, tea, etc. A commercial chum roe fishery developed in the Middle Yukon in the early 1970s and operated through the late 1990s; the mean household earnings from salmon roe fishery in 1985 was $5,436.72 (Fall et al. 2004, see also Wheeler 1987 for a history of commercial fishing on the Yukon River).

Both subsistence and commercial salmon fishing practices in Kaltag have been affected by regulatory actions over the years, resulting in different adaptive strategies (Wheeler 1987:111) that persist today, such as smaller work groups that cooperate in subsistence fishing effort and the shifts in the harvest and use of summer chum with the introduction of the commercial fishery and then again with its demise.

Kaltag fishers expressed some concerns about changes to the landscape that affect their fishing practices. Primarily, they commented on recent low water that interferes with travel in the area and with certain harvest locations.

> *There's willows and sandbars that never used to be, up and down the river. And um, my uncle and I always thought about it, we can go about 12 miles up here, go out around Kaiyuh and come out at 22 mile. And um, about the 10th of September, the water's pretty low. And we have hard time going round.*
>
> Laurence Saunders, Kaltag

Additionally, two fishers felt that the quantity of fish has decreased in the last 5 years, an observation born out by increasing restrictions placed on subsistence fishers over the past several years.

Natural Indicators – Kaltag

In Kaltag, fishers pay special attention to a variety of animals and plants when watching and waiting for the salmon to come. Butterflies play an important role in determining when to go salmon fishing. Yellow and black butterflies (referred to locally as the king salmon butterfly) appear when the king salmon are in the river and white ones (dog salmon butterfly) come out late when the dog salmon (fall chum) are in the river. Other animals are important indicators as well. According to one fisherman, the elders often watch the bears, who were also preparing to fish.

> *All the bears would disappear from the Yukon River. They go back to the creek, they go fishing in the creek, you know, so they quit traveling. You used to see them all along the Yukon but then after a while they're gone. They used to say it's 'cause they're fishing in the shallower waters in the creek…it means they're [the king salmon] coming. Before the fish come, they [the bears] head back to their fishing areas…after the salmon stop running, then they come back to the Yukon and try to steal from our fish wheels!*
>
> Albert Nicholi, Kaltag

Kaltag fishermen also noted that observing flocks of black ducks, or scoters, helped them to know when salmon were coming up river, as the ducks were said to be heading downriver to meet the fish. Finally, as in Grayling, the presence of sheefish could indicate the arrival of king salmon and the run timing and distribution of different salmon species.

> *And sheefish come. And they used to say that, you know, sheefish and then the kings and then the dogs…Yeah. Well dogs are now coming, but all the kings will be on that side of the river [east]…Dogs will be on this side of the river…That's just the way they run…every year. They don't mix...That's another thing what the people used to tell us to watch for. The sheefish. After the sheefish is all done, then we'll catch nothing but kings.*
>
> Laurence Saunders, Kaltag

Plants also play an important role. Several plants appear to mature to predictable levels at the same time that salmon appear near the village. Bluebell flowers indicate to fishers that the salmon are in the river near Kaltag. When the grass reaches 2 feet or more, the king salmon are in the river. The same is true with wild rhubarb. When it gets to a certain height, then the salmon will be in Kaltag.

As also reported by Grayling fishers, cotton, or the seed pods from cottonwood trees that float around in the air, are indicators to fishers in Kaltag that Chinook salmon season is about to begin. Fishers in Kaltag use the cotton indicator to know when to start repairing nets and putting up fish racks. "For king salmon, they watch for that cotton flying around - that's an indication the fish were coming up. And they get in a big rush to start getting ready – get the wheel out, fix the net, put up fish racks!" (Albert Nicholi, Kaltag).   Cotton is also useful in understanding salmon abundance and most Kaltag fishers observed a positive relationship between the amount of cotton and the amount of salmon. If there's not as much cotton, there won't be as much fish.

> *Most everybody around here, even the younger people know when the cotton fly, those fish are coming up… sometimes when it's not as much as usual, some times it's thinner than other years, they say there won't be as much fish. And that's what happened this year [2008], not very much king salmon. It's like that all over. Some friends of mine from Grayling, Anvik, they call me up and say there's no cotton flying around…no king salmon, but they say there's a lot of chum, though.*
>
> Albert Nicholi, Kaltag

During our last summer of fieldwork in 2008, there was very little cotton blowing around and Kaltag fishers were concerned that the run would not develop; ultimately, it did not develop as expected and subsistence opportunities were restricted. Fishermen between communities reportedly discuss this particular indicator as the season develops.

Finally, Kaltag fishers had limited experience with weather and river water acting as an indicator for salmon run timing and abundance. While most indicators involved plants or other fauna, wind was mentioned as an indicator, and echoed by Grayling elders. "When there's a south wind all the time in the spring, is when the king salmon are coming up. You know, around here they say south wind is coming up river. Just before the fish come up." (Albert Nicholi, Kaltag). Another long time fisherman observed changes in water levels just prior to fish arrival. "Right now the water's way down, and it's just sitting...and when that water start coming up, then you know there's fish coming. I don't care if it rain or no....I've noticed it. I keep going down and check it." (Laurence Saunders, Kaltag). According to this elder, the water levels can sometimes rise 3 feet, indicating the imminent arrival of fish.

Kaltag fishers also commented on the development of the king salmon run. Kaltag fishers made local distinctions between components of the Chinook run, as did fishers from other study communities. Bluebacks come first and tend to be richer, then the whitenoses come afterwards and tend to be larger, usually passing Kaltag by about early to mid July. In general, as also reported by Grayling fishermen, the first fish to swim past the community are smaller in size; salmon size tends to increase as the run develops. This is perhaps consistent with research that suggests that the early pulses or components of the Chinook run tend to be comprised of a larger percentage of male fish, which are usually smaller than the females.

DISCUSSION AND CONCLUSION

Natural indicators of salmon run timing and abundance are an aspect of local environmental observations and traditional knowledge (LTK) along the Yukon River. LTK is a local, informal knowledge structure that helps regulate fishing on the Yukon River by assisting people to understand when fish are coming, when to prepare fishing equipment, and what kind of run to expect.

Setting nets

The following paragraph summarizes the extent to which project objectives and goals were fulfilled as required by funding agencies. The project objective of documenting LTK related to natural indicators of the salmon run on the Yukon River was met through 61 interviews with knowledgeable elders and active fishers. The mapping portion of this objective to document salmon fishing sites and historical use was met in four of five communities. The respondents in St. Mary's were given the opportunity to map their use areas and chose not to participate. The map information collected has been compiled into GIS and included here. The second objective was capacity building through consulting with local village entities to develop the research plan, interview questions, and collecting, reviewing, and analyzing data. This objective was met through approval and partnership with the tribal councils of each study community. The tribal councils acted as the liaison for the project investigators, suggesting local assistants and project participants, meeting with project investigators and reviewing study design, interview questions and reviewing data. Due to time constraints, community presentations were conducted in four of the five study communities to present and discuss the research results and maps. All tribal councils were given the opportunity to review the final report. YRDFA staff and ADF&G staff received training with ArcMap to collect and present fish camp and fishing site data and build maps for all communities except St. Mary's. The ArcMap GIS program has been updated to 9.2 and is available for YRDFA staff use to increase the organization's capacity.

Natural indicators are used in each village of this project. The type of indicator used, what the observation reveals to the subject, and when the indicator is observed varies among villages. Some indicators are shared in two or more villages, while others are unique to a particular community. The following figure (Figure 7) depicts a summary of the indicators researchers documented in each village, grouped together by indicator type, such as weather or fauna.

Some indicators are unique to the village where they are observed. However, other indicators such as snow levels or the arrival of geese are prevalent in multiple communities. This graphic provides an understanding of how prevalent certain indicators are throughout the study area. The prevalence of indicators suggests how common or how unique certain indicators are and, as a result, what kinds of relationships are recognized in each community or throughout the study area.

Table 2 presents the same information as Figure 7 in a different format. This different perspective offered by grouping data by individual village allows for other inferences to be drawn more readily. The upriver communities of Kaltag and Grayling have a higher predominance of natural indicators that fall into the "flora and fauna" categories, whereas the lower river communities lean more heavily toward the "marine environment and weather" categories. This suggests that certain types of environmental observations and relationships predominate in different areas.

Results of this study suggest that fishermen implicitly separate their observations of natural phenomena into either causal or correlative indicators. Causal indicators are those events that influence the timing, size or quality of the salmon run in a direct or an indirect way; they are directly tied to how the salmon run develops. For example, causal indicators include wind direction and intensity at specific times of the year that affect when fish run, which mouth they enter, and according to some key respondents, run abundance and quality. Correlative indicators, on the other hand, are observations that occur with the salmon run. Indicators that correlate observations of natural phenomena to the salmon runs are useful as they provide information to the fishers about the salmon run, but do not have any effect on the run. Some examples of correlations between natural phenomena and the salmon run include migrating birds, the appearance of butterflies or bluebell flowers, cotton from trees, and the growth of grass and rhubarb.

The distinction between causal and correlative indicators is an important one to make, especially viewing the data from the perspective of incorporating LTK into management decisions. Underlying each observation of an indicator is a particular relationship or mechanism working to create the event that is observed. For the fisher in a community, the indicator appears to be the most important feature as it tells the fisher something about the fish run that can be readily acted upon. However, from a management perspective, the relationship or underlying mechanism that is revealed by the indicator, if it can be uncovered or discovered, may be more useful as it can be incorporated into the body of information used to inform future management decisions. Table 2 shows which are causal (indicated by a ▫ bullet) and which are correlative (indicated by a ⊙ bullet). Colored entries represent those indicators dealing with salmon abundance. The indicators in black represent salmon arrival information.

Lower river villages showed a stronger reliance on causal indicators. Fishermen described wind as a key consideration in their evaluation of the upcoming salmon run; many fishermen carefully observe wind direction and intensity throughout the year in order to predict aspects of the next summer's salmon returns. For instance, fishermen reported that wind direction affects when and which of the three mouths of the Yukon River the salmon will enter: "...the older folks know from which areas the fish were gonna come, by observing the weather and the condition of the wind... All the fish coming through middle mouth and this river right here. Because of the observations they had made through the winter" (Mary Ann Immammak, Emmonak). This can be critical knowledge for subsistence fishermen in the Yukon delta villages as their access to the salmon may depend on which mouth they enter. In order to maximize their fishing efforts, fishermen of other communities must know which mouth to travel to.

Tides and wind are important for lower river and coastal fishermen and women because they affect the timing and abundance of the salmon arrival. According to respondents in Emmonak, a south wind combined with a high tide when the salmon are ready to migrate increases their numbers locally. The explanation offered for this behavior is that a high tide allows the salmon to swim into the river easily and west wind pushes the salmon into the river. A south wind combined with a high tide work together to bring salmon into the Yukon River.

> *Since it's so shallow around here, she's referring to the wind action that it has on the tide. It might say according to the [tide] book it'll come up today at 3 o'clock. Well according to the wind it means it's gonna push the water away from us for another hour or two and then it'll come up... The wind will push the water away in certain winds. If we're getting north wind, it'll make the tide come up a little bit slower. If we're getting south wind, it'll make the tide come up a little quicker.*
>
> Ted Hamilton (translator for Mary Ann and Michael Andrews)

In Hooper Bay, a high tide will bring the salmon into the bay where the community lives. Observations and knowledge of the tides are particularly critical for Hooper Bay fishermen who can completely miss a salmon run if the tides are not in coordination with the winds.

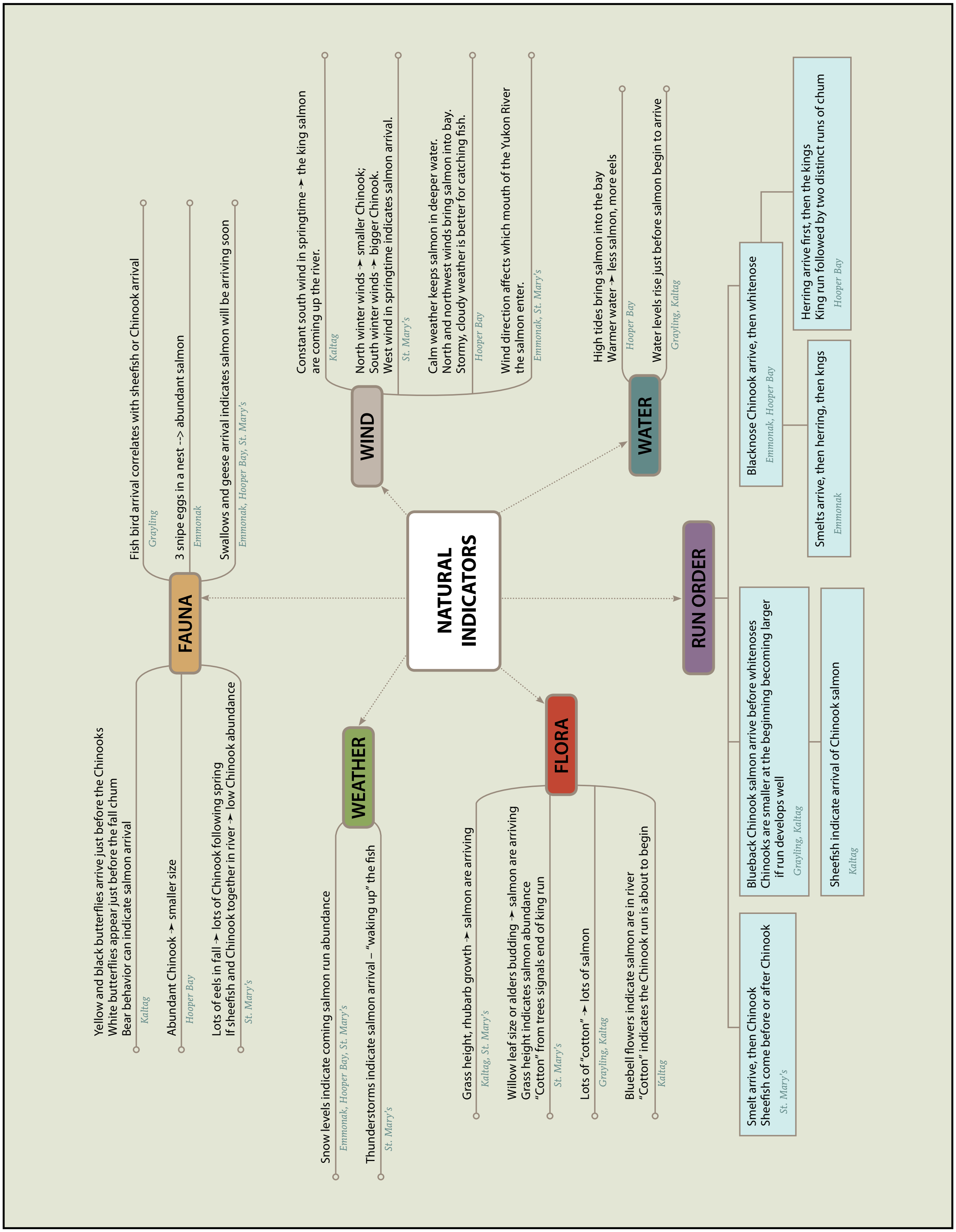


Figure 7. *Documented natural indicators in five villages, grouped by indicator type.*

Table 2. Documented natural indicators by village and indicator type.

	ENVIRONMENT		FLORA AND FAUNA	
	Wind	**Water/Weather**	**Flora & Non-fish**	**Run Order**
Hooper Bay	Calm weather keeps salmon in deeper water North and northwest winds bring salmon into bay Stormy, cloudy weather is better for catching fish	High tides bring salmon into the bay Warmer water → less salmon, more eels Heavy snow load → more salmon following season	Swallows and geese arrival indicates salmon will be arriving soon	Herring arrive first, then the kings Blacknose Chinook arrive, then whitenose King run followed by two distinct runs of chum Abundant Chinook → smaller size
Emmonak	Wind direction affects which mouth of the Yukon River the salmon enter	Heavy snow load → more salmon the following season	Geese arrival and behavior indicates salmon arrival and behavior 3 snipe eggs in a nest → abundant salmon Many black flies and mosquitoes → a lot of salmon that year	Smelts arrive, then herring, then kings Two distinct runs of Chinook – blacknose followed by whitenose
St. Mary's	North winter winds → smaller Chinook; south winter winds → bigger Chinook Wind direction affects which mouth of the Yukon River the salmon will enter West wind in springtime indicates salmon arrival	Thunderstorms indicate salmon arrival – "waking up" the fish Snow levels indicate how abundant the coming salmon run will be	Grass height, willow leaf size, rhubarb growing, alders budding → salmon are arriving Grass height indicates salmon abundance "Cotton" falling from trees signals end of run Geese arrival and behavior indicates salmon arrival and behavior	Lots of eels in fall → lots of Chinook following spring Smelt arrive, then Chinook Sheefish come before or after Chinook; if together in river → low Chinook abundance
Grayling		Water levels rise just before salmon begin to arrive	Fish bird arrival correlates with sheefish or Chinook arrival A lot of "cotton" indicates there will be a lot of salmon	Blueback Chinook salmon arrive before whitenoses Chinooks are smaller at the beginning, should become larger if the run develops well
Kaltag	Constant south wind in spring time → the king salmon are coming up the river	Water levels rise just before salmon begin to arrive	Yellow and black butterflies arrive just before the Chinooks White butterflies appear just before the fall chum Bear behavior can indicate salmon arrival Bluebell flowers indicate salmon are in river Grass height of 2 feet or more → salmon are in the river Rhubarb at a certain height → salmon in river "Cotton" indicates the Chinook run is about to begin Lots of "cotton," → lots of salmon Scoters head downriver to meet the fish	Sheefish indicate arrival of Chinook salmon Blueback Chinook first, then whitenose Small kings in beginning of run, get bigger as run develops

Some study participants reported that wind direction also affects the quality and abundance of salmon in the river. In Hooper Bay, it is observed that north and west winds bring fat Chinook salmon into the bay. In 2004, for example, continuous offshore winds (east) near Hooper Bay interfered with subsistence harvests, necessitating those fishers to go elsewhere to harvest salmon (Lingnau and Salomone 2004). In Emmonak, wind direction determines the color of the fish skin. North winds bring salmon with black backs and dark spots while south winds bring lighter-colored salmon that are bigger and more oily and rich. In St. Mary's participants reported that winter winds affect the abundance of salmon. In addition, St. Mary's fishers reported that winter winds affect the size or length of Chinook salmon that enter the Yukon River.

Other causal indictors relating to weather include thunderstorms and El Niño years. In St. Mary's, elders described thunderstorms as "waking up" the salmon, causing them to come in to the river to spawn. In Hooper Bay, participants observed more arctic lamprey, warmer water and fewer salmon and more sores on the salmon during the El Niño years of 1997-1998.

In two communities, Hooper Bay and St. Mary's, fishermen reported that they often observe a relationship between the number of salmon in the river and the general size of salmon that year. When Chinook salmon are abundant or compressed in the run as to be crowded in the river, they are described as smaller or skinny and flat as they are packed together. This was also related to another species that sometimes shares the river with the Chinook salmon; sheefish were observed to have an inverse relationship with Chinook salmon. In the lower parts of the river (Grayling and downriver), sheefish are said to precede the Chinook salmon run. If there were many sheefish there would be few salmon and if there were few sheefish, there would be many salmon. Several fishers observed that while sheefish appeared to precede the salmon, they also "got out of the way" of the salmon once the run was in full swing; that is, they stayed in the mouths of tributaries and sloughs until the salmon runs had passed before re-entering the mainstem in larger numbers again. If there are sheefish in the river during the Chinook salmon run then that means there is a low abundance of Chinook salmon.

As stated above, fishermen on the Yukon River also observe correlative indicators, or observations of events that occur in close time proximity to the salmon runs. This type of natural indicator appears to be most strongly related to seasonal timing, such as warming weather or longer day lengths. Correlative indicators include the behavior of other animals and plant development, events that might be affected by the same set of circumstances affecting the salmon run. As opposed to the causal indicators that predominated in the coastal and lower river villages, correlative indicators are found more readily in the upriver study communities. This comparative lack of causal indicators in the upriver communities may be explained by their distance from the ocean. Removed from the direct influences of the marine environment, correlative indicators take on a more dominant role when anticipating the coming salmon run. For instance, many fishermen look to the spring migration of birds to predict the timing and abundance of the first salmon run of the season. One individual observed that the timing, pattern, and speed of the migrating birds often predict the arrival and behavior of the salmon (A. Nick, personal communication, 2007). Mr. Nick further informed project investigators that Yup'ik elders predict a large number of returning Chinook salmon when large numbers of White Fronted geese and Taverner Canadian geese arrive in St. Mary's for their spring migration (A. Nick, personal communication 2009). In 2007, while investigators were in St. Mary's, the geese arrived late in the season in an unusually scattered pattern. As the above observation suggested would happen, that year the Chinook run trickled in throughout the summer in low numbers instead of developing into characteristically distinct pulses (Hayes and Clark 2007).

Correlative observations of other animals have long been documented. For example, Osgood (1959) noted in his work in the lower-middle Yukon area that the longer frogs croak in the spring, the more salmon there will be in the runs. Additionally, if the pectoral fins of the first chum salmon caught in the summer are white, it meant that there would be abundant salmon (Osgood 1959). For this study's participants, other animal behavior correlated to the salmon runs are the arrival of the "fish bird" and butterflies. The fish bird appears or calls out about the time that the salmon arrive in Hooper Bay on the coast as well as in Grayling, one of the upper river villages. These birds are described as mud swallows in Hooper Bay and as a grey-and-white bird (sparrow-like) in Grayling, likely a dark-eyed junco, though the exact species could not be identified through the interviews. In Kaltag, elders look for two kinds of butterflies to know when the Chinook and chum salmon will arrive. When the yellow and black butterfly or "king salmon butterfly," as it is referred to locally, appears then Chinook salmon are in the river. When the white butterfly appears, fishermen in Kaltag expect chum salmon to be close to Kaltag. Finally, the presence of flocks of "black ducks" or scoters, floating downriver suggests to Kaltag fishermen that salmon are moving upriver towards the village. The ducks are described as going to meet the salmon.

Drying salmon

Observations of flora are also important correlative indicators. Fishermen in St. Mary's watch for the grass and other plants, such as wild rhubarb, to reach a certain height to help them know when the Chinook salmon will be arriving. Elders in Kaltag watch for the appearance of bluebell blooms to know that Chinook salmon are near and to begin preparing their nets and boats. Many St. Mary's residents reported that in the past the elders would say that the salmon arrived when the willow leaves were large enough to cover the harvested salmon as shade. Willow leaves and grass would be cut to build shade for the drying salmon strips.

The cotton from aspen and cottonwood trees flies around in the air and lands on the surface of the water about the time that the salmon arrive in Grayling and Kaltag. This cotton is called 'fish food' because it is often found in the bellies of the harvested salmon. Not only alerting fishermen of salmon arrival, in Kaltag the quantity of cotton flying around can suggest how abundant salmon will be that year; less cotton means fewer salmon and vice versa. While blowing cotton is an indicator of the beginning of Chinook fishing in Grayling and Kaltag, in St. Mary's it is a sign that the Chinook salmon run is just about finished.

Fishers from the two upriver study villages, Grayling and Kaltag, reported that they observe a change in the water level when the mass of salmon enter the river. This observed rise in water levels alerts them to prepare for the salmon arrival. The interpretation of the rise in water levels is that the water is being displaced by thousands of salmon in the river swimming towards their village. While fishery managers believe that water displacement is an unlikely explanation for such an event, high water may indicate an unidentified phenomenon related to the fish runs.

The above examples of natural indicators, both causal and correlative, illustrate the ways in which Yukon River residents observe and understand the environmental cycles around them and how they connect those cycles to important aspects of their seasonal subsistence round. In this sense, local knowledge is an informal institution that regulates fishing on the Yukon River by helping people to understand when fish are coming, when to get ready, and how to prepare. These same indicators reveal mechanisms at work in the environment that, if better understood, may help managers more completely and holistically understand the trends and causes of variations in salmon abundance and run characteristics.

Implications

This study highlighted several issues that go beyond documentation of local and traditional knowledge. Documenting local knowledge of natural indicators also underlines the importance of understanding how these indicators influence choices and perceptions of fishers and managers alike, especially within the context of changing social and economic situations. From the fishers' perspectives, climate change and fishery management regulations figured prominently in their abilities to observe and utilize natural indicators. From the fishery managers' perspective, understanding the causal mechanisms and relationships responsible for producing the events long documented by local fishers may increase managers' capacity to understand and manage salmon runs within complex ecological systems.

Implications for fishers: Climate Change

Fishers discussed aspects of both climate change and fishery management regulations that negatively affect their ability to observe and use natural indicators to prepare for salmon fishing. In each study village, participants repeatedly voiced their concerns that things are changing and the natural indicators they have used for generations are becoming less predictable or less reliable. The arctic has long been characterized by high levels of variability and change in the environment and observations by local people of increased variability and unpredictability of weather and other seasonal patterns is well documented (cf. Krupnik and Jolly, 2002). As Krupnik and Jolly point out, "What people actually know is closely related to both historical and contemporary land use and occupancy" (Krupnik and Jolly 2002:2). It is a reflection and aggregation of the minutia of everyday activities on the land in terms of observations, decision-making, and success or failure. This detailed knowledge and experience and understanding the specifics of how change affects local places is one of the primary contributions of LTK research. What and how people see these changes in short-term weather observations and longer-term climate regimes may prove immensely valuable to a greater understanding of complex environmental systems (Riedlinger & Berkes 2001).

The difference between weather and climate should not be underemphasized in the analysis of local observations of environmental change, however. Within a climate regime, there may be a great deal of variability already present in geographically and temporally localized places. However, for most local residents, cumulative experience over time provides a baseline of understanding normal variation and change that is generally assessed in comparison to this baseline (Jolly et al, 2002). Some of the changes respondents discussed along the Yukon River included more frequent storms, warmer winter air temperatures, an increase in sandbars, and reduced salmon abundance.

In Emmonak, respondents reported that the overall climate has changed; today it is warmer, with more storms than in the past, and the storms come from the south:

> *It's a lot of difference now. The weather's no more good. That's what elders say. The people are getting no more good. The weather followed them. Fished with them when I was younger. There was hardly any storms. It used to be really cold too.* ***Really*** *cold. It storms all right when it's south wind. It used to rain in the wintertime. It used to rain even when it's south wind it used to rain. Once it rains and then blowing hard. And then switch it to west and the rain stop right there, right away. But now it never does that. It's different nowadays. We didn't have many storms those days. It's always something. Before we had big boats, most people just hunt just using their kayak for hunting. Must be some- Maybe the Creator know that they needed good waters around there. But now things are getting really bad now. Less snow now. Those days on the flats, those little houses used to be covered with snow. Only their snow pipes are sticking out.*
>
> Benedict Tucker, Emmonak

Respondents in Grayling and St. Mary's also reported that winters have become warmer. Both Herman Deacon and Gabe Nicholi informed project investigators that in the 1960s it was commonly 65-70 °F below zero, but today the temperatures go down to 30-40°F below zero for only a couple of days. With warmer winters, ice travel has become more dangerous:

> *Our winters are getting warmer. We don't get as much snow as we used to, and that's quite evident. And usually while I was growing up, usually mid-December, we'd get like a thaw. One thaw and they used to be happy with that. And they'd say usually when that come- And if it rains a little bit even then or gets slushy, it's feeding the tundra, so that the berries would be more plentiful. And then it would freeze up and get cold again. And it would stay cold until mid- or end-March. Instead of get warm-cool-warm-cool like it has been these last- I remember when I was growing up, the snow used to be so high. Sometimes if you open your door you'd see big piles of snow. And we'd play and dig. We don't see that.*
>
> Nina Weingarth (translator for Mary Patsy) St. Mary's

Two respondents from St. Mary's discussed the increase in sandbars. Both Charlie Paukan and Pat Beans, Jr. were very concerned as sandbars change where the salmon swim. Changing sandbars affect traditional fishing sites. Eddies that have been used for generations by a fishing family become obsolete. However, a certain amount of riverine fluctuation is normal and always occurring. How and where changes in sandbars may be related to other changes, such as erosion, increased precipitation or decreased water levels that might indicate climate shifts over time exceeds the objectives of this study. However, these are topics for future research. Mr. Beans explained that, in addition, the river current has weakened:

> *Last spring (2006) we had some kind of break-up that we never seen before. I haven't seen. Where we have hardly any action, or low water, really low. Sand, there's a lot of sandbars out in the Yukon now. Even though right now the current's not as strong as it used to be, seems like, through the sandbars I guess. We don't have strong current out there like we used to, certain places.*
>
> Pat Beans, Jr. St. Mary's

> *There's willows and sandbars that never used to be, up and down the river. And my uncle and I always thought about it, we can go about 12 miles up here, go out around Kaiyuh and come out at 22 mile. And about the 10th of September, the water's pretty low. And we have hard time going round. The river's shifting. Sand....[And it didn't used to do that?]...Not as often as it does now."*
>
> Lawrence Saunders Kaltag

Implications for fishers: Management Regulations

In addition to changes in weather patterns and river characteristics, key respondents also explained how the windowed subsistence fishing schedule interferes with fishing times dictated by natural indicators. The regulated opening and closing of fishing times set people on a different schedule than natural indicators would dictate, thus constraining people's ability to use them.

The windowed fishing schedule also sometimes causes disagreement or miscommunication about whether there are fish in the river or the timing of their arrival. The natural indicators may inform fishers that fish are in the river or that they will be arriving soon, but they are unable to set their nets to catch them due to regulations. One of the respondents explains the frustration some fishers feel when they believe that the salmon have arrived yet the managers disagree on salmon numbers.

> *Let's say Fish and Game say there's no fish down there. Okay, we have fish finders. And last summer, a friend of mine I told him 'Okay let's go out'. And we went out and we went from the bank right here all the way to the other bank over there, and there was fish. But we couldn't really tell if it was white fish, sheefish, dog salmon. But we know it's the bigger ones that were kings.*
>
> Lawrence Saunders, Kaltag

In particular, fishers object to the windows as a prescribed schedule that dictates fishing by the calendar and clock rather than the practices that have long dictated the best times for fishing based on observations of run timing, run quality, and run abundance.

> *I really wish they would just at least, take the time to listen to our elders, instead of trying to set days, even preset days. If it's a rainy day on one preset time, they should close that and open it when it's good. You can't try to regulate times, the weather is our boss when we're putting fish away.*
>
> Charlie and Maggie Paukan, in Moncrieff and Klein 2003.

Scheduled fishing, which allows some fish to travel upriver unexploited for escapement and upriver users, conflicts with the local natural indicators which promotes harvest and processing efficiently in some cases. These two approaches to harvest management causes tension between the formal regulatory frameworks and informal rules characterized by historical fishing patterns and long-term observations of natural indicators. Traditional knowledge and local observations have guided local fishers for many generations and have helped to prepare for the salmon run and to ensure they have enough food for the winter. However, technological and political changes, as well as increased pressure on declining runs in a fully allocated fishery have created the need for a highly regulated fishery in order to ensure sustainable management.

A good example of this dynamic comes from Grayling where fishers set their nets for sheefish because they are an indicator species of Chinook salmon arrival. The arrival of the sheefish informs fishers that they can start drifting for salmon, but fishing windows may be closed and they are not allowed to begin salmon fishing, despite an LTK indicator that it's time to start salmon fishing. This is an example of how LTK indicators can be compromised by western regulatory framework.

Implications for management

With documentation of this body of natural indicators from these five villages, the next logical step was to see how this information could be incorporated into western management actions. By comparing the observations of fishers, and what those observations mean, to biological and historical climate data on Chinook salmon run abundance and timing, investigators hoped to be able to draw conclusions that would be useful in salmon management. A separate project, funded by the National Oceanic and Atmospheric Administration (NOAA) and carried out by YRDFA, was established to complement the Natural Indicators of Salmon Run Abundance and Timing project by looking at these relationships (DuBey, 2009).

A number of data sets were reviewed for Chinook salmon abundance and timing. ADFG provided total Chinook salmon run data based on the Pilot Station sonar for the years 1995, 1997-2008. Escapement numbers and harvest amounts from below Pilot Station were also provided. Lower Yukon Test Fishery (LYTF) data was obtained to establish run-timing, the median point of the run and the date of the first fish caught for the years 1989-2007. The longest term data set reviewed was historic harvest data, for both subsistence and commercial uses within Alaska. This data set extends from 1961 – 2007. Canadian harvest data was also obtained from the Department of Fisheries and Oceans (DFO). Climatic datasets of water temperature, wind direction and speed, Yukon River ice break-up timing, and air temperature were reviewed. The datasets were obtained from the USGS and NOAA's National Weather Service from sites located in the region, including Alakanuk, Nome, Hooper Bay, Emmonak, St. Mary's, Grayling and Kaltag.

From the data that was available, it was difficult to evaluate total Chinook salmon run abundance over a long period of time. Data from the Pilot Station sonar prior to 1995 is not comparable to post-1995 data as the sonar used a different configuration. The most comprehensive data set available is the total harvest numbers. However, using total catch as a proxy for Chinook salmon run abundance is problematic as the harvest data is a function of both run abundance as well as fishing effort, among other factors. Due to the lack of robust salmon run abundance over a significant time period, the analysis focused on salmon run timing. The best indicator of run timing comes from the LYTF, which began operating in 1961. However, the test fish site switched in 1980, and the north mouth test site changed in 1989. Therefore, only data from 1989 on was used in this analysis.

Datasets were evaluated for comparable time series and analyzed using linear regression and ANOVA. A review of the water temperature datasets revealed that they represented a very limited time series and were therefore not used in this analysis. No significant relationships were found between run timing and Chinook total catch ($p>.05$). A limited time series data set of average wind direction and speed from Nome in March, April and May from 1993 to 1999 was regressed against Chinook salmon total harvest and run-timing data. No significant relationships were found. This was possibly due to the limited time series available or that the information reflected in these measurements may show local conditions rather than regional trends.

In comparing break-up timing of the Yukon River with Chinook salmon run, data taken at Alakanuk (provided by the National Weather Service) corresponded best in terms of time series available. The analysis used break-up date data from 1983 to 2007, omitting the years 1990 and 1991 as no data on break up at Alakanuk was available. The median break-up date for this time series is May 22nd. There was no significant relationship found between the break up date and run strength as indicated by total Chinook catch ($r2 = 0.065$; $p = 0.278$). Nor was there a significant relationship with date of break-up and the median point of run ($r2 = 0.124$; $p = 0.218$). However, a significant relationship was exhibited between date of break up and date of first Chinook salmon caught in the lower Yukon River ($r2 = 0.75$; $p < 0.001$) (Figure 8). Years where break-up happens earlier in the year, the fish begin running earlier in the year. This may relate to the relationships seen with air temperatures and run timing, as seen below, or may be indicative of changes in water temperatures or another mechanism as yet unexplored.

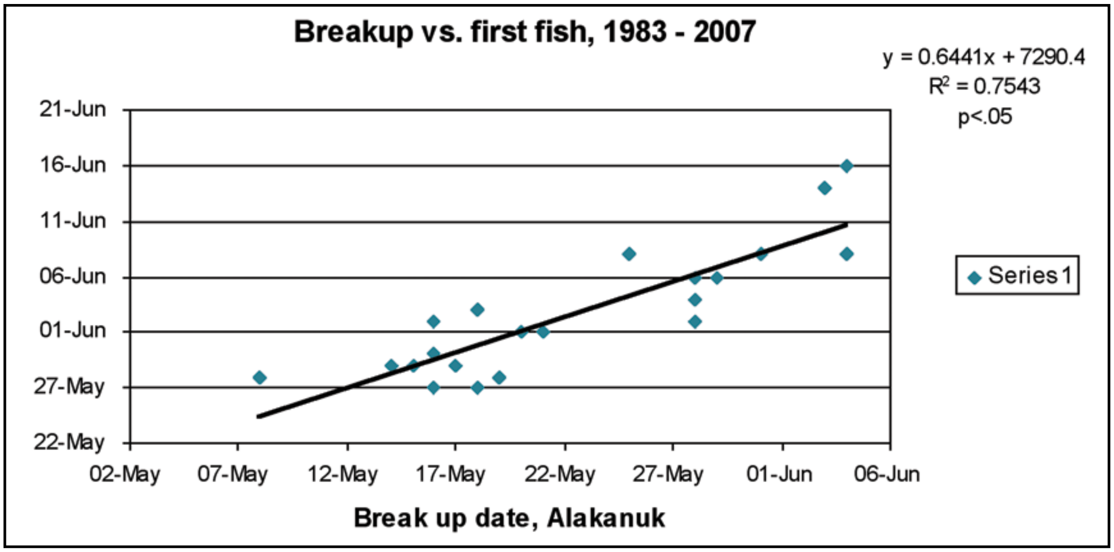


Figure 8. *Regression analysis of date of first Chinook salmon caught in the Lower Yukon River Test Fishery and Yukon River ice breakup date at Alakanuk, Alaska from 1983 to 2007 (Dubey 2009).*

Limited air temperature data was available from the National Weather Service. The only data in the region that corresponded with Chinook total catch and run timing from 1989 to 2006 was collected at the Nome Airport. A significant relationship was exhibited between Nome mean temperature in May and date of first Chinook salmon caught in the lower Yukon River (r2 = 0.692; p < 0.001) (Figure 9.). This relationship shows that Chinook salmon run timing (here shown by the date of first fish caught in the lower river fisheries) is earlier with higher May mean temperatures. This may indicate that late spring mean temperature records are reflective of region climate and ice conditions and that these factors may influence run timing.

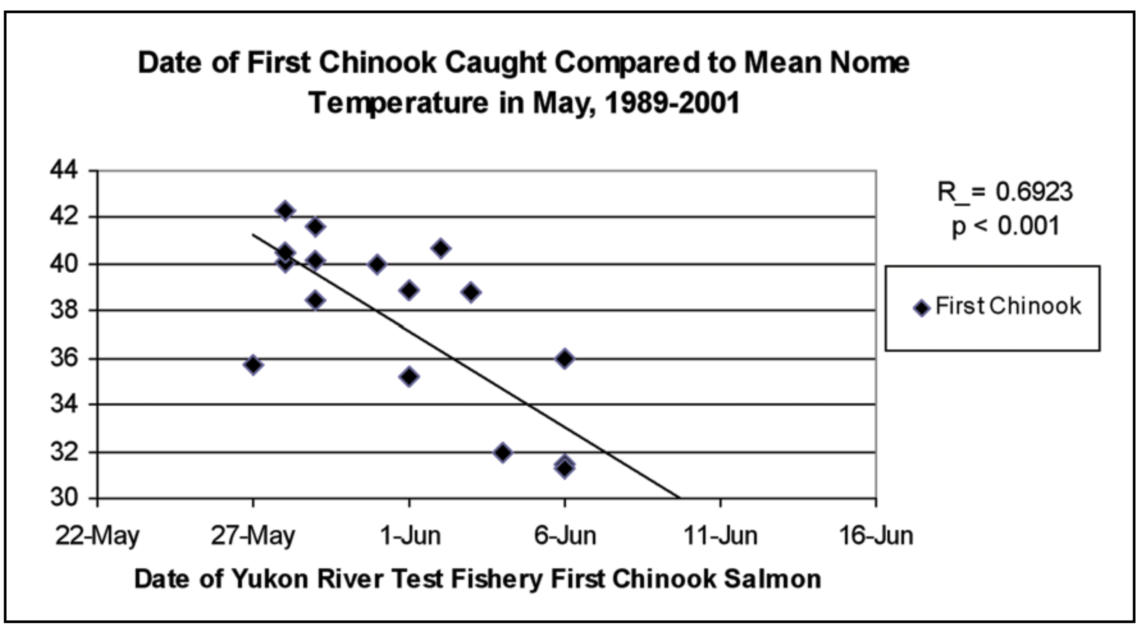


Figure 9. *Regression analysis of the date of the first salmon caught in the Lower Yukon River Test Fishery and the mean temperature in may as recorded at Nome (Dubey 2009).*

RECOMMENDATIONS

During the course of this project, investigators found that causal indicators predominate in the lower river communities while correlative indicators were found throughout the study region. Respondents clearly recognized relationships between weather, animals, plant growth and salmon run timing and abundance. More information is needed about the mechanisms underlying these observations. Further research on environmental and ecological factors that dictate or shape plant growth and how their timing is related to salmon may explain these observed relationships and provide useful information to managers about these mechanisms.

An example of such research would be to focus on the observation reported in multiple communities that related heavy snowfall to salmon abundance in the following season. Investigators heard in Hooper Bay, Emmonak and St. Mary's that subsequent years of heavy snowfall correlate with years of abundant salmon. In related comments, we heard that when the Yukon River has low water levels the salmon have trouble traveling upriver. Further research could clarify what this relationship actually is and possibly assist managers with understanding weather patterns that could provide information about salmon run numbers.

Other angles from which to approach the question of underlying relationships observed as natural indicators would be to look at the indicators of salmon size and water levels. In both Hooper Bay and St. Mary's, fishermen reported that they often observe a relationship between the number of salmon in the river and the general size of salmon that year. Age/sex/length data, commonly collected annually, could be compared to Chinook salmon abundance data run size.

In both Grayling and Kaltag, respondents reported that they observe a change in the water level when the mass of salmon enter the river. To them, this indicates the water is being displaced as thousands of salmon are in the river swimming towards their village. Fishery managers believe this is an unlikely explanation. However, the observed pattern of high water prior to salmon arrival could be the manifestation of another relationship that does affect salmon that is as yet unidentified.

Finally, in St. Mary's residents believe that a strong run of Arctic lamprey in the fall time means there will be a large salmon run the following summer. In contrast, biologists with ADF&G believe that a large salmon run one summer means there will be a large lamprey run that fall (personal communication Paul Salomone). Understanding what mechanism is actually in evidence here could inform managers' view of upcoming salmon runs.

Net repair

While attempting to compare natural indicators learned about through community residents with historical biologic and climate data, it became apparent to the investigators that future research on Yukon River Chinook salmon would benefit from a long term run re-construction. Currently, the best data available are harvest estimates as a measure of run size, a dataset which is inherently biased as harvest rates are a function of effort and timing as well as abundance. In addition, long term climate and ecological data sets are lacking for the region and this lack of data may seriously impair future research efforts.

Other recommendations for further research include research into salmon movements in the Bering Sea and their relationships to water and air temperature, and research into wind direction and its relationship to water and air temperature. The hypothesis behind these recommendations is that Chinook salmon seek cold water (as measured by sea surface temperatures) which, combined with winds, are the primary factor in Bering Sea temperature regime. This is backed up by the natural indicators that north and northwest winds bring cold water which is desirable to salmon.

Finally, as a next step some of the authors of this study plan to convene a multidisciplinary team made up of anthropologists, climatologists, biologists, Native leaders, knowledgeable elders and active fishers to review the natural indicators reported through this project. They will also research and review relevant climate data, salmon size data, salmon records, and flora and fauna records. By comparing these two sets of data and holding discussions to determine their significance we hope to enrich our understanding of the natural indicators and find ways to bridge the local and non-local knowledge systems, to discuss the agency interpretation of the observed phenomena, and to seek a better understanding of the mechanisms behind the natural indicator observations.

REFERENCES CITED

Alaska Department of Fish and Game. 2009. 2009 Preliminary Yukon River Summer Season Summary. Available at http://www.cf.adfg.state.ak.us/region3/yukhome.php Accessed December 17, 2009.

Alaska Department of Fish and Game, ANILCA Program Office. 1993. Report on Dual State and Federal Management of Fish and Wildlife Harvest; Examples of Problems and Related Issues. Anchorage.

Andersen, D.B., Brown, C.L., Walker R.J., and Elkin, K. 2004. Traditional ecological knowledge and contemporary subsistence harvest of non-salmon fish in the Koyukuk River drainage, Alaska. Division of Subsistence, Alaska Department of Fish and Game, Technical Paper No. 282.

Andrews, E. 1986. Yukon River subsistence fall chum fisheries: an overview. Division of Subsistence, Alaska Department of Fish and Game, Technical Paper No. 147.

Andrews, E. and Coffing, M. 1986. Kuskokwim River subsistence Chinook fisheries: an overview. Division of Subsistence, Alaska Department of Fish and Game, Technical Paper No. 146.

AYK-SSI. 2006.Arctic-Yukon-Kuskokwim Salmon Research and Restoration Plan. Bering Sea Fisherman's Association. 705 Christensen Drive, Anchorage 99501

Benedict, N. W. 1969. A History of Emmonak. Summer Institute in Teaching Alaskan Native Youth. Alaska Methodist University, Anchorage, Alaska.

Brown, E.D., Seitz, J., Norcross, B.L., and Huntington, H.P. 2002. Ecology of herring and other forage fish as recorded by resource users of Prince William Sound and the outer Kenai Peninsula, Alaska. Alaska Fishery Research Bulletin 9(2): 75-101.

Brown, C. L., J. Burr, K. Elkin, and R. J. Walker . 2005. Contemporary subsistence uses and population distribution of non-salmon fish in Grayling, Anvik, Shageluk, and Holy Cross. Alaska Department of Fish and Game Division of Subsistence, Technical Paper 289. Fairbanks, Alaska.

Bryner, W.M. 1995. Towards a Group Rights Theory for Remedying Harm to the Subsistence Culture of Alaska Natives. Alaska Law Review 12:293-334.

Bue, F.J., B.M. Borba, and D.J. Bergstrom. 2006. Yukon River fall chum salmon stock status and fall season salmon fisheries. Report of Alaska Department of Fish and Game, Division of Commercial Fisheries to the Alaska Board of Fisheries. Special Publication No. 06-36, Anchorage, Alaska.

Busher, W. H., T. Hamazaki, and A. M. Marsh. 2007. Subsistence and personal use salmon harvests in the Alaskan portion of the Yukon River Drainage, 2005. Alaska Department of Fish and Game, Fishery Data Series No. 07-52, Anchorage.

Case, M., and Halpin, E. 1990. Contemporary wild resource use patterns in Tanana, Alaska, 1987. Division of Subsistence, Alaska Department of Fish and Game, Technical Paper No. 178.

Clark, A.M. 1981. Koyukon. *In* Handbook of North American Indians: Subarctic. *Edited by* J. Helm. Smithsonian Institution, Washington, D.C. 6: 582-601.

Clark, K. J., D. J. Bergstrom, and D. F. Evenson. 2006. Yukon River summer chum salmon stock status, 2006; Report of Alaska Department of Fish and Game, Division of Commercial Fisheries to the Alaska Board of Fisheries. Special Publication No. 06-34, Anchorage, Alaska.

David, C. 1998. Will Federal or State Management Afford Alaska Natives a More Effective Voice? Cultural Survival Quarterly 22(3).

DCRA (Alaska Department of Commerce, Division of Community and Regional Affairs). 2006. Alaska Community Database: Community Information Summaries Available: www.commerce.state.ak.us/dca/commdb/CF_CIS.htm (June 2007): “Hooper Bay”, “Emmonak”, “Saint Mary’s”, “Grayling”, “Kaltag”, and “Nulato”

DuBey, R.J. 2009. Natural Indicators Supplement: Climate Data Analysis Yukon River Drainage Fisheries Association, Anchorage, Alaska.

Fall, J., D. Caylor, M. Turek, C. Brown, T. Krauthoefer, B. Davis, and D. Koster. 2007. Alaska Subsistence Salmon Fisheries 2004 Annual Report. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 317, Juneau, Alaska.

Fall J. A., C. Brown, M. Turek, N. Braem, J. Simon, A. Russell, W. Simeone, D. Holen, L. Naves, L. Hutchinson-Scarbrough, T. Lemons, V. Ciccone, T. Krieg, and D. Koster 2009. Alaska subsistence salmon fisheries 2006 annual report. Alaska Department of Fish and Game, Division of Subsistence, Techncial Paper No. 344. Juneau, Alaska.

Fienup-Riordan, A. 1986. When our bad season comes: a cultural account of subsistence harvesting and harvest disruption on the Yukon Delta. Alaska Anthropological Association, Anchorage, Alaska.

Hayes, S. and K. Clark. 2007. 2007 Preliminary Yukon River Summer Season Summary. Alaska Department of Fish and Game, Anchorage, Alaska.

Hull, T. and L. Leask. 2000. Dividing Alaska, 1867-2000: Changing Land Ownership and Management. ISER Review of Social and Economic Conditions, November 2000.

Huntington, H.P. 2000. Using traditional ecological knowledge in science: methods and applications. Ecological Applications 10(5): 1270-1274.

Inglis, J.T. (ed.). 1993. Traditional ecological knowledge: concepts and cases. International Program on Traditional Ecological Knowledge and International Development Research Centre, Ottawa.

Jette, J. 1911. On the superstitions of the Ten'a Indians, Anthropos 6: 721-722.

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

Lingnau, T. and P. Salomone. 2004. Preliminary 2004 Yukon area Chinook and summer chum salmon fishery summary. Alaska Department of Fish & Game Division of Commercial Fisheries, Informational Letter, Anchorage.

Loyens, W.J. 1966. The changing culture of the Nulato Koyukon Indians. Ph.D. Dissertation, University of Wisconsin, Madison, Wisconsin.

McLaughlin, M. J. (1969). The City of St. Mary's. Summer Institute in Teaching Alaskan Native Youth. Alaska Methodist University.

Marcotte, J. R., 1982. The king salmon drift net fishery on the Middle Yukon: an overview and study of the 1982 season. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 18. Juneau, Alaska.

Moncrieff, C. F. 2004. Listen To Our Elders: Investigating Traditional Ecological Knowledge of Salmon in Communities of the Lower and Middle Yukon River. Master's thesis. University of Alaska, Anchorage.

——. 2007. Traditional ecological knowledge of customary trade of subsistence-harvested fish on the Yukon River. Report of Yukon River Drainage Fisheries Association to U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program, 2007. Report 04-265., Anchorage, Alaska.

Moncrieff, C. F., and J. Klein 2003. Traditional Ecological Knowledge Along the Yukon River. Report of Yukon River Drainage Fisheries Association to the U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program. Anchorage, Alaska.

Moncrieff, C. F., D. W. Wiswar, and P. A. Crane. 2005. Phenotypic Characterization of Chinook Salmon in the Subsistence Harvest. Report of Yukon River Drainage Fisheries Association to U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program, 2005. Report 03-015., Anchorage, Alaska.

Nelson, R. K.1983. The Athabaskans: People of the Boreal Forest = Ts'ibaa laalta hut'aana. Fairbanks: University of Alaska Museum.

A. Nick, personal communication, 2007

——, personal communication, 2009

Osgood, C. 1958. Ingalik social culture. Publications in Anthropology 53. Yale University Press, New Haven, Connecticut.

—— 1959. Ingalik Mental Culture. New Haven: Yale University Press.

Riedlinger, D. and F. Berkes. 2001. Contributions of Traditional Knowledge to Understanding Climate Change in the Canadian Arctic. Polar Record 37:315-328.

Robert, M. 1984. Trapping patterns in the vicinity of the Kaiyuh Flats, West Central Alaska. Alaska Department of Fish and Game Division of Subsistence, Technical Paper 84. Juneau, Alaska.

Salomone, P. 2005. Hooper Bay Subsistence Salmon Monitoring Project, 2004. Alaska Department of Fish and Game, Fishery Data Series No. 05-09, Anchorage, Alaska.

Shapiro, D. 1997. Jurisdiction and the Hunt: Subsistence Regulation, ANILCA and *Totemoff*. Alaska Law Review 14:115-140.

Stickney, A. 1984. Coastal Ecology and Wild Resource Use in the Central Bering Sea Area: Hooper Bay and Kwigillingok. Alaska Department of Fish and Game, Division of Subsistence. Technical paper 85. Juneau, Alaska.

Vania T., V. Golembeski, B. M. Borba, T. Lingnau, J. S. Hayes, K. R.Boeck, W. H. Busher 2002. Annual Management Report Yukon and Northern Areas 2000. Alaska Department of Fish and Game. Report nr 3A02-29. Anchorage, Alaska.

Vanstone, J. 1974. Athabaskan Adaptations: Hunters and Fishermen of the Subarctic Forests. Arlington Heights: Harlan Davidson, Inc.

—— 1984. Mainland Southwest Alaska Eskimo. *In* Handbook of North American Indians. volume 5. pp. 224-242. Smithsonian Institution. Washington, D.C.

Wheeler, P. 1987. Salmon Fishing Patterns Along the Middle Yukon River at Kaltag, Alaska. Alaska Department of Fish and Game, Division of Subsistence. Technical paper 156. Juneau, Alaska.

Wheeler, P. and T. Thornton. 2005. Subsistence Research in Alaska: A Thirty-Year Retrospective. Alaska Journal of Anthropology 3(1):69-103.

Wolfe, R. J. 1981. Norton Sound/ Yukon Delta Sociocultural Systems Baseline Analysis. Anchorage: ADF&G.

—— 1984. Commercial Fishing in the Hunting-Gathering Economy of the Yukon River Yup'ik Society. Etudes/ Inuit/ Studies 8:159-183.

—— 2000. Subsistence in Alaska: A Year 2000 Update. Juneau: Division of Subsistence, Alaska Department of Fish & Game.

Woodbury, A. C. 1984. Eskimo and Aleut Languages. *In* Handbook of North American Indians. volume. 5. pp 49-63. Smithsonian Institution. Washington, D. C.

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APPENDIX 1

Chinoook Salmon Harvest Totals

***1a.** Chinook salmon commercial harvests, Yukon River 1999-2009*

Appendix 1a. Chinook salmon commercial harvests, Yukon River 1999 - 2009

District/Subdistrict	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	recent 10-year average (1999-2009)
Y-1	37,161	4,735		11,159	22,750	28,401	16,694	23,748	18,615	2,530	90	18,421
Y-2	27,133	3,783		11,434	14,178	24,164	13,413	19,843	13,302	2,111	226	14,373
Subtotal of Y-1 and Y-2	64,294	8,518		22,593	36,928	52,565	30,107	43,591	31,917	4,641	316	32,795
Y-3	538							315	190			
Y-4A												
Y-4BC	1,437				562							
Subtotal Y-4	1,437				562							
Y-5ABC	2,189			564	908	1,546	1,469	1,839	1,241			1,394
Y-5D	415			207	226							283
Subtotal Y-5	2,604			771	1,134	1,546	1,469	1,839	1,241			1,515
Y-6	689			1,066	1,813	2,057	453	84	281			920
Total Alaska	69,562	8,518		24,430	40,437	56,168	32,029	45,829	33,629	4,641	316	35,027

(Source: ADF&G 2009)

1b. *Chinook salmon subsistence harvest totals by fishing district and community of residence, as estimated from postseason survey, returned permits and test fish projects, Yukon Area, 1995-2005.*

Appendix 1b. Chinook salmon subsistence harvest totals by fishing district and community of residence, as estimated from postseason survey, returned permits and test fish projects, Yukon Area, 1995 - 2005.

Community	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	1995-1999 Average	2000-2004 Average
Hooper Bay	1,500	1,127	613	13	173	114	2,150	282	722	1,042	157	685	862
Scammon Bay	585	1,238	526	378	938	449	732	840	1,128	996	691	733	829
Coastal District Total	***2,085***	***2,365***	***1,139***	***391***	***1,111***	***563***	***2,882***	***1,122***	***1,850***	***2,038***	***848***	***1,418***	***1,691***
Nunam Iqua	459	450	970	527	855	684	550	393	925	647	338	652	640
Alakanuk	1,191	662	2,058	1,930	1,236	1,109	973	1,773	1,707	1,317	860	1,415	1,376
Emmonak	1,711	702	3,080	2,396	3,337	2,205	2,473	1,751	2,763	2,768	1,730	2,245	2,392
Kotlik	2,599	1,832	1,442	2,389	1,420	1,893	3,093	1,686	937	1,148	2,130	1,936	1,751
District 1 Subtotal	***5,960***	***3,646***	***7,550***	***7,242***	***6,848***	***5,891***	***7,089***	***5,603***	***6,332***	***5,880***	***5,058***	***6,249***	***6,159***
Mountain Village	1,542	1,315	2,081	2,533	2,162	1,715	1,864	1,523	2,174	2,362	2,383	1,927	1,928
Pitkas Point	559	762	793	817	632	753	651	566	633	609	618	713	642
St. Mary's	2,031	1,766	2,592	2,679	2,150	1,810	3,815	2,045	1,916	2,357	2,693	2,244	2,389
Pilot Station	1,614	1,811	2,373	1,715	2,715	2,378	2,614	2,530	2,886	2,406	1,658	2,046	2,563
Marshall	3,291	2,126	1,511	1,711	2,780	3,279	4,498	2,290	2,059	1,990	1,804	2,284	2,823
District 2 Subtotal	***9,037***	***7,780***	***9,350***	***9,455***	***10,439***	***9,935***	***13,442***	***8,954***	***9,668***	***9,724***	***9,156***	***9,212***	***10,345***
Russian Miussion	2,450	2,709	1,459	1,314	2,722	1,860	3,428	1,887	2,057	2,337	1,894	2,131	2,314
Holy Cross	2,808	3,953	3,472	2,648	4,581	1,249	2,711	1,813	2,395	1,993	2,817	3,492	2,032
Shageluk	161	121	1,380	552	412	805	222	439	550	418	420	525	487
District 3 Subtotal	***5,419***	***6,783***	***6,311***	***4,514***	***7,715***	***3,914***	***6,361***	***4,139***	***5,002***	***4,748***	***5,131***	***6,148***	***4,833***
Lower Yukon River Total	**20,416**	**18,209**	**23,211**	**21,211**	**25,002**	**19,740**	**26,892**	**18,696**	**21,002**	**20,352**	**19,345**	**21,610**	**21,336**
Anvik	450	768	951	1,025	776	205	608	708	1,286	1,588	1,206	794	879
Grayling	1,340	1,036	2,391	2,177	2,476	839	1,077	2,249	1,613	1,869	1,878	1,884	1,529
Kaltag	1,890	994	1,036	1,870	2,051	1,074	1,506	1,435	1,838	1,656	3,367	1,568	1,502
Nulato	1,533	1,461	1,576	4,147	1,799	1,083	2,127	1,773	2,531	5,199	2,749	2,103	2,543
Koyukuk	146	402	851	800	506	175	449	323	860	400	396	541	441
Galena	1,336	2,770	2,350	1,668	2,539	788	1,755	1,522	3,112	3,296	2,864	2,133	2,095
Ruby/Kokrines	1,435	557	2,260	3,891	777	1,577	2,033	954	631	1,620	1,193	1,784	1,363
District 4 Subtotal (Excluding Koyukuk River)	***8,130***	***7,988***	***11,415***	***15,578***	***10,924***	***5,741***	***9,555***	***8,964***	***11,871***	***15,628***	***13,653***	***10,807***	***10,352***
Huslia	932	67	57	23	90	424	377	222	469	285	207	234	355
Hughes	77	54	34	91	105	50	144	67	113	291	33	72	133
Allakaket	321	82	423	85	108	41	76	200	306	65	68	204	138
Alatna	10	2	38	4	10	8	0	3	12	0	0	13	5
Bettles	4	0	39	20	1	0	0	0	0	0	3	13	0
Koyukuk River Subtotal	***1,344***	***205***	***591***	***223***	***314***	***523***	***597***	***492***	***900***	***641***	***311***	***535***	***631***
District 4 Total	***9,474***	***8,193***	***12,006***	***15,801***	***11,238***	***6,264***	***10,152***	***9,456***	***12,771***	***16,269***	***13,964***	***11,342***	***10,982***

APPENDIX 2

Interview Protocol

Natural Indicators of Salmon Run Abundance and Timing Interview Protocol

(Can you tell us where and when you were born? Parents? Did you go to fish camp as a child? After you were married? Kinds of activities at camp? Who was at camp?)

Personal history

- Birthdate
- Residence/upbringing – go to fishcamp?
- Fishing experience (subs v. comm.?; location?)
- Individual understanding of a "good" year?
- Set up maps for reference and documenting harvest locations or other significant sites

Questions about how salmon runs have varied in size and timing in the past

1. how was last year's run (Chinook? Fall chum?); how do you think this year's run will be and why? [timing and abundance, other factors?]
2. do you remember any particularly bad or good years? (low/high salmon runs?; came early or late?) [possibly relate to age of respondent]

(Do you remember your elders talking about how they knew when fish were coming?)

Environmental cues used to predict salmon arrival/run size/abundance

1. how do you know when the run is coming? Kinds of signs:
   a. other animals (snow geese, water fowl, and other migratory birds, frogs, etc.)
   b. other fish (lamprey, sheefish, smelt)
   c. long-term weather (cold winter, long winter, snow load)
   d. short-term weather (winds, tides, rain, clear or pale skies, break-up, water temperature, etc.)
   e. lunar and solar cycles – ask Alex Nick?
   f. Do things about the land change?
   g. Vegetation (cotton)
2. do any of these things tell you how strong the run will be? Water fowl
3. how do predict which mouth of the river salmon will enter?

(Did the early salmon tell you anything about what to expect later in the run?)

In-season indicators

1. once the salmon have arrived, does the size (coloration, belly)/condition (fat or thin, meat firmness, color)/position of fish (one bank? depth?) tell you anything about how the run will progress? Signs you look for in early fish?
   a. blueback/whitenose – local classificatory systems? Do people distinguish fish within species? Components of a Chinook run?
   b. relationship between timing and abundance – if the salmon are early, does that tell you anything about how many fish there might be?
   c. Relationship between size or condition (disease? Fat content?) of fish in early part of run and abundance?

d. How do king or chum swim in the river – different depths? Stay to one bank? Does that tell us anything about abundance?

(Do you remember seeing baby fish?)

Questions regarding relationship of one salmon run to another

1. presence of juveniles (1" fish) – notice seasonally? Any relationship to presence of juveniles and future salmon runs?
2. does the size of a run one summer have any relationship to the next year? previous year? future year? (how does respondent understand salmon cycles?)

(How has fishing changed for you? Have you noticed anything in the land or environment that has affected fishing?)

Environmental events – relationship to salmon runs

1. have you noticed changes in the land, animals, or river/streams over time?
2. have these changed the way you fish? (locations of harvest
3. do you remember major environmental events in this area: any relationship to salmon runs that year or in future years?
   a. floods (glacial melt and snow) – high water events in Anvik make chums stop as they like to move in shallow water by the banks while king and coho like deeper water
   b. fires
   c. earthquakes
   d. unusual weather patterns (radical temperature shifts, storms, etc.)
   e. droughts
   f. erosion – what is the effect on a salmon run of the river changing shape? Over time? More recently?
   g. relationship between light/dark to fish location – does light or darkness make fish travel to one side of the river or travel during the day or night?