

**Technical Paper No. 450**

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# **Local Traditional Knowledge of Salmon Freshwater Ecology in the Middle and Upper Kuskokwim River**

by

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June 2019

Alaska Department of Fish and Game

Division of Subsistence



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### Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

### Weights and measures (English)

cubic feet per second	ft <sup>3</sup> /s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

### Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

### Physics and chemistry

<i>all atomic symbols</i>	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

### General

Alaska Administrative Code	AAC
all commonly-accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly-accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures) first three letters (Jan.,...,Dec)	
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. states	two-letter abbreviations (e.g., AK, WA)

### Measures (fisheries)

fork length	FL
mid-eye-to-fork	MEF
mid-eye-to-tail-fork	METF
standard length	SL
total length	TL

### Mathematics, statistics

<i>all standard mathematical signs, symbols and abbreviations</i>	
alternate hypothesis	H <sub>A</sub>
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, $\chi^2$ , etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log <sub>2</sub> , etc.
minute (angular)	'
not significant	NS
null hypothesis	H <sub>0</sub>
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	$\alpha$
probability of a type II error (acceptance of the null hypothesis when false)	$\beta$
second (angular)	"
standard deviation	SD
standard error	SE
variance:	
population	Var
sample	var

***TECHNICAL PAPER NO. 450***

**LOCAL TRADITIONAL KNOWLEDGE OF SALMON FRESHWATER  
ECOLOGY IN THE MIDDLE AND UPPER KUSKOKWIM RIVER**

by

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# ABSTRACT

Chinook salmon *Oncorhynchus tshawytscha* are an integral part of the subsistence diet of residents of the Kuskokwim River. Sharp declines in Chinook salmon abundance began in 2010 and brought severe hardship and unprecedented restrictions to Kuskokwim River fish-dependent communities. This report summarizes local and traditional knowledge (LTK) provided by residents of the communities of Aniak, Sleetmute, Stony River, McGrath, and Nikolai. Ethnographic interviews focused on respondent knowledge of freshwater systems, salmon spawning grounds, juvenile rearing habitats, and other environmental factors that affect salmon spawning migration and reproduction. Researchers worked with respondents to map environmental changes that may have affected salmon movements and spawning locations. Key respondents discussed a number of major themes, including observations of Chinook salmon behavior and environmental change, perspectives on declining Chinook salmon populations, potential causes of the decline, and concerns over management of the fishery. This project documented a rich body of local and traditional knowledge about the middle and upper Kuskokwim River regions.

Key words: Kuskokwim River, Aniak, Sleetmute, Stony River, McGrath, Nikolai, local and traditional knowledge, subsistence fishing, Chinook salmon, climate change

# 1. INTRODUCTION

Chinook salmon *Oncorhynchus tshawytscha* is one of five species of Pacific salmon<sup>1</sup> harvested in the Kuskokwim River for subsistence uses, and it represents a key part of the subsistence diet. “It is the major eating fish,” according to an Alaska Department of Fish and Game (ADF&G) Division of Subsistence study about the region’s Chinook salmon fisheries (Andrews and Coffing 1986). Until recent declines in Chinook salmon abundance and the resulting low subsistence harvests, approximately half of all Alaska subsistence Chinook salmon were taken from the Kuskokwim River each year, which made it the state’s largest subsistence Chinook salmon fishery (Brazil et al. 2011).

These declines in Chinook salmon abundance began approximately in 2010 and have caused severe hardship for Kuskokwim River fish-dependent communities. Subsistence fishing families experienced restrictions in 2010, 2011, and 2012 (Elison et al. 2015). Frustrations over restrictions and shortages culminated in widespread protests, a lawsuit, and ongoing tensions between resource users and managers.<sup>2</sup> In 2012, a poor Chinook salmon run and unprecedented management restrictions resulted in harvests of Chinook salmon that were about 70% below the recent 10-year average (Elison et al. 2015). As a result, the U.S. Department of Commerce declared a resource disaster for the Kuskokwim River Chinook salmon fishery on September 13, 2012 (Shelden et al. 2014). Subsistence fishers have experienced similarly severe restrictions in subsequent years in the Kuskokwim River salmon fishery. Additionally, in 2013 Alaska Department of Fish & Game Chinook Salmon Research Team selected Kuskokwim Chinook salmon as one of 12 indicator stocks to explore possible factors in reduced productivity and abundance of Chinook salmon in the Pacific Basin.<sup>3</sup> The difficulty in ensuring sustainable salmon management during this period has resulted in part from a lack of knowledge about the underlying causes of the declines. This study is a part of the Chinook Salmon Research Initiative (CSRI), which was established in order to develop a list of research priorities to better understand factors affecting Chinook salmon abundance in Alaska.

The research presented in this report, supported by CSRI funds (ADF&G Chinook Salmon Research Team 2013), explores a currently underexamined body of knowledge represented in local and traditional knowledge (LTK) of freshwater systems with a focus on spawning grounds, juvenile rearing habitats, and other environmental factors that affect salmon spawning migration and reproduction. LTK allows for a more holistic and intuitively-generated understanding of natural ecological processes than traditional western scientific methodology (Freeman 1992; Georgette and Shiedt 2005:2–3). The documentation of 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). However, because of the qualitative nature of LTK and the unfamiliarity among some natural science researchers with social science methods, this type of knowledge is often overlooked (Huntington 2000). When systematically documented and analyzed, LTK can provide invaluable long-term observational data to fisheries managers and scientists and aid in understanding the environmental variability that influences fluctuations in populations of salmon.

More recently, the incorporation of LTK in fisheries management and biological studies has become more common and has generated further discussion of the methods for documenting and applying LTK (e.g., Freeman 1992; Huntington 1998; Usher 2000). For example, Brown et al. (2002) compiled LTK regarding

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1. Hereinafter *salmon*.

2. Medred. Craig. 2016. “Alaska subsistence salmon case draws to a weird close in Bethel courtroom.” Alaska Dispatch News. Accessed September 17, 2018. <https://www.adn.com/rural-alaska/article/defendant-far-away-takes-stand-final-day-kuskokwim-king-fishing-trial/2013/05/23/>

3. Alaska Department of Fish and Game. n.d. Chinook Salmon Research Initiative. Accessed September 6, 2018. <http://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main>

the distribution, abundance, ecology, and changes over time of Pacific herring (*Clupea pallasii*) in Prince William Sound. Using interviews and mapping exercises with resource users, researchers also analyzed and stored data in a geographic information system (GIS) to aid in developing study and management plans for herring. In addition, they were able to document historical changes in the distribution of herring that occurred prior to the collection of scientific data by ADF&G.

Although people throughout the Kuskokwim River drainage are dependent upon and knowledgeable about salmon resources, this study focused specifically on documentation of LTK held by experienced lifelong fishers in the middle and upper Kuskokwim River regions. The communities of Aniak, Sleetmute, McGrath, Nikolai, and Stony River were invited to participate in the project because of their proximity to Chinook salmon spawning tributaries and local fishers' familiarity and knowledge of these river systems.

The ethnographic documentation of subsistence fisheries in the Kuskokwim River drainage is limited. Few researchers have studied the contemporary subsistence salmon fishing practices of Kuskokwim River drainage residents (Hensel 1996; Oswalt 1967; 1980). Ethnographic information has also been gathered as part of subsistence harvest and use surveys in the Kuskokwim region (Brown et al. 2012; 2013; Charnley 1984; Coffing 1991; Ikuta et al. 2014); however, these studies were not solely focused on fisheries, and social scientists have only recently begun to explore the rich body of local knowledge about various aspects of Kuskokwim River salmon runs. Aniak, Sleetmute, Stony River, McGrath, and Nikolai were also included as study communities in another of the division's CSRI projects: "Patterns and trends in subsistence salmon fishing on the Kuskokwim River." ADF&G has conducted comprehensive subsistence surveys in all five study communities within the past seven years (Brown et al. 2012; 2013; Ikuta et al. 2014) in addition to annual postseason subsistence salmon harvest surveys. Results of earlier studies have been incorporated into this report in order to contextualize LTK of salmon ecology within harvest trends over time.

## **ENVIRONMENTAL SETTING AND HISTORICAL OVERVIEW**

The Kuskokwim River flows approximately 800 river miles from the headwaters of the South Fork Kuskokwim River in the Alaska Range and more than 900 river miles from the headwaters of the North Fork Kuskokwim River near Lake Minchumina to its mouth at Kuskokwim Bay in the Bering Sea (Brazil et al. 2013:65). The Kuskokwim Management Area encompasses approximately 50,000 square miles of land, primarily low-lying tundra or muskeg flats, including Nunivak and St. Matthew islands and all Alaska waters that flow into the Bering Sea between Cape Newenham and the Naskonat Peninsula (Figure 1-1). Thirty-eight communities are located within the Kuskokwim Area. This research focused specifically on five of the 14 communities of the middle and upper Kuskokwim River areas.

The study area encompasses traditional lands of two Alaska Native cultural groups. Aniak and Sleetmute lie in the eastern edge of the region historically inhabited by Central Yup'ik people; Stony River is on the traditional boundary between Central Yup'ik and Athabascan areas; and McGrath and Nikolai are found in Athabascan territory (Krauss et al. 2010). Prior to the 1900s, semi-nomadic family groups in these areas traveled seasonally to gather, hunt, and fish, often using the same sites from year to year. During the mid-19th century, the region was visited by Russian explorers and fur traders who created written records of the people and their practices (Brown 1983:156; VanStone and VanStone 1978; Wheeler 1998). By the early 1900s, the cumulative effects of Christian missionary activities and economic development—primarily in commercial fishing, fur trapping, mining, and transportation—ultimately consolidated these settlements roughly into the permanent communities present along the Kuskokwim River today. However, residents of these early settlements still employed a pattern of seasonal migrations for the purpose of accessing and obtaining various wild resources. Many contemporary inhabitants still follow seasonal patterns of harvest while maintaining permanent residence in established communities.

Residents of this region depend upon many wild foods that they harvest seasonally during the year. With some exceptions, patterns of seasonal harvests are still largely the same as they have been for centuries. Residents have adopted new technologies to increase efficiency and safety of harvesting. Motorized skiffs have replaced handmade skin-covered boats, for example, and snowmachines have replaced dog teams. Modern tools and equipment have improved efficiencies in transportation and have enabled families

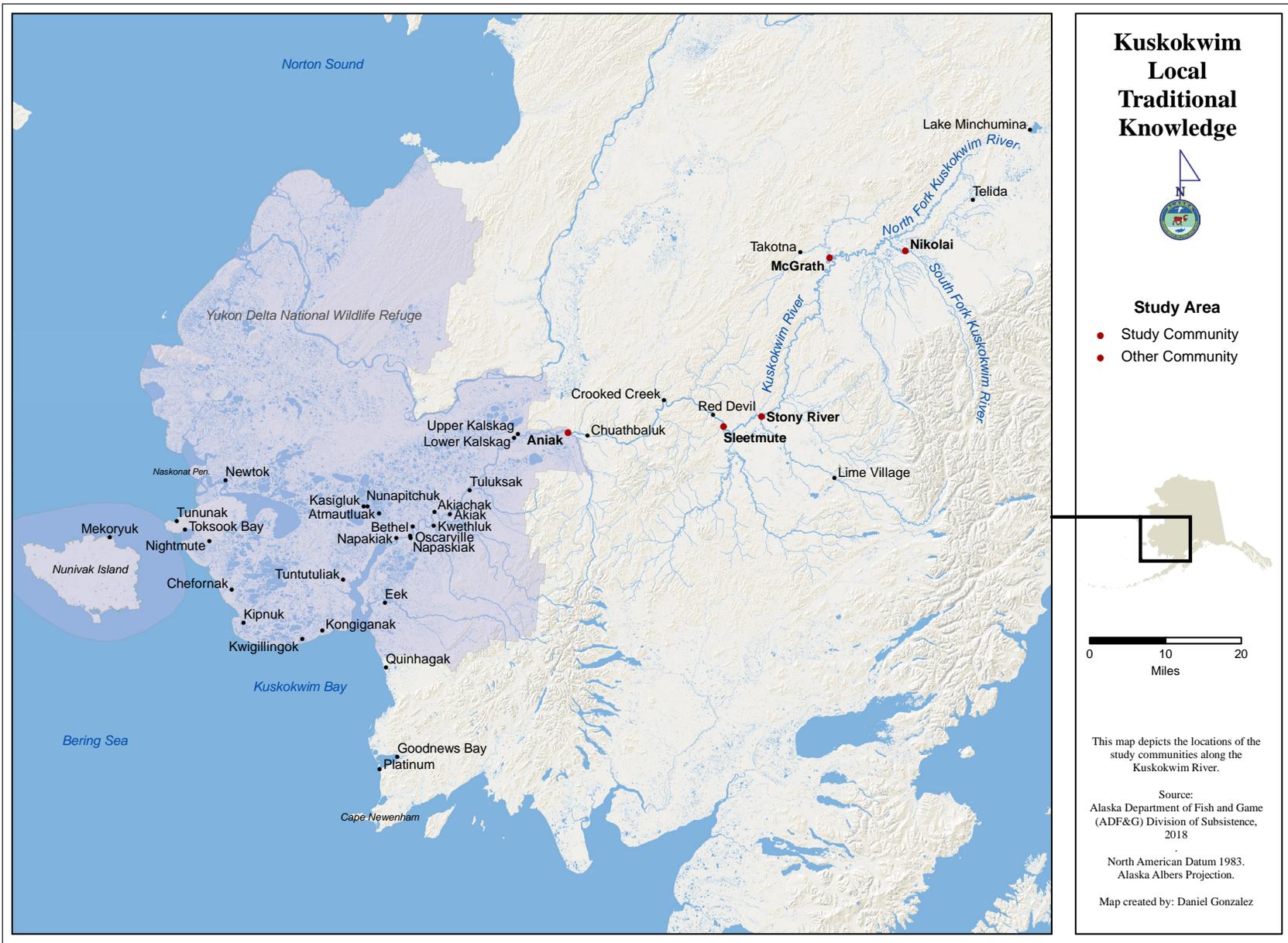


Figure 1-1.—Study communities and other communities, Kuskokwim River drainage.

to execute faster trips compared to the traditional practice of spending whole summers at fish camp. Notwithstanding, traditional areas are still frequented for fishing. Beginning in the 20th century, residents of the middle and upper Kuskokwim River began incorporating wage-earning jobs into their seasonal rounds, including commercial fishing.

## SEASONAL ROUND

Understanding the seasonal nature of life in the region provides context to the intimate knowledge of the landscape that respondents shared with researchers during this project. For residents of Kuskokwim River communities, seasonal shifts are a critical part of life and signify changes in harvesting activities, weather, and diet. The seasonal nature of subsistence is an important characteristic of traditional knowledge because people engage in certain activities during specific seasons and develop a rich understanding of the local environment.

Though the seasonal round varies by community, availability of resources, and other factors, residents of the middle and upper Kuskokwim River communities follow a largely similar pattern. The seasonal round begins each year with ice breakup on the Kuskokwim River and tributaries in April and May. Near the community of Aniak, for example, the areas that generally open first include the mouths of the Kolmakof River, Owhut River, and Birch Creek; several sloughs downriver from Aniak near Morgan's Camp; and sections of the lower Aniak River. Historically, the Kuskokwim River is completely free of ice by June (Brown et al. 2012).

Following breakup in spring, subsistence fishers set fishing gear in anticipation of harvesting whitefishes and sheefish, and they commonly hunt for migratory birds concurrently with these activities. Whitefishes are soon followed by the first pulse of Chinook salmon. Near the mouth of the Kuskokwim River, Chinook salmon fishing can begin as early as June 1 and is typically concluded by mid-July. In the middle and upper sections of the river, fishing begins later, around mid-June in Aniak and the first week of July in McGrath and Nikolai. Unlike fishers on the lower river, most middle and upper river fishers do not engage in commercial fishing as part of their seasonal round of fishing activities. Chinook salmon are followed by runs of chum, sockeye, and coho salmon.

Summer salmon fishing activities vary slightly by community, but generally, fishers are based either at a fish camp or near the home community. Many residents maintain fish camps along the mainstem of the Kuskokwim River within close proximity to their respective communities, while some residents' fish camps are situated along adjoining sloughs or tributaries of the mainstem. One key respondent from Nikolai recalled spending his childhood at his grandfather's fish camp:

A couple bends up, my grandpa's fish camp was, and ours was always up around the bend...When we set, stay up there at the camp to dry the fish and then move back down before school start. A lot of times we just stay there, and then me and my brothers have to walk down to go to school in the mornings and go back in the evening. I don't know, 30 minutes? (NIB3)

Fishers attempt to harvest as much Chinook salmon as they need during the summer. If they are unable to harvest enough in a particular year, fishers often supplement the catch with another salmon species run later that summer such as coho salmon. However, later in the season, abundant flies and rainy weather may interfere with processing fish, especially if fishers are smoking or drying fish (Brown et al. 2012).

Although the harvest of chum salmon remains an important component of subsistence, this resource was targeted for more than human consumption in the past. Several respondents discussed memories of harvesting chum salmon for dog teams, which was once commonplace on the Kuskokwim River in the summer months. "Everybody had a dog team then," recalled an Aniak man (ANI2). Increased trade on the river required more use of dog teams, which prompted more intensive fishing during the summer (Mason 1972:44). Dogs pulling sleds were used for transportation during winter months and required significant stores of food, primarily salmon:

In the old days we'd depend on dogs. Those were the ultimate. You took care of them for three months, the other nine they paid you back. Once the ice and snow were on the ground, they brought you everywhere: hunting, fishing, trapping, visiting, everything. I mean, daylight to dark every day, you're out there fishing, cutting, drying, preparing, storing. When the first salmon hit the river until almost freeze-up, every day. And the first fish that were caught were what we call eating fish. The rest of the summer was spent catching dog feed. That's where the poor name of dog salmon comes in, I hate that word. (ANI2)

As summer progresses into fall, residents of middle and upper Kuskokwim River communities target whitefishes in rivers, creeks, and lakes. Berry picking is a common activity, as is targeting migratory birds during their fall migrations. Moose hunting is an important fall pursuit, and black bears are harvested opportunistically. Caribou are generally hunted in the later fall and winter months, but they are not as readily available in the region as they were in the past (Brown et al. 2012; Ikuta et al. 2014). A key respondent said that in the fall time he used to travel up the Holokuk, the Oskawalik, and the Holitna rivers to hunt caribou from the Mulchatna herd. Later, after the caribou became scarce and managers legalized an area wolf hunt, he would hunt wolves by snowmachine. "We'd go up there right after it snowed, take off, because we know them tracks are fresh, we can see them (ANI2)." Although hunting and trapping for furbearers has declined in the middle and upper Kuskokwim River regions, this activity still supplements some household incomes. Trapping furbearers occurs throughout the winter months. The pursuit of various wild foods occurs as they become available, and harvests of different resources often overlap. For example, several respondents described harvesting berries or fishing for Arctic grayling in the fall as they travel on the river in search of moose.

One McGrath respondent not of Alaska Native descent was born outside Alaska, but when he moved to the area nearly 30 years ago, he adopted the seasonal way of life. This respondent is just one example of the minority non-Native population of this region, drawn for jobs in mining or government. Some homesteaded in areas like the Holitna River drainage, later moving into communities and closer to modern conveniences. The respondent summarized his adoption of a subsistence lifestyle:

Living in Alaska, period, is very seasonal. I mean, you cut your wood, you do what you need to do to make it through the season. I had a dog team and I had a net set and then also had a nice large garden and of course a huge wood shed that was never big enough, but you just start cutting wood and harvesting your garden and bringing in fish and then moose season comes along and you shoot a moose. And then in the winter time, right off the bat, moving into McGrath, I trapped in Shageluk and Lime Village, but then started to establish a trap line here in McGrath. (MCG3)

One key respondent spoke about his instruction in what he referred to as "Yup'ik University" during seasonal subsistence pursuits in his youth. Although contemporary residents of the middle and upper Kuskokwim River region often conduct subsistence activities on shorter trips, his recollections from the time period around the 1960s capture the seasonal nature of subsistence in the region:

And every fall I remember we used to go up the Aniak River, fall camp, stay there until around Christmas and then come back down for couple weeks, or a month sometimes, and then go back up to winter camp which is right around the same area. Stay there until end of March, go home for a couple weeks and go to spring camp. Then after breakup, we all came back down, stopped in the fish camps to check them out, and if they were dry, most of the family would stop there and get ready for fishing. If not, if it was wet after a flood, they would come back up here and stay until fish camp dried out and go and clean it up. And that was pretty much the, the way of life then. (ANI1)

## REGIONAL BACKGROUND

All five study communities lie in the middle or upper Kuskokwim River area, which encompasses both state and federal waters used for subsistence fishing. Federal subsistence managers identify the middle and upper river as the Western Interior Region. The State of Alaska fisheries management defines the entire basin as the Kuskokwim Management Area<sup>4</sup> and divides it into four commercial fishing districts. Aniak is the only study community to lie within a commercial fishing district and is within the boundary of District 2 (Poetter et al. 2016).<sup>5</sup> Subsistence fishing for Chinook salmon has been regulated under dual management of federal (USFWS) and state (ADF&G) agencies since 1999 (Poetter and Tiernan 2017).

Communities in the study region are represented by a number of organizations. The Association of Village Council Presidents, a regional nonprofit tribal consortium, serves communities in the Yukon-Kuskokwim Delta and middle Kuskokwim River including Aniak, Sleetmute, and Stony River.<sup>6</sup> Members of these communities are also shareholders in the Calista Corporation<sup>7</sup>, an ANSCA regional corporation. Upper Kuskokwim River communities, including McGrath and Nikolai, are represented by the Tanana Chiefs Conference<sup>8</sup>, a regional nonprofit corporation, and by Doyon, Limited<sup>9</sup>, an ANSCA regional corporation.

Bethel is the largest community in southwestern Alaska and functions as a transportation, communications, and supply hub for the region. The Bethel airport is the third busiest state-owned airport in Alaska and serves 56 rural communities.<sup>10</sup> Bethel is also home to the Yukon-Kuskokwim Health Corporation, which provides health services for 58 federally recognized tribes.<sup>11</sup> Aniak serves as a subregional hub for the middle Kuskokwim River and is the home of the Kuspuk School District, which operates schools in Aniak, Sleetmute, and Stony River, among several other communities<sup>12</sup>. McGrath is the northernmost point on the Kuskokwim River that barges can reach and serves as a transportation and economic hub for upper Kuskokwim river communities.<sup>13</sup> McGrath is the home of the Iditarod School District, which operates schools in both McGrath and Nikolai.<sup>14</sup>

The middle Kuskokwim River flows through the Kuskokwim Mountains and is characterized by many small clearwater streams and boreal forest of spruces, paper birch, cottonwood, and aspen (Charnley 1984:7; Hegg and Sieverding 1979). Some large, glacier-fed tributaries to the central Kuskokwim River originate in the Alaska Range, such as the Stony River, whereas most clearwater tributaries, such as the Holitna River, originate in the Kuskokwim Mountains. Chinook salmon usually begin to arrive to the middle river in mid to late June. Chum salmon, quickly followed by sockeye salmon, begin to arrive in late June. Coho salmon arrive in late July and run through August (Ikuta et al. 2013:73). The middle Kuskokwim River region is “an area of cultural and linguistic interface” between Yup’ik and Athabascan people (Charnley 1984:6). It is

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4. The Kuskokwim Management Area includes the Kuskokwim River drainage as well as all Alaska waters that flow into the Bering Sea from Cape Newenham to the Naskonat Peninsula, and Nunivak Island and St Matthew Island.

5. The upper Kuskokwim River was designated as District 3 but removed from regulations in 1966 due to lack of landings (Poetter et al. 2016).

6. Association of Village Council Presidents. 2018. “About AVCP.” Accessed May 22, 2018. <http://www.avcp.org/>

7. Calista Corporation. 2018. “Calista Corporation.” Accessed June 7, 2018. <http://www.calistacorp.com>

8. Tanana Chiefs Conference. 2007. “Communities in Our Region.” Accessed June 7, 2018. <https://www.tananachiefs.org/about/>

9. Doyon Limited. 2018. “Our Corporation.” Accessed May 22, 2018. <https://www.doyon.com/our-corporation>

10. Alaska Department of Commerce, Community, and Economic Development (ADCCED) Division of Community and Regional Affairs, Juneau. n.d. “Alaska Community Database Online: Community Information.” Accessed September 6, 2018. <http://commerce.alaska.gov/dcra/DCRAExternal> Hereinafter *ADCCED n.d.*

11. Yukon-Kuskokwim Health Corporation. 2018. “About YKHC.” Accessed September 6, 2018. <https://www.ykhc.org>

12. Kuspuk School District. n.d. “Our Communities.” Accessed September 6, 2018. <https://www.kuspuk.org>

13. ADCCED n.d.

14. Iditarod Area School District. 2018. “Iditarod Area School District.” Accessed September 6, 2018. <https://www.iditarodsd.org>

likely that land mammals were the primary source of food for people living in the middle Kuskokwim River region, at least until contact with Euro-American settlers (Ikuta et al. 2013); the use of salmon increased in the middle Kuskokwim River area early in the 20th century as demand for dog food increased and more efficient means of harvest, such as fish wheels, became available (Jonrowe 1980). Economic opportunities in the form of commercial fishing were available in the middle river in the 1950s through the 1980s, but those opportunities began to diminish in the late 1980s and early 1990s due to changes in the market demand and potential biological conservation concerns (ADF&G Division of Commercial Fisheries 1988; Pennoyer et al. 1961). The size of the middle section of river where commercial fishing was allowed (District 2) was reduced in 1988 and again in 1990, and no commercial fishing has occurred there since 2000 (Brazil et al. 2013; Ikuta et al. 2013:72).

The upper Kuskokwim River drainage is characterized by glacial streams originating from the western slopes of the Alaska Range as well as many low-gradient, groundwater-fed streams that drain the lakes, bogs, and mixed spruce and hardwood boreal forest of the region (Brown et al. 2012:172–174; Brown 1983:12–16; Van Lanen et al. 2015:92–95). Chinook salmon arrive in the upper river in early to mid-July, followed in mid-July by chum salmon; coho salmon run from mid-August through September (Ikuta et al. 2014). Salmon are less abundant in the upper river and have exhausted much of their vitality due to the length of their journey (Ikuta et al. 2014:30). However, Chinook salmon were historically harvested using fish fences and spears (Collins 2004rev.; Stokes 1983; 1985), which were later augmented by fish wheels for harvesting chum salmon during the first half of the 20th century as the need for dog food increased (Jonrowe et al. 1977). Land mammals were the primary source of protein for human consumption: caribou in the 19th century and moose in the 20th. The need for dog food declined as advances in motorized transportation replaced dog teams.

## **REGULATORY CONTEXT<sup>15</sup>**

Regulatory authority for Kuskokwim River salmon is shared by the State of Alaska Board of Fisheries (BOF) and the Federal Subsistence Board (FSB). ADF&G is responsible for implementing regulations in accordance with the Kuskokwim River Salmon Management Plan (5 AAC 07.365). ADF&G has inseason discretionary management authority of salmon in Alaska navigable waters. Waters of the lower Kuskokwim River are largely within or adjacent to federal public lands, namely the Yukon Delta National Wildlife Refuge. As such, the U.S. Fish and Wildlife Service (USFWS) shares inseason subsistence fishing management decision-making with ADF&G. The USFWS may exercise authority over management of salmon in these waters when the FSB determines that all other uses of salmon must be eliminated in order to meet the federal subsistence priority. The Kuskokwim River Salmon Management Working Group<sup>16</sup> established in 1988, advises state and federal managers through an established process and is currently the primary public forum through which management decisions regarding Kuskokwim River subsistence, commercial, and sport salmon fisheries are considered (Smith and Linderman Jr. 2008:1). It is composed of knowledgeable stakeholders acting in a representative capacity for communities throughout the Kuskokwim River drainage, processors, sport fishery representatives, and an ADF&G management biologist.

During this study, subsistence harvest of salmon species in the Kuskokwim River was allowed without a permit.<sup>17</sup> Alaska regulations allow a variety of gear types to be used in the Kuskokwim River for subsistence salmon fishing and include specifications regarding the use of gillnets (5 AAC 01.270). There are no federal or state bag or possession limits for subsistence salmon harvests in the Kuskokwim River, except from June 1 through August 31, when subsistence fishing with a hook and line attached to a rod or pole in that portion of the Aniak River drainage upstream of Doestock Creek. In that area, the bag and possession limit is two

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15. Text excerpted from Ikuta et al. (2013) and Fall et al. (2018) and revised by this chapter's author.

16. Hereinafter *Working Group*.

17. In March 2017, the Alaska Board of Fisheries established a temporary subsistence Chinook salmon permit to be implemented in state waters of the Kuskokwim River from 2018–2021. The permit provides an opportunity for fishing households to harvest up to ten Chinook salmon during periods when targeted salmon fishing with gillnets is closed in times of Chinook salmon conservation (5 AAC 1.280).

Chinook salmon, and rainbow trout *O. mykiss* may not be retained (5 AAC 01.295). Federal regulations for all subsistence fish harvests in Alaska federal public lands and waterways are administered under 50 CFR §100.27, including seasons, gear types, and bag and possession limits on all salmon and nonsalmon species. By regulation, therefore, the subsistence salmon fishing season in the Kuskokwim Area is generally open unless a subsistence fishing closure is implemented.

Alaska Statute 16.05.258, “Subsistence use and allocation of fish and game,” establishes the subsistence use priority (above sport, commercial, and personal use) when resources are not abundant enough to provide for all consumptive uses and while remaining in accordance with principles of sustained yield. Subsistence uses protected by the subsistence priority are those practices identified as “customary and traditional” as determined by the BOF. As detailed in the *Policy for the Management of Sustainable Salmon Fisheries*, the primary goal of salmon management is to ensure conservation of salmon (5 AAC 39.222(b)). This policy also directs ADF&G to manage salmon stocks so that a sufficient number of migrating adult salmon will reach their spawning grounds each year, the purpose of which is to conserve and sustain potential salmon production (5 AAC 39.222(c)(2)).

Following Alaska statehood in 1959, responsibility for the management of commercial fishing was transferred from the federal government<sup>18</sup> to the new State of Alaska in 1960 (Pennoyer 1965:4). ADF&G revised commercial fishing quotas and included provisions for coho salmon in August. In 1961, the department revised the system of management in the lower river from commercial harvest quotas to timed openings in order to distribute catches through the Chinook salmon run and to include provisions for coho salmon in August (Pennoyer et al. 1965:43). Subsistence fishers, some of whom traveled from the upper river to participate in the fishery (Charnley 1984; Kari 1985), integrated these opportunities into their seasonal round of activities (Ikuta et al. 2013). For decades, subsistence fishing was only restricted by statewide subsistence standards, but by the late 1980s, subsistence fishing was closed before, during, and after commercial openings to clearly distinguish the fisheries and dissuade unlawful fishing (Fall et al. 2013; Francisco et al. 1991).

In 1993, the BOF made positive findings for customary and traditional uses of all salmon species in the entire Kuskokwim Area. As part of these findings, the BOF then determined the amount reasonably necessary for subsistence (ANS) as one means to provide reasonable opportunities for subsistence uses. Based on historical harvest information, an ANS of 192,000–242,000 for salmon of all species in the Kuskokwim Area was determined (5 AAC 01.286).

In September 2000, the BOF classified the Kuskokwim River Chinook and chum salmon as stocks of “yield concern.” A stock of yield concern is defined as “a concern arising from a chronic inability, despite the use of specific management measures, to maintain expected yields, or harvestable surpluses, above a stock’s escapement needs; a yield concern is less severe than a management concern” (5 AAC 39.222(f)(42)). The determination was based on low harvest levels for the previous five-year period (1996–2000). The State of Alaska declared economic disasters for the Kuskokwim Management Area in 1997, 1998, 2000, and 2001 because of extremely low Chinook and chum salmon commercial harvests (Elison et al. 2015:4). The U.S. government joined the state with federal economic disaster declarations in 1997 and 1998. These poor returns prompted conservative management to rebuild stock abundance (Simon et al. 2007). Populations of both species began increasing in 2002, and the Alaska Board of Fisheries (BOF) discontinued the stock of concern status for both species early in 2007. However, Chinook salmon abundance began to decline again; in both 2011 and 2012, the State of Alaska and U.S. governments again declared fisheries disasters for the Kuskokwim River because of low Chinook salmon returns (Dischner 2012; Elison et al. 2015:4). A subsistence fishing schedule with periodic fishing closures (openings between these closures were often referred to as “windows” or “openers”) was implemented from 2001–2006. Since 2007, closures to the

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18. Authority to manage Kuskokwim River fisheries rested with the U.S. Secretary of Commerce until 1940, at which point control of the fisheries was assumed by U.S. Department of the Interior, Fish and Wildlife Service (Pennoyer et al. 1965:1–3).

fishery have been implemented by emergency order prior to, during, and after commercial fishing periods, and for conservation purposes (see 5 AAC 01.260 and 5 AAC 07.365).

In 2011, subsistence fishing was restricted to gillnets with mesh size of four inches or less to allow the harvest of whitefishes while minimizing Chinook salmon harvests until June. In 2012, because of indications that the Chinook salmon run was late and weak, a rolling closure<sup>19</sup> of subsistence fishing was implemented for the first time. The original closure of seven days was supported by the Working Group, but a 12-day closure was implemented by ADF&G without the group's support (Runfola 2013). This restriction succeeded in reducing the harvest of Chinook salmon, but amplified tension between regulatory agencies and subsistence users culminated in unlawful protest fishing (Hopkins 2012).

Because the highest priority in state and federal management of Kuskokwim River salmon populations is the biological sustainability of the resources based on principles of sustained yield,<sup>20</sup> when returning salmon numbers are not sufficient to meet established escapement goals, consumptive uses of salmon may be restricted. When there is a harvestable surplus beyond minimum escapement levels, consumptive uses of salmon are prioritized for different user groups with subsistence as the first priority. These decisions must be made in-season (as the run develops) and depend on accurate assessments of both run enumeration and desired escapement goals. ADF&G Division of Commercial Fisheries employs a variety of methods to monitor Kuskokwim River Chinook salmon and is responsible for developing recommended escapement goals for salmon stocks in the Kuskokwim River. Escapement goals are reviewed and evaluated every three years, concurrent with the BOF regulatory cycle. Policy definitions and escapement goals effective during the study period were adopted by the BOF during the 2001 regulatory cycle (5 AAC 39.222 and 5 AAC 39.223).

Managers are tasked with both meeting established escapement goals as well as providing for subsistence and commercial harvest opportunities. "In some cases, providing for stable subsistence harvests over time may be a higher-priority management objective than maximizing yield from commercial harvest," according to the *Escapement Goal Recommendations for Select Arctic-Yukon-Kuskokwim Region Salmon Stocks, 2016* (Conitz et al. 2015). A majority of tributary escapement goals were not met in 2010 and 2012. Escapement goals and ANS ranges for salmon in the Kuskokwim Management Area were revised in 2013 (Runfola et al. 2018). The Board established that 67,200–109,800 Chinook salmon; 41,200–116,400 chum salmon; 32,200–58,700 sockeye salmon; 27,400–57,600 coho salmon; and 500–2,000 pink salmon are reasonably necessary for subsistence uses (5 AAC 01.286).

## RESEARCH COMMUNITIES

### Aniak

Aniak (*Anyaraq* in Central Yup'ik<sup>21</sup>) is located about 92 air miles east of Bethel and sits on the south bank of the Kuskokwim River at the head of Aniak Slough, just downriver from the mouth of the Aniak River. The origin of its name is a Yup'ik word meaning "the place where it comes out," referring to the mouth of

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19. Fishing was closed in each section of river as the main pulse of Chinook salmon moved through it.

20. "Scientifically defensible Pacific salmon escapement goals are a central tenet of fisheries management in Alaska. Escapement goals are founded in the sustained yield principle highlighted in the State of Alaska Constitution (Article VIII, section 4) and in state statute (AS 16.05.020). Several policies in Alaska Administrative Code also provide guidance for establishing escapement goals, including the policy for the management of sustainable salmon fisheries (5 AAC 39.222), the policy for statewide salmon escapement goals (5 AAC 39.223), and the policy for the management of mixed stock fisheries (5 AAC 39.220). These policies provide detailed definitions of specific escapement goal types, outline the responsibilities of the Alaska Department of Fish and Game (ADF&G) and the Alaska Board of Fisheries (BOF) in establishing goals, and provide general direction for development and application of escapement goals in Alaska" (Munro and Volk 2016).

21. University of Alaska Fairbanks, Alaska Native Language Archive. 2017. "Alaska Native Place Names." Accessed September 6, 2018. <https://www.uaf.edu/anla/collections/map/names/index.xml> Hereinafter *Alaska Native Language Archive 2017*.

the Aniak River, a 140-mile long tributary of the Kuskokwim River. This river is a known spawning area for chum, pink, sockeye, and Chinook salmon.<sup>22</sup> With an estimated population of 501 residents, Aniak is the largest community by population in the middle and upper Kuskokwim area, according to the 2010 U.S. Census.<sup>23</sup> An estimated 80% of residents are Alaska Native and 20% are non-Native. Aniak serves as the subregional hub for the middle Kuskokwim River and is the only middle Kuskokwim community with a direct flight to Alaska's urban center of Anchorage.

Though fish camps are still utilized during summer months, they are a less common sight than they were decades ago. According to one elder respondent:

From Kalskag to here [Aniak], every bend in the river had a fish camp. And every bend in the river there was a fish wheel. I mean that's 75 years ago, I remember. To me, that's like yesterday, but you know, people can't believe I'm 79. (ANI1)

Salmon bound for the Aniak River are bank-oriented at Aniak, which enables successful rod and reel fishing for salmon species from the town's beachfront<sup>24</sup> when lethal (net) gear is disallowed for the preservation of Chinook salmon, as has been common in recent years. During the salmon season, community members can often procure fish taken during the operation of the Aniak test fishery, a fishery assessment project implemented cooperatively by the Native Village of Napaimute and ADF&G.<sup>25</sup> These fish are made available for community use.

The ADF&G Division of Subsistence conducted a comprehensive survey in Aniak for the 2009 study year, and the important role of fish was evident (Brown et al. 2012). The total estimated harvest of wild resources was 147,346 edible pounds (lb), of which 120,187 lb (82%) was salmon and nonsalmon species. Salmon composed 79% of the total harvest of fish, and Chinook salmon accounted for 35% of the salmon harvest. The per capita harvest of Chinook salmon was 68 lb.

## Sleetmute

Sleetmute (*Cellitemiut* in Central Yup'ik<sup>26</sup>) is located on the east bank of the Kuskokwim River along a section of the river that runs north, roughly one and a half miles downriver from the mouth of the Holitna River. The town is 243 miles west of Anchorage and about 166 miles northeast of Bethel. According to Oswalt (1980), Sleetmute was originally settled by Athabascan Indians (likely of the Deg Hit'an band, Dena'ina band, or both), and interior Yup'ik peoples eventually assimilated into the group. The middle Kuskokwim River region has likely been a long-standing and important point of contact between Kuskokwim Athabascans and Yup'ik groups (Charnley 1984; Kari 1985). In 2010, the community's population was estimated to be 86 residents, including 77% Alaska Native and 23% non-Native people, according to the U.S. Census.<sup>27</sup> Several sources have reported that the origin of the name "Sleetmute" can be translated to "stones people" or "whetstone place," probably referencing a nearby slate deposit historically utilized for making sharpening stones valued for trade (Brown et al. 2012).

The Holitna River drains the Kilbuck and Kuskokwim mountains and is fed by the Hoholitna and the Kogruluk rivers, which are important spawning grounds for stocks of Chinook, chum, sockeye, and coho

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22. Alaska Department of Fish and Game, Division of Habitat. "Anadromous Waters Catalog: Fish Resource Monitor." Accessed September 6, 2018. <http://extra.sf.adfg.state.ak.us/FishResourceMonitor/>

23. U.S. Census Bureau, Washington, D.C., n.d. "American FactFinder: Aniak." Accessed September 6, 2018. <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

24. C. McDevitt field notes.

25. Demer, Lisa. 2015. "New Kuskokwim test fishery near Aniak started Monday." Alaska Dispatch News. Accessed September 17, 2018. <https://www.adn.com/rural-alaska/article/new-kuskokwim-test-fishery-near-aniak-started-monday/2015/06/02/>

26. Alaska Native Language Archive 2017.

27. U.S. Census Bureau, Washington, D.C., n.d. "American FactFinder: Sleetmute." Accessed September 6, 2018. <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

salmon<sup>28</sup>. Settlements in the Holitna River drainage, including Kashegelok and Nogamut, were occupied long after contact (Alaska Department of Natural Resources and ADF&G 1988). For example, Nogamut was occupied until the 1950s (Oswalt 1980). Historically, people from those settlements used the Sleetmute site because it provided excellent salmon fishing and relief from mosquitos (Charnley 1984). Two respondents discussed these former settlements:

I mean, Kashegelok and Nogamut used to actually be small villages. And they weren't by the time I came into the country. They were just individual extended families. But that has been a change. In terms of humans, people, that's been a huge change. (SLQ1)

There's nobody who lives on the Holitna River anymore. There used to be 40 people living up there. Now there's nobody left there, zero. There is virtually no subsistence fishing on the Holitna River at all today. It's probably better for the fish. There's less pressure on them. There's fewer people trapping and we've had no moose season now but otherwise the only heavy use this country has anymore is moose hunting. (SLQ7)

Two key respondents interviewed in Sleetmute had spent significant time living in Red Devil, a mining town six miles northwest of Sleetmute on the Kuskokwim River. In 2010, Red Devil had an estimated population of 23 people.<sup>29</sup> Many people were drawn to the area to work at the Red Devil Mine, a former mercury mine established in 1933 that ceased operations in 1971. For a brief period, it was one of the largest mercury producers in the United States (Alaska Department of Environmental Conservation 2009). "When the mine used to be going there'd be a lot of people," said a respondent whose father was employed at the mine. After the mine closed, Red Devil's population quickly declined:

People just move out. A lot of people move because our school closed down, not enough kids. You got to have ten or more to keep a school open. We were down to like seven, so that was too much to run it for their budget to keep it open. We had to start either send your kids to other families where there's school or send them to Mt. Edgecombe or Anchorage or Galena or wherever they send them. (SLQ4)

Some of those who left Red Devil resettled in Sleetmute. Sleetmute's population has also declined over the years, from about 120 residents in the 1960s to about 86 during the 2010 census (Brown et al. 2012).<sup>30</sup> One resident said that the population is constantly changing, and this change often depends upon local employment opportunities:

If there is heavy employment here, the population will grow with family and relatives coming in and looking for work from town, but it stays around 80, maybe 100. It's all just based on economics, people being able to survive here and fuel costs, and energy, electricity. The country can provide pretty well for you, but if you want to have some creature comforts, those things are nice. And even if you were burning gas lamps, the price of Coleman fuel here makes electricity look pretty cheap. There is nothing cheap about living here. It is very, very expensive. And people, they all proportion their incomes around those energy costs and what they do. (SLQ3)

The ADF&G Division of Subsistence conducted a comprehensive harvest survey in Sleetmute for 2009 and found that salmon and nonsalmon fish contributed an estimated 29,770 edible pounds, or 81% of the

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28. Alaska Department of Fish and Game, Division of Habitat. "Anadromous Waters Catalog: Fish Resource Monitor." Accessed September 6, 2018. <http://extra.sf.adfg.state.ak.us/FishResourceMonitor/>

29. ADCCED n.d.

30. U.S. Census Bureau, Washington, D.C., n.d. "American FactFinder: Sleetmute." Accessed September 6, 2018. <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

community's total subsistence harvest (Brown et al. 2012). Nearly 100% of households said they utilized salmon, including an estimated 9,844 edible pounds of Chinook salmon (about 109 lb per person).

### **Stony River**

Stony River is located on an island between sloughs of the Kuskokwim River, about one mile north of its junction with the Stony River and about 185 miles northeast of Bethel. In 2010, the population was 54 residents, 83% of whom were Alaska Native, according to the U.S. Census.<sup>31</sup> Stony River was once known as "Moose Village" or "Moose Creek" and was a center for trade and riverboat traffic to support area mining operations (Oswalt 1980). Ora Barnhardt, an Euroamerican settler, established the first trading post near the mouth of the Stony River in 1930, and a post office was built five years later (Ricks 1965). A second Euroamerican trader, Reginald M. White, established a trading post in 1937 and later became the postmaster, an airline representative, and a welfare agent (Oswalt 1980). Although local people visited the community to shop at the local store, families from the region first built homes near Stony River in 1960. A school and airport soon followed the influx of new residents, and construction began in 1961 and 1962, respectively. The community lies along the boundary between Central Yup'ik and Athabascan territories. Kari (1985) describes the ethnohistory and linguistic interactions of four distinct languages in the middle Kuskokwim area: Central Yup'ik and the Athabascan languages of Deg Hit'an, Dena'ina, and Upper Kuskokwim.

The ADF&G Division of Subsistence conducted a comprehensive harvest survey in Stony River for the 2009 study year and found that salmon and nonsalmon fish constituted about 86% of the community's total wild food supply (Brown et al. 2012). More than one quarter (28%) of the total weight (33,726 lb) was Chinook salmon—an estimated 9,294 edible pounds (147 lb per person).

### **McGrath**

McGrath is located on the southern bank of the Kuskokwim River across the river from where the Takotna River flows into the Kuskokwim River. The community is 221 miles northwest of Anchorage and about 430 river miles from Bethel. McGrath is considered the hub community of the upper Kuskokwim River region and a critical transportation, communication, and supply center. As of the 2010 census, the population was 346 people.<sup>32</sup> In 2011, the population of McGrath was estimated to be 59% Alaska Native and 41% non-Native (Ikuta et al. 2014) McGrath was originally a seasonal Upper Kuskokwim Athabascan settlement; in the early 1900s, it was used as a meeting and trading site for Big River, Nikolai, Telida, and Lake Minchumina residents (Brown 1983). It was also the northernmost point on the Kuskokwim River that was reachable by large riverboats. The original townsite, now called "Old Town" or "Old McGrath," was located on the north side of the river and is also referred to as "Tochak" which means "Takotna mouth" in Upper Kuskokwim Athabascan (Oswalt 1980).

The 2011 study found that McGrath residents travel significantly throughout the region: households reported using a total of 3,857 square miles for subsistence activities (Ikuta et al. 2014). Residents traveled along the Kuskokwim River from the mouth of the Swift Fork (about 80 miles upstream from McGrath), down to the community of Stony River. They also used a large area surrounding the community, including many tributaries of the Kuskokwim River such as the Takotna River, Fourth of July Creek, Nixon Fork, Carl Creek, and Stony River. In 2011, salmon and nonsalmon fish constituted about 39% of the community's total wild food supply (Ikuta et al. 2014). One-third (33%) of the total weight of the fish harvest (32,646 lb) was Chinook salmon, an estimated 10,933 edible pounds (31 lb per capita). Eighty-nine percent of households reported using salmon species during the study year.

A few respondents discussed their connection to Takotna, a tiny community on the north bank of the Takotna River in a broad river valley, 17 air miles west of McGrath in the Kilbuck-Kuskokwim Mountains. The community was founded in 1908 at the farthest point on the river that a small sternwheeler was able to

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31. U.S. Census Bureau, Washington, D.C., n.d. "American FactFinder: Stony River." Accessed September 6, 2018. <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

32. U.S. Census Bureau, Washington, D.C., n.d. "American FactFinder: McGrath." Accessed September 6, 2018. <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

reach (Oswalt 1980) though low water made access to Takotna often unreliable. Within just a few years, the community's population had grown dramatically and several stores were built to supply miners who were exploring the upper Innoko Region in search of gold. Takotna was once large, with a population numbering in the several thousands. Several respondents mentioned this historical population trend and expressed concern that the salmon runs were affected.

It was mentioned to me that they almost cleaned them [salmon] out of the Nixon River, just to feed that large population. Kings, that's all I've heard, but you're talking around the 1920s or whenever that was. It was way before my time. (MCG4)

## **Nikolai**

Nikolai (*Edzeno' Nikolai* in Upper Kuskokwim) is located about 45 air miles east of McGrath on the south fork of the Kuskokwim River. As of the 2010 census, the estimated population was 94 people.<sup>33</sup> The original community ("Old Nikolai") was located at the confluence of the South Fork Kuskokwim and Little Tonzona rivers, and the site was likely chosen by early inhabitants due to the presence of Chinook salmon that migrated through the area each summer to spawn in the Little Tonzona River (Collins 2004rev.; Van Lanen et al. 2015:95). After significant gold discoveries in the Innoko River drainage in 1906, mining opportunities in the upper Kuskokwim River region led to a large influx of Euroamerican prospectors. The arrival of settlers increased the need for large quantities of game meat and fish, which led to the adoption of highly efficient fish wheels in upriver communities by 1918 (Schneider 1985). Native residents of Nikolai established their winter community in the present-day location due to the construction of a trading post upriver from the original village site in 1910 (Collins 2004rev.). Mining intensity in the region decreased following the beginning of World War II and the population of the upper Kuskokwim River region decreased as settlers left the region (Collins 2004rev.; Stokes 1985). A permanent school was established in Nikolai in 1948, a post office in 1949, and an airstrip in 1963.<sup>34</sup>

Until the 1960s, area residents constructed fish weirs in area streams primarily for the harvest of Chinook salmon, but also for other salmon and nonsalmon species (Stokes 1985:383). Weirs were constructed of pickets or "leads" spanning the width of a salmon spawning stream; a central pen opened on the downstream side. Fish would swim into the opening of the pen and search for a passage upstream. Smaller fish swam through the trap but larger fish were corralled by the configuration of the pen into attached funnel traps, from which they could be easily retrieved. Traps like this worked best particularly in shallow, clear tributaries of the Kuskokwim River, including the Pitka Fork Salmon River where many Nikolai families maintain fish camps to the present day. These traps had likely been in use since the era prior to contact with Russian and American explorers, but they were abandoned following Alaska statehood. In 1962, the new State of Alaska initiated regulatory changes that prohibited any method of fishing that blocked entire channels. One key respondent from McGrath who has wide knowledge of the history of the region explained the importance of fish weirs to the upper Kuskokwim River:

There were no planes flying out here then so they had to eat something. They had to get moose; they had to get fish. Fish was something, and dog teams, they had a lot of dogs. I could see them fencing the river off, I could see it happening in places. (MCG6)

The ADF&G Division of Subsistence conducted a comprehensive harvest survey in Nikolai for the 2011 study year and found that salmon and nonsalmon fish constituted about 42% of the community's total wild food supply (Ikuta et al. 2014). Nearly one half (45%) of the total fish harvest of 24,218 lb was Chinook

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33. U.S. Census Bureau, Washington, D.C., n.d. "American FactFinder: Nikolai." Accessed September 6, 2018. <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

34. Alaska Department of Commerce, Community, and Economic Development (ADCCED) Division of Community and Regional Affairs, Juneau. n.d. "Alaska Community Database Online: Community Information." Accessed May 24, 2018. <http://commerce.alaska.gov/dcra/DCRAexternal>

salmon, an estimated 10,801 edible pounds (92 lb per capita). Eighty-four percent of households said they used salmon during the study year.

## **FINAL REPORT ORGANIZATION**

This project collected local knowledge of the freshwater system as it pertains to Chinook salmon migration, spawning, and juvenile rearing through in-depth ethnographic interviews and mapping. Observations of change to the local environment and salmon abundance were also collected. The following chapter will discuss project methods in greater detail. In the third chapter, findings will be presented organized by a number of subtopics including environmental factors, salmon ecology, and management. The discussion synthesizes results from all five study communities and makes suggestions for future research.

## 2. RESEARCH METHODS

### STUDY GOALS AND DESIGN

The project had the following objectives regarding Kuskokwim River Chinook salmon:

1. Identify and map the specific areas associated with Chinook salmon spawning grounds or rearing habitats where local residents have personal experience through fishing or other activities.
2. Conduct in-depth ethnographic interviews with local residents from Aniak, Sleetmute, Stony River, McGrath, and Nikolai along the middle and upper Kuskokwim River to document local and traditional knowledge (LTK) about the Chinook salmon of these areas with specific reference to:
  - a. Spawning density, run timing, and sexual distribution
  - b. Migratory access to spawning grounds
  - c. Spawning behavior
  - d. Predation on spawning grounds
  - e. Water quality (e.g., temperature)
  - f. Streambed quality (upwellings, erosion, thawing permafrost, changes in depth)
  - g. Debris loads
  - h. Fish food sources
  - i. Undocumented spawning grounds or areas where spawning populations have been extirpated
3. Compare ethnographic data to results of area enumeration projects (Bethel test fishery, Kwethluk River weir, Tuluksak River weir, Salmon River [Aniak River] weir, George River weir, Kogruklu River weir, Tatlawiksuk River weir, Takotna River weir, and Telaquana River weir) for potential correlation.
4. Consult the Anadromous Waters Catalog<sup>1</sup> regarding areas identified by respondents and compare with results of key respondent interviews and maps.

This project also asked the following research questions:

1. What observational and experiential knowledge do active subsistence harvesters maintain relevant to the biological and environmental factors important to the freshwater aspects of Kuskokwim River Chinook salmon migration, spawning, and larvae/juvenile survival?
2. What changes have they observed regarding these factors, and how do they explain these changes?

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1. ADF&G. n.d. "Anadromous Waters Catalog." Accessed August 14, 2018.  
<http://www.adfg.alaska.gov/sf/SARR/AWC/>

## **METHODS**

### **Ethical Principles for the Conduct of Research**

The project was guided by the research principles outlined in the Alaska Federation of Natives Guidelines for Research and by the National Science Foundation, Office of Polar Programs in its Principles for the Conduct of Research in the Arctic, the Ethical Principles for the Conduct of Research in the North (Association of Canadian Universities for Northern Studies 2003), as well as the State of Alaska confidentiality statute (AS 16.05.815). These principles stress community approval of research designs, informed consent, anonymity or confidentiality of study participants, community review of draft study findings, and the provision of study findings to each study community upon completion of the research.

### **Project Planning**

This study encompassed five communities located along the middle and upper Kuskokwim River: Aniak, Sleetmute, Stony River, McGrath, and Nikolai (Figure 1-1). Communities were selected based on their proximity to known Chinook salmon spawning areas.<sup>2</sup> The tribal councils of each community were approached in spring 2014 and asked to participate in the research between May and October 2014. During the initial meetings, ADF&G staff members provided a presentation of the proposed research and were available to answer questions.

### **Ethnographic Methodology**

The project followed accepted standard methods of traditional ecological knowledge (TEK) documentation outlined by Miraglia (1998). Methods for this project were largely characterized by a qualitative ethnographic approach, including a heavy reliance on in-person, semistructured interviews with knowledgeable fishers and community members. In each community, Division staff with the assistance of tribal council and other community members identified individuals considered to be knowledgeable about the salmon habitats in their areas. Because this type of knowledge can be highly specialized, researchers endeavored to include experts from a variety of demographics, including age, gender, and profession.

The ethnographic research for this project included anthropological methods of participant observation; in-depth, semistructured interviews; and mapping. Participant observation fundamentally involves spending time with people in a way that allows the researcher to build rapport and trust and to gain the ability to record observations about the community members' lives (Bernard 2011). Participant observation can take at least two forms: spending time with people to build relationships (such as visiting, attending community events, traveling around the landscape, and helping community members with chores) or participating in harvesting or processing activities. Harvesting and processing activities are often opportunistic and so can be difficult to prescribe in advance. Research field trips for this project lasted approximately seven to ten days, all of which were spent either conducting interviews and mapping or in participant observation.

Semistructured interview protocols provide a format for systematically documenting comparable information about the same or an overlapping set of topics in each community while providing flexibility for each key respondent's level of expertise, experience, and focus. Investigators used a general semistructured interview guide (Appendix) framed around the research questions and developed in consultation with the tribal councils and other knowledgeable individuals, including research biologists and resource specialists at ADF&G, U.S. Fish and Wildlife Service (USFWS), Tanana Chiefs Conference (TCC), and Association of Village Council Presidents (AVCP). The interviews covered the weather patterns, timing of harvest, observations of environmental change, fishing areas, relative abundance and population trends, observations of barriers to fish passage (e.g., beaver dams), spawning grounds observations, and other observations of salmon habitat and life history. Every interview did not cover every topic, because some respondents were more familiar with some topics than with others. Researchers conducted interviews in English. Athabascan and Central Yup'ik language retention in the region is not strong, and many elders are competent English

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2. Alaska Department of Fish and Game, Division of Habitat. "Anadromous Waters Catalog: Fish Resource Monitor." Accessed June 6, 2019. <http://extra.sf.adfg.state.ak.us/FishResourceMonitor/>

speakers.<sup>3</sup> During interviews, photographs and maps were used as prompts, and relevant information (e.g., significant habitats, traditional harvesting areas) were mapped.

U.S. Geological Service (USGS) 1:250,000 topographical maps were used during interviews to document observed environmental changes, traditional fishing areas, observed spawning grounds, and other relevant information. Although mapped information was collected in each study community, the quantity and content varied. Much of this variation is due to the differing specialized knowledge brought by various key respondents. Mapping information is provided for specific topics that included the largest amount of information available, including areas of erosion and deposition, fishing locations, and observed spawning locations of salmon.

## **Fieldwork**

Researchers conducted 32 interviews between August and November 2014. Participation in key respondent interviews was voluntary, and respondents were assured that identifying information would be kept confidential. Respondents were paid an honorarium of \$50. All interviews were audio recorded with permission.

### ***Aniak***

Researchers conducted a total of five interviews with five men in Aniak. The eldest respondent interviewed was born in 1935, the youngest in 1983. Two respondents were born in or near Aniak; one respondent was born at fish camp near Paimiut on the Yukon River. Two participants were born outside Alaska in other U.S. states. One respondent spends time in both Aniak and Napaimiut and offered several observations about that community as well. All interview participants had significant experience fishing the Kuskokwim River mainstem near Aniak, up the Aniak River, and other waterways in the region.

### ***Sleetmute***

Division staff conducted total of eight interviews with eight individuals in Sleetmute. The interview participants included one woman and seven men. The eldest respondent was born in 1942, the youngest in 1970. Half of the respondents were born in or near a community on the Kuskokwim River (Sleetmute or Bethel); the other half were born either outside Alaska or in other regions of Alaska (Matanuska-Susitna Valley and Southeast Alaska). All respondents had significant experience fishing the Kuskokwim River mainstem near Sleetmute as well as in the Holitna and Hoholitna river drainages. One respondent used to trap up the Holitna River with a dog team and another was a former homesteader. Interview participants also commonly used the Swift, Stony, Kasheglok, Totnik, and Itolilik rivers.

### ***Stony River***

A total of six interviews were conducted with seven individuals in Stony River. Six interview participants were men, and one was a woman. All respondents had significant experience fishing the Kuskokwim River mainstem near Stony River, and several had frequented the Holitna and Hoholitna river drainages. Respondents had also the Swift, Gagaryah, Cheeneetnuk, Kasheglok, and Tatlawiksuk rivers. One respondent had a cabin on the Swift River.

### ***McGrath***

Researchers conducted a total of nine interviews with ten men in McGrath. ADF&G staff hired a local liaison to assist with interviews; because he provided important expertise during interviews, he was included as a respondent. The eldest respondent was born in 1934, the youngest in 1978. At least three respondents were born outside Alaska, and the remainder were born either in or near McGrath or Takotna. All interview participants had significant experience fishing the Kuskokwim River mainstem near McGrath. One respondent was an active pilot and trapper. One had experience as a fishing guide on the Aniak and Takotna rivers. A few respondents had significant experience especially on the Takotna River. Other areas

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3. M. Krauss and S. Jacobson, Alaska Native Language Center, personal communications with B. Retherford, November 2013.

of expertise included the upper Kuskokwim, Nixon, and Big rivers and Grayling Creek. One respondent spends time in both McGrath and Lime Village and had specific knowledge of this area and the Stony River.

### *Nikolai*

ADF&G staff conducted a total of four interviews with six individuals in Nikolai. Four respondents were men, and two were women. Personal information about birthplace and age was not collected for the respondents in Nikolai. All the respondents had significant experience fishing the area around Nikolai as well as the Tonzona River. One respondent had spent time in Medfra and another formerly had a fish fence at the “Forks.”

## **DATA REDUCTION AND ANALYSIS**

Subsequent to the interviews, recorded interview data was transcribed. Transcriptions were reviewed and then uploaded into ATLAS.ti<sup>4</sup>, a qualitative data analysis software program, where it was coded and analyzed. The development of an appropriate coding structure was critical to the analysis. Coding of transcribed interviews was accomplished using an inductive process that allows for the development and refinement of codes based on emergent themes and relationships present in the interview data, as opposed to using a predetermined code list. The software assisted researchers in identifying important relationships within the data that may have been challenging to track without the software (Friese 2012).

Mapped data were organized in an ArcGIS platform, highlighting those habitats that are familiar to or used by key respondents along with valuable information regarding the freshwater aspects of Chinook salmon life cycle or other environmental factors that may affect that life cycle.

Researchers presented results to each community for review in the spring of 2019. Presentations included information about data collected, analysis of ethnographic work, and consideration of assessment projects and escapement enumeration projects. All study communities have had the opportunity to review and comment upon the preliminary study findings, and final results have been distributed to the communities.

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4. Product names are given because they are established standards for the State of Alaska or for scientific completeness; they do not constitute product endorsement.

### 3. FINDINGS

This chapter is organized by topic and summarizes the traditional knowledge of the lifecycle of Chinook salmon gathered during key respondent interviews conducted for this project in middle and upper Kuskokwim River communities. The narrative begins with observations of changes to the environment over time and effects on salmon species and fishing patterns, followed by a discussion of the natural history of Chinook salmon as understood by fishers of the middle and upper Kuskokwim River study communities. The natural history section includes observations of distribution, seasonal movements, feeding habits, spawning, health and abundance, and environmental change and its effects.

Though the focus of the project is Chinook salmon, observations about other salmon and nonsalmon fish species are interwoven into the narrative to reflect that valuable knowledge of local conditions and change is often gathered by spending time on the land during the pursuit of multiple subsistence resources. Subsistence fishers in rural Alaska are uniquely positioned to observe small- and large-scale changes to the place in which they dwell and the surrounding wildlife, fish, and natural habitat.

#### **ENVIRONMENTAL FACTORS**

Subsistence fishers interviewed for this report were asked about their observations of physical changes to their natural environment. Every respondent said that he or she has noticed differences in weather patterns, in the timing and nature of breakup and freeze-up, in the landscape, and in water levels. Fishers' observations varied by community, but also by respondent. Each individual has a unique relationship to the land, and participation in particular activities or travel to certain areas can influence knowledge.

#### **Weather Conditions**

Weather is a critical part of daily life for communities on the Kuskokwim River and is closely monitored. Even the most minute changes in weather may affect residents' ability to travel to nearby communities for cultural events or other activities or to access hunting or fishing areas. Altered weather patterns may also influence decisions about subsistence practices such as preserving fish. Because of this, respondents in the five study communities are uniquely positioned as observers to local climactic shifts over time. A majority of respondents in all communities agreed that weather patterns have changed in recent decades. The most commonly cited observations were milder winters and rainier summers.

Nearly every respondent mentioned that he or she had observed warmer winter temperatures. Many respondents explained how changing conditions affected their daily lives or subsistence activities. One Nikolai man discussed his experience as a community grave digger as it related to weather: "I noticed that digging winter graves in the area, too. That, some...are only frozen so far. Just not freezing as much" (NIB4). A McGrath respondent who runs a trap line in winter said that he has observed fewer days of extreme cold:

I don't think there was a day last year that I had the excuse that I should, or I needed to stay home from my trap line because it was too cold. And that just didn't happen before; we'd get a week of 40 below and it's enough, take this week off, but it wasn't that way and it hasn't been. (MCG3)

He has noticed this change over the past 15 years or so. This respondent uses a wood-burning stove for heat in winter and said that he has been less concerned with filling his woodshed recently than in the past because winters have been warmer.

Two other longtime McGrath residents discussed how warmer winter weather has impacted their ability to access a winter cabin they used to frequent located about 27 river miles from McGrath (MCG2, MCG10). One explained the difficulties in traveling due to weather conditions:

If it was like the old times, I would've been back up there now before I leave the country. But I don't even plan to go up this year. There was a couple of winters we were able to drive a car, a pickup, all the way up to the cabin on the ice. But that was unusual weather. It had to be an early freeze and really cold and not much snow. (MCG4)

In addition to warmer temperatures, winters have seen more unpredictable snowfall, according to at least four respondents. Two respondents described snow in recent years as widely variable: "It's either you have too much snow and it's wet snow, or you have too little snow and it's too cold. It's been fluctuating, I'd say crazily in the last decade" (SLQ8). This respondent said that he recalled past winters when it was not uncommon to have three to four feet of snow overnight, "and that's including the snow that was blowing and sometimes we would have to shovel out of the porch" (SLQ8). Another Sleetmute resident said that the snow still falls in his community, "but it may not come at the same time each year" (SLQ1).

Respondents were not always in agreement over whether milder winter temperatures and less snowfall had made travel easier or more difficult during winter months. According to one respondent, freeze-thaw cycles have become more common in winter and have prevented river ice from freezing uniformly:

It's getting harder and harder to travel. I mean, when you're going on snowmachines you've got to go slow because of the bumps. So if there's more snow you can just [go] smooth. Nowadays it seems like ice stop, then warms up, then goes again. (SLQ2)

He also described an increase in overflow events on the Kuskokwim, which can be more dangerous for travelers: "We see a lot of overflow on the river. When it's wintertime and you try to go somewhere and hit the overflow" (SLQ2).

A McGrath resident observed that low snow during spring had a negative impact on spring hunting because he had to burn more fuel in search of wolves, which were scarcer that time of year:

Now last year we had, didn't have much spring snow. Wolf hunting and stuff was real poor because there wasn't much snow all along the foothills, and the Alaska Range had all melted out real fast. We hunted some around here, but not as much as we'd like and the conditions weren't favorable. We burned lot more gas. (MCG9)

Another McGrath resident shared a different experience: "Last year [the snow] never got to my knees, which is wonderful, actually. It was just enough to cover the brush, but not deep enough to get stuck in. I could travel. It was good" (MCG2). Because of the low snowfall, area hunters were able to see the benefits of the last decade's predator control efforts<sup>1</sup>: "[Moose] had such an easy winter that they did really well [with] reproduction, so that was good. It's pretty nice to be able to harvest a big healthy adult bull moose versus anything that has antlers."

A Sleetmute fisher linked warmer weather in the late winter and early spring to better fishing for salmon in summer. He said that warmer spring temperatures mean that ice goes out faster during breakup, salmon arrive earlier, and they are easier to catch: "I think it's better when it's warm because you catch more fish. They usually wait til this ice is gone for a couple months before they come up this way. So it all depends on how cold and stuff the river is" (SLQ2). A respondent from McGrath said the waters of the Kuskokwim River appear to be clearer than in the past, which happens when the levels are low. He connected this to the lower snowfall amounts in recent years (MCG4).

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1. Intensive management (IM) programs are authorized when the Alaska Board of Game determines that an ungulate population is important for providing high levels of human consumptive uses and sets population and harvest objectives for deer, caribou, or moose in specific areas. The Commissioner of ADF&G may authorize predation control in which predators will be reduced but not eliminated. An IM program has been in place in Game Management Unit (GMU) 19A for wolves since 2004 and bears since 2012, and in GMU 19D for wolves and bears since 2003.

Respondents also observed changes in summer weather patterns on the Kuskokwim River. Several cited changes in weather patterns over time. At least four respondents observed rainier weather conditions. In the words of a Sleetmute fisher: “It’s moved to...being more rain in the summer and less precipitation in the winter” (SLQ1). Another fisher described the effects of low water on fishing, which can be caused by less snowfall in the winter months:

Your setnet sites disappear because your eddies are not there. They diminish as that river drops, and velocity increases. So that has an effect, pro and con, for people. We’re so weather-dependent. We can have just heavy rains for four or five days and water comes up and everything’s back to normal. (SLQ3)

However, other respondents said that high water levels can make fishing more difficult than low water levels (SLQ1, ANI2). One Sleetmute resident described halting fishing during high water because of debris in the river:

We have randomly high rainfall years. It affects fishing up here probably most greatly because we have to pull the nets when we start getting too much trash in the river. Trash as in trees and branches and just stuff that would fill your nets up that you don’t want. There’s more trash because the gravel bars collect driftwood and when the water comes up that all starts moving down river. And that will catch in your nets and you do not want an entire tree with the root system caught in your net. So you pull your net when the water gets high like that. I don’t know that it affects the fish because we don’t have nets in a water then. But it certainly affects our ability to fish. (SLQ1)

An Aniak fisherman agreed:

I don’t want to set a net because there’s too much sticks and it takes hours to take sticks out then fish. So we just pull out nets and wait till the water start dropping down and then set our net and hopefully set our net back in before they all pass, especially the kings. (ANI2)

One respondent also said that low snow conditions affect the structure of the Kuskokwim River:

When you have a lack of snow, you have a lot of thick ice. And when ice is heavier and it runs through there, it seems to me that when we do have spells and the creeks start pushing out more water and there is more melt, run off, it does a change to the channels. And it’s actually cut off a lot of channels, you know.” (SLQ8)

Key respondents were not certain if water levels affect salmon movements on the mainstem of the Kuskokwim River, but most felt that it is unlikely. “I don’t know, they probably going on by because I won’t go out in this weather” (SLQ4). Another respondent believes that fish are not greatly affected by water levels: “I think once they [the salmon] get in the river at Bethel, they’re on a mission, they’re coming” (SLQ3). One respondent observed that salmon are “slower, in general, coming up the river when the water’s real high” (SRV3). Respondents also shared many observations about persistent low water levels in tributaries and sloughs, which will be discussed in a separate section.

The rainy weather that causes high water levels can also influence processing decisions. A Sleetmute fisherman said he fishes less on rainy days because of concern that the precipitation will cause fish to rot during the drying process: “My auntie won’t cut fish in the rain and all that. Your fish got to dry and all that before you smoke them and there’s no use in hanging them. So I just wait for a good day and dry overnight and hang them in the smoke house” (SLQ4).

Several respondents discussed more specific observations about connection between subsistence fishing conditions, breakup and freeze-up, access, and the structure of the river itself. These will be detailed in the following sections.

## **Breakup and Freeze-up**

Spring and fall mark the transitions between a frozen and ice-free river and the beginning or ending of fish and wildlife migration. Changes to the timing, rate, and nature of breakup and freeze-up are closely observed by locals, especially as they prepare for the different subsistence hunting and fishing opportunities available each season.

During the weeks in spring and fall when breakup and freeze-up occur, travel in waterways can be treacherous. In all study communities, breakup proceeds over the course of a few weeks in the spring, beginning with deteriorating ice conditions that limit travel. The peak of breakup usually occurs on a single day when ice visibly breaks apart and begins to move downstream. This event is followed by several days of high water levels in tributaries, sloughs, and the mainstem. Occasionally, severe flooding results from ice jams and high water. In fall, freeze-up also occurs over the course of several weeks, and travel is restricted until the ice is thick enough to bear the weight of snowmachines.

Respondents agreed that the timing of breakup and freeze-up have become less predictable over the past 10–15 years, although breakup is often earlier and freeze-up later than in the past. An Aniak respondent said, “There’s no normal cycle anymore” (ANI1); and a Sleetmute respondent added, “Things aren’t as fixed as they used to be” (SLQ7). A successful subsistence fishery relies on fishers’ ability to adequately assess these factors. Increased unpredictability in seasonal shifts can directly affect subsistence activities, and fishers must adapt to changing conditions.

### ***Breakup***

Springtime breakup has historically occurred in mid-May in the middle and upper Kuskokwim River study communities. Nowadays, “breakup is anywhere from the end of April to the middle of May, usually the first week of May now,” said one respondent (SLQ7).

A Nikolai respondent described difficulties in subsistence hunting because of earlier breakups and warmer winters:

So you don’t have much time. Seems sooner now, breakup, because a lot of times you haven’t been able to get over there when the birds come because it’s all melted out. Not having snow, some years we haven’t had much ice either, I mean the ground doesn’t even freeze. Usually, 20 years ago, there’d be guaranteed a foot of muck while it’s the ground thawing out, you know how the ground gets muddy? It doesn’t do that. Maybe two, three days and it’s all dry, completely dry already, just whatever moisture soaks right in now because the ground’s not frozen. (NIB4)

One respondent from McGrath said that breakup events are less dramatic than they were in the past, which may be a result of less snowfall and milder winter weather conditions:

You know, the breakups are a lot more mellow than they used to be. I remember I was young, ice would come up the banks, it’d be a thicker ice. It would be a lot more dramatic when it went out. Nowadays, it just warms up and there’s not much ice. It’s been fairly warm so it just kind of slushes out, doesn’t scour the sandbars or anything else like it used to. Knock all the willows down where the moose had a lot better habitat. (MCG9)

Respondents described effects on the river from changes to the nature of breakups in many different ways. For example, this respondent connected changing water levels after breakup to the subsistence activity of gathering driftwood for heating wood stoves from sandbars:

Back in the day, when the river would come up there, like during breakup, a lot of that dead wood would go out with the ice, and you’d see big huge piles of dead wood on the sandbars. I’ve known guys go up the river in the wintertime and cut up cords of dead wood that’s landlocked on sandbars. High water. And floods. We don’t see that no more either. (MCG2)

Several respondents observed that the amount of snow in winter affects water levels during spring breakup (SLQ5, SLQ8, ANI1, NIB4). They note that water levels have been lower lately because less snow has fallen during the winter (MCG4).

Respondents had varying observations about the connection between breakup timing and the timing of the Chinook salmon run. Several respondents said that the timing of breakup affects the timing of the subsistence salmon fishery. Several respondents observed changes to the annual run timing of salmon, often correlating it with earlier or later breakups. An Aniak respondent explained the change:

When things start happening late, [the run] has to catch up. By the time it's catching up it's already spring, so it then confuses the normal cycle of fish coming up river because they know when to come up river. They sense temperature changes and all that, and what weather, what the river conditions are. Something in them that determines when they're going to start coming up river. The old days it was pretty regular. In the old days we depended on our old people to tell us what things are going to be. (ANI1)

A Sleetmute respondent said that during years when breakup occurs later, fishing begins later, but he said that this could either be because the run has been delayed, or because fishermen must wait for an opportunity to fish in ice-free waters (SLQ3). Another active Sleetmute fisher said that she can tell if the Chinook salmon will be early by observing breakup at the mouth of the Kuskokwim River:

In the years when the ice is going out of the mouth, [the run is] a little earlier and we've had more of those years. So, an early breakup here does not necessarily mean an early run, but it has not changed dramatically. (SLQ1)

Reflecting on the most recent year (2014), an Aniak fisher said:

This year was an exceptionally early year. This was like the earliest I've seen them. We had an early breakup this year, everything was just super, super, duper early this year. I think maybe three years ago it was super late, the run was super late. We had a late breakup maybe. (ANI3)

A few respondents drew a connection between salmon movements and water temperature, including the respondent who observed: "I think the temperature of the water has a lot to do when they start getting up here. I think our fish are coming back earlier now because the breakups are a little bit earlier than it used to be" (ANI4).

### ***Freeze-up***

Breakups may be coming earlier, but freeze-ups are happening later, observed several respondents in communities located in the middle and upper Kuskokwim River communities. Some respondents felt that later fall freeze-ups are more noticeable than earlier breakups. In the words of one person: "I've noticed mainly the fall is the big difference. Fall is two months of cold rain instead of two weeks of cool, cold weather and then freeze-up. That's the big difference, is the fall" (SLQ7).

Elder respondents in most communities recalled childhood experiences traveling the frozen Kuskokwim River in mid- to late October (NIB4, SLQ5, SLQ7, MCG3). A McGrath respondent provided a detailed observation about overall changes to the timing of freeze-up:

Certainly freeze-up has been later and later, it seems like to me. I've done some trapping in years past and I always try to get out on November first or as near to that as possible. But in recent years...it seems like you don't dare try to get out [on the main river] until end of November sometime because the ice isn't solid enough. I think usually [in the past] you could count on being able to get out by the first of November and travel on the river with a snowmachine or dogs or whatever. (MCG2)

A respondent from Aniak recalled activities that he and his family were able to do in fall that are impossible today because of later freeze-up:

My kids back then used to always be able to walk over to Aniak over the ice to get to go trick-or-treating on Halloween night. That doesn't happen anymore. I mean, it was frozen good, we were walking up the mouth of Aniak [River] catching hundreds of grayling through the ice up there usually by around October the 20th. October 15th or 20th they just come down big schools and all the old women in town used to punch a [little hole]. There'd be about that much ice, enough you could walk on, punch your little holes in the ice, get your grayling, go home and eat them for supper. [Freeze-up has] been as late as Thanksgiving. I wasn't here for this last year, but my son was, and I think it was up into the first part of November before they were able to do it reliably this year. (ANI4)

## **Landscape Changes**

Respondents in this study hold a vast store of knowledge of the lands of the middle and upper Kuskokwim River region as a result of years of traveling on the land, interacting with and observing the environment, and participating in subsistence fisheries and other activities such as trapping, hunting, and gathering. Respondents observed changes occurring to the physical landscape of the area, including erosion and deposition, melting permafrost, new riparian growth, and effects of wildfire.

One respondent said though there were changes on the river, "everything seems to be healthy" (MCG1). Though respondents agreed, for the most part, that change was a natural characteristic of their physical environment, some expressed concern about the rate of change that they had observed.

### ***Erosion and Deposition***

Respondents discussed observations about erosion on several occasions during interviews. In many cases, this erosion is linked to melting permafrost. Though it is normal for permafrost to melt each year, causing river banks and lake edges to slump, many respondents observed this to be occurring at a faster rate than what they recalled in the past. Figures 3-1 and 3-2 portray areas of erosion and deposition noted by key respondents during mapping portions of interviews conducted for this research. Although these processes were noted by residents of middle river communities, residents of the upriver communities of McGrath and Nikolai indicated widespread erosion and deposition in their area. One respondent from McGrath noted: "This river, down here, I would say, [is] a third wider than it used to be. Used to be houses way out in front of these houses here. They're all gone" (MCG1).

Another McGrath resident discussed changes in the river due to deposition:

It's like that sandbar out here, that wasn't here when I was a kid. And that Father's Day Island, it must have grown a half a mile from what it used to be. When I first come back [in] '78, we would go down on the Father's Day Island, as they call it now. [A local resident] would call it Rabbit Island because about seven of us go abreast and hit the willows and chase the rabbits down to the end. And now you'd need a hundred people or more to walk that island. (MCG5)

This respondent also noticed that river banks have become steeper and connected this change to rate of melt of permafrost: "Everything seems to be cutting more this year than I have seen it cut in a long time. And we blame it on permafrost disappearing when we're talking about it earlier this summer" (MCG5).

A few respondents have noticed changes to the land because of direct effects on their subsistence fishing activities. These effects most often involved the total disappearance of traditional fishing locations. For example, one Aniak fisher talked about a setnet site that no longer exists:

We used to put a fish net down here across the river there, and you'd have to check it twice a day, actually. And all the corks would be sunk. And we'd fish for those

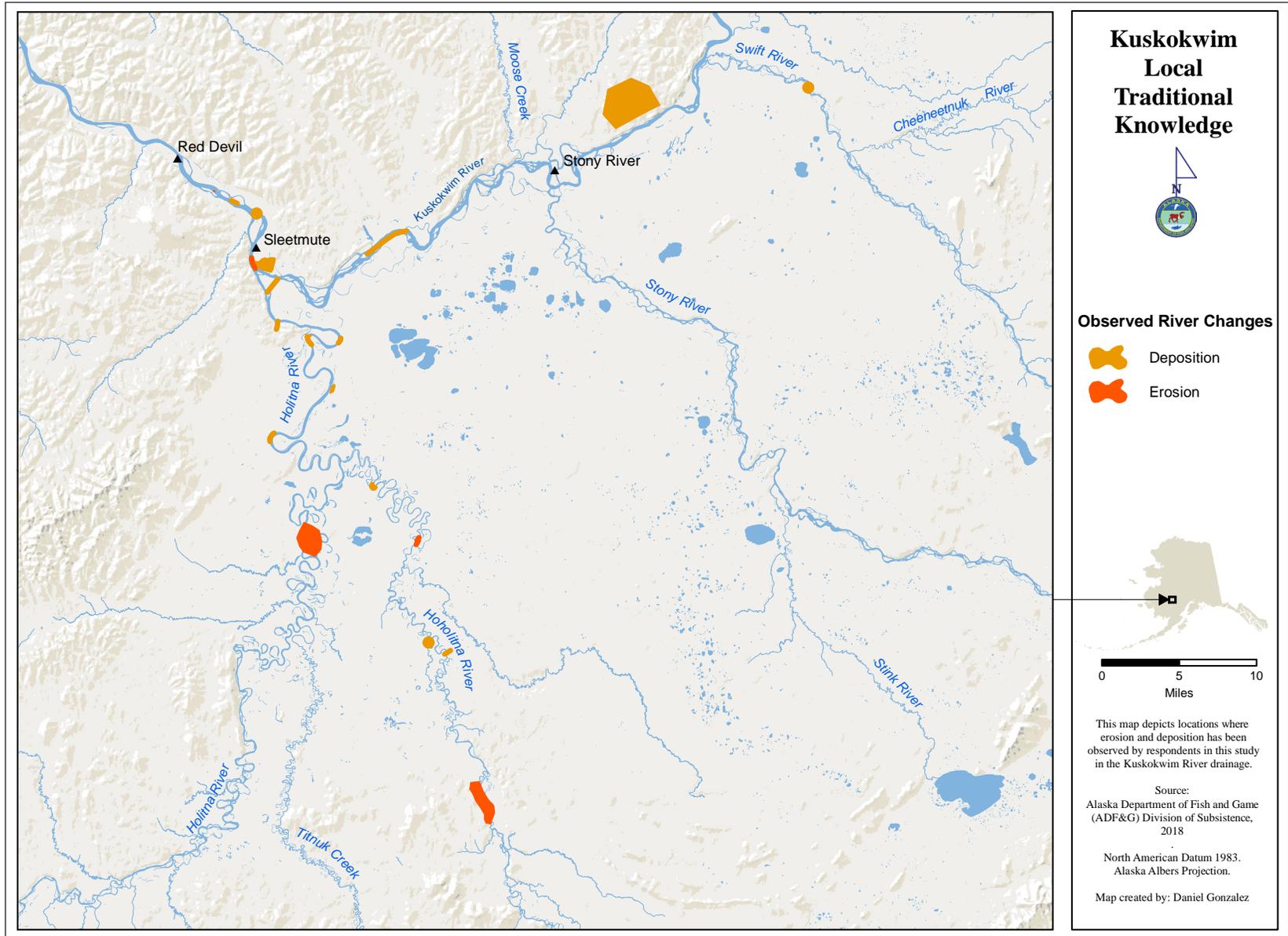


Figure 3-1.—Observed erosion and deposition areas, middle Kuskokwim River.

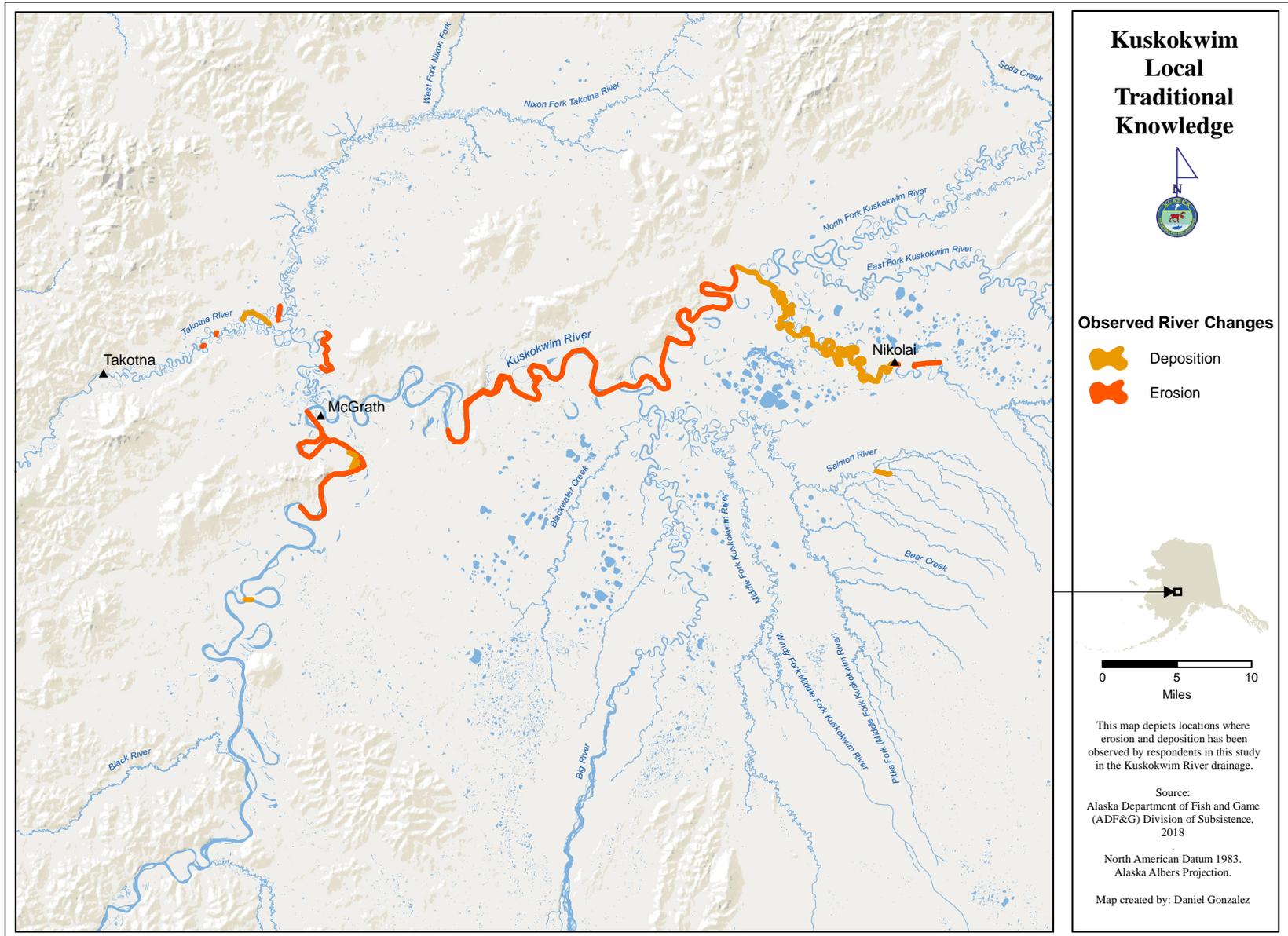


Figure 3-2.—Observed erosion and deposition areas, upper Kuskokwim River.

little dog salmon for dogs. So we'd fish for about a week, and we'd have plenty of fish for the winter for the dogs. That would be probably in the late '40s, early '50s. (ANI2)

A fisher from Sleetmute also observed a loss of fishing areas, especially setnet sites in eddies: "The eddies have changed because of erosion. I've had one eddy that used to be excellent and it's no longer really in the eddy. It's dead water now. And it is horrible. I can't catch anything there" (SLQ1). This respondent also said that fishing spots may become less effective on occasion; subsistence fishers must take the time to seek new fishing areas. However, when fishing areas erode or change more quickly, adapting and finding new fishing spots can be cumbersome and time-consuming. Similarly, another Sleetmute respondent noted:

I noticed my parents used to set a net down here. And there used to be an eddy where they always had their net set. That eddy's no longer there. [It changed] probably about 15 to 20 years ago. That's the only part I know about. Because that's where my parents used to have their net. (SLQ5)

## ***Vegetation***

Several respondents discussed the increasing amount of brushy vegetation around lakes and sloughs. They speculated that the growth may be connected to beaver dams. In some cases, areas that had been lakes have transitioned into meadows: "We don't seem to have any more lakes in the area. They've just turned into meadows or ponds. A lot of the beaver are going into the river or the sloughs" (SRV6).

Another respondent discussed the potential for beaver dams to accelerate the creation of grassy meadows from sloughs:

It's like the sloughs above town here. They are slowly filling in. The one main slough that comes around, there's a beaver dam that kind of keeps that down, and it doesn't seem to carry enough water to knock it out. It used to knock it out. And so you can almost drive across it anymore. And the two sloughs above that, they are starting to grass in. It's definitely diminished in its water volume. (SLQ3)

A respondent in McGrath drew a correlation between low water and increased riparian growth:

We haven't seen it this low in, like I said, seems like we are getting less water in the river. I think it just keeps growing. I mean, you know the willows move over and then the spruce grow up, and I don't think that overall it's getting wider. That's why it's a good moose area, because it keeps cutting the bank and it keeps growing the willows, and that's why we have a lot of moose in this area, I assume. (MCG5)

One respondent observed that the amount of vegetation is also increasing on the Takotna River: "It's been gradually changing for the last 20 years. The river is a lot narrower now than it used to be. We still have the sandbars, gravel bars, rocks. And they used to be a lot bigger than what they are now, but they're growing over with brush" (MCG7). Another McGrath respondent said that in the past, breakups typically helped to naturally remove vegetation growth alongside riverbanks. The more gradual breakups of recent years do not perform this function: "I think that's [more willows on the Takotna River sandbars] part of the scouring again you know, not having the ice, the dramatic breakup and scouring all the willows back" (MCG9).

One McGrath respondent who also spends time in Lime Village observed growth of vegetation there over the past 13 years:

Lime is in tundra country. It used to be a lot of little trees, those trees have all got big. When we built our house, you could see the river from the house and now, to see the river, I had to cut down a bunch of those black spruce. Everything, all the plants have gotten bigger, and more of them. (MCG7)

Respondents also discussed changes in the type and quantity of vegetation along river banks. An Aniak respondent said that he has noticed changes to the areas where people harvest timber, such as around Aniak Slough. The respondent has observed an increase in landslides and an increase in the number of cottonwood

and yellow pine trees: “We go up the Aniak River up to about Doestock, and try to not stay in the river too much. You need to get off because the [current] in that river gets dangerous” (ANI2).

### ***Wildfires***

Many respondents had comments and observations about the impacts of wildfires on their subsistence use areas. Aniak respondents said that they have not seen any major wildfires in the area for some time. “Major, no. Little ones. We haven’t had a good fire in this country in a while” (ANI5). One respondent explained that positive changes to the landscape come from forest fires: “Most of [the changes] we seen is after forest fires, which is good for us” (ANI2).

A Sleetmute respondent explained her observations of several fires near that community in recent years:

There was the big [wildfire], I don’t even know where it’s started, but it burned on this side of the river, and you could see from Stony, you could see it from my house at Midway, it burned all over the George River. It was basically this whole area, was involved. And this would’ve been 15 years ago, I believe. There’s been smaller fire since, there’s one up the [Hoholitna River] two summers ago. But it didn’t involve as much and the only reason we knew is because it was affecting people’s homesteads and they brought fire crews up. Seems to drive bears out. (SLQ1)

A few respondents from Nikolai recalled the Bear Creek Fire that burned areas around the Salmon River in 1977. The fires burned the 60–70 foot white spruce trees that had been there. “Took out everything. I mean it just burned everything right to the ground it was such a big fire. Some places yeah, you still see the old burned trees and stuff. Yeah, you can still see it, stumps on the ground and stuff” (NIB4).

One Nikolai respondent said that after the 1977 fire:

...Birch came back, mostly birch. That’s the first thing that always comes back after a fire, so there’s tons of birch trees. The spruce are coming back pretty good. [The birch trees are] at least 30 feet, 30 to 40 feet. Cottonwoods burned off of there, we always used to use them for smoke wood, and there’s no more. So we switched to alder. It works real good. They’re smaller and you use a lot more work getting them, but they bring oil out in the fish a certain way, different from cottonwood. (NIB4)

Another respondent said that since the 1977 fire, the waters of the Salmon River had become clearer: “Before it used to be muddy in the Pitka Fork [between Middle Fork and Pitka Fork]. Muddy, muddy water coming out of here. But after the burn, you know, water got cleared up. Could almost see Chinook salmon in that Pitka Fork” (NIB2). In the years immediately following the Bear Creek Fire:

Everything was hot, and the brush was smaller, so you were getting less shade everywhere. At the mouth [of] Salmon River, there’s no shade because everything burned off and you’re sitting right in the sun on the bank, grassy bank, and absolutely no shade, you know. It gets brutal when it’s in the 80s and 90s over there. (NIB4)

More recently, in 2002, the Vinasale Fire burned roughly 100,000 acres and approached within six miles of McGrath. Three respondents talked specifically about the fire’s effects on the area, including improved moose and berry habitats (MCG3, MCG5, MCG7). One person provided a particularly detailed description about the considerable changes to moose hunting near town:

Right here locally it’s really easy to see how [wildfire] changes community’s access on the river. We had the burn in 2002, it started down here at Vinasale and burned this whole area all the way over to Big River. Moose used to come here and now this is a burn that is 12 years old. It changed the habitat completely. It was dead zone and now it is just unbelievable—the willows, the aspens, the quaking—

The moose are, are wintering in there. I mean that was actually a blessing for the population of moose. The black spruce tundra really didn't support much of anything. And then now it has fantastic blueberries and shrubs now that moose went in. And it's going to change the whole thing. Of course, you're going to have moose in there, and rabbits, and then all the marten will come back in. So, then the bears are hitting it very hard because of the blueberry patch, you know. So that's changed a lot of what's happening here in McGrath, I mean, now there's this place everybody in McGrath goes to get their blueberries. This is the place everybody goes to get their firewood because it's standing black wood that's been killed. I noticed that this year, there's so much less use of the river with motorboats because there is one road that goes 13 miles out there and they can drive it out to hunt their moose there. Before they had to be out on the river, and it's lessened some of that pressure on the habitat, the moose weren't there. The habitat has changed enough that it is being used for many other things than what it was used for before. The road was just going to a quarry. Oh, so much better. It's a lot easier to load a moose in the back of your truck than it is to drag him off to the river and put him in your boat. (MCG3)

Respondents shared fewer observations of any negative effects of wildfires. Among those that might fall in that category were an increase in erosion of river banks and a temporary increase in water turbidity (ANI2). One respondent said, "I'm sure [wildfires] have an effect on the river you know, the banks lose a lot of their stability for a bit. But in general fire's really good for everything because all the animals come back strong after a fire you know?" (MCG9). Another respondent added, "You get a lot erosion, like down in the States, but up here is that peat moss and it just burns down and birch trees growing up the next season" (MCG6). Neither respondent said that they believed fish habitat was affected by wildfire activity.

### **Water Levels and Access**

Respondents from all communities discussed changes in river conditions during summer and winter as well as effects of changing conditions on the ability to access to traditional hunting and fishing areas in the Kuskokwim River mainstem and its tributaries. Figures 3-3 and 3-4 portray contemporary and former salmon fishing areas identified by respondents during interviews. Residents of the upper Kuskokwim River identified more past fishing areas, particularly those used for fish fences prior to regulatory changes in the 1960s

#### ***Summer Access***

During ice-free months, typically May to October, access to hunting and fishing areas reached via tributaries is often dependent upon water levels being high enough for boats to pass. Water levels have often fluctuated, respondents said, but people have seen more limitations in recent years in some areas.

One Aniak elder said that traveling conditions on the Aniak River have always been unpredictable and recalled early memories of boating up the Aniak River in fall: "If the water was high enough in the fall, we'd go up by boat right away" (ANI1). Even today, he said, if you want to go up the Aniak River, you must wait for high water: "And if there's no log jams, then you can pass." This respondent said that water levels in the Aniak River typically change about "four or five times a year," and that the river channel changes from year to year:

And you never know in the spring time which area is the weakest for the new channel to be dug. It changes every year. The access to the areas up there, it depends on the river and what the weather, what the spring time does, because when the ice melts out the river starts moving, it cuts new channels wherever the permafrost is shallowest. Or the deepest, I mean. If permafrost is way down, then it's easy for the river to wash up, out to the permafrost. And then that changes all the time. (ANI1)

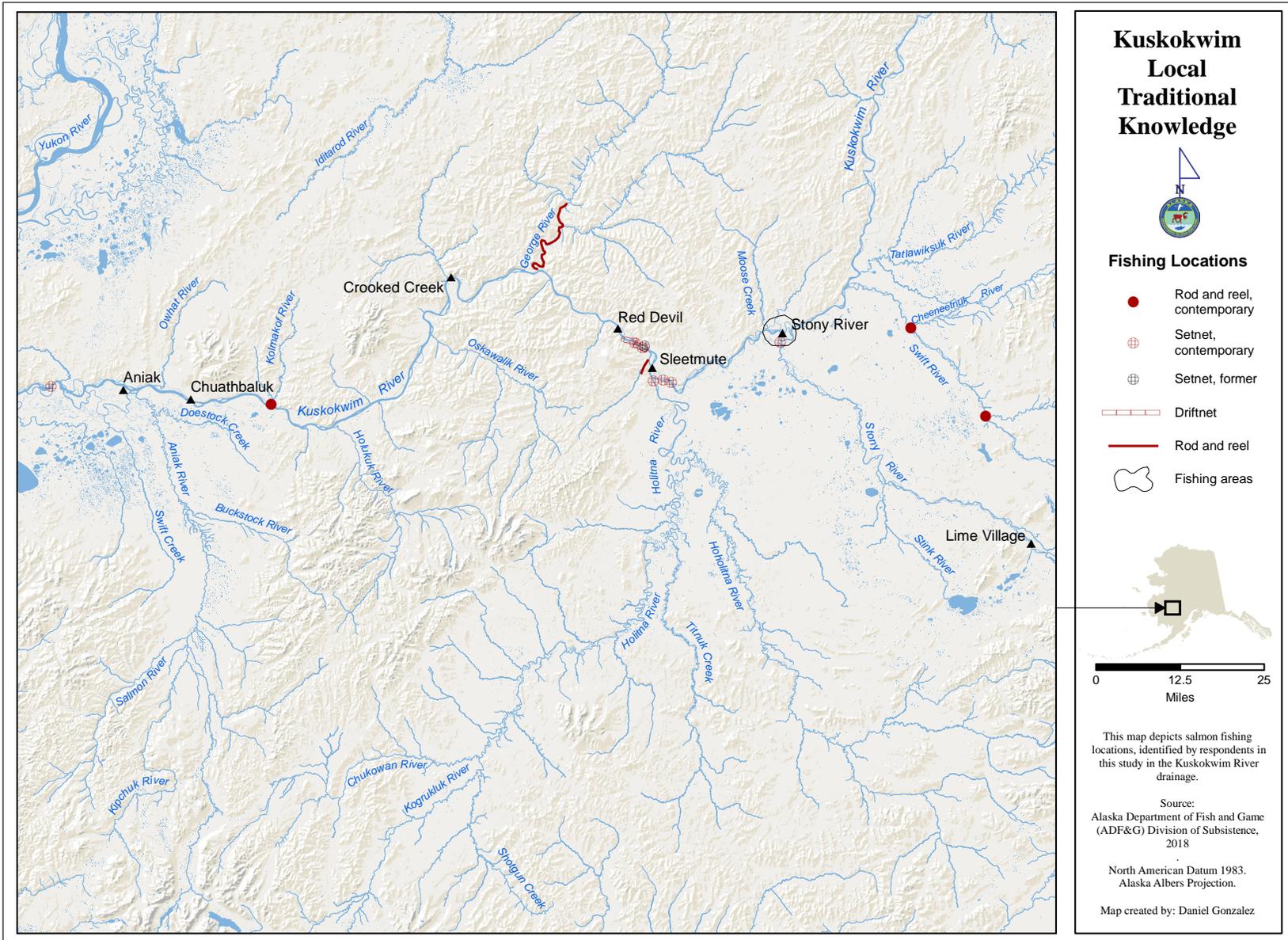


Figure 3-3.—Fishing areas, middle Kuskokwim River.

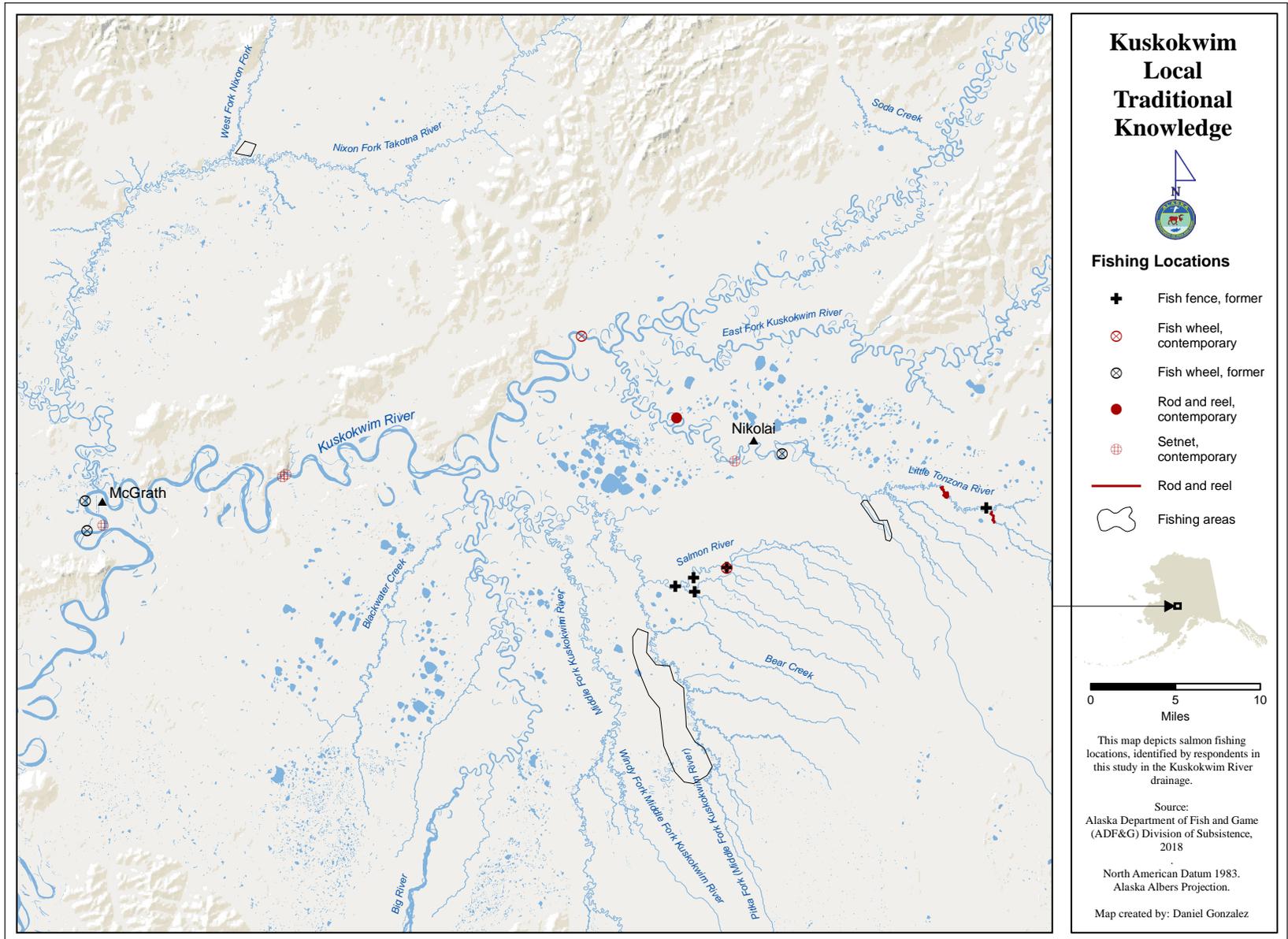


Figure 3-4.—Fishing areas, upper Kuskokwim River.

Another Aniak respondent has also noticed other sloughs traveled by Aniak fishers and hunters have become nearly inaccessible. For example, Discovery Slough has dried out and Whitefish Lake was difficult to access this year (2014):

And you can't get, there's a place you have to turn around, turn back. Even the Whitefish Lake, I went up, even if it was low water we'd make it. But this year we're hitting bottom in the creek. (ANI2)

Physical river changes are part of a "natural cycle," said one respondent, "because the channels are changing all the time. You can go up there [the Aniak River] and see where that channel's been. Some of those trees are probably 200 years old" (ANI4).

Several Sleetmute respondents had extensive experience traveling in the Holitna River drainage. They noticed that water levels have changed over the years:

We had not too much snow up until the last part of, when the heck was that, December, January, January or somewhere around there. They had very little snow after it froze up. And then the low water changed a lot of the channels and now you have sandbars. It's the same way all the way up the Holitna River. We been going up there since our first time in 1993, and the river has changed so much. You can pretty much go on the same route for two years, but the next year it'll be totally [impassable]. (SLQ8)

Another Sleetmute respondent also observed low water conditions in some sloughs, which he said is changing the structure of the river itself:

It seems like we're getting, when it's low water we get really different channels. Some of [the riverbanks are] washing away. It all depends on how much water. When there's high water it really takes out a lot of sand on the banks. Only we used to go hunting up in [GMU] 19B, we went one way and now we have to go a different way. Our lake up there, it's getting dried out. Used to be clear right in front of our cabin and now there's so much grass. It's a trapping camp about in 65 miles or something, 40-something miles upriver. That first slough we used to go in with boat now we can't. It's getting too much sand, willows. Thirteen bends it is. It's got like a horseshoe lake. (SLQ2)

One Stony River respondent discussed access to the Cheeneetnuk River, where he has a lodge. He said that the river is always changing: "And the channel changes a lot. The access is harder some years on the Cheeneetnuk" (SRV3).

Access to the Kuskokwim River's uppermost tributaries is similarly dependent upon water levels. However, several respondents in Nikolai and McGrath who frequent these areas have observed that shallower conditions have prevented access in the past several decades. In the words of one respondent, "it just seems to be shallower than what it was in places. I mean, when we were young we used to go up there and we used to jump out of the boat and float up all those sandbars and start motoring up. It just seems to be getting shallower" (MCG6).

One McGrath respondent was born and raised in Takotna and has frequently traveled between Takotna and McGrath during his lifetime. He explained the impact of water levels on travel:

When the water is shallow, you can't get up there even with a jet boat. Back in the day, my mother and my dad had a 24-foot wood skiff and a ten-horse Johnson on it and I'd haul six barrels of gas up to Takotna. It'd take me two days, but I never had no problem with shallow water. Well, it was shallow, but you just had to know where you were going. As of now, it's way changed. (MCG10)

This respondent recalled getting stuck because of low water during a hunting excursion in 2012. He shot a moose just downriver of the Five Mile Slough, and he and his hunting partner had planned to continue to Takotna.

I walked across the whole river trying to find a channel and there was none. We had to stop right there. Of course, he had his Carolina skiff and they're heavy, you know, water-logged, but we had to stop there and come back down. We were just three bends from Takotna. (MCG10)

This respondent said that traveling downriver has always been easier than traveling upriver, but that this experience was particularly unusual:

Going up the river they might've gotten stuck at some point, but they always either pulled or poled the boat across shallow waters. I've never had to do that. Back when I was a kid, we always knew the channel and there seemed like there was always a channel that even if it was narrow, you'd make it, go, with your boat across that channel through the shallow spots. But never have I seen [it] like at Five Mile, with three inches of water all the way across. There was no channel whatsoever. I've never seen that before. (MCG10)

Another McGrath respondent discussed another area with predictably low water:

There's certainly places when there's low water, like traveling up the Nixon, there's places where you have to know where to go, but it just depends on the water level and those spots haven't changed. (MCG2)

One McGrath respondent said he was worried this past year about whether supply and fuel barges would be even be able to travel there after such a low water year: "This spring was the lowest I've seen it during the time when the ice went out. Remember this summer? We were afraid the barges weren't going to make it this summer. And, all of a sudden, we had that big rainstorm and, oh, no problem, the barges made it up with no problem" (MCG10).

A Nikolai respondent observed that the Salmon River has gotten shallower. He has a fish camp on the river, and, although he can still reach his camp, he can no longer reliably access some areas of the river in summer (NIB4).

### ***Winter Access***

In winter, the frozen Kuskokwim River and its tributaries are often utilized as ice roads and trails for vehicle traffic. Hunters and trappers rely on frozen river conditions for travel to trap lines and hunting areas. Respondents discussed the difficulty in accessing winter subsistence opportunities because of the timing of freeze-up and breakup, poor ice conditions during the winter, and other aspects specific to their local routes.

Respondents observed that later freeze-ups delay opportunity to travel to traplines: "That gives less time to do our trapping, because we have to wait for it to get thick enough to travel on" (SLQ5).

Two McGrath trappers, one currently active and one retired, explained that later freeze-ups and earlier breakups shorten the trapping season. When the retired trapper was active, he said that he could travel on the Kuskokwim River by November 1 with no problems: "Just overflow sometimes, but that wasn't because of warming weather. I mean it was, you know, how it is year-to-year. Snow covers it and then you hit a bad spot and things like that" (MCG2). However, the active trapper described different conditions in the present day:

We can't cross the river as early as we used to be able to cross the river because right now, like 15th of November, barely can cross the river here and there, but then we can't go anywhere...at any rate, because there is no snow. In the spring, the same way. Last year, what was it, the third? No, heck no, it was in late April when our ice broke up, and I've been here on the 18th to 23rd, I think, so the latest of May, when the river has gone out. That a lot. So it's giving us almost a full

two months of river that's not usable, you know, in the spring and in the fall. So yeah, there's a big change. No use through the 15th of October through the 15th of November, and then the same with the spring. There's nothing worse than having no snow and then still crummy ice on the river for six weeks, so nobody can travel. It shortens your season, your harvest season, especially if you're a trapper, or even a wood gatherer. (MCG3)

The timing of freeze-up in the fall and breakup in the spring have significantly limited the time that subsistence users can travel on the ice. A Sleetmute respondent also observed deteriorating conditions during the wintertime, such as an increase in overflow on the river (SLQ7). A Nikolai respondent concurred: "Stuff doesn't freeze. That makes it hard on the trappers because it opens in November and they can't go out anywhere" (NIB4).

These observations were shared by respondents in other communities, many of whom discussed specific traditional hunting or fishing areas that are now inaccessible or difficult to access during winter as a result of overflow, late freeze-up, or other factors.

Aniak respondents discussed travel conditions on the Aniak River and the observation that ice conditions have become problematic and sometimes unsafe: "Well, the Aniak's just not safe like it used to be. You just have to be really careful now," explained one elder with considerable experience traveling the river (ANI4). In the past opportunity to travel upriver in winter lasted several months. Nowadays, ice conditions are unpredictable:

You could never run up the Aniak, that was entirely too dangerous. But you could go across, places where the water slowed down enough to freeze good, there may be a hundred yards on that side of you would be running water and hundred yards on that side would be running water and you'd always stop and check those bridges out. Well, those bridges just don't form hardly anymore. You know, not nearly as often as they used to. (ANI4)

Another Aniak respondent also said that he has observed more open water on the Aniak River than in the past. In late February or early March of 2014, he traveled by snowmachine from Aniak on an overland "cat trail" to the Buckstock River and:

There was a lot of open water between the Buckstock [River] and, they call it, the Red Roof Cabin, which is 17 miles up the river. I was actually up there rainbow [trout] fishing so I was just looking, and there was just a lot of open water to fish and I was able to fish with my fishing pole pretty much the whole way down the Aniak. So, fishing kinda nice. (ANI3)

Nowadays, a respondent explained, breakup is different than in the past. He said that this change to the nature of breakup has affected traditional spring hunting and fishing activities:

The Aniak always used to open up differently than it opens up now. It used to be really cold, we'd have four, five, six feet of ice, and then the Aniak would just cut a channel, just be a little narrow channel and you could run up with outboard or something like that. I don't know long term what that means, but that certainly has changed. It'd depend upon the climate, the weather at that time, but you'd get a week or ten days where you could get in that little channel and run up the Aniak to fish or hunt subsistence ducks or whatever you wanted to do during that time. (ANI4)

River conditions near McGrath have been similarly problematic for winter travel:

But such as now, you can't even go up to the mouth of Takotna River. Big open place right there right now. Takotna River itself is frozen, but you got to go around Old Slough and around Old Town of McGrath and then come back onto Takotna River. (MCG10)

One respondent who grew up in McGrath recalled setting a net under the ice at the mouth of the Takotna River in past decades. However, during the study year, an open lead impeded travel to the fishing area:

That's right at, right at the mouth of the Takotna River right out here we would [set a net under ice]...I went and got [another fisher] and that's where he set it and that's where he said my dad set it, so we play there almost every fall and when the ice gets good enough we'll go across. But right now there's an open lead over there so we're not planning on because we got to go around and, and your hands get cold enough already playing. But yeah, we've been setting net under the ice. (MCG5)

A Nikolai respondent said that later freeze-up near the community hindered travel and access to trapping areas: "We used to go out first day of November to go set traps and everything would be frozen solid but nowadays you can't go out till probably January. Earliest I ever seen the [South Fork] freeze up here is October 12th, you know, early" (NIB2).

## **SALMON ECOLOGY**

Salmon are a critical resource for residents of the Kuskokwim River region due to their historical abundance and seasonal predictability. When salmon return to their spawning grounds each summer, they provide subsistence fishing families with a fresh source of nutritious food, an important cultural activity, and the opportunity to put away food for the leaner winter months. Movements of salmon can vary by geographic location and by species, and successful participation in the salmon fishery requires specialized knowledge about when, where, and how to fish. Many subsistence fishers who participated in this study noted changes in fish distribution, abundance, and quality. This section provides an overview of these changes observed by study participants, especially as they related to seasonal movements, abundance and health, spawning activities, and fish predation.

### **Run Timing**

#### ***Chinook Salmon***

Fishers must know precisely when salmon arrive so that they are prepared to fish. Each year, they must ensure that nets are repaired, boats and engines are in proper working order, and smokehouses or drying racks are cleaned in anticipation of the run. Oftentimes, fishing families must coordinate work schedules or out-of-town visits from relatives who assist in harvest. Knowledge of run timing is based on generations of participation and observations. Subsistence Division staff asked study respondents several questions about the seasonality of Chinook salmon, especially related to run timing and natural indicators of salmon arrival. Subsistence fishers in all communities monitored the arrival of the Chinook salmon run.

Fishers in the study communities said that they are in constant communication with family and friends downstream and hear about the impending arrival of Chinook salmon by word of mouth, a process made simpler with technological advances and the easy availability of internet and cell phones in the study communities. In the words of a Sleetmute fisher: "We usually hear from downriver first, like it's hitting slowly, coming up, and we hear that they catch like in Kalskag. Next we hear in Aniak, next Crooked. And next we know that they are up here" (SLQ5). A Nikolai fisher said, "Oh, we just listen to where they are downriver. They caught them in Aniak, they caught them in Stony, they caught them in McGrath" (NIB4). However, Sleetmute respondents said the only way to know for sure whether salmon have arrived is "by putting their nets in the water and trying" (SLQ1). "I have to fish to know if there's any," said another fisher (SLQ8).

In the furthest downriver the study community, Aniak fishers typically see Chinook salmon in early June (ANI1, ANI3). One active Aniak fisher said that he usually starts to fish earlier than most people in his community:

I start looking for king salmon and I believe that fish are entering the river earlier than Fish and Game thinks. I start fishing earlier here than the other people around me in Chuathbaluk and Aniak. And those first fish are better. They're going further

and they're in nice shape. They're silver, they're fatter and then if you wait for the real king run, when everybody else starts fishing, their quality is much lower. I have tried, I don't always do it but I'm trying to push the envelope and see what's the earliest that I can catch a king here you know. We caught a red [sockeye salmon] one time [in a] set net in May, the 28th of May or something. I beat everybody in Bethel. (ANI5)

Upriver fishers monitor the fishing downriver to gauge when they should put nets in the water. "You can time Aniak about five to seven days and they'll be here," said a Sleetmute fisher, "usually you try to get them at the peak of the run. You've got a window of about five or six days there" (SLQ3).

A Nikolai respondent who once lived in the upriver community of Medfra said that he used to observe Chinook salmon arrive in the first week of July: "Most of the time, I think first part of July. Seems like a little after the fourth of July most of the time, or a little before, somewhere in there, maybe a little bit earlier or a little later on a different year" (NIB1).

Some respondents believed that the first pulse of Chinook salmon arrive in the middle Kuskokwim River before breakup, which would mean that these fish are passing under the ice. Three respondents from Aniak discussed this observation. One Aniak fisher recalled hearing local elders talk about the harvest practice of setting nets under the ice during springtime. He believes that because this practice is no longer common in the Aniak area, fishers are less aware of which fish are passing under the ice than they were in the past (ANI3). Another Aniak respondent explained that local observations have gathered evidence that Chinook salmon travel under the ice:

I bet you I could blow away a lot of theories about the fish. That's something that we've gone 'round and 'round about, that there's fish coming up the river a lot earlier than they think. And last year proved it because those fish hit Crooked Creek and according to their travel speeds they have for king salmon, those fish had to come in under the ice. Because we had late breakup. There was still ice below Bethel June 1st, and there was fish in Crooked Creek by June 10th, June 11th. What I remember years ago, they used to say something about water temperature at the mouth of the river has to be such and such before the fish will come in. No way man, there's fish coming in under the ice. (ANI5)

A third Aniak respondent explained that during the 2013 fishing season, Nikolai fishermen reported catching Chinook salmon in early June:

So we backtracked up 20 miles a day or whatever, all the way down to Bethel. And some of those fish that hit up there were, if you had a late spring they'd be going under the ice. And Fish and Game, they never believed that until last year, it was proven. (ANI1)

A Sleetmute fisher who operates a setnet is often one of the first fishers to put her net in the water each summer right after breakup. She catches a number of species in her net, and is often one of the first fishers to catch Chinook salmon upon their arrival:

As soon as the river drops enough that you're not catching trash, because there's sheefish right away. So even if the salmon aren't there, there's a reason to be fishing. So, we usually have our nets in, you know, we usually, you know, do sheefish and you'd always catch some broad whitefish during that time. They are not as firm as the fall ones but it's still nice to have whitefish in a spring. (SLQ1)

This respondent said that people sometimes get so excited about the news of the arrival of Chinook salmon that they end up burning a lot of gas drifting to ensure that they do not miss the peak of the run:

Usually the first king is caught in this area, when I say this area, maybe between Crooked and Stony. First king would be caught about June 1st and people will burn an amount of gas drifting trying to catch kings, and you know, they might catch

one king every third drift. Pretty soon everybody quit burning gas and you wait until, you know, maybe the 20th and then you start fishing hard. (SLQ1)

Some subsistence fishers look to natural indicators to signal the arrival of salmon, such as the sighting of butterflies or the swirling of seeds from cottonwood trees (*Populus ssp.*; MCG5, SLQ5). A Sleetmute respondent said that people in his community know Chinook salmon are in the river when the butterflies have arrived: “Yellow and black ones, then we know that the salmon are here” (SLQ1).

A Stony River respondent was also taught that the presence of butterflies and change in water quality signaled the arrival of Chinook salmon:

This came from my parents, so we just always thought it was true. They said, ‘if some of the butterflies have come, that means the salmon are here.’ They said, ‘there’s—those are salmon butterflies: the salmon are here.’ [Also], the water, gets dirtier. It turns from a clear color to a muddy color and that’s when we know the salmon are, here also. (SRV5)

One Sleetmute fisher noted that the natural indicators do not provide clues about the run strength (SLQ1). Another said, “There are no indicators predicting a good or bad fishing year. You don’t know until you’re done fishing. That’s, your guess is as good as mine. It’s just mumbo jumbo if anybody tells you any different” (SLQ7).

Multiple respondents have observed increased variability in run timing, which may explain why people were less likely to mention a reliance on traditional natural indicators such as the presence of butterflies or cottonwood seeds. Often, respondents were able to easily recall the previous season, and they utilized that as a baseline for comparison to the current year. For example, one Sleetmute resident stated:

We did notice this year they came early seem like. I mean they had the kings and then they had the dogs and then they had reds all at the same time. The only thing they never had was the silvers. One of few years I’ve ever seen that. They had them so darn close apart that they were catching a little bit of everything in their nets. (SLQ7)

However, a second Sleetmute fisher said that Chinook salmon used to arrive in Sleetmute beginning in late June, but in the past five years or so they have arrived later (SLQ2).

A Nikolai couple said that they used to go over to their family fish camp around the beginning of July in anticipation of the arrival of Chinook salmon, but the timing of the run has changed as have productive fishing locations:

In these last ten years, seems like we’ve had to wait almost a week, half a week to a week, before the fish get there. Whereas before that, we’d go in over and that was just when they got there, usually we got there just when they got there. But it seems late. But we’ve noticed, yeah, where we had to go you know up and down the river, there’s pot holes along where they pool up and we’ve had to go fishing in those, rather than just being able to fish right at our camp like normal. (NIB4)

In contrast, another respondent said that they rely on the predictable nature of the run:

You look for it. I mean, somebody always has a net in the water somewhere to catch something you know, for whitefish or whatever. And then one day, all of a sudden, there’s a Chinook salmon, and ‘oh, they’re here.’ This has been going on for generations, people just know. ‘Okay, it’s June, Chinook salmon are coming. They should be coming.’ (ANI5)

A Sleetmute respondent explained how arrival timing affects the fish he catches in relation to fishing activities downriver:

We usually put a net out there early in the spring to get dog food, to get sheefish. They come up first and they usually show up. An odd salmon could be caught in

the very end of May but you don't get any numbers on them until the middle of June. Then they start showing up and then when they start fishing down around Bethel, they choke off the river, and then the fish disappear. (SLQ7)

Respondents also discussed differences in fish behavior between their communities and communities on the lower Kuskokwim River. A fisher in McGrath observed that at the mouth of the Kuskokwim River, salmon tend to lump together in giant schools. Fishers located in communities near Bethel are able to utilize drift gillnets to easily capture entire schools of salmon in a few sets. As salmon ascend the Kuskokwim, "they're all spread out," this respondent explained. "And there are leaders; there's a few in a bunch in this little pack and stuff. And that's where I see the fishing running up here [in McGrath]" (MCG6).

Many respondents expressed a preference for targeting the first part of the Chinook salmon run because the quality of fish is better:

They look like they're right out of the ocean, some of them [are] silver looking. But I wouldn't say a majority of them, let's say about a quarter of them maybe are really nice looking. And then later when they're really running, they get run down quite a bit. (MCG6)

Another respondent explained the deterioration of Chinook salmon quality in later runs and discussed the relative benefits of targeting other species of salmon:

The reason I target the earlier ones, the percentage of better fish would probably be in the earlier run and I just have never targeted [the later] run. The later kings, there's such a high percentage that are not suitable fish as far as I'm concerned. Their flesh is breaking down, they are soft. So they are more of a hassle to work with. They are great for canning fish, things like that, but for freezing storage fish, the reds are such better quality that they store really well so I like those. The chum, you can get some nice looking chum, but chum do not keep nearly as well as the reds do. And the king the same way, their quality is down enough, but the reds are not. The reds are really a great storing fish and they make an excellent strip. They are not big like king strips, but I like the quality of them. (SLQ3)

Many respondents said they specifically target this early part of the run because the fish are better quality:

When we fish around here we try to fish as early as we can because the later that it is the water temperatures get warmer and the fish begin to spoil. Of course, you know, when they're soft it's just like the silvers [coho salmon] now, you know, they are pretty much spawned out and they're just soft, soft when they first get up in there. We don't do no fishing after. Same with the [Chinook] salmon, you know after that first week of run is a good run and after that they get kind of soft and really sour in the smokehouse. (SLQ6)

However, a McGrath respondent believes that upper Kuskokwim River fishers often miss the early run of Chinook salmon because they use setnets: "Since we have to set in the eddies I think you miss that run because they'll stay right in the main current and head right up the river" (MCG6).

Although many respondents said that they preferred to harvest the earliest salmon, one Sleetmute respondent waited until the peak of the run. "Oh, you'll start seeing them at the end of June, but when I really like to go after them is when people are already catching them in their set nets. That means the bulk of the run is coming in" (SLQ3). This fisher said that the Chinook salmon run can last well into the second week of July, but that people prefer to fish earlier in the summer:

The quality of them is going down rapidly. Most people here want to fish early for the kings because they're the better kings. The early ones are going to far reaches, so those people want those. And then, of course, June is traditionally warmer

weather, drying, so they want to put up their blanket fish<sup>2</sup> and their dried fish at that period of time. (SLQ3)

A Sleetmute respondent said that if they just want to catch a few Chinook salmon, they can put their nets in the water any time between about June 10th and July 10th, but targeting the peak yields the greatest return for the effort (SLQ3). Another Sleetmute fisher confirmed that the run lasts about a month, “but we don’t usually catch that much. We usually just get enough for what we think we need and then we quit” (SLQ2). This fisher said that he harvests more males in the later part of the run (SLQ2). He attributed this to the reproductive cycle of Chinook salmon: female salmon arrive first to the spawning grounds, followed by the males.

A Sleetmute respondent explained that Chinook salmon tend to diminish in quality over the course of the run, in contrast with coho salmon (locally known as silver salmon):

But for catching them here, depending on which side of the river you are, the kings, as the later season, the quality gets less because they are spawning within close proximities of this area. For silvers, they are in pretty good shape, nice fish. (SLQ3)

### ***Other Salmon Species***

Chum salmon typically arrive almost immediately after Chinook salmon, and the duration of the run is similar to Chinook salmon, according to several respondents. Sockeye salmon arrive after the Chinook and chum salmon (SLQ2). One respondent from Sleetmute said that he preferred sockeye salmon over chum salmon: “Well, the main reason is I like the reds better. Because they are better quality fish and they smoke better” (SLQ3).

Coho or “silver” salmon are the last salmon of summer fishing season. Two Sleetmute fishermen said that coho salmon begin to arrive at the end of July and can be harvested “up until ice starts running” (SLQ1). This respondent said that the run peaks near Sleetmute around the first or second week of October, but the quality of the fish declines rapidly and they become more difficult to harvest:

I mean, you’ll still be catching silvers, there’s lots of them, but it’s usually seven or eight a day. And with their small setnet. They are not pretty. But they are there. This is like the second week of October. By then usually ice is running and you got to pull your net. I mean there may be fish there in November, but I don’t know. Your net is collecting ice and you’re crying because your hands hurt so badly when you pick it. (SLQ1)

## **Abundance and Health**

### ***Chinook Salmon***

Nearly every respondent had observed a decline in the abundance of Chinook salmon in their fishing area. Respondents shared observations about changes to abundance in specific drainages, such as the Aniak, Holitna, Tonzona, and others. An Aniak resident described the aerial view of the Chinook salmon run during a recent helicopter ride:

To me this country is, and that river, especially, has become sterile. This summer... it was looking for a little while because of the closures, there were more Chinook salmon going in there than we have seen in a decade or so. But it didn’t last very long. As you see the escapement numbers for Chinook salmon, they are low. Everywhere they are pretty low. It looked good for a while because nobody was fishing. One day, helicopter land here from Donlin Creek, one of my buddies that works back there, I asked him, “Can you do me a favor? Can you bring me for a helicopter ride up Holokuk, I want to try to document the fish, there’s a lot of fish

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2. “Blanket fish” refers to a style of cutting and scoring salmon filets for drying.

in there this year.” So we flew up there a few miles, there were a lot more fish than we have seen, but in the end it wasn’t that much. (ANI5)

A Sleetmute fisher said that the decline experienced in the 1990s was similar, but “it wasn’t nearly as drastic as this” (SLQ1). Two Stony River respondents said that there were fewer Chinook salmon in general in the rivers near their community (SRV3, SRV5). One respondent had observed sharp declines in Chinook salmon numbers in the Gagaryah and Cheeneetnuk rivers, tributaries of the Swift River: “Well, not like they don’t have any, but they have damn few compared to what they had ten years ago” (SRV3).

Two Nikolai respondents agreed that Chinook salmon in the Tonzona River have declined:

That time there was a lot of fish [in the Tonzona]. Where I used to go up there, there was a lot of fish all the time. You might catch six or less [now]. When I used to go up there we used to catch, overnight, we used to catch about 20 of them. Fish net. (NIB1)

The second fisher recalled a time when he could fish the Tonzona River at an area locally known as “The Forks” and catch a plentiful supply of salmon, “I could fish there one night, get 60 Chinook salmon. One hour. Two hours. You have to close in river, throw net across. It’s good for only four or five hours. In the morning, lots of junk go in there” (NIB5).

One McGrath respondent said that as a conservation measure, he stopped targeting Chinook salmon altogether and instead fished for coho salmon: “I quit fishing the Chinook salmon over 20 years ago because the numbers, they were complaining about the number being low. And I noticed the decrease in the numbers myself, so I just quit fishing them. I did my part” (MCG4).

Several key respondents described their observations of the decline and speculated as to possible reasons it has occurred. A McGrath respondent who used to frequent the South Fork Kuskokwim River had observed decreases in both average fish size and abundance:

I just know they were big salmon up there [South Fork] back then. There was good fishing, that’s what we went up there for. I think that’s what happened maybe. We went up there and fished all of them males and females out. A lot of people start going up there and, starting in the 80s. I mean, they caught a ton. Yeah, I know a lot blame it on the commercial [fishers]” (MCG5)

Another McGrath fisher also tied the decline to overharvesting:

Why the fish aren’t there? The countryside looks the same, the weather’s changing, but are the fish getting here and not spawning or are they getting caught out in [the ocean]? It’s so tough to say. I almost in my mind figured it was just overharvesting out. (MCG9)

Besides the decreased number of Chinook salmon in the Kuskokwim River and tributaries, respondents discussed the decreased size of individual salmon harvested. A Nikolai fisher typically likes to reserve the larger Chinook salmon as “drying fish,” and the smaller ones as “eating fish at camp” (NIB4). However, this fisher has seen fewer fish over 20 lb in recent years. He said, “if all we can get are the small ones we’ll cut those” (NIB4). A Sleetmute respondent described the diminished size as more memorable than the decreased strength of the overall run:

The thing that sticks in my mind more than the drop in the numbers was the change in size, that we were not getting the big females and males. Catching 40-pound kings in my little five and a quarter inch net. We weren’t catching lots of them, but boy, you know, 40-pound king’s a lot of king meat as compared to a six-pound jack. (SLQ6)

An Aniak fisher recalled his father having trouble hauling 40 to 60 lb Chinook salmon into the boat, but he said that catching fish of this size is rare nowadays:

Now, pretty much the average fish I see is anywhere between 15 and maybe 35 pounds is the biggest one that I've seen. So there's definitely a big, big decrease in size. I mean even the little kings, the 15- to 20-pounders, back then, would give that net hell. But now, it's just nice and soft. (ANI3)

A Stony River respondent recalled harvesting Chinook salmon that were three and a half feet long, "really big ones that we could hardly lift into the boat," but it has been at least a decade since she has seen salmon that size:

The kings are definitely smaller than they used to be. Well I haven't hardly seen any big kings this way for many years now. At least the past ten years or so. And I remember when my daughter was five she was, I don't know how big. But, the king salmon were as big as her. And I haven't seen that for many years. And we're lucky to get king salmon that are like that. (SRV6)

Several fishers noted that they are now harvesting more small Chinook salmon, locally known as "jack salmon," than in the past: "Yeah, a lot smaller kings, they're jack, a lot of jack salmon lately" (MCG6). According to another fisher, jack salmon are "Those young ones. It's just a small king salmon" (MCG4). The average length of a jack salmon is about 18 inches, said one respondent, "maybe a little less. Say, I caught 20 kings, if I caught 20 jacks and if I caught twenty 40-pound kings, that's a huge difference" (SLQ1).

A McGrath fisher estimated the start of the size decrease:

Oh boy. I think the first time we caught a small [jack], gee, that must be 20 years ago. That's the first time ever seen one, and, I think, right about then it was starting. I don't fish a lot, but I'm saying that about that time we used to catch big salmon, you know? And then after that it seemed like they got smaller. (MCG5)

A respondent in Stony River wondered why large Chinook salmon are still caught downriver by subsistence fishermen, "in Bethel. But up here we don't get that kind of big Chinook salmon. They never reach up here. Why is that we don't get those big ones like that?" (SRV2).

In 2014, a restriction required fishers to use a four-inch mesh on a 60-foot long net, but one Aniak fisher had his made of monofilament with a regular salmon cork line, a combination that he referred to as "deadly." He was conflicted about its use:

Everybody has stories about them 80-pound kings. But this summer, we seen big kings up here, which we don't usually see because they all get caught in the lower river with eight-inch gear when it's wide open. But this year my daughter got to see it, she never seen it in her life yet, she's 24 years old. We were allowed to drift up here with four-inch, 60-foot net...So I ordered one from Donaldson's and the first question they asked me, "You want it hung for salmon?" And I said, "What does that mean?" And they told me, and I said, "Okay yeah." Because it'll last longer for one thing. One of those little light whitefish nets gets ripped to pieces you know. So I drifted with that thing and it catches everything. I never caught suckers in a net before drifting. In any typical drift, I would catch suckers, whitefish, chums, reds, sheefish, and kings. And big ones. I sunk that 60-foot net down there...one big king after another...I tell my wife, I'm not going to do this anymore, this isn't what subsistence is about. I said I'm going to start keeping them, those guys downriver are keeping all the ones they get in their setnets, you know. I had friends that got 80 king salmon. And my daughter sitting there [said], "You can't do that! You'll be a hypocrite!" [I told her], "Okay you come with me and you see how it is." So we go out there, and we throw the net out, and right off the bat, boom. Two-thirds of the way out, 40 feet out in the net, ten floats go down. We pull out, there's a 60-pound king salmon. She's never seen that in her life and she's in awe. She's in

awe, and I'm looking at her, "You want me to let go? You want me to let it go?"  
"You got to!" (ANI5)

Respondents were also asked whether they noticed any behavioral changes in the Chinook salmon in recent years. A few had observations, such as this Sleetmute respondent who said that she has noticed a change in "how lively the fish are:"

Seems to be associated with the water temperature. So when the water temperature is higher, the fish dies more quickly in the net. Like at this time of the year [when it's cooler], almost every fish in the net is not only alive but flopping and biting and snapping like you just got in there, but you know that some of them been there overnight. So it seems to be a water temperature-associated thing. (SLQ1)

### *Other Salmon Species*

Although researchers and respondents were primarily focused on the decline of Chinook salmon, respondents shared observations of changes in other salmon species. Several respondents noted an apparent increase in the number of sockeye salmon.

The red [sockeye] salmon, when I first came to Aniak 1967, if you saw a red salmon spawning up the river you remembered where it was because you know they're so pretty with their green heads and their bright red bodies and stuff. My parents used to come out occasionally and then I'd have friends come out, I'd always take them to where I saw these reds spawn just so they could see them in the clear water up there. And then, Fish and Game could give you this information, we just had an explosion in their numbers up there. We never used to have very many reds up there at all. We have good numbers of reds going up the Aniak River virtually every year now. I don't know what's brought that change about, but that allows people down here to get more fish than they've gotten in the past. (ANI4)

A Sleetmute fisher has noticed that fishing nowadays requires more effort, a signal to him that there are fewer fish available to harvest: "Long ago when we used to go fishing, we used to make two drifts. We used to catch about 250 fish. Nowadays we get lucky just to get maybe five in one drift. Kings, dogs, reds, silvers" (SLQ2).

One respondent observed that the health of the chum salmon appeared to decline faster than normal during the 2014 fishing season:

When I had checked, I said, 'man these dogs are getting kind of rotten early this year. When I caught some, I said, "Look at this, its head's already got mold on it already." And I said, "Whoa, this is pretty fast this year for that." And that was before they even start spawning and stuff like that, and I said, "Yeah, that seems pretty early." (SLQ4)

A respondent in Aniak who has been fishing in the region for over five decades observed a noticeable decline of the fall chum salmon run:

There used to be [a second chum salmon run] I think, I think there used to be a good number of chum that came in the fall but I don't see them anymore like I used to. Like I was up the Aniak River fishing last night with my grandson, I saw some chums up there that I think are fall run chums, but they don't seem to come in the numbers they used to. It used to be in the fall time we'd get some pretty bright chums that were really good eating...They may be coming back now but I haven't spent that much time on the river in the last couple years to see. Well, I got here in 67, and I'm going say that for at least 20 or 25 years after I first got here I felt like we had a bit of a fall chum run. And what made me think that is that the chums would just be so fresh looking like they, they're not, they've been freshly out of the ocean you know. And then they suddenly seemed to drop off, we weren't getting

them at all, you know. So I think that's, they may be coming back 'cause I did see some yesterday. (ANI4)

A McGrath respondent felt that the coho salmon population may be rebounding after mining decreased in the region:

When I was flying up with my brother-in-law when I was 19 and 20, maybe even, yeah, later than that, we flying around and up there in the lakes you could see, I don't know what kind, I forgot what kind we saw there. Silvers maybe they were beaucoup up there, in the lakes, but I only see that maybe once or twice when we were flying up there in the mountains. Well, didn't, when the big, when all the mining was going on, didn't they block the Takotna River off completely... They just blocked, yeah, cause it's a slow-moving river really, so you just block it off with a bunch of, you know, like they do with willows and sticks and everything, I heard they did. And then they just and that's the reason why they say, some people say we don't have the salmon run we used to. And then...it seems like the silver, they're really coming back because we never used to catch silvers by rod and reel up the Takotna River until eight, ten years ago. And maybe they weren't aware of them all of the time, I don't know. (MCG7)

## **Spawning Areas**

Respondents had varying knowledge of spawning and rearing areas. Subsistence fishers prefer to harvest salmon in prime condition and while they are still in the mainstem of the Kuskokwim River or further from spawning areas. One key respondent from Sleetmute described the varying quality of salmon away from the mainstem:

The mainstem is always be best fish. Yeah, the tributaries, they are going up to spawn. The Holitna, you can go 40 miles up and you can still catch decent kings because they are going a long ways yet up the Holitna. There will be a percentage of them, a percentage of the ones that are weak, the ones that are going to spawn in closer proximity increases, you know. The percentage of salmon...to eat, diminishes. I caught them at the mouth of the Hoho [Hoholitna River] there, one will be really pretty nice looking fish and the other will be weak. (SLQ8)

Many critical spawning areas are located in tributaries, and several respondents discussed observations of these areas during late summer or fall months while traveling or pursuing other subsistence activities.

This section discusses respondent observations of salmon spawning and rearing areas, including changes to tributaries, barriers to passage, and others. This section is organized by critical salmon spawning tributaries as discussed by respondents. Spawning locations of Chinook salmon and other species as identified by respondents in the five study communities are portrayed on figures 3-5 and 3-6. Occasionally, key respondents reported spawning locations in a general area by circling the locations; in these cases, waterways are highlighted within these more general areas.

### ***Mainstem Kuskokwim River***

One Aniak respondent said that fishers commonly understand that salmon that travel on the north side of the Kuskokwim River are destined for more distant spawning grounds. The salmon that travel on the south side are going to the lower tributaries, including the Eek, Kwethluk, Kisaralik, Tuluksak, and Eenayarak rivers. The respondent indicated that these observations have been confirmed by research<sup>3</sup> conducted in the region:

They did a study, tagging fish at Lower Kalskag. First, they did some tagging below Kalskag and they brought two wheels; one on the south side, one on the north side. And sure enough, the salmon that are coming up to the headwaters

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3. Stuby (2007) observed bank orientation by tagged Aniak River-bound salmon in research that used fish wheels and drift gillnets to estimate Chinook salmon abundance and to evaluate run timing and spawning distribution.

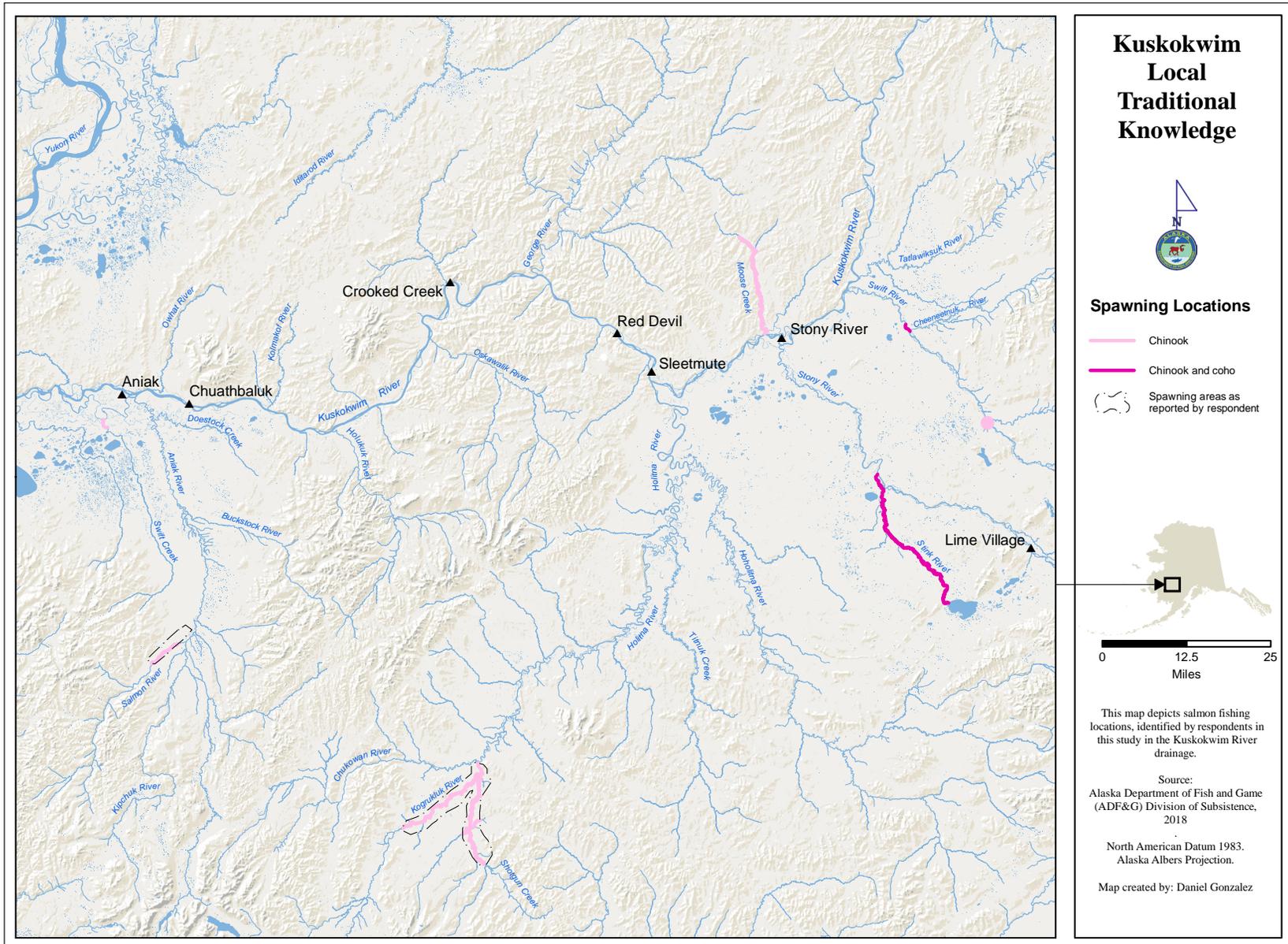


Figure 3-5.—Observed Chinook and coho salmon spawning areas, middle Kuskokwim River.

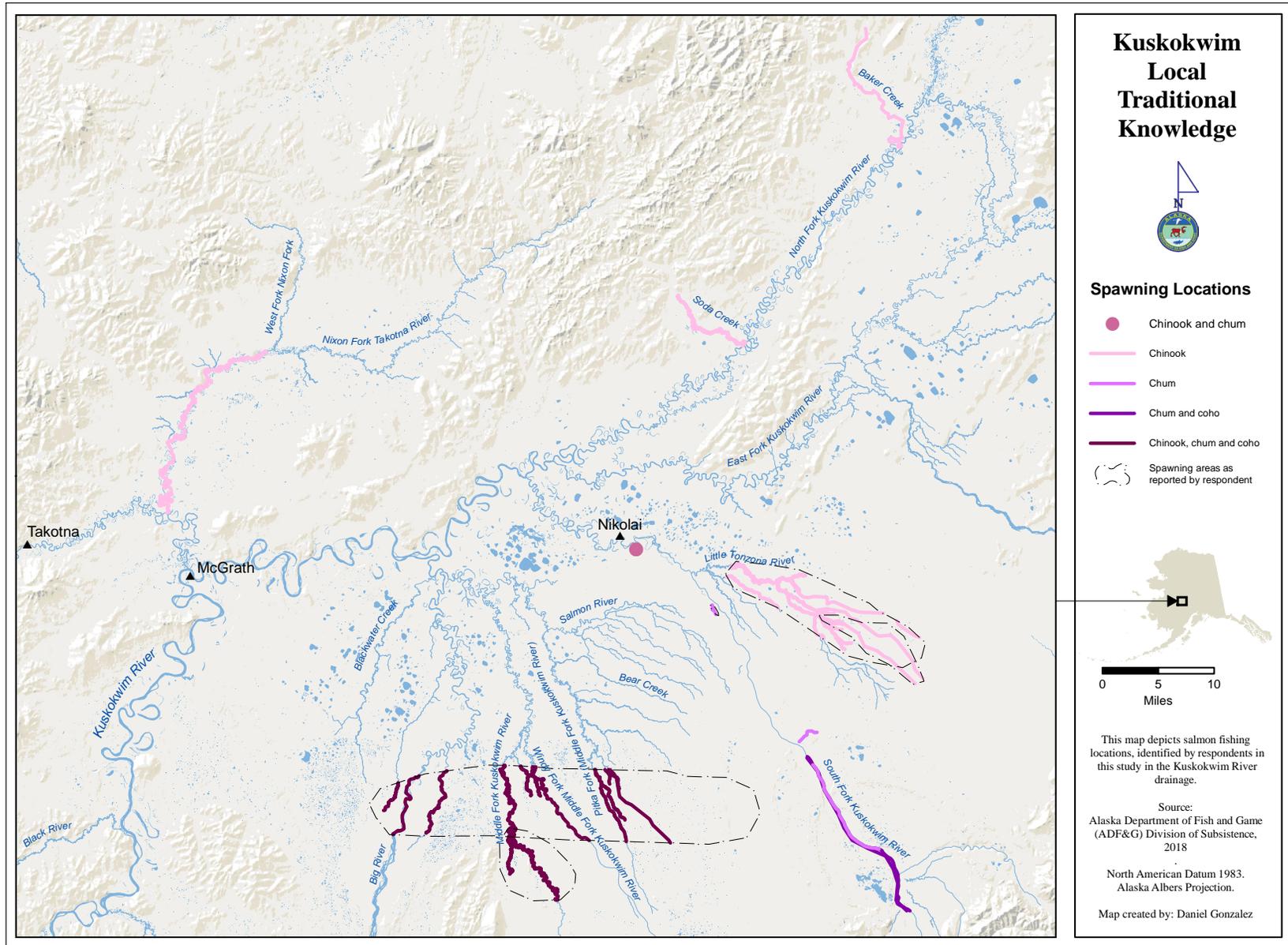


Figure 3-6.—Observed Chinook, chum, and coho salmon spawning areas, upper Kuskokwim River.

come up first and they're always on the north side, because they have a long way to go...and the ones by the south side are going shorter distance and they change color as soon as they hit the river. (ANI1)

### ***South Fork Kuskokwim River***

A respondent from McGrath noted changes to spawning numbers near the community:

Around the South Fork and stuff you'd used to have some pretty good runs where all the bears would congregate and stuff. I remember taking [name removed for privacy] up there on the Middle Forks, Pitka Fork. There used to be lots of real nice holes where the salmon would be and you don't see 'em lately but, I don't know why...It's always late fall so it's, you know, at end of September, first part of October where you'd see those pools I mean hundreds and hundreds, and just these deeper pools and the bears come out and eat 'em. Late enough in the year, I think it must have been not Chinook salmon you know, something else. (MCG9)

### ***Stony River***

Stony River respondents reported seeing spawning activity in number of waterways near the community. One respondent indicated that the quality of the fish is tied to the distance they have to travel to spawn:

And then accidentally found out about the Gagaryah [River]. That's another hot spot. When these fish make it up to the Gagaryah, they're in their prime. They're the strongest, they're just nice looking fish. Only the strongest make it up there. (SRV5)

This respondent also recalled seeing salmon fry at the mouths of the Sunitna, Tatlawiksuk, and Gagaryah rivers when he was a child: "It looks like they're tiny little salmon, small ones. Bunches of them...We've seen them year-round. Just not as much as we used to" (SRV5).

Another respondent reported observing spawning behavior in small creeks flowing into the Swift and Gagaryah rivers:

We never go much outside of Swift River, much, just Gagaryah...They're [spawning] in the cricks around here when it gets shallow, head up around in here...They start to spawn I see in that, roll around on the bottom, clear water. It's just gotta lay eggs around there. And them things, towards winter time they dry. We see [the eggs] in beaver hut, beaver dam. (SRV2)

### ***Aniak River***

Respondents in Aniak had a variety of perspectives on spawning locations and changes to numbers of spawning salmon in the Aniak River. One respondent tied a decrease in the run size to traffic on the river:

The stench, the smell in the river when they all start to die and stuff and then the number of birds I think is, you know you just don't see as many birds as you used to. You don't see marten and ermine feeding on the fish carcasses, you know. When you're guiding people, you're sitting in these back sloughs and stuff and you get, you have time to make all these observations. And you just don't see the fox, that's another creatures that depend on 'em, you just don't see the numbers that you used to see. But there could be the reason for that...could be the traffic on the river now. It used to be that there wasn't nearly the traffic on the river. (ANI4)

One Aniak respondent said that each year he travels up the Aniak River up to Hoken [Doestock] Creek<sup>4</sup>, but always stops when he reaches the first logjam, typically about four or miles upstream of the junction with the Aniak River. He does so in order to not disturb spawning fish:

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4. The local name for Doestock Creek is Hoken Creek (ANI1).

And that ‘Y’ ...it’s like a nursery where the salmon are spawning all over that area and they don’t want anybody disturbing them. And they said it’s like if you had a newborn baby in your house [and] some drunk come in there and start raising hell in their house. Who’s going to get pissed off? Mom, dad, everybody else in there. And so that’s what happens to the salmon. You disturb them and they’re going die, I mean, you’re going to hurt their spirit, their mind, and heart. And they say, “Heck, it’s no use being around here. We’re not going to come back next year.” That’s the connection the people had with the food source: that if you mistreat it, [the salmon are] saying that “Well, we’re causing these people to have fights over this that and the other, so we’re not going to come back next year.” (ANI1)

Another Aniak man has observed changes to the Aniak River, especially sloughs that are no longer accessible where he used to witness salmon spawning:

I mean, before we used to be able to drive super close to the beach. I used to get like holes in my waders from walking through spawning beds and like the red [sockeye] salmon coming up and like nailing me. The red salmon are pretty aggressive. I just really don’t see that, you don’t see that anymore. A lot of the sloughs, a lot of the back sloughs and stuff on the Aniak are now dammed off. (ANI3)

Some Aniak respondents described how the sloughs and tributaries of the Kuskokwim River are constantly changing. A beaver dam or sandbar could block a free-flowing slough, creating a dead end slough: “And those are full of [salmon] carcasses. And then the predators are there: the rainbows, dollies, pike, sheefish are there, going crazy in those areas” (ANI3).

### ***Near McGrath***

McGrath respondents mentioned two common themes: observations of coho salmon spawning grounds and an increase in the amount of coho salmon in the area. One respondent from McGrath mentioned spawning areas on Fourth of July Creek:

Yeah, there’s more salmon going up headwaters of Takotna than ever, that’s what I was told. Might be, yeah, last couple years...I caught two silver [coho] salmon right at Fourth of July Creek, and that was years ago, and my dad showed me where they were spawning, years ago, I was about nine years old or something. (MCG5)

Another respondent commented on the number of coho salmon on the upper Kuskowkim River and had also seen evidence of their spawning behavior:

The West Fork is where the gravel starts. I mean...that’s where you’re going to start seeing the silvers [coho salmon] pooling and, and being there in September for spawning, August. First, even on the Takotna, there’s a lot of silvers that run up the Takotna and go up, up the Takotna as well as up the Nixon, and uh, the first gravel you see is at The Forks there, on the Nixon. Yeah, at The Forks, here. (MCG3)

## **MANAGEMENT**

The interview protocol specifically asked respondents about whether they had any comments or concerns regarding management of the Kuskokwim River Chinook salmon fishery. Responses were varied and informative. A few respondents were former or active members of local fishery management working groups. The most commonly referenced topics were downriver commercial or subsistence fishing and Bering Sea bycatch.

### **Downriver Fishing**

Several respondents felt that fishers downriver, particularly in the Bethel region, were affecting Chinook salmon populations due to heavy harvesting. One respondent had this to say about Bethel and other communities along the lower river:

You can't have a population that size choking off a river. That's reality. It's not the State depriving people or anything. It's just you have a population base of, what, twelve thousand people congregating around the city of Bethel, you can't have an unrestricted fishery around there. It doesn't work. Up here there's nobody left up here. That and it's obvious that you have something going on in the ocean but the river's the only place you can control anything, so that's where you have to start. You need to start managing the lower river there. You know you put a, you have a commercial opening down around Bethel and four days later, five days later there isn't a fish up here. (SLQ7)

Another respondent had a similar view and associated it with the sheer numbers of salmon harvested by households closer to the coast:

Our biggest argument up in this area is you take your fish reports that they used to send out, remember for [each] community how many fish, different species that you catch. You look from Akiachak down to the coast. One household is putting like 200 king salmon for their subsistence use. Now do you think salmon's going to deplete? I mean, do you need 200 king salmon, 200 red salmon, 200 silvers per household? You're going to have to eat breakfast, lunch, and dinner to eat all your fish that you subsisted for. They need to take that into consideration. (SLQ6)

Some respondents blamed commercial fishing opportunities downriver for the decline of Chinook salmon populations. One respondent felt the current decline of Chinook salmon is directly tied to the past commercial fishery:

There has, there's been a gradual decline in the kings, definitely. And I certainly associate some of it with the commercial king fishery back in the '80s. But it's not like when we stopped doing it, they suddenly picked back up again. They continued to decline, and of course the latest years, it's become truly disconcerting because we're not anywhere coming close to meeting our escapement numbers. Especially not on the Kogrukluk, which...was a huge percentage of the salmon in the Kuskokwim spawn in the Kogrukluk or in the Holitna drainage. And that was very disconcerting to know that they were not going to meet escapement this year. (SLQ1)

Another respondent hailed the benefits of delaying the commercial fishery for a period of time to protect the Chinook salmon run in 2014:

Well, it is for sure this year, nobody got enough king salmon that they wanted to, so they had to get something else. People sure, people in the middle and upper sure relied on the silvers this year. That's why we fought so hard to keep them from commercial fishing and it was good and it worked out in the end. In the end it worked out to be a win-win for everybody. People up here got a lot of fish, they took advantage of it, like my uncle in Kalskag, he put up 95 silvers. And then they had commercial fishing, they had several periods and people got to make money. I certainly know the economic value of commercial fishing, but this year, man they needed to let the people get their food. Before they start hammering them...I don't think people are going to make up less king salmon by, I mean it's like, if you don't get all the apples that you want, are you going to buy bananas instead? (ANI5)

Another respondent felt that fishing pressure in general has had a negative impact on Chinook salmon, both in the past and currently:

I think, that had a lot to do with it; fishing pressure. Commercial, and you know it was, it was the commercial plus the subsistence use plus the sport use, it was all three of them combined. You know, I can't say "It's because," but I say commercial had a big part. It's all three. (ANI2)

## Bering Sea Trawl Fisheries

They're catching the salmon; they're catching the food of the salmon. They're also scraping the bottom of the food of the fish that the salmon feed on. People don't realize that vicious cycle of when you're trawling, you're scraping the bottom, you're not only catching the fish, you're disturbing the food source of the fish that salmon, that the salmon feed on. (ANI1)

Several respondents discussed anxieties about the Bering Sea pollock fishery's multidimensional effects on the Kuskokwim River subsistence salmon fishery, especially on the Chinook salmon fishery. Most commonly, respondents discussed the harvest of Chinook salmon as bycatch by commercial trawlers in the Bering Sea. Subsistence fishers along the Kuskokwim River have long expressed concern about the role of allowable bycatch in the overall abundance and of Chinook salmon and other salmon species.

Commercial fishers catch and discard bycatch for a variety of reasons: they may be unable to sell, do not want, or are not allowed to keep a type of fish.<sup>5</sup> The Magnuson-Stevens Fishery Conservation and Management Act requires that bycatch be "minimized to the extent practicable," and the Bering Sea pollock industry has made some efforts to develop a Chinook salmon excluder device that allows salmon to escape from a trawl net underwater without affecting catches of pollock. Additionally, in 2011, the North Pacific Fishery Management Council implemented a hard cap on the number of Chinook salmon that can be taken as bycatch, as well as programs aimed at addressing the bycatch situation (NOAA, North Pacific Fishery Management Council [*n.d.*]).

A lifelong fisher from Aniak said that the Chinook salmon population was already declining in abundance when trawlers began harvesting pollock off the coast of Alaska, but felt that the decline increased after the fishery began: "You could see the steady declines, and all of a sudden, I don't remember when, the first trawlers start getting to the salmon bycatch" (ANI1). The peak of the bycatch occurred in 2007, he said, with an estimated bycatch of 140,000 Chinook salmon, but he questioned the veracity of this estimate.

That, they say that was counted and reported, but who knows? It could mean ten times more than that. There's no accurate record...and who are the people, and who paid the people who are the observers on deck? The industry, not the government. So, who do you have loyalty to when you get paid? (ANI1)

A Nikolai respondent also felt that trawling in the Bering Sea had the biggest effect on the Chinook salmon run, but that its effects, combined with commercial fishing near the mouth of the Kuskokwim River, were only recently being felt:

The biggest, I think the bycatch, deep sea fishing. Ever since they started bottom fishing that's when the fish start going down, and now we got a real way down, depleted our fish. And I guess the number of fish had never affected us before, but the people are, the number of days that it's open down around the mouth of the river is one that they clean it out before it gets up here. And that affects us. I guess we hadn't noticed it because there's always been a lot of fish before the bycatch, before they almost clean it out. (NIB1)

Another respondent felt that bycatch by trawlers has affected both Chinook salmon abundance and the ecosystem as a whole:

It's not here and with the climate change you have the advent of industrial fishing in the Bering Sea with pollock herring. You've altered the food chain there. That's what's happening to the fish here. (SLQ7)

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5. National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service, Alaska Regional Office. n.d. "Bycatch and prohibited species catch (PSC) in groundfish and shellfish fisheries." Accessed October 4, 2018. <https://alaskafisheries.noaa.gov/fisheries/bycatch-reduction>

One McGrath respondent summed up the local need for Chinook salmon for subsistence and its importance to the region. He explained that selling fish for customary trade by residents of the river helps the subsistence economy, and contrasts this idea with the negative impact of Bering Sea trawlers:

To me, subsistence is more important than commercial. That's the way I, it's more important to, when you got those big companies, they don't care...They're selling it for money. Most of the people that are on the river are doing it for subsistence, and even subsistence, commercial subsistence too, I mean, if they can make strips and sell them, and to make, not to get rich from, but to help them make ends meet, I don't see any problem with that either because jobs are scarce. People need that income, they need that fish. (MCG4)

Overall, key respondents in the five study communities offered varied and valuable insight into a number of important topics, including perspectives on the Chinook salmon decline and potential causes of this decline, observations of species behavior and environmental change, and concerns over management of the subsistence fishery. Their insights are poised to provide valuable context and insight to resource management, conservation education, and environmental assessment.

## 4. DISCUSSION

Residents of the Kuskokwim River drainage have long depended on salmon species as an integral part of their subsistence diet, and Chinook salmon hold particular importance. As mentioned earlier in this report, the Kuskokwim River is, historically, Alaska's largest subsistence Chinook salmon fishery, and sharp declines in Chinook salmon abundance have affected fishers throughout the region. The purpose of this study was to document local and traditional ecological knowledge (LTK) of freshwater systems on the middle and upper Kuskokwim River with attention to spawning grounds, juvenile rearing habitats, and environmental factors that affect salmon migration and reproduction. Key respondents discussed a number of major themes, including observations of Chinook salmon behavior and environmental change, perspectives on the decline of Chinook salmon, and potential causes of the decline, and concerns over management of the fishery. Many of the environmental observations shared by key respondents in this study bear marked similarity to LTK gathered in 2010 and 2011 in six Yukon River drainage communities: Grayling, Nulato, Koyukuk, Allakaket, Fort Yukon, and Northway (Andersen et al. 2013). The discussion will explore these similarities in the topics presented below.

### **ENVIRONMENTAL CHANGE**

Key respondents in the five study communities shared observations of environmental change including changes to local temperature, timing of breakup and freeze-up, landscape and vegetation, and river conditions. Although some of these topics were not directly tied to changes in fishing patterns in the region, others were perceived as affecting the subsistence fishery in terms of access or salmon behavior; these topics included water levels and precipitation, earlier breakups, and erosion and deposition.

### **Water Levels and Precipitation**

Key respondents cited water levels, influenced by both lower snowfall in the winter and rainier weather in the summer, as affecting access in terms of travel as well as influencing fishing decisions. According to some respondents, low water levels impede access early in the fishing season particularly in sloughs and certain tributaries of the Kuskokwim River. In a 2010–2011 Yukon River study, community residents reported a high level of consensus that low water levels have affected subsistence practices, particularly access to traditional hunting and fishing areas (Andersen et al. 2013:35–36). Respondents in the Yukon River drainage study did not discuss the effects of high water in detail, although one Grayling resident did indicate that ice jams during breakup have increased high water and flooding in their area. In contrast, some Kuskokwim River key respondents did tie increased summer rainfall to high water conditions, which cause debris in the river to become entrapped in nets. Although some respondents observed changes in fishing success related on water levels, most felt that salmon movements were not affected by water levels. Respondents also cited increased rainfall as a hindrance to fishing in terms of processing decisions; some respondents indicated that they fish less during rainy periods due to the fear of spoilage when drying and smoking salmon. Key respondents in the Yukon River drainage TEK study shared less agreement as to whether there has been increased summer rains in their region; residents of Fort Yukon and Allakaket felt that summers were drier in their area, while Grayling and Northway residents reported wetter summers (Andersen et al. 2013:22–25).

### **Earlier Breakups**

Many key respondents mentioned the timing and character of spring breakup on the Kuskokwim River. Nearly all interviewed fishers felt that breakup is generally occurring earlier than it has in the past and that the nature of breakup has changed due to thinner ice and warmer temperatures in the spring. Yukon River drainage study communities also pointed to significantly earlier and less dramatic breakup conditions (Andersen et al. 2013:28–29). Some Kuskokwim respondents connected the timing of breakup with the timing of the first pulse of Chinook salmon, observing that salmon run earlier when breakup occurs earlier. These fishers felt that warmer water temperatures have signaled Chinook salmon to make their way upstream earlier. Key respondents in the Yukon River community of Grayling also noted the effects of water

temperature on salmon movements; they indicated that salmon runs are less predictable recently and tied the movements of salmon to the timing of breakup. Fort Yukon respondents, in contrast, said that Chinook salmon runs are later now than they were in past (Andersen et al. 2013:67–68). Kuskokwim respondents tied later breakups to later Chinook salmon runs, however respondents were unclear as to whether the fish run later or if fishers must simply wait for an opportunity to fish in ice-free waters.

### **Erosion and Deposition**

Many Kuskokwim River respondents observed that warmer temperatures have caused an increased rate of erosion due to more rapid thawing of permafrost. Respondents offered varied perceptions of the effects of erosion in recent years: some areas of the river have widened significantly, sandbars have greatly increased in size, and riverbanks have become steeper. Some fishers indicated that traditional fishing locations have been altered, and once-productive eddies for setting nets have disappeared. Although respondents indicated that some fishing areas do become less productive over time, they stressed that the current more rapid changes to the landscape make fishing for salmon more challenging. In the 2010–2011 Yukon River drainage TEK study, key respondents in all study communities also observed that riverbank erosion was increasing and had negative effects on camp and fishing locations (Andersen et al. 2013:40–41) (Anderson et al. 2013: 40–41). Likewise, respondents also noted an increasing number of sandbars in their regions.

### **SALMON ECOLOGY**

Key respondents across the five middle and upper Kuskokwim River communities shared varied perceptions of changes to fish distribution, abundance, and health throughout the region. Although a majority of these discussions centered around Chinook salmon, some respondents also shared observations about other salmon species that they target during the summer fishery. Major topics included seasonal movements, abundance and health, and observations of spawning areas.

#### **Seasonal Movements**

Fishers in all study communities explained that they maintain close communication with family and friends downstream to obtain news about the arrival timing of Chinook salmon. As mentioned above, several respondents felt that the run timing has shifted earlier due to earlier breakups in recent years, however there was no agreement as to whether this shift is consistent in nature. In contrast, some respondents felt that Chinook salmon were arriving later to their fishing locations, however a few tied this change in timing to fish behavior such as pooling in deeper sections of the river on their way upstream. Key respondents in the Yukon River communities of Grayling and Koyukuk also noted the potential for changes in salmon movements due to increasing water temperatures. A Grayling respondent felt that the salmon are likely staying in the main channel of the river due to warmer water temperatures instead of traveling along the bank of the river as they usually do (Andersen et al. 2013:67). A fisher in Koyukuk observed that Chinook salmon appear to be traveling deeper in the water column in search of colder water (Andersen et al. 2013:68).

#### **Abundance and Health**

Almost all key respondents observed a decline in Chinook salmon abundance in fishing areas near their communities, and some have decided to no longer target the species as a conservation measure. Fishers in the middle and upper Kuskokwim River also pointed to a decrease in the size of Chinook salmon; many explained that they used to catch much larger fish decades ago. Some Yukon River drainage key respondents also noted that Chinook salmon seem to be smaller now in comparison with the fish they harvested in the past (Andersen et al. 2013:63).

Some respondents mentioned changes in abundance of other species of salmon. For example, several noted an increase in the number of sockeye salmon. A few McGrath respondents felt that the coho salmon population has rebounded after mining activity decreased in the upper Kuskokwim River region.

## Spawning Areas

A few key respondents had varied observations of spawning areas near their communities, and these observations were of spawning behavior in general and not often species specific. One respondent explained that the movement of fish at the mouth of the Kuskokwim River is indicative of the general area where they spawn; fish on the south side are going to lower tributaries and those on the north are destined for more distant spawning grounds upriver. Others noted that they had seen less spawning activity near their communities than was common in the past, including the Aniak River and areas near Stony River in the mouths of the Sunitna, Tatlawiksuk, and Gagaryah rivers. For coho salmon specifically, McGrath respondents observed spawning grounds near their communities and also noted an increase of coho salmon in general.

## PERCEPTIONS ON THE CAUSES OF CHINOOK SALMON DECLINE

Key respondents did not agree about which factors have contributed to the decline of Chinook salmon in their region, and several explained that they were simply unsure as to the causes. One theme that emerged was concern about overharvesting, both in terms of subsistence harvest in the lower river and, more commonly, commercial harvest. Some respondents explained that they felt that the sheer size of the subsistence harvest in communities closer to the mouth of the Kuskokwim River had contributed to Chinook salmon decline; they pointed to the population density in lower river communities as compared to the middle and upper river, especially the community of Bethel. A few respondents indicated issues with commercial fisheries in the lower river, but many more cited concerns over the effects of Chinook salmon bycatch by Bering Sea pollock fisheries. Overall, all key respondents indicated the overwhelming importance of Chinook salmon's contribution to subsistence diets and the struggles brought about by declining populations. As one key respondent explained, the decline of this resource has had cascading implications to the region:

Because of the fish population going down, it's not only affecting the fish and the wildlife, it's affecting the people as well. People don't let their kids play out as much. They avoid night time. We've had bears running across our yard, on the island, on the road. There's not enough fish or berries, they're coming to the villages and going through the trash dump. I don't want to see them get shot for no reason and that's what's happening now. So the fish population is affecting everything and everybody, it's just like a chain reaction. So that's why I'm helping you. I want to find out why they're declining. (SRV5)

## ENUMERATION PROJECTS

One of the objectives of this research was to consider the ethnographic data documented as part of this research alongside area enumeration projects in an attempt to understand potential connections between or convergences in the data. In the late 1960s, ADF&G identified the need to improve its precision in estimating salmon escapement and run sizes in support of more effective management strategies. Managers formerly relied mostly on aerial survey counts for escapement estimation; however, in the early 1970s they shifted their emphasis to the use of counting towers or weirs on what were perceived to be the key spawning tributaries for the two species of greatest commercial importance: Chinook and chum salmon (Jonrowe et al. 1977). Managers had the additional goal of establishing a long-term escapement monitoring program by using weirs in highly productive tributaries paired with continued aerial surveys in other smaller headwater streams (Head and Liller 2017). Department research staff selected weir sites based upon several criteria including the known or perceived importance of the stream to the spawning population of interest and the feasibility of successfully operating a weir at the locations they identified.<sup>1</sup> Weirs in the Kuskokwim Management Area have included sites in the Kogruluk River of the Holitna River drainage, the Salmon River of the Aniak River drainage (Salmon River-Aniak), the George River, the Tatlawiksuk River, the Takotna River, the Salmon River in the Pitka Fork drainage (Salmon River-Pitka Fork), and in the Telaquana River (Head and Liller 2017; Schwanke and Molyneux 2002).

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1. Nicholas Smith, ADF&G Division of Commercial Fisheries, Kuskokwim Area Research Biologist, personal communication, April 4, 2019

The Kogruklu River is a tributary within the Holitna River drainage, which is a highly productive spawning system for Chinook, chum, and coho salmon. It is also the primary spawning location for river-type sockeye salmon in the Kuskokwim River drainage (Molyneaux and Brannian 2006). The Holitna River flows into the Kuskokwim River approximately two river miles upstream of Sleetmute. In 1976, the department initiated the first weir project in the Kuskokwim River drainage in the Kogruklu River near its mouth, approximately 138 river miles upstream of Sleetmute. This weir was preceded by a salmon counting tower at the same location and was established due to the need for accurate salmon escapement estimates in the middle and upper Kuskokwim River drainage. The Kogruklu River weir was the first of its kind in the Kuskokwim Area, and it established the current system of salmon enumeration weirs for the drainage (Schneiderhan 1988).

Historically, residents of Sleetmute and Red Devil and their ancestors spent much of their time living and traveling in the Holitna River drainage. Several key respondents in this study and in a comprehensive survey and ethnographic study conducted for study year 2010 by the Division of Subsistence discussed their families' uses of the drainage (Brown et al. 2012). Historical residents of the Holitna River utilized the area year-round for salmon fishing as well as large land mammal hunting and trapping. One key respondent resided near the mouth of the Kogruklu River his entire life until the age of 86 when he relocated to Red Devil. He and others all described the significance of the upper Holitna River drainage to the histories of Sleetmute and Red Devil families, and their reliance on the region for their food. Key respondents said that compared to the past, in recent years water levels had been lower in the upper Holitna River drainage in July and August when Chinook salmon were spawning. They expressed concern that current conditions were not ideal for Chinook salmon spawning in the headwaters of the Holitna River. Key respondents also regretted the decline in hunting and fishing activity in the drainage in comparison to previous decades. They felt that due to environmental change, area residents had lost their ability to access the area to obtain the foods their families need as they had for generations in the past.

In operation since 2006, the Salmon River-Aniak weir is located at the Salmon River's confluence with the Aniak River, approximately 50 river miles upstream of the Aniak River mouth where it flows into the Kuskokwim River. Because of its location, this weir allows for monitoring of essentially all Chinook, chum, and sockeye salmon that spawn in the Salmon River drainage. Aniak residents use the upper Aniak River drainage including the Salmon River for moose and caribou hunting, hunting and trapping of furbearers and small land mammals, and for some subsistence salmon and nonsalmon fishing with rod and reel (Brown et al. 2012). Aniak respondents' greatest concern regarding the Aniak River headwaters was the effect of guided sport fishing on Chinook salmon spawning. Key respondents in this study as well as division research conducted in 2010 described high traffic by boats whose wakes disturb riverbanks and streambeds, frequently stirring up sediment during times of Chinook salmon spawning. Key respondents also described their perceptions that sport fishers interfere with salmon spawning and contribute to the physical disturbance of Chinook salmon spawning habitat by walking in streams and on riverbanks.

The George River weir is located four miles upstream of its confluence with the Kuskokwim River. The seasonal community of Georgetown is situated at the mouth of the George River, between the immediately downriver community of Crooked Creek and the nearby upstream community of Red Devil. The weir has been in operation since 1996. Historically, middle Kuskokwim River area residents of several communities have used the George River drainage including its headwaters to fish for nonsalmon fish such as Arctic grayling, Dolly Varden, and whitefishes and to hunt for moose (Brown et al. 2012).

Between 1999 and 2017, ADF&G maintained the Tatlawiksuk River weir near the mouth of that river where it joins the Kuskokwim River, about 15 miles upstream of the community of Stony River. Some Stony River families have traditionally used the Tatlawiksuk River for subsistence fishing, hunting, and gathering (Brown et al. 2012). Although residents of Stony River have historically used portions of the upper Tatlawiksuk River drainage for moose hunting and salmon and nonsalmon fishing,<sup>2</sup> this project did not document additional, more detailed local knowledge about salmon habitats in the area.

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2. Kevin Gusty, Stony River resident, personal communication, July 2014.

Other weirs include the Takotna River weir and the Salmon River-Pitka Fork weir. Both monitor escapements of Chinook, chum, and coho salmon (Head and Liller 2017; Schwanke and Molyneaux 2002). The latter is located in the Takotna River near McGrath and the former in the Middle Fork drainage in the upper Kuskokwim River region. The Salmon River-Pitka Fork is located in an area used by many Nikolai fishing families for their summer salmon fishing camps. ADF&G originally chose the site in 1981 because it met the criteria for ideal weir operations; however, Nikolai fishers also recommended the site because it was the location of one of their traditional fish traps used for subsistence salmon harvests until that fishing gear type was prohibited by State of Alaska Statute in 1961 (AS 16.10.070; Collins 2004rev.; Stokes 1985). The department originally operated the Salmon River-Pitka Fork weir in 1981 and 1982 only, but then reestablished the weir in 2015. The ADF&G resumed weir operation in the Salmon River-Pitka Fork primarily to document the abundance of Chinook salmon in the uppermost headwater streams of the Kuskokwim River. Following the initial year (2014) of a Chinook salmon mark-recapture study in the Kuskokwim River coupled with historical aerial survey data, department researchers determined that the Salmon River-Pitka Fork was the dominant Chinook salmon spawning river in the headwaters area. The Nikolai tribal council and members of the community had also expressed their observations of the river's importance to Chinook salmon spawning from their historical use of the drainage for subsistence fishing in the Salmon River-Pitka Fork (Ikuta et al. 2014). Together, these agency and local perspectives renewed interest in reopening the weir operations at the same site (Smith and Liller 2017).

Finally, a salmon counting weir is also located in the Telaquana River where it flows out of Telaquana Lake in the Lake Clark National Park. The Telaquana River flows into the Stony River approximately 17 river miles upstream of Lime Village. This weir was established in 2010 to monitor sockeye salmon escapements into Telaquana Lake, the primary lake-type sockeye salmon spawning location in the Kuskokwim River drainage (Gilk et al. 2011). Although Chinook salmon are present in the Stony River drainage, sockeye, chum, and coho salmon compose nearly the entirety of Lime Village salmon harvests annually (Fall et al. 2019). Except for a very small number fish each year, the migrating adult Chinook salmon in the Stony River are typically not fit for human consumption when they reach Lime Village fishers.<sup>3</sup>

## **SUGGESTIONS FOR FUTURE RESEARCH**

One of the strengths of this study's design was the documentation of a rich body of local and traditional ecological knowledge about the middle and upper Kuskokwim River regions. This information was provided by a large number of key respondents who all had an intimate understanding of the local environment. Area residents know and understand their surrounding environment deeply, and they perceive even minor changes in that environment. However, rapid change may be obscuring earlier observations of spawning or other significant habitats. Landscape change is contributing to challenges in accessing these areas for subsistence activities, and that access is the foundation of much of the experiential knowledge of the resource populations. Many of these topics could not be examined in depth, and future researchers could consider using participant-observation methods for in-depth exploration of specific topics such as spawning locations, changes to fishing locations and methods, and changes to salmon behavior.

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3. Fred Bobby, Sr., First Chief Lime Village Tribe, personal communication, April 2018



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## **APPENDIX–INTERVIEW PROTOCOL**

<b>LTK INTERVIEW PROTOCOL</b> <b>SHORT VERSION</b>
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*The protocol below is intended to summarize the kinds of information we aim to gather during our LTK interviews. While the content listed in the present protocol is important, the way to gather the information will differ with each interview. Please, adapt your strategy according to the interviewee you are talking to (age, specific interest/knowledge, quantity/quality of information provided with each answer, etc.).*

## **INTRODUCTION**

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1. Indicate the following basic information that needs to be on record:
  - Interviewer(s) name
  - Date and place of interview
  - Respondent's name and place/year of birth (+ their parents' name/place of birth)
  - Name of project this interview is conducted for
  
2. Remind respondent about the goals of the LTK project:
  - WHO we are,
  - WHY is this project conducted,
  - WHAT kind of information we are hoping to gather,
  - WHICH AREAS we are interested in learning about,
  - HOW the interview will be conducted/the kinds of questions we will be asking to try and get the information we are looking for.

## **MAPPING EXERCISE**

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I would like to start this interview with looking at a few maps with you. I will ask you about places where you have been conducting different subsistence activities to better understand which areas you have been utilizing throughout your lifetime. This will help me identify specific areas of the watershed where you may have observed important changes related to salmon habitat.

1. Where do you go and what do you do out on the land/along the river/in the watershed?
2. Map present use areas by season/activities (*in relation to the watershed of interest*):
  - a. Spring (Non-salmon fishing / Bird hunting)
  - b. Summer (Salmon fishing / Berry picking)
  - c. Fall (Moose hunting / Berry picking / Non-salmon fishing / Bird hunting)
  - d. Winter (Caribou hunting / Trapping / Wood gathering)
3. Map use areas through time, also by season/activities:
  - ⇒ Last 5-10 years / 10-30 years ago / Pre 1980 / Pre 1950

## PROMPTS FOR QUESTIONS

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Discuss the following points with regards to both:

- ⇒ MIGRATION WATERS and SPAWNING GROUNDS
- ⇒ PRESENT OBSERVATIONS versus HISTORICAL OBSERVATIONS

## GENERAL QUESTIONS

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1. What are the primary changes you have seen on the rivers that have been happening over time?
2. What roles can the knowledge of people who have spent their life living off the land play in resource management? Do have any specific ideas how this knowledge can be used to advance western science?
3. Have you ever heard elders talk about any particular traditional knowledge that you thought should be acknowledged by western science?
4. What information would you use to manage salmon populations if you were in charge?
5. Do you know of any efforts at “traditional” salmon management in the past?
6. Do you know the reasons behind any particular traditions or cultural beliefs related to salmon?

## WEATHER/ CLIMATE CHANGE

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In this first section, I am interested in learning a bit more about any **changes in the climate** you may have witnessed since you have been living in [COMMUNITY X]. I would like to hear your observations regarding the kinds of **affect** these changes may have had **on the river condition, fishing** and also any impact you may have observed on **fish behavior**.

- **Break-up/freeze-up**
  - Change in magnitude or timing of break-up events? Freeze-up?
  - How does this impact the river?
  - How does it affect salmon fishing/fish behavior?
- **Precipitations** [*should we combine snowfall & rainfall?*]

- ✓ **Snowfall** (*winter*)
  - Any changes in the amount of snow loads over time?
  - Low snowfall years (winter 2013/14?): When? Any effects observed on the river condition? Impact on fishing? Impact on fish behavior?
  - High snowfall years: When? Any effects observed on the river condition? Impact on fishing? Impact on fish behavior?
- ✓ **Rainfall** (*spring/summer*)
  - Any changes in the amount of rainfall over time?
  - Low rainfall years (spring/summer 2013/14?): When? Any effects observed on the river condition? Impact on fishing? Impact on fish behavior?
  - High rainfall years: When? Any effects observed on the river condition? Impact on fishing? Impact on fish behavior?
- **Temperatures**
  - Any years with exceptional warm/cold temperatures? Effects on the river? Effects on fishing/fish behavior?
  - (*Changes in water temperature: does the water “feel warmer” in some areas than it did in the past? Any impact on fishing/fish behavior?*)
  - Has ice thickness any particular rivers and ponds changed over time?

## **WATER ECOSYSTEMS** (*river, tributaries, lakes, etc.*)

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With this second set of questions, I would like to discuss with you about changes you may have observed in the nature of the river itself, and how these may have affected salmon distribution and behavior as well as the way you interact with the river (*watershed?*).

### ➤ Nature of the water bodies

- **Structure of the river**
  - Any changes in the location and amount of **sandbars** formed along the river?
  - Any major **erosion** of the river banks observed in the slough and tributaries? Any erosion close to spawning areas?
  - Has the width of the river, or number of side channels and sloughs changed?
  - Has the size or smoothness of the gravel in the riverbed changed in any particular area?
  - Have you seen changes in how dense or compacted the riverbed gravel is?
- **Water level** [*See section above: “Precipitations”*]
  - Impact of low/high water levels on the river?
  - Impact of low/high water on fishing? Salmon migration?

- Any observation of new/**alternative spawning ground** in case of low/high water?
  - Any **slough or lakes that have dried up** in the area? Were there salmon in those before?
  - Any **flooding** events in the area? Has that changed over the years? Any effect on the river/fishing/fish?
  - Aware of areas where **overflows/open water** are usual during winter time?
  - Have you noticed more or fewer exposed gravel bars in the rivers at average water height?
  - Are there any areas where the ability access by boat has changed?
- **Water clarity**
    - Any observations of areas where water clarity has been changing?
    - Any area with noticeable **sedimentation** issues?
    - How does clear **water vs. turbid water** affect your fishing?
    - How does clear water vs. turbid water affect fishing behavior?
  - **Potential barriers to fish passage**
    - Aware of any **structural barrier** that could impede salmon to access to their fishing spawning (**beaver dams, log jams, drying lakes, etc.**)?
    - How do they affect the river system?
    - Why do you think these may impact fish passage? Observations?
    - Have these barriers more numerous today than they used to be?
    - Any **other kind of barrier** preventing salmon from getting upriver?
  - **Insects/Invertebrates**
    - Difference in the **quantity/diversity of insects** present in the river/lakes compared to the past? Observed impact of these changes on salmon?

➤ Use of the River

- **Fishing**
  - What/where/when do you fish [*Mapping Section*]? Gear type used?
  - Most significant **environmental factors** affecting when/where you fish?
  - Does the fishing location/gear used changes with the time of day/year or with the **weather conditions**?
  - Is the presence of **debris** (*drift wood, log jam, "sweeper", "sleeper"*) in the river an issue in the area? How is it nowadays compared to the past?
  - Changes in the location and numbers of eddies? Impact on your fishing? Any changes observed in fish behavior?
- **Travel/access**
  - ✓ Boat use => [*Mapping Section*]
  - Where on the river and its tributaries do you boat for other subsistence activities (berry picking, hunting, etc)?
  - ✓ Other activities => [*Mapping Section*]

- Do you travel on the river during hunting season? Where/when?
- Do you travel on the river for berry picking? Where/when?
- Do you use ATVs around the river or its tributaries? When/where?
- Have you seen ATV use on the river change?
- Where on the river, its tributaries, and its banks do you snow machine in the winter?

### LAND CHANGES *(in the vicinity of water bodies of interest)*

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I also would like to hear about your observations regarding any changes you may have observed in the landscape since what happens on the riverbanks will often impact the river ecology as well.

- **Riparian changes**
  - Any major erosion/permafrost melt along the river banks affecting river morphology?
  - Any changes in the **vegetation type, size, or density** along the river banks (*shrubs, tree species, berry crops, lichen condition*)?
  - Any changes in the **moisture levels in the soil** (*berry crops, lichen condition*)?
- **Wildfire**
  - Any major wildfires within the watershed? Where? When?
  - Any **impact on the surrounding ecosystem** (*animals, plants composition, water quality, etc.*)?
  - Any **effect on where king salmon would go**? Did you see king salmon in the area affected by the wildfire during spawning season (before vs. after the fire)?

### DEVELOPMENT

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Let's focus now on the potential impacts of human activities on the ecosystem surrounding your community:

- **Population size**
  - Has the population of "community X" changed over time (grown/shrunk)?
  - Effects of population change on the river and surrounding environment?
- **Fishing pressure**
  - Have the **fishing pressure** changed over time in your community?
  - Do **people from other villages** fish in the same areas you do? When did they start fishing there?
- **Boat traffic**

- Have the **boat traffic** been increasing or decreasing on the river? Any changes in fish behavior that may be related to boat traffic?
- Is there any **barge traffic** around the area? How does this affect the river? Your fishing?
- **Local pollution**
  - Any places you know of along the river or its tributaries where **pollution** (gas, oil, sewage, etc.) may be affecting salmon runs? What kind of pollution? How has it affected the river or surrounding land?
- **Development projects**
  - Any **development project** (mining, construction work, etc.) along the river or its tributaries that you worry affects salmon runs? What kind of development? How has it affected the river or surrounding land (noise, pollution, sedimentation, wake of boats, etc.)?
- **Other factors**
  - Are you aware of any **other factors** potentially altering the **water quality** of the river/streams/lakes around your community?
  - What about any **other factors** potentially altering the land?

## SALMON ECOLOGY

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Now that we have a better understanding of the environmental and human-induced changes that have affected the area, I am really interested in hearing specifically about your life-time experience fishing for and interacting with king salmon.

- Natural indicators
  - How do people know when salmon are in the area?
  - Are there signs indicating a good or bad salmon year?
- Changes in populations
  - **Run timing**
    - **When** do Chinook salmon arrive in your area?
    - Has the **timing** of salmon arrival changed?
    - **How long** are salmon in your area for?
    - Different **local names** according to the different kinds of kings present in this area?
  - **Run abundance**
    - Any change in **salmon abundance** overtime?

- Has there ever been a **time in the past** when there were relatively very few king salmon? When/how long did it last? What happened?
  - Have you noticed a change in the number of **salmon in nearby tributaries**?
  - Has the number of salmon carcasses, seen in the tributaries changed over time?
  - Have you noticed any other changes in the river following the salmon runs – odor of decay, number of animals feeding on carcasses, etc?
- **Run composition**
    - Thinking about a normal king salmon fishing year (*=for most of the year that you have fished for king salmon*), if you fished all season, would there be **any changes in the fish you are catching from the beginning to the end of the season** (size change, color, number of eggs, etc.)? Has that changed in recent years?
    - Any **differences** between the king salmon you catch in the **mainstem** and the ones you catch in **smaller tributaries**?
    - Do you know of any **area that formerly had king salmon** that don't anymore?
- Changes in fish health
- Any changes in **salmon size** over time? May it be linked to gear type?
  - Any changes in the general **shape of the fish** (*ex: "torpedo fish" on the Yukon*)?
  - What do you call a **"jack"**? Describe.
  - Any changes in the **fat/oil content**?
  - Any changes in **flesh quality/lesions** on the fish (parasites, wounds/bites, worms, color, net wounds, other observations) [**Provide pictures**]? Does that change how you process or eat fish?
  - Any changes in **how fish act** when you catch them or when you see them swimming?
- Changes in reproduction
- **Sex-ratio**
    - Any **changes in the sex ratio male vs. female overtime**?
    - Does sex-ratio in harvests usually vary **throughout the fishing season**? Do you think this may be related to the **gear-type** you use?
  - **Spawning ground** [*Define spawning vs. migration*]
    - Do you know of any **current spawning ground**/ Are there any areas where you normally see king salmon carcasses? [*Mapping*]
    - What about **old spawning grounds** that are not used anymore? [*Mapping*]
    - What are characteristics of a good or bad spawning ground for king salmon? What about rearing habitat?
    - Do you know of any present/past spawning ground for **other salmon species**?
  - **Females health**
    - Any changes in **the size of roe sacs** or the **quality of the eggs** (size, color, opacity, shape, taste)? What have you observed?

- Have you noticed any females releasing their eggs early (*in harvest prior to spawning ground*)?

➤ Changes in fishing levels

- Are there places where people tend to lose their nets (summer or under the ice net) or traps (blackfish, lush)? When/where?
- Historical harvests levels (prior to harvest monitoring): do you remember about how many king salmon your family got each year in the past (especially before 1980)?

➤ Predation

- Any changes in the population of adult salmon predators (bears, seals, eagles, etc.)?
- Any changes in the number or size of species who may feed on salmon juveniles (sheefish, pikes, dolly varden, trout, grayling, sculpins, minks, otters, kingfishers, mergansers, etc.)?
- Has there been a change in the level of harvest of these species?
- Any areas that used to not have pike that do now?