Technical Paper No. 351

Cultural Models of Copper River Salmon Fisheries

Final report to the North Pacific Research Board for Project No. 823

by

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Alaska Department of Fish and Game **Division of Subsistence**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the reports by the Division of Subsistence. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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^3/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

all atomic symbols	
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

all commonly-accepted abbreviations; e.g., Mr., Mrs., AM, PM, etc.	
all commonly-accepted professional titles; e.g., Dr., Ph.D., R.N., etc.	
Alaska Administrative Code	AAC
Alaska Department of Fish and Game	ADF&G
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. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
approximately	~
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)	log2, etc.
mean	$\bar{x}$
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
plus or minus	±
population size	*N*
probability	*P*
sample size	*n*
second (angular)	"
standard deviation	σ or *s*
standard error (of the mean)	$s_{\bar{x}}$
type I error probability	P_a
type II error probability	P_b
variance	σ^2 or s^2

TECHNICAL PAPER NO. 351

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Technical Paper series reports are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and professional review.

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ABSTRACT

This project assessed similarities and differences between local and traditional knowledge (LTK) and scientific knowledge of Pacific salmon *Oncorhynchus* spp. returning to Alaska's Copper River. Recent studies demonstrated that indigenous Ahtna fishers, commercial harvesters, and fishery scientists/managers have different perspectives on the long term sustainability of the Copper River salmon fisheries. Using consensus analysis, researchers systematically addressed these differences by interviewing 86 respondents: 30 Ahtna from 2 communities located near the headwaters of the Copper River, 30 commercial fishers from Cordova at the delta, and 26 fishery scientists/managers with jurisdiction throughout the entire Copper River watershed. Findings were drawn from the analysis of data sets from 5 sources: demographic characteristics of the study populations, geospatial data, consensus analysis, qualitative coding and analysis of the comment data, and analysis of agreement on specific propositions. Results of consensus analysis revealed that there was generally no consensus when considering all 3 groups together. Consensus analysis did show agreement within individual study groups. There was evidence of a strong consensus between commercial fishers and fishery scientists/managers. Ahtna appeared distinct from the other 2 groups in terms of culture, demographics, and temporal and geospatial orientation. The 3 groups of respondents indicated an overall concern regarding abundance of Copper River salmon, particularly Ahtna respondents who demonstrated a collective concern about perceived diminishing abundance. Fishery scientists/managers were the most cohesive of the 3 groups in their shared view, perhaps due to individuals' similar training and education.

Key words: Copper River, salmon, commercial fishing, subsistence fishing, cultural consensus analysis, Ahtna, Cordova, local and traditional knowledge, LTK, fisheries management.

STUDY CHRONOLOGY

As proposed, project completion was planned for June 30, 2009. The research team contacted the North Pacific Research Board (NPRB) in August 2008 to request a new end date due to unforeseen circumstances relating to the study populations. When researchers began contacting collaborators and respondents from each of the groups, it became clear that the project goals were controversial at the time because of intraregional allocation issues. As participants likely would be more comfortable if the interview period were postponed until after the December 2008 Alaska Board of Fisheries (BOF) meeting, NPRB granted a request for a new end date of December 31, 2009.

Two project progress reports were submitted to the NPRB: one on January 15, 2009, and one on July 13, 2009. Those reports contributed to this final report.

INTRODUCTION

This study assessed similarities and differences between 3 groups' local and traditional knowledge (LTK) and scientific knowledge of Pacific salmon *Oncorhynchus* spp. returning to Alaska's Copper River (Figure 1). The 3 expert groups included in the study were the Ahtna, who are an Alaska Native group indigenous to the upper Copper River, commercial fishers who fish at the mouth of the Copper River, and fishery scientists/managers from state and federal agencies whose jurisdiction includes the entire Copper River watershed. Recent studies conducted by the Alaska Department of Fish and Game (ADF&G) demonstrated that indigenous Ahtna fishers and fishery scientists/managers had different perspectives on the long term sustainability of the Copper River salmon fisheries. These differences appeared to be based on different cultural, spatial, and temporal orientations (Simeone et al. 2007). This study used the social science method of consensus analysis to systematically evaluate and understand where expert knowledge and opinions converged and diverged on the subject of Copper River salmon.

COPPER RIVER SALMON FISHERIES

The Copper River begins in the Wrangell Mountains of east central Alaska and flows south for 300 miles before emptying into the Gulf of Alaska (Figure 1). Its extensive network of tributaries and lakes are the spawning grounds for 3 species of salmon: Chinook salmon *Oncorhynchus tshawytscha,* sockeye salmon

O. nerka, and coho salmon *O. kisutch*. Chum salmon *O. keta* and pink salmon *O. gorbuscha* spawn in the intertidal reaches of the lower river.

There are 4 main salmon fisheries in the Copper River region: a commercial gillnet fishery at the delta; a personal use dip net fishery located mid river, near the town of Chitina; a subsistence fish wheel and dip net fishery located on the upper Copper River upstream of Chitina; and a sport rod and reel fishery that takes place on several tributaries.

The commercial fishery accounts for the largest harvest component, averaging approximately 1.8 million salmon (all species combined) annually from 1997 to 2006 (Lewis et al. 2008:59). Sockeye salmon accounts for about 80% of the commercial harvest. The harvest is taken by about 500 limited-entry permit holders. The personal use dip net fishery has the second largest harvest, averaging 133,000 salmon for the same period. On average, 8,000 household permits are issued per year for this personal use fishery. The majority of permit holders are from the urban centers of Anchorage and Fairbanks. The subsistence dip net and fish wheel fishery is third in harvest amount, with an average harvest of 68,000 (Lewis et al. 2008:185) during the same period. This fishery operates along the mainstream Copper River between the communities of Chitina and Slana. The average annual number of household permits issued for this subsistence fishery is about 1,200. Smaller subsistence fisheries operate in the commercial fishing area of the Copper River Delta as well as at the traditional village site of Batzulnetas, near the headwaters of the Copper River. The sport fishery has the highest participation, with as many as 60,000 estimated angler days per year (Somerville 2008), but the lowest annual harvest of the 4 fisheries. The sport fishery targets Chinook salmon and accounts for the second largest harvest component for this species behind the commercial fishery. Under both state and federal law, subsistence fishing has a priority over the other fisheries on the river.[1]

Of the 4 user groups participating in the Copper River fisheries, commercial fishers are the most tightly regulated and, unlike the other user groups, there has been no growth in the number of permit holders. The sport rod and reel fishery is small in terms of harvest, but it is the only group allowed to fish in tributary streams or lakes where salmon spawn. Interest in all upriver fisheries is growing and will probably continue to grow as the state's population grows. Because of the priority for subsistence uses, growth in the subsistence fisheries may increase the allocation of salmon to that user group.

THE AHTNA

Ahtna are an Athabascan-speaking people who are indigenous to the upper Copper River. In 2008, there was a population of approximately 1,474 Ahtna.[2] The population is separated into 4 groups based on language and geographic location. Ahtna respondents for this project came from the 2 Upper Ahtna communities of Mentasta and Cheesh′na (Chistochina). In the Ahtna language, the Upper Ahtna are called *Tatl'ahwt'aenn*, the "headwaters people" (Kari 1986).

Ahtna relations with salmon date back nearly 2,000 years (Workman 1977). Over this time, Ahtna have developed a fishing culture that includes sophisticated methods for harvesting and processing salmon, protocols that govern the treatment and use of salmon, and an oral tradition that accounts for the origin of Copper River salmon. As a group, Ahtna have experienced considerable change in the fisheries, especially since the 1920s. These changes include the development of fully allocated fisheries, increased competition for salmon, environmental changes, and changes in their traditional harvest and use patterns (Simeone and Kari 2002; Simeone and Fall 2003; Simeone et al. 2007).

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[1] Federal and state law both provide a priority for subsistence uses, but under Title VIII of ANILCA, the federal government maintains subsistence hunting and fishing preference for rural residents. Under state law, all Alaska residents must be considered potential subsistence users.

[2] Alaska Department of Commerce Division of Community and Regional Affairs. Alaska community database custom data queries. http://www.commerce.state.ak.us/dcra/commdb/CF_CUSTM.htm.

COMMERCIAL FISHERS IN CORDOVA

Commercial fishing in the Copper River began at its mouth in 1889. The city of Cordova, located on the western edge of the Copper River Delta, was incorporated in 1909 during the development of commercial mining and fishing interests in the region. Although Alaska Native groups, notably the Eyak, have inhabited the delta region for thousands of years, their numbers today are few and Cordova is predominantly Euro-American. Commercial salmon fishing has been the mainstay of Cordova's economy for over 100 years, since the growth of local small-boat fisheries and the corresponding boom in the canning industry in the early part of the 20th century. Today, commercial fishing is still critical to both the economy and culture of Cordova's 2,161[3] residents.

Cordova's fishing-based economy and population grew through the 1970s and 1980s until the 1989 *Exxon Valdez* oil spill. This ecological tragedy, combined with new challenges from competition with international salmon farming, still presents Cordova's fishers with considerable economic challenges—challenges which may threaten long-term community viability. Although other economic sectors are developing, notably tourism, commercial fishing and processing remain central to local livelihoods. Cordova salmon fishers have faced their economic challenges by marketing their salmon as an internationally-renowned, high quality, gourmet food, thus creating a viable niche market for themselves. Almost 50% of Cordova's households report that they have a member working in either fish harvesting or processing. The Alaska Commercial Fisheries Entry Commission (CFEC) reports 350 local salmon permits issued to Cordova residents, 49,706,525 pounds of salmon landed, and estimated local earnings of $29,621,212 in 2008[4]. In one of its publications, the Cordova District Fishermen United (CDFU), a nonprofit commercial fishing organization, notes:

> Cordova is truly an economy based on the sustainable harvest of fishery resources. With no major opportunities for economic diversification on the horizon, our continued economic well-being is predicated on continued access to our traditional fishery resources.[5]

COPPER RIVER FISHERY SCIENTISTS/MANAGERS

Formal government oversight and management of the Copper River fisheries evolved in tandem with the commercial fisheries and thus has been in place for about 100 years. Today, all Copper River salmon fisheries are managed under a policy of sustained yield, which closely regulates combined harvests in order to allow an optimal number of salmon to reach the spawning grounds each year, thereby sustaining healthy populations. Decisions about harvest allocations to the 4 major user groups are made by the Alaska Board of Fisheries (BOF), an independent regulatory body whose members are appointed by the governor. The actions of the BOF are often codified into regulatory management plans that provide direction to ADF&G. Management actions are often triggered by sustainable escapement goals (SEGs) developed by ADF&G for the major salmon stock groups in the watershed. Fish in excess of the sustained yield spawning requirements are available for harvest by the 4 user groups.

Fishery scientists/managers are charged with maintaining sustained yields and have authority to open and close fisheries, which they do through field announcements or "emergency orders." Management actions therefore have considerable impact on the livelihoods of all user groups, but especially the closely-regulated commercial fishers.

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[3] 2008 population estimate from the Alaska Division of Community and Regional Affairs community database online: http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.cfm.

[4] CFEC participation & earnings. On-line database at http://cfec.state.ak.us/fishery_statistics/earnings.htm. Accessed November 20, 2008.

[5] Cordova District Fishermen United. An historical narrative of fishing in the Prince William Sound/Copper River area. Electronic document posted at http://www.cdfu.org/about.html. Accessed January 8, 2010.

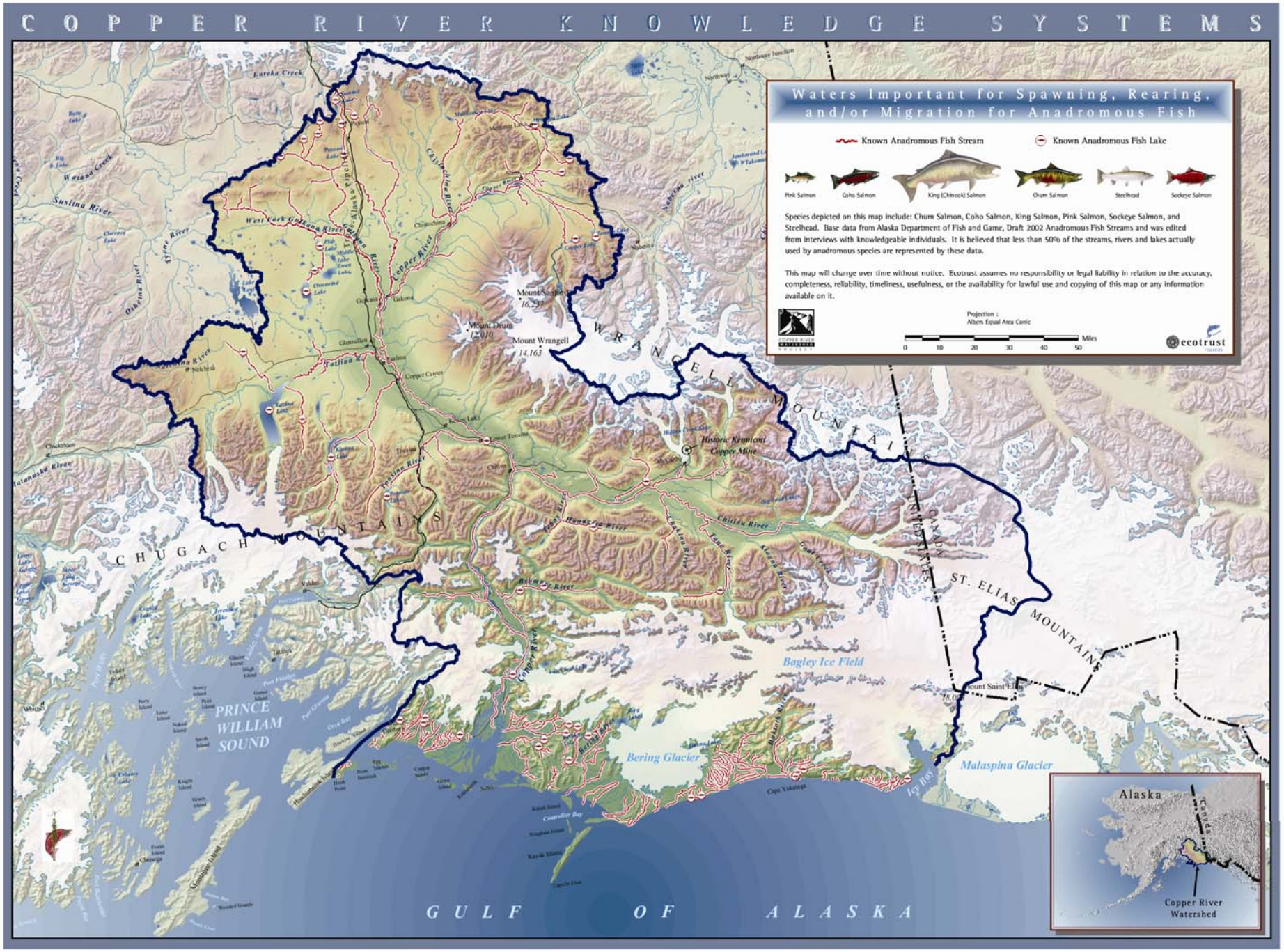

Figure 1.–Distribution of selected anadromous fishes, Copper River drainage, Alaska.
Map data compiled by Ecotrust for the Copper River Knowledge System. http://www.inforain.org/copperriver/content/pages/maps/standard.htm.

COPPER RIVER SALMON MANAGEMENT

The complexity of the salmon stocks that enter the river complicates management of Copper River salmon fisheries. Each species of salmon that spawns in each tributary of the Copper River is considered a separate stock. There are no escapement goals or management plans specific to individual stocks of salmon or individual tributaries on the Copper River. These stocks can vary widely in abundance and timing from year to year. Individual stocks can be identified using genetic techniques or by location after they have reached their spawning grounds. However, when at the delta or when migrating through the silty mainstream Copper River, all stocks are mixed together and it is not possible to manage individual stock components. To avoid overharvest of individual stocks of salmon, fishery scientists/managers regulate the commercial fishery through openings and closures timed throughout the salmon migration, assuming that some fish from each stock group can pass through the commercial fisheries to reach the upstream spawning grounds.

Chinook salmon enter the river first, beginning in early or mid May. Accompanying them is an early run of sockeye salmon headed for upper tributaries, such as the Slana River and Tanada Creek (Figure 1). Later runs of sockeye salmon enter the river from late June through August, along with salmon that spawn in the smaller systems adjacent to the Copper River Delta. Concurrent with the timing of these later runs of wild fish are the hatchery sockeye salmon returning to the Gulkana Hatchery (Hollowell and Taube 2005:5). The last species to migrate up the Copper River is coho salmon.

Sonar technologies provide critical data to the management of salmon migrating up the glacial waters of the Copper River. An ADF&G riverine sonar is located at the outlet of the mainstream Copper River into Miles Lake, approximately 28 miles above the commercial fishing district. The sonar provides data used in the management plan for the salmon stocks of the Copper River District (5 AAC 24.360), in which an annual inriver goal of about 600,000 to 800,000 sockeye salmon has been set by the BOF. The passage goal is broken into weekly increments to accommodate management of the mixture of stocks in the Copper River salmon run. The commercial fishery, which typically has 2 openings per week, is intensely regulated: fishery scientists/managers closely monitor the daily passage estimates at the Miles Lake sonar and make biweekly emergency order announcements that adjust or close fishing times and areas based on trend data from the sonar (Hollowell and Taube 2005:4).

The Miles Lake inriver passage goal is scaled to provide for the upriver harvest allocations to the subsistence, personal use, and sport fisheries. When the number of fish estimated to have passed the Miles Lake sonar exceeds the weekly goal, weekly fishing times for the upriver personal use fishery may be liberalized. Unlike the other fisheries in the watershed, the subsistence fishery is open to continuous fishing through the entire salmon migration and usually does not experience inseason management adjustments. Due to the subsistence priority, all other fisheries in the Copper River management area would need to be closed before restrictions could be placed on the subsistence fishery.

In summary, the Copper River salmon fisheries are fully allocated: all salmon returning to the Copper River in excess of the sustainable escapement goal are consigned to user groups through an allocation system governed by regulatory management plans. To increase allocation to a group, it would be necessary to decrease allocation(s) to other group(s).

LOCAL AND TRADITIONAL KNOWLEDGE AND SCIENTIFIC KNOWLEDGE

Resource managers and scientists have recognized that local and traditional knowledge (LTK) can increase an overall understanding of the environment and be applied to resource management (Feit 1998; Pitcher 1998; Usher 2000; Andersen and Fleener 2001; Van Daele et al. 2001; Huntington 2002; Krupnik and Jolly 2002; NPRB 2005). But difficulties remain in translating LTK into forms of data that can be used in conjunction with Alaska's current fisheries management systems(Brelsford 2009). Over the last decade, considerable effort has been made to document the LTK of Alaska Natives (Huntington 1998, 1999; Wheeler and Craver 2005; Brelsford 2009) and a number of strategies have been employed to

collect and make LTK available to a broader audience. These strategies include compiling databases of existing information (Burwell 2001; see also Coiley-Kenner et al. 2003[6] and Mishler 1999[7]), convening regional workshops attended by managers and LTK holders (Huntington et al. 2002; Ecotrust 2005, 2006), and conducting ethnographic research to document LTK (Andersen and Fleener 2001; Simeone and Kari 2002; Brown et al. 2005; Langdon 2006).

Recent studies conducted by ADF&G and the U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Information Service demonstrated that indigenous Ahtna fishers and fishery scientists/managers have different perspectives on the long term sustainability of the Copper River salmon fisheries. Ahtna perspectives on the fisheries are based on cultural models of nature and temporal and spatial scales that differ from those of the fishery scientists/managers overseeing the management of the Copper River fisheries (Simeone and Kari 2002; Simeone et al. 2007). Ahtna believe salmon to be sentient, moral beings who permit humans to use their bodies provided that they are treated with respect and that users are not wasteful (de Laguna 1969/70; Simeone and Kari 2002; Simeone et al. 2007). Ahtna spatial perspectives are oriented to specific streams and fishing sites, while the perspectives of fishery scientists/managers tend to focus on entire populations of salmon. Temporal perceptions also differ greatly between Ahtna fishers and fishery scientists/managers.

Ahtna interviewed for this project said they had noticed a decline from historical levels of salmon stocks that spawn in the headwaters of the Copper River including the possible extirpation of one particular type of sockeye salmon that used to spawn in Tanada Lake. Ahtna elders attributed these changes to increased human activity in the Copper River Basin, including increased noise and water pollution in spawning areas as well as environmental changes that have altered spawning habitat. While Ahtna attributed changes in Upper Copper River salmon stocks to human agency, fishery scientists/managers interviewed for this project reported that changes in the abundance of these stocks are largely the result of natural variability and that they saw no evidence of stock extirpation (Simeone et al. 2007). As measured by harvest data and drainagewide escapement estimates from the last 20 years, management of the Copper River salmon fisheries has been a success. Fishery scientists/managers posit that spawning habitat in the upper reaches of the Copper River is highly diverse; furthermore, they point to escapement data gathered since the 1960s and weir data collected over the last decade to show that Upper Copper River salmon stocks are dynamic and fluctuate from year to year (Raeder et al. 1998; Veach 2003; Veach and McCormick 2005; K. Roberson in interview with William E. Simeone and Erica McCall Valentine, March 7, 2005, Glennallen, Alaska; T. Taube, ADF&G Fishery Biologist IV, pers. comm).

In this study, researchers attempted to systematically address these differences using consensus analysis to understand where the knowledge and opinions of LTK holders (Ahtna and commercial fishers) and fishery scientists/managers converged and diverged on the subject of Copper River salmon.

STUDY HYPOTHESES

Based on LTK literature (e.g., Fraser et al. 2006) and earlier social science research in the Copper River Basin (Simeone and Kari 2002; Simeone et al. 2007), researchers hypothesized that Ahtna and commercial fishers' knowledge and understanding of the fisheries would resemble scientific knowledge, but that long term experience on the water, cultural backgrounds, academic training, and spatial/temporal foci would affect each group's knowledge and opinions about the fisheries. Specifically, researchers attempted to measure whether:

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[6] Coiley-Kenner, P., T. M. Krieg, and D. Holen. 2003. From *Neqa* to *Tepa*: a database with traditional knowledge about the fish of Bristol Bay and Northern Alaska Peninsula. Version 2.0. Alaska Department of Fish and Game Division of Subsistence, Anchorage.

[7] Mishler, C. 1999. Whiskers! The multicultural multimedia database for Alaska's marine mammals. Version 2.0. Alaska Department of Fish and Game Division of Subsistence, Anchorage, and the Alaska Native Harbor Seal Commission, Juneau.

1. Ahtna and commercial fishers share common opinions based on their long term experiences on the water;
2. Fishery scientists/managers are distinct from Ahtna and commercial fishers based on their academic training and professional status;
3. Ahtna and commercial fishers share similar opinions because their knowledge is more spatially localized than that of fishery scientists/managers, who tend to adopt broad-scale approaches; and
4. The opinions and beliefs of Ahtna, commercial fishers, and fishery scientists/managers are culturally distinct.

OBJECTIVES

The project had 4 objectives:

1. Formally assess different cultural models or perspectives on the Copper River salmon biology and fisheries using consensus analysis, which is a formal mathematical model;
2. Understand where the knowledge and opinions of Ahtna, commercial fishers, and fishery scientists/managers converge or diverge on the subject of the Copper River salmon biology and fisheries;
3. Find common ground among user groups and fishery scientists/managers on the subject of the management of Copper River salmon fisheries; and
4. Initiate a process that includes user knowledge as a tool that can be used by fishery scientists/managers to maintain the health of the Copper River salmon fisheries.

METHODS

CULTURAL CONSENSUS ANALYSIS

Cultural consensus analysis (Weller 1998) was used to assess similarities and differences in the knowledge and or beliefs about salmon held by Ahtna, commercial fishers, and fishery scientists/managers. Other studies have shown that consensus analysis is an efficient and replicable method for understanding culturally shared models of the world and for measuring differences and similarities in perspectives between and within cultural groups (Grant and Miller 2004). This method measures the level of agreement on a particular cultural domain within a defined cultural group. Cultural domain has been defined as "a set of related words, concepts, or statements about a single theme" (Weller 1998). In this study, researchers proposed to distinguish between the local and traditional knowledge of Copper River salmon biology held by Ahtna and commercial fishers, and the scientific knowledge of Copper River salmon biology held by fishery scientists/managers.

Using consensus analysis, respondents who are considered experts on a specific cultural domain are asked to offer their knowledge or beliefs on a set of related propositions that lead to categorical answers (yes/no, true/false, agree/disagree). The propositions must be about beliefs (what people have concluded about reality or what they assume to be true or false in the course of their daily lives) or knowledge (understanding gained through experience or study), and not preferences (what people desire if given alternatives) or value judgments (what is good or what is bad) (Grant and Miller 2004).Cultural consensus analysis identifies culturally correct answers to questions that demonstrate shared knowledge by a cultural group but may not necessarily represent absolute truth. Rather than evaluating answers one at a time, cultural consensus analysis explores patterns of agreement across an entire series of propositions. The cultural consensus model relies on 3 assumptions:

1. Respondents within each group share a common culture, defined as "patterns of learned behavior and beliefs that are shared within a group." An aggregation of propositions is not valid unless there is reasonable consistency across individuals;
2. Respondents answer questions independently of each other and they answer the same questions; and
3. All propositions concern the same cultural domain (or topic) and are at the same level of difficulty.

Consensus analysis was done using the software Anthropac© (Borgatti 1996), which generates 5 main sets of outputs:

(1) Eingenvalues for each factor, the percentage of variability in informant responses that each factor accounts for, and the ratio of the first (largest) eingenvalue to the others;

(2) The loadings on the first factor (knowledge scores of each informant), which identify the correlation between the responses of each informant and the first factor, and the average level of agreement among all informants;

(3) The loadings on the second factor, which provides a measure of "disagreement" among informants;

(4) A matrix of similarities among responses of pairs of informants; and

(5) An estimated answer key.

The first output set contains provisional information to assess whether the informants express consensus about the study topic. A large percentage of the variance among informants explained by the first factor is evidence (subject to further testing) of the existence of a single answer key for the group of respondents considered. In general, it is considered that a ratio of at least three between the first and second factor constitutes provisional evidence that the data fit the consensus model (there is consensus among respondents). Negative or low knowledge scores (<0.5) indicate that the respondents considered may represent more than one cultural group. The estimated answer key is based on the proportion of respondents that responded to a proposition in the same manner and on the individual knowledge scores.

A low first factor ratio and low or negative individual knowledge scores would suggest that informants may be drawing from different cultural models for their perceptions about the study subject. Lack of support to the existence of a single answer key may emerge because:

- A few respondents do not fit the general cultural model;
- There is weak consensus, i.e., low level of agreement among informants;
- There are sub-populations representing different cultural models;
- Sub-populations differ in their level of agreement.

Consensus analysis was initially done considering all respondents together to assess whether the 3 groups of respondents (Ahtna, commercial fishers, and fishery scientists/managers) could be differentiated based on their answers to the propositions. A low first eigenvalue rate together with the presence of low and negative knowledge scores (loadings on the first factor) suggested that there was no strong agreement among all respondents across the 22 propositions (see Results). A second set of analysis was then performed for each of the 3 groups. Because of the presence of a similarity in responses between commercial fishers and fishery scientists/managers, a third set of analysis was done combining these 2 groups.

SELECTION OF RESPONDENTS

This study included respondents from 3 groups knowledgeable about Copper River salmon fisheries, who were chosen because they had the longest history with the fisheries and they presently or at one time made their living by the fisheries:

1. The contemporary indigenous Ahtna who live in the headwaters of the Copper River Basin;
2. The commercial salmon permit holders who live in Cordova, Alaska, and who actively participate in the Copper River commercial salmon fishery; and
3. Fishery scientists/managers from state and federal agencies who presently manage, or at one time managed, the Copper River salmon fisheries.

Using consensus analysis, the sample size (number of respondents) can be relatively small if there is a high level of consensus. However, because the level of consensus is unknown beforehand, a minimum of 30 respondents is recommended (Weller 2007). In this study, a strong consensus within study groups was not assumed and researchers planned to interview at least 30 expert respondents in each group.

Ahtna respondents were residents of the Upper Ahtna communities of Cheesh′na (Chistochina) and Mentasta, both of which are located on the upper Copper River. Researchers worked with members of the Mentasta and Cheesh′na tribal councils to develop a list of Upper Ahtna who were age 40 and over. Because the population of these 2 communities is small, the list contained only 30 names.

Researchers compiled a list of 26 fishery scientists/managers from the ADF&G telephone directory (ADF&G 2008) and by consulting various ADF&G employees who were former Copper River fishery scientists/managers.

For respondents in the commercial fishers group, researchers generated lists of drift gillnet permit holders for the years 1988–2008 from the State of Alaska Commercial Fisheries Entry Commission (CFEC) permit holder database.[8] These lists were compared to generate a population of 155 commercial fishers who had been fishing in the Copper River Delta for a minimum of 20 years. A representative from the Cordova District Fishermen United (CDFU), a nonprofit commercial fishing organization, helped to identify fishers who were current residents of Cordova and who were available for an in-person interview. A random sample generated from this list included 50 permit holders, enough for 30 interviewees and 20 alternate respondents (in case some initially selected respondents had moved from the community, ceased fishing, declined to participate, or were otherwise unavailable for an interview). A letter of invitation was mailed to the potential respondents to introduce the project and its methods, goals, and expected outcomes (Appendix A). Interviews were arranged with respondents who agreed to participate in the study.

DEVELOPMENT OF PROPOSITIONS

Researchers conducted structured interviews using an interview instrument based on a set of propositions (Appendix B). The propositions used in consensus analysis should be reasonable indicators of the concept being measured. A series of meetings was convened to develop 45 preliminary propositions allowing dichotomous answers (agree/disagree). The preliminary propositions were refined and tested with the assistance of 2 consultants from each of the 3 cultural groups to ensure that 1) questions were clear and properly formulated and that 2) the interview time would be no longer than 1 hour. The final set included 22 propositions. The consultants' participation was limited to the development of the propositions and consultants were not subsequently included in the pool of respondents. Since there were no commercial fishers among the researchers, the executive director of CDFU participated in the assessment of the

[8] http://www.cfec.state.ak.us/plook. Accessed November 20, 2008.

preliminary propositions to help avoid sensitive subjects, preferences, or value judgments that could potentially lead to strategic answers to propositions.

Researchers considered the possibility that respondents could provide political or strategic answers to the propositions, although it was not possible to determine if this occurred. Respondents had no access to the propositions beforehand and all respondents were interviewed individually, so there was little opportunity for collusion. It was considered that the answers to the propositions reflected the respondents' worldview including their view of the fishery, regardless of whether their answer could have been strategic.

ADMINISTRATION OF INTERVIEWS

At the beginning of each interview, respondents provided demographic information including name, gender, age, stakeholder group, education, length of residence in the area, length of participation in the fisheries, and whether his/her parents fished in the Copper River (Appendix B). During the interviews, respondents were asked to express their opinion (agree/disagree) to each of the 22 propositions. Interviewers emphasized that there were no right or wrong answers to the propositions. Although "I don't know" was not offered as a choice, some respondents could not "agree" or "disagree" to some propositions, which resulted in a small proportion of missing answers.[9] Missing answers were treated as missing data. Interviewers encouraged respondents to briefly explain their answers in narrative format. These explanations were recorded as field notes.

GEOGRAPHIC AREAS OF EXPERIENCE AND KNOWLEDGE

On a map of the watershed showing the major drainages and communities (Figure 2), respondents were asked to circle their area(s) of expertise and to mark with an "X" each specific location where they fished or collected data on Copper River salmon. Analysis of the geographic areas of expertise was based on the 10 drainage units of the Copper River watershed (Table 1). A respondent was identified as having experience in a specific watershed drainage unit if that respondent recorded a polygon and/or point within any portion of the unit. If there were no notations recorded on the map for a given respondent, geographic references were captured in the interview notes.

Table 1.–Copper River watershed drainage units.

Code	Watershed drainage units
1.	Copper River Delta
2.	Central Copper area: Miles Lake to Wood Canyon
3.	Chitina River drainage
4.	Wrangell area: Tonsina Lake, Kenny Lake, Copper Center, Tazlina Lake, Glennallen, Gulkana
5.	Tonsina River drainage
6.	Klutina River drainage
7.	Tazlina River drainage
8.	Gulkana River drainage
9.	Mentasta/Chistochina area
10.	Mount Sanford–Tanada Lake area

Source Copper River Knowledge System planning map of watershed units important to spawning, rearing, and migration of salmon. http://www.inforain.org/copperriver/content/pages/maps/pdfs/crc_anad_pu.pdf (Accessed August 20, 2009).

[9] Commercial fishers: 30 respondents, 8 missing answers; fisheries scientists/managers: 26 respondents, 10 missing answers; Ahtna: no missing answers.

Data analysis was conducted by team members Liliana C. Naves, Marie E. Lowe, William E. Simeone, and James Brady. The demographic profiles and the quantitative data from the consensus analysis were analyzed by Naves. Lowe conducted the analysis of qualitative data and Brady analyzed the geographic map data. Simeone conducted the analysis of the responses to the propositions.

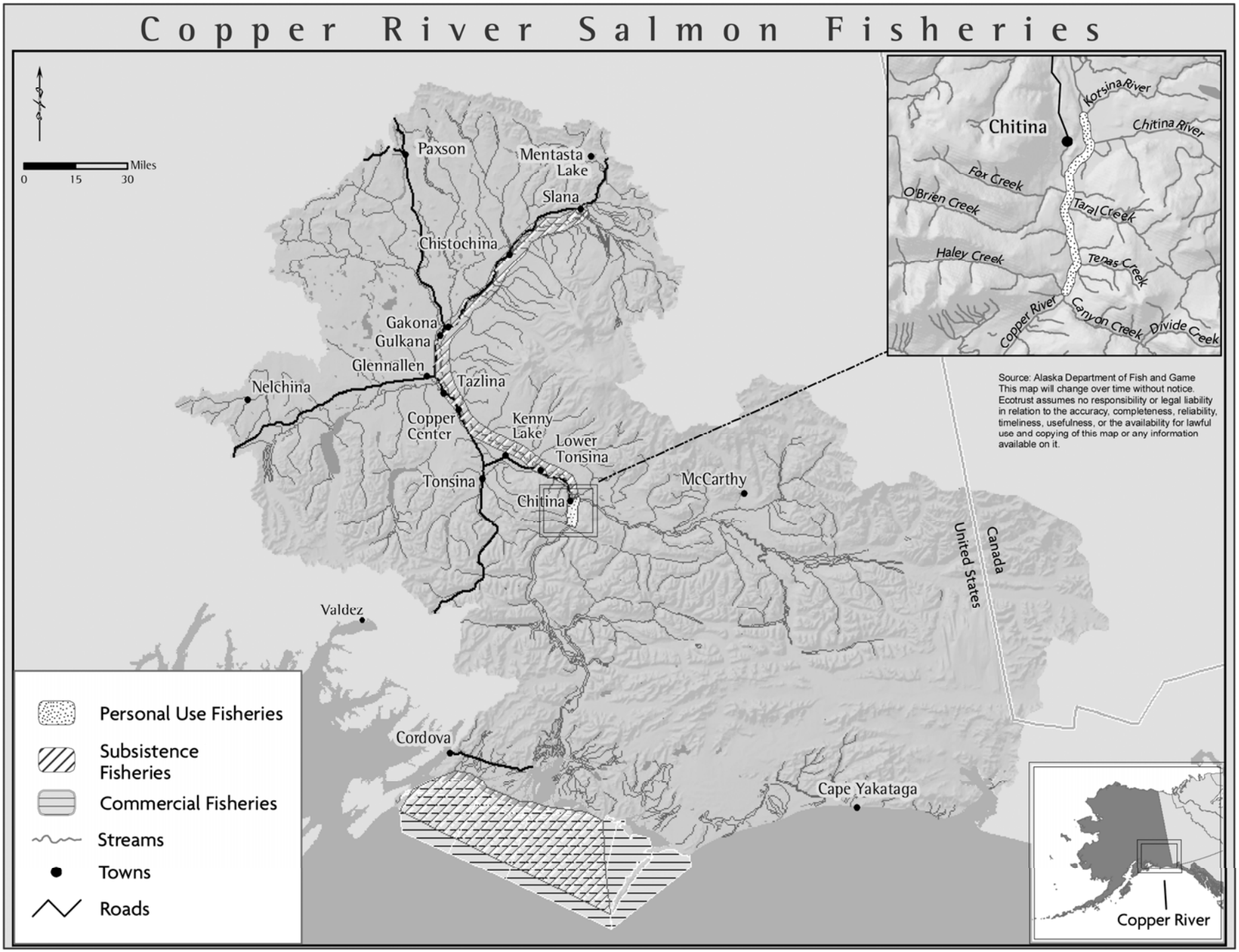

Figure 2.– Copper River drainages showing locations of subsistence, sport, and commercial fisheries, 2009.

ANALYSIS OF THE QUALITATIVE DATA

Qualitative data analysis was undertaken from 2 perspectives: 1) content analysis on respondents' comments to propositions, and 2) analysis of specific propositions.

Content Analysis on Respondent Comments to Propositions

Respondents' explanations and comments were recorded during their interviews to provide context to their responses to the 22 propositions. The field notes were transcribed into Microsoft Word and coded for content using the software ATLAS.ti. Using a team approach, researchers generated a codebook that used a hierarchical coding scheme to identify broad themes used to support and explain the consensus analysis outputs.

Analysis of Specific Propositions

The estimated answer key provided a general view of cultural knowledge within groups of respondents. Specific propositions showing strong consensus within each group were analyzed to further assess group differences. To do so, researchers referred to the absolute proportion of respondents answering "agree" to each proposition in order to elucidate potential cultural patterns, especially how Ahtna appeared to be distinct from the other 2 groups in their responses, and the nature of the apparent shared perspective of the commercial fishers and fishery scientists/managers. When 80% or more of respondents concurred (either agreed or disagreed) on a proposition, the result was considered representative of the group's view on that proposition.

RESULTS

RESPONDENT GROUP PROFILES

A total of 86 respondents were interviewed: 30 Ahtna, 30 commercial fishers, and 26 fishery scientists/managers (Table 2). The average duration of the interviews with Ahtna and fishery scientists/managers was 37 minutes.[10] The average interview duration of commercial fishers was 26 minutes, a statistically significant difference from averages for Ahtna[11] and fishery scientists/managers.[12] Ahtna explanations of their answers were shorter than those provided by commercial fishers and fishery scientists/managers. Ahtna respondents may have had some difficulty in interpreting the propositions (see below).

The average age of respondents was 60 years for Ahtna, 56 years for commercial fishers, and 48 years for fishery scientists/managers.

The Ahtna group included similar numbers of male (16) and female (14) respondents. Only 1 female commercial fisher and 2 female fishery scientists/managers were interviewed, likely because of the greater proportion of males within these 2 occupations over the time period identified.

Ahtna respondents had resided in the basin for a longer period of time (average of 57 years) than the commercial fishers (45 years) or fishery scientists/managers (14 years).

Ahtna respondents reported a longer time fishing/working in the area (average of 52 years) compared to commercial fishers (36 years) and fishery scientists/managers (11 years). Almost all Ahtna (29) and commercial fishers (28) currently fished/worked in the area while 35% of the fishery scientists/managers interviewed no longer worked/fished in the area (many had retired and left the state).

[10] No statistically significant difference: Kolmogorov-Smirnov test revealed $Z = 0.900$, $P = 0.393$.
[11] Kolmogorov-Smirnov test revealed $Z = 2.283$, $P < 0.005$.
[12] Kolmogorov-Smirnov test revealed $Z = 1.360$, $P = 0.05$.

All Ahtna respondents reported that their parents fished in the Copper River. This number was 18 for commercial fishers and 3 for fishery scientists/managers.

About one-half of the Ahtna (14) and one-half of the commercial fishers (15) reported that they had earned a high school diploma or GED as their highest level of education. Seven commercial fishers reported that they had earned a postsecondary degree. Among fishery scientists/managers, 12 reported earning a college degree and 13 reported having earned postgraduate degrees. Ten Ahtna and 2 commercial fishers reported having some other type of formal education.

Table 2.–Respondent group profiles.

Characteristic	Ahtna (n = 30)	Commercial fishers (n = 30)	Fishery scientists/managers (n = 26)
Interview duration (minutes)[a]	36.6 ± 9.0 (25–60; n = 19)	26.0 ± 17.9 (10–82; n = 28)	37.0 ± 21.7 (10–95; n = 17)
Age (years)	59.6 ± 13.5 (41–84; n = 30)	55.8 ± 7.9 (40–69; n = 26)	48.3 ± 8.8 (29–69; n = 26)
Gender [b]			
Female	14	1	2
Male	16	29	24
Years living in the area [a]	57.4 ± 16.2 (13–84; n = 30)	44.7 ± 13.7 (12–67; n = 28)	13.7 ± 9.0 (5–39; n = 19)
Years fishing/working in the area [a]	51.6 ± 14.3 (13–80; n = 28)	36.2 ± 10.0 (21–65; n = 30)	10.9 ± 9.2 (1–39; n = 25)
Currently fish/work in the area? [b]			
Yes	29	28	17
No	1	1	9
Did/do parents fish in the area? [b]			
Yes	30	18	3
No	0	12	23
Education [b]			
High school or GED	14	15	0
Some college	6	5	1
College degree	0	7	12
Graduate degree	0	0	13
Other	10	2	0

a. Mean ± standard deviation (minimum–maximum; sample size).
b. Number of cases.

GEOGRAPHIC AREAS OF EXPERIENCE AND KNOWLEDGE

Based on mapped areas of experience, Ahtna were familiar with 1.5 drainage units on average (SD = 0.508), commercial fishers with 1 drainage unit (SD = 0), and fishery scientists/managers with 7.0 units (SD = 3.418). The Ahtna and commercial fisher groups indicated that a high proportion of their respondents had experience in only 1 of the 10 drainage units. For Ahtna this was the Mentasta/Chistochina unit, which is located at the headwaters of the watershed. One-hundred percent of commercial fishers indicated experience in the Copper River Delta unit located at the opposite end of the watershed. The fishery scientists/managers as a group showed some degree of experience across all 10 drainage units (Figure 3).

Ahtna respondents were predominately from the Mentasta/Chistochina and Mount Sanford drainage units, both located at the headwaters of the Copper River watershed. Ninety-three percent of Ahtna respondents

indicated that they had experience in the Mentasta/Chistochina drainage unit and 50% indicated experience in the Mount Sanford unit. A small group (7%) indicated experience in the Glennallen area.

All commercial fishers indicated experience in the Copper River Delta drainage unit, which closely corresponds with the Copper River commercial fishing district. Only 1 commercial fisher indicated experience in another part of the watershed. There were only 5 maps in the commercial fisher group that had data recorded on them in response to questions 13 and 14 of the demographic questionnaire. On most questionnaires, there were handwritten comments that included geographic references to areas fished.

As a group, the fishery scientists/managers had some degree of experience in each of the 10 drainage units. This suggests that the fishery scientists/managers had more of a watershed perspective. The Miles Lake/Chitina Unit was the most frequently cited: 88% of the respondents indicated some degree of experience in that unit. The unit for which the smallest proportion of fishery scientists/managers indicated experience was the Mount Sanford Unit, at the headwaters of the Copper River (58% of the respondents indicated some degree of experience).

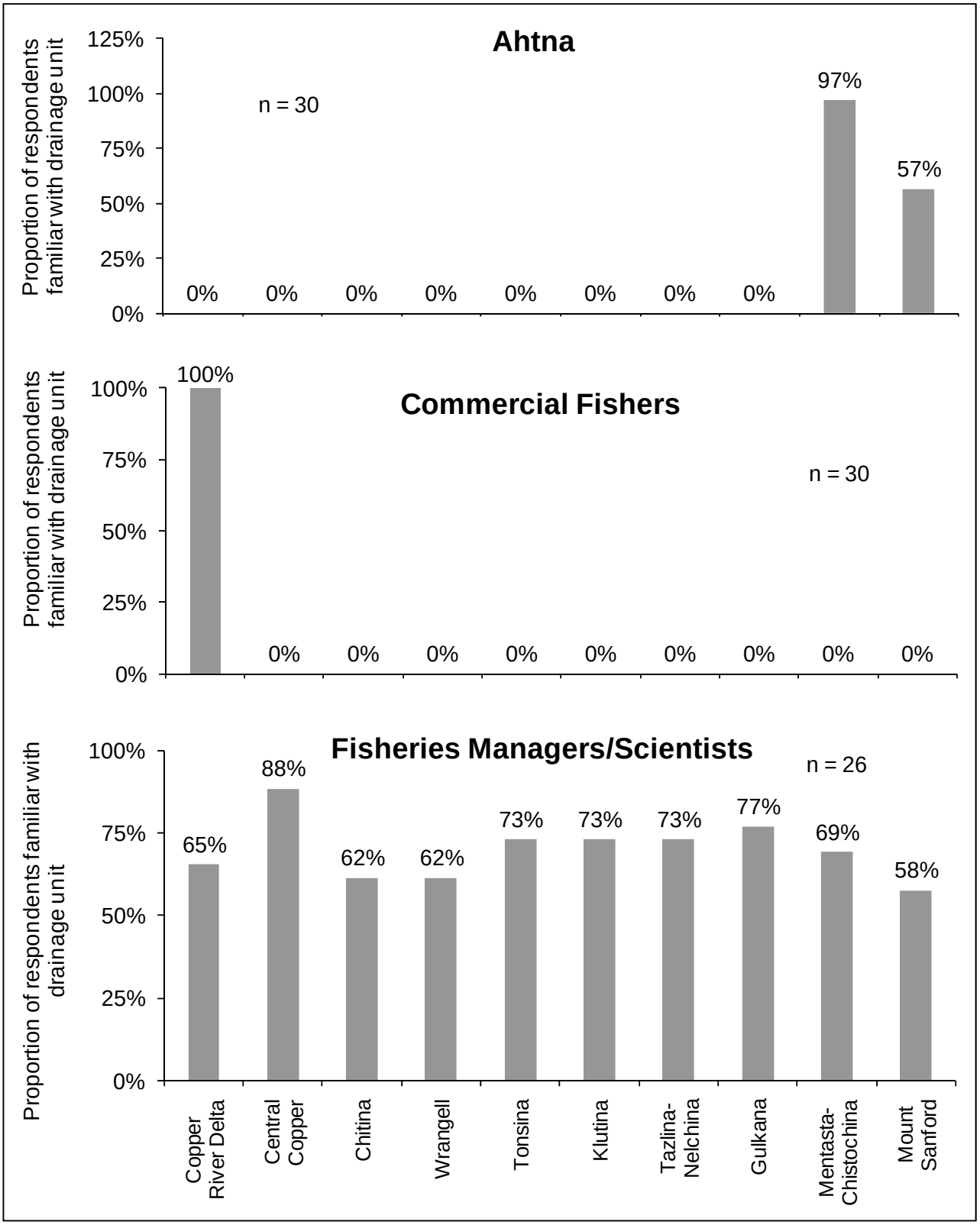

Figure 3.–Geographic distribution of experience of Ahtna, commercial fishers, and fishery scientists/managers in drainage units of the Copper River watershed.

CULTURAL CONSENSUS

When responses to propositions (agree/disagree) from the 3 groups were analyzed together, there was a low first-to-second eigenvalue ratio (Table 3) as well as a relatively high percentage of low (<0.5) and negative knowledge scores (loadings on the first factor, Table 4). These results suggested no strong agreement among all respondents across the 22 propositions. A second set of analysis was performed accounting for each of the 3 groups. The first eigenvalue rate was larger than 3 for each of the groups (Table 3), indicating some level of consensus within each of the study groups. However, low individual knowledge scores were still observed within the 3 groups and negative scores were observed in Ahtna (3%) and commercial fishers (7%, Table 4). Fisheries scientists/managers seemed to be the group with the highest level of consensus as indicated by its highest average first factor ratio when compared to the 2 other groups and the absence of negative individual knowledge scores (tables 4 and 5).

When contrasting the knowledge scores (loadings on first factor) with the loadings on the second factor for the 3 groups together, the distance between clusters is an indicator of the level of similarity between groups (the larger the distance the smaller the similarity). Relatively high loadings on the second factor indicate that the knowledge scores (loadings on first factor) do not account for a significant proportion of the variability of the system. Figure 4 indicates similarity between commercial fishers and fisheries scientists/manager while Athna is distinct from these 2 groups. Based on these results, analyses were performed including commercial fishers and fishery scientists/managers as a single group to assess whether this pool of respondents would share a cultural model. For these 2 groups together, although the first factor ratio was larger than 3 (Table 3), the average knowledge score was lower than for each group individually (tables 4 and 5).

Table 3.–Eigenvalues for assessment of goodness of fit to the consensus model.

Factor	Eigenvalue	% of variance explained	Ratio
Three groups together			
1st	21.150	55.9	1.944
2nd	10.882	28.8	1.882
3rd	5.781	15.3	
Ahtna			
1st	9.456	69.7	4.184
2nd	2.260	16.7	1.227
3rd	1.842	13.6	
Commercial fishers			
1st	10.878	68.2	3.484
2nd	3.122	19.6	1.594
3rd	1.958	12.3	
Fisheries scientists/managers			
1st	10.070	70.6	4.247
2nd	2.371	16.6	1.301
3rd	1.823	12.8	
Commercial fishers and fisheries managers/scientists			
1st	19.009	67.3	3.934
2nd	4.832	17.1	1.092
3rd	4.424	15.7	

Table 4.–Proportion of low and negative individual knowledge scores for groups of respondents.

Group	Percentage of low knowledge scores	Percentage of negative scores
Three groups together	63%	34%
Ahtna	40%	3%
Commercial fishers	37%	7%
Fishery scientists/managers	35%	0%
Commercial fishers and fishery scientists/managers	40%	5%

Table 5.–Average respondent knowledge scores.

Group	Average	Standard deviation
Three groups together	0.265	0.419
Ahtna	0.529	0.189
Commercial fishers	0.530	0.286
Fishery scientists/managers	0.570	0.251
Commercial fishers and fishery scientists/managers	0.520	0.263

Figure 4.–Loadings on first and second factors (all groups considered together).

The estimated answer key is presented in Table 6. All 3 groups were estimated to agree with propositions 1, 3, 12, 13, 15, 17, 19, 22 and to disagree with Proposition 20.

Estimated answers for Ahtna and commercial fishers concurred for only 2 propositions: agreement with proposition 2 “Winter and spring environmental conditions (amount of snow, budding, temperature, etc.) can be used to predict salmon abundance” and disagreement with proposition 5 “King salmon are more abundant now than they were 25 years ago.”

Estimated answers of Ahtna and fishery scientists/managers concurred on only 1 proposition: disagreement with Proposition 10 "Hatchery salmon is necessary to support fisheries in the Copper River."

Estimated answers for commercial fishers and fishery scientists/managers concurred in 10 of 22 propositions: agreement with propositions 6, 8, 9, and 14 and disagreement with propositions 4, 7, 11, 16, 18, and 21. The estimated answer key suggests that commercial fishers and fishery scientists/managers share a cultural model of Copper River salmon.

The absolute proportion of respondents that agreed (and disagreed) to each proposition is presented in Table 7.

Characteristics of respondent profiles (age, years lived in the area, years fishing/working in the area, and education) were contrasted with individual knowledge scores in an attempt to explain levels of consensus within and between groups. For Ahtna respondents, there was a tendency toward low knowledge scores (<0.5) in young (40–55 years old) and old (75–85 years old) respondents while high knowledge scores were observed in respondents of intermediary age (45–70 years old; Figure 5). There may be multiple non-exclusive explanations for this pattern related to age and knowledge scores for Ahtna. Some considerations put forward are:

1. Although older Ahtna had considerable experience in the fisheries, they were less fluent in English and they may have had difficulty understanding the propositions.
2. Younger Ahtna had more formal education and were fluent in English, but had less experience in the fisheries.
3. Middle-aged Ahtna had more formal education, were generally fluent in English, and had considerable experience in the fisheries.

No such trends related to demographic characteristics and knowledge scores were observed for commercial fishers or fishery scientists/managers.

Figure 5.–Relationships between age of respondents and individual knowledge scores.

Table 6– Estimated answer key.

Proposition	Ahtna	Commercial fishers	Fishery scientists/managers
1. There are more than 50 sockeye salmon spawning groups in the Copper River.	agree	agree	agree
2. Winter and spring environmental conditions (amount of snow, budding, temperature, etc.) can be used to predict salmon abundance.	agree	agree	disagree
3. The loss of habitat is the greatest threat to salmon abundance.	agree	agree	agree
4. Salmon in the Copper River drainage are being overfished.	agree	disagree	disagree
5. King salmon are more abundant now than they were 25 years ago.	disagree	disagree	agree
6. Sockeye salmon are more abundant now than they were 25 years ago.	disagree	agree	agree
7. Hatchery sockeye salmon look different from wild sockeye.	agree	disagree	disagree
8. Too many spawning salmon in a stream can reduce future salmon abundance.	disagree	agree	agree
9. Current fisheries management in the Copper River provides healthy fisheries for now and for future generations.	disagree	agree	agree
10. Hatchery salmon is necessary to support fisheries in the Copper River.	disagree	agree	disagree
11. Sockeye salmon are smaller in size now than they were 25 years ago.	agree	disagree	disagree
12. The size of salmon varies from year to year.	agree	agree	agree
13. Fisheries in the lower Copper River affect fisheries in the upper river.	agree	agree	agree
14. Fisheries in the upper Copper River affect fisheries in the lower river.	disagree	agree	agree
15. Nature manages salmon.	agree	agree	agree
16. Human activity over the past 25 years has reduced the number of different sockeye spawning groups in the Copper River.	agree	disagree	disagree
17. Fishing on the spawning grounds is bad for that particular spawning group of salmon.	agree	agree	agree
18. Copper River sockeye salmon should be managed for each different stream rather than as a whole group.	agree	disagree	disagree
19. Salmon diversity is important to maintain overall salmon abundance.	agree	agree	agree
20. The Copper River floods more now than 25 years ago.	disagree	disagree	disagree
21. Run timing of salmon has changed over the last 30 years.	agree	disagree	disagree
22. Salmon have a spirit.	agree	agree	agree

Note Solid gray: concurrence among all 3 respondent groups.
Diagonal: concurrence between commercial fishers and Ahtna.
Black: concurrence between commercial fishers and fishery scientists/managers.
Vertical: concurrence between Ahtna and fishery scientists/managers.

Table 7.–Proportion of respondents answering "agree."

Proposition	Ahtna	Commercial fishers	Fishery scientists/managers
1. There are more than 50 sockeye salmon spawning groups in the Copper River.	53%	83%	88%
2. Winter and spring environmental conditions (amount of snow, budding, temperature, etc.) can be used to predict salmon abundance.	73%	73%	31%
3. The loss of habitat is the greatest threat to salmon abundance.	93%	77%	58%
4. Salmon in the Copper River drainage are being overfished.	83%	30%	15%
5. King salmon are more abundant now than they were 25 years ago.	37%	38%	50%
6. Sockeye salmon are more abundant now than they were 25 years ago.	7%	90%	58%
7. Hatchery sockeye salmon look different from wild sockeye.	77%	33%	19%
8. Too many spawning salmon in a stream can reduce future salmon abundance.	10%	80%	81%
9. Current fisheries management in the Copper River provides healthy fisheries for now and for future generations.	50%	90%	88%
10. Hatchery salmon is necessary to support fisheries in the Copper River.	40%	70%	15%
11. Sockeye salmon are smaller in size now than they were 25 years ago.	73%	10%	20%
12. The size of salmon varies from year to year.	63%	90%	96%
13. Fisheries in the lower Copper River affect fisheries in the upper river.	83%	87%	100%
14. Fisheries in the upper Copper River affect fisheries in the lower river.	23%	93%	92%
15. Nature manages salmon.	73%	87%	81%
16. Human activity over the past 25 years has reduced the number of different sockeye spawning groups in the Copper River.	93%	57%	40%
17. Fishing on the spawning grounds is bad for that particular spawning group of salmon.	87%	90%	69%
18. Copper River sockeye salmon should be managed for each different stream rather than as a whole group.	80%	27%	50%
19. Salmon diversity is important to maintain overall salmon abundance.	100%	93%	96%
20. The Copper River floods more now than 25 years ago.	50%	28%	13%
21. Run timing of salmon has changed over the last 30 years.	70%	30%	27%
22. Salmon have a spirit.	87%	61%	54%

QUALITATIVE ANALYSIS

Qualitative analysis was performed on the comment data collected from respondents to contextualize the consensus analysis findings. Qualitative analysis also provided a finer resolution of points of agreement and disagreement both within and between groups. Qualitative analysis proceeded in 2 stages: 1) content analysis using qualitative data management software, and 2) analysis of specific propositions.

Content Analysis

During the interviews, respondents' comments to the propositions were recorded by the interviewers in the form of field notes and then typed into word processing software. The comments provided in the following sections are therefore not direct quotes from respondents, but rather the comment as written by the researcher during the course of the interview. The comment data were coded for thematic content in ATLAS.ti qualitative data analysis software. Data analysis produced 2 sets of codes: one for proposition numbers and one for themes.

Content analysis is a data analysis methodology used in the social sciences to analyze textual data such as interview transcripts. The transcripts are reviewed for patterns such as the frequent use of certain words or themes by informants. Common themes are assigned codes and blocks of text are coded using qualitative data analysis software. This procedure allows the identification of salient themes within the body of textual material. The code list (codebook) is reduced to a minimum length to focus efforts on the most commonly shared themes. Codes may be grouped into hierarchical categories. As a qualitative code, the term "knowledge" is a descriptive rubric for the themes related to the following themes frequently commented upon and emergent from our consensus analysis interview: abundance, environmental conditions, sockeye salmon, Chinook salmon, traditional ecological knowledge, habitat loss, run time, and interannual variation. These themes represent facets of our informants' understanding of the dynamics of salmon fisheries in the Copper River. Overall, the qualitative content analysis was performed as a method of both explaining and triangulating results from the consensus analysis.

Proposition Codes

ATLAS.ti software tallies the number of times a code has been applied to a textual data point. For the individual propositions, respondents commented most frequently on Proposition 2 (Table 8), which suggested that "[w]inter and spring environmental conditions (amount of snow, budding, temperature, etc.) can be used to predict salmon abundance."

Table 8.–Qualitative coding (those propositions with comments).

Proposition	Number of mentions	Proposition	Number of mentions	Proposition	Number of mentions	Proposition	Number of mentions
2.	50	20.	34	4.	30	8.	20
18.	42	3.	33	16.	30	12.	19
15.	36	6.	33	11.	29		
21.	36	7.	32	14.	28		
22.	35	10.	32	9.	27		
5.	34	1.	31	17.	25		

Proposition 2 was 1 of 2 propositions for which Ahtna and commercial fishers were in agreement and the fishery scientists/managers were in disagreement. In general, Ahtna agreed with Proposition 2 whereas fishery scientists/managers disagreed with it. The agreement to this proposition might demonstrate a similarity between Ahtna and the commercial fishers in their intimate understanding of environmental conditions and salmon fisheries. Researchers did hypothesize that Ahtna and commercial fishers would share more understanding because of their LTK resulting from the amount of time they have spent on the water; in fact, they did not agree on many propositions. Researchers surmise that this was due to their

separate and localized understanding of their own regions: the headwaters for the Ahtna and the delta for the commercial fishers. Geospatial orientation appears to be a main determining factor that influences a group's cultural model.

Thematic Codes

Thematic codes were applied to the textual qualitative data (Table 9). The code hierarchy revealed 3 main themes: 1) knowledge, 2) belief, and 3) management. Content analysis demonstrated considerable interest in the topic of salmon abundance, particularly reflected by the Ahtna's perception of diminishing abundance. Ahtna appeared to differ most from the other 2 groups on the subject of fisheries management. All 3 groups shared some beliefs about nature and salmon, but these beliefs differed in degree and form. Again, geospatial orientation appears to influence these groups' perspectives, knowledge, beliefs, and management of Copper River salmon fisheries.

Table 9.–Codebook for qualitative data analysis.

Code hierarchy	Codes	Number of times codes applied to text
Knowledge	Abundance	132
	Environmental conditions	85
	Sockeye salmon	57
	Chinook salmon	40
	LTK/TEK	40
	Habitat loss	39
	Run timing	35
	Inter-annual variation	25
Belief	Worldview	80
	Stocks	59
	Upriver	41
	Downriver	16
Management	Management	87
	Hatchery	74
	Overfishing	62
	Escapement	12
	Politics	7

Analysis of Specific Propositions

Specific propositions showing strong consensus within each group were analyzed to further assess differences between groups. Researchers looked specifically for cultural patterns to better understand how Ahtna are distinct from the other 2 groups and how the commercial fishers and fishery scientists/managers are similar to each other. Researchers used an 80% agreement threshold on a proposition within a group to indicate majority (Table 7). The propositions listed in Table 10 are those reflecting an 80% or more agreement or disagreement. Comments on these propositions are included below to provide additional insight to each group's perspective. Comments, data, and their analysis are

grouped into the 3 thematic areas that emerged from the content analysis: knowledge, belief, and management.

Table 10.–Propositions in which 80% of respondents in each group agreed or disagreed.

Propositions in which 80% or more of **Ahtna** agreed or disagreed	Propositions in which 80% or more of **commercial fishers** agreed or disagreed	Propositions in which 80% or more of **fishery scientists/managers** agreed or disagreed
	1. There are more than 50 sockeye salmon spawning groups in the Copper River (**agree**).	1. There are more than 50 sockeye salmon spawning groups in the Copper River (**agree**).
3. The loss of habitat is the greatest threat to salmon abundance (**agree**).		
4. Salmon in the Copper River drainage are being overfished (**agree**).		4. Salmon in the Copper River drainage are being overfished (**disagree**).
6. Sockeye salmon are more abundant now than they were 25 years ago (**disagree**).	6. Sockeye salmon are more abundant now than they were 25 years ago (**agree**).	
		7. Hatchery sockeye salmon look different from wild sockeye (**disagree**)
8. Too many spawning salmon in a stream can reduce future salmon abundance (**disagree**).	8. Too many spawning salmon in a stream can reduce future salmon abundance (**agree**).	8. Too many spawning salmon in a stream can reduce future salmon abundance (**agree**).
	9. Current fisheries management in the Copper River provides healthy fisheries for now and for future generations (**agree**).	9. Current fisheries management in the Copper River provides healthy fisheries for now and for future generations (**agree**).
		10. Hatchery salmon is necessary to support fisheries in the Copper River (**disagree**)
	11. Sockeye salmon are smaller in size now than they were 25 years ago (**disagree**).	11. Sockeye salmon are smaller in size now than they were 25 years ago (**disagree**).
	12. The size of salmon varies from year to year (**agree**).	12. The size of salmon varies from year to year (**agree**).
13. Fisheries in the lower Copper River affect fisheries in the upper river (**agree**)	13. Fisheries in the lower Copper River affect fisheries in the upper river (**agree**).	13. Fisheries in the lower Copper River affect fisheries in the upper river (**agree**).
	14. Fisheries in the upper Copper River affect fisheries in the lower river (**agree**).	14. Fisheries in the upper Copper River affect fisheries in the lower river (**agree**).

-continued-

Table 10.–Page 2 of 2.

Propositions in which 80% or more of **Ahtna** agreed or disagreed	Propositions in which 80% or more of **commercial fishers** agreed or disagreed	Propositions in which 80% or more of **fishery scientists/managers** agreed or disagreed
	15. Nature manages salmon (**agree**).	15. Nature manages salmon (**agree**).
16. Human activity over the past 25 years has reduced the number of different sockeye spawning groups in the Copper River (**agree**)		
17. Fishing on the spawning grounds is bad for that particular spawning group of salmon (**agree**)	17. Fishing on the spawning grounds is bad for that particular spawning group of salmon (**agree**).	
18. Copper River sockeye salmon should be managed for each different stream rather than as a whole group (**agree**)		
19. Salmon diversity is important to maintain overall salmon abundance (**agree**).	19. Salmon diversity is important to maintain overall salmon abundance (**agree**).	19. Salmon diversity is important to maintain overall salmon abundance (**agree**).
		20. The Copper River floods more now than 25 years ago (**disagree**).
22. Salmon have a spirit (**agree**).		

Code Hierarchy: Knowledge

The results demonstrated that all groups were very concerned about the abundance of Copper River salmon populations (tables 9 and 10). A careful examination of the results revealed details of the Ahtna's general concern with changes in salmon abundance, which they attributed to habitat loss, changing environmental conditions, increased human activity, and overfishing.

Proposition 3: "The loss of habitat is the greatest threat to salmon abundance."

Ahtna comments attributed habitat loss to a range of phenomena that potentially could affect salmon abundance, including ocean pollution, obstruction of streams by beaver dams, damage from all-terrain vehicles (ATVs) driven across spawning streams, and an increase in longnose suckers *Catostomus catostomus*.

- "The water in the ocean is polluted, that's why there is no fish."
- "It's not only habitat loss, it is other things taking over. Right now there are too many sucker fish. They eat all the salmon eggs."
- "Beaver dams are a threat to salmon habitat. People need to be allowed to take care of their own local salmon streams. If beaver move in, we have to be allowed to get the beaver out of there."
- "There used to be salmon going up Bone Creek. But people are driving big rigs across and disturbing the habitat."

Proposition 17: "Fishing on the spawning grounds is bad for that particular spawning group of salmon."

There was almost unanimous agreement between Ahtna and commercial fishers on the proposition that fishing on the spawning grounds was bad. Comments made by respondents in both groups reflected the opinion that it was wrong to disturb spawning salmon. Ahtna said:

- "People not supposed to bother salmon where they lay their eggs and they used to tell me about Sinona Creek ... they said don't bother them kings when they go up there."

The following comments from commercial fishers were recorded:

- "Not necessarily [bad for that particular spawning group of salmon] but I don't like the practice of it. There should be 'spawning reserve areas.' Once the fish get past a certain point the fishing should be closed."
- "Believe it can wipe out a run."
- "Absolutely. There are laws elsewhere—including Washington—that restrict fishing on spawning grounds. We are behind the times in enforcing. Clear water streams equals spawning habitat, but clear water is also the best for sport fishing. True throughout the flats—silvers in the delta, too."

Proposition 8: "Too many spawning salmon in a stream can reduce future salmon abundance."

Ahtna strongly disagreed (90%) with the proposition that too many spawning salmon in a stream could reduce future salmon abundance. This view was contrary to the majority of commercial fishers and fishery scientists/managers. The idea that too many salmon on the spawning grounds may have an adverse impact on the number of fish that survive to adulthood is central to current Alaska salmon management and it is used to set escapement goals. Two commercial fishers commented that the negative effect of overescapement is proven to be "true," while a fishery scientist/manager said:

- "What number [of returning salmon] is the million dollar question. Which is the right balance of spawners so there are not too many or too few [fish]."

Proposition 16: "Human activity over the past 25 years has reduced the number of different sockeye spawning groups in the Copper River."

Over 90% of Ahtna respondents thought that human activity had reduced salmon populations, but only 2 Ahtna commented on Proposition 16. One comment reflected the traditional Ahtna view that humans must take care of salmon, and if they do not, then the salmon will disappear. The respondent used the Ahtna term *'engii*, which loosely translated means "taboo" or "rule." In traditional Ahtna culture, young people are taught that there are rules for handling salmon, and that they are not to "bother" animals by handling them disrespectfully or needlessly. The other comment was about reduced abundance and a decline in quality of fish, both of which Ahtna connect to human activity.

- "I don't know if everybody thinks the way I do ... but I think this way, even still today ... Like I was telling you before, people used to know how to take care of things. We learn about *'engii* ... we should never bother the animals ... We gone too far away ... nobody cares anymore."
- "There used to be a lot more fish. My mother alone used to cut 200 fish. Them days we had good fish—greasy. We made dry fish. I remember Sinona Creek was just red. So many fish ... grayling, sockeye, kings ... all in Sinona Creek …"

Over one-half of commercial fishers agreed with Proposition 16 and this group provided 12 comments, many of which were that they "did not know" because they had no information. The responses to this proposition may also reflect differences in spatial orientation between the Ahtna and the commercial

fishers. The upper Copper River is road accessible and attracts thousands of fishers, hunters, and tourists every year. During the lifetimes of most Ahtna interviewed for this study, there have been significant changes in this area, including commercial development during World War II and the building of the Trans-Alaska Pipeline. By contrast, the lower Copper River is largely inaccessible by road. One commercial fisher commented that it would be "hard for human activity to reduce salmon populations on the Copper River flats because management was strict." This comment was echoed by another commercial fisher: "Most of the human activities throughout the delta, in particular, have remained neutral, or have had no impact." Other comments from commercial fishers mentioned human activity on the upper Copper River, although one commercial fisher said he "did not know" because he did not "know enough about the upper Copper River to agree or disagree." Another said that he had:

- "…not much experience in the Upper Copper River. Suspect sport fishing in accessible areas. Possibly already happened. Military building highways and taking salmon from creeks. Highway/culverts, change in access to spawning beds impact fish stocks in some areas."

Responses to this proposition also reflected a cultural difference between Ahtna and fishery scientists/managers. Fewer than one-half of fishery scientists/managers agreed with this proposition. One Ahtna comment referred to a metaphysical problem regarding the relationship between humans and salmon, and another expressed a sense of loss.

The fishery scientists/managers who commented on this proposition generally said that they could not gauge the effect of human activity because they had no data.

- "[I] don't feel like I have the scientific knowledge of these things, but [I] think about creeks that have been tinkered with, Mentasta area, the upper Gulkana. Don't know really because was not here 25 years ago."

Another fishery scientist/manager commented that he thought salmon abundance had increased, while another said that he thought natural changes were having a greater effect than human activity:

- "I know of a couple of increases (as opposed to reductions) in recent years … Sheraton Glacier has receded on the east side, now has spawning sockeye. Telemetry studies documented new Chinook spawning in the Chitina River."
- "Natural habitat changes have a greater effect than human activity. Martin River and Johnson River have changed channels, which has affected abundance. 17 Mile River has also changed available spawning habitat."

Proposition 4: "Salmon in the Copper River drainage are being overfished."

The majority of Ahtna respondents agreed with this proposition and the majority of commercial fishers and fishery scientists/managers disagreed with it. Ahtna comments on overfishing reflected the upriver–downriver spatial divide. Their comments did not appear to be directed at a particular group, but seemed to present their perception of overfishing in the downriver area:

- "There is not overfishing upriver, but there is overfishing downriver."
- "I know the [downriver] fishermen are getting enough fish. Sometimes more fish got to go up the river."
- "We used to take a lot of fish ... but now there's more people ... maybe we can't take so many fish now."
- "They're [downriver fishers] taking too many fish."
- "Probably they [downriver fishers] take too many."

Fishery scientists/managers provided detailed comments on Proposition 4, which generally disagreed with the idea that Copper River salmon were overfished. They tended to consider both the total salmon population and the stocks returning to individual streams. Some expressed the belief that although individual stocks could be overharvested, the entire population was not overharvested because escapement goals were being met.

- "Maybe specific stocks appear overfished in specific years, or groups of fish, but overall, no, they are not being overharvested."
- "Don't really know the answer … lot of pressure on them but we do meet escapement to the extent that is reasonable. Are particular stocks being hit harder than others?"
- "Not consistently. There might be some years and stocks when overharvest occurs, but looking at the aggregate, no."
- "This ties in with my explanation for [proposition] number 3. Think habitat is good now, but there is a potential with development to degrade the habitat. If not managed properly, there could be a problem with overharvest, but oil or other development has greater potential [to degrade habitat] than overharvest."
- "Chinook salmon are larger runs now than in the 1970s. Sockeye are about the same, but the harvest is more. Runs in general, the runs are sustained, but the fishing can be poor. Run sizes do not dictate a healthy population; it is whether they come back or not, unlike the Yukon [River]. Fish are not properly allocated now, but I cannot change that unless I become a manager."
- "We are right on the edge of 'maxing out' exploitation, but we have not gone over the edge."
- "[I am] out of touch with current trends [but I] disagree with respect to when I was there."
- "Don't know that much, they [have been] hammered hard for years. Management seems to be working."
- "Management keeps it within bounds, but … being a former basin resident I see the user pressure more."
- "The way people fish now is different: more aggressive and effective—using boats."
- "Not the case in the 1990s; not informed enough to have an opinion."

Commercial fishers tended to disagree with Proposition 4. One commercial fisher said that "management does not allow for overfishing":

- "[There is] sufficient escapement in the upper reaches of the watershed, so there are management protections in place so overfishing does not happen. Last year, sonar was down and the delta fish were not accounted for, so the managers held off and didn't allow for any early commercial openers, and once the Gulkana fish [hatchery fish] came through [and there was] a sufficient escapement, [that] is when the commercial fishery was opened."

Other comments by commercial fishers appeared to highlight the divisions between upriver and downriver user groups. The commercial fishers expressed the belief that the commercial fishery was highly regulated, but that there was little regulation of the upriver fisheries. One commercial fisher remarked, there could be no overharvest from the "lower river perspective," because salmon were "definitely getting by us, the way the fishery is managed." He further remarked that "we hear stories [down here] about pressure cookers [i.e., upriver harvesters hiding their illegal harvests by canning it in the field], and no law enforcement."

Proposition 19: "Salmon diversity is important to maintain overall salmon abundance."

There was strong consensus among all 3 groups on the importance of salmon diversity. However, while commercial fishers agreed that salmon diversity was important, unlike the Ahtna, they disagreed with Proposition 18, that salmon should be managed for each stream.

Proposition 6: "Sockeye salmon are more abundant now than they were 25 years ago."

Even though since the early 1980s sockeye salmon runs have generally surpassed historical averages (Lewis et al. 2008), 93% of Ahtna disagreed with this proposition while 90% of the commercial fishers agreed with it. One reason for this result may be that the commercial fishers harvest at the mouth of the Copper River, where they have opportunity to observe a greater number of stocks than upriver fishers. By contrast, Ahtna respondents live and fish on the upper Copper River, upstream of the Klutina and Gulkana rivers, which are the major sockeye spawning streams within the Copper River system.

The following comments were made by commercial fishers:

- "Excellent runs until last year [2008]."
- "Runs have been bigger in the past 20 years."
- "Except for last year [2008], because environmental conditions restricted, diminished, the number of sockeye returning."
- "There are a higher number of harvests with a higher number of escapements. This, in my mind, answers the question."
- "There were total failures in the [19]80s."
- "Larger runs than there used to be."

The following comments were made by the Ahtna:

- "For the past 2 years they [sockeye] haven't been too good. They used to come in heavy, but not now."
- "Some years are good, some not ... but I don't think there are more now."
- "Not so many sockeye. In Gulkana they have lotsy [lots of] sockeye salmon."
- "Used to be them sockeye go up the creek, used to be a lot more."

Proposition 14: "Fisheries in the upper Copper River affect fisheries in the lower river."

Ninety-three percent of commercial fishers agreed with Proposition 14 and 77% of Ahtna disagreed. Ahtna interviewed for this study fish upstream of all other major user groups. The commercial fishery occurs at the mouth of the river, the personal use dip net fishery (with about 8,000 permit holders) takes place at Chitina, and most subsistence fishing takes place between Chitina and the mouth of the Gulkana River. In addition, there are sport fisheries on several major downstream tributaries, including the Klutina and Gulkana rivers. In short, a majority of the salmon fishing on the Copper River takes place downstream of Ahtna who participated in this study. Comments from Ahtna revealed their perspective on this situation:

- "I don't think the fisheries on the upper river affect those on the lower river because the fisheries on the upper river are so small."
- "Up here, people usually get the same amount of fish every year ... not too many. Downriver there's too many people taking fish."

Other comments by Ahtna respondents appeared to present a different point of view: that the headwaters of the river are important in terms of the health of the entire system as well as all salmon populations. For example, 2 Ahtna respondents pointed out that:

- "Just [the] fishing [alone] up here does not affect the fishing downriver, but there are other factors that we see first upriver and then they show up downriver."
- "Fisheries upriver don't affect downriver, but the upriver situation should affect policies. We have to look at the headwaters to determine the health of future salmon abundance."

The majority of commercial fishers saw the situation in reverse, as represented by one respondent's comment to Proposition 13 ("Fisheries in the lower Copper River affect fisheries in the upper river"):

- "Too many sport fishermen, personal use and subsistence fishermen, are taking fish out of the spawning streams. Doesn't understand why sport fishermen can take Chinook out of the spawning streams, if the commercial fishermen cannot, the regulations should be the same across the board."

Code Hierarchy: Belief

Comments on propositions 15 and 22 were coded as pertaining to respondents' worldviews. On average, all 3 groups agreed with these propositions. The major differences appeared in each group's beliefs regarding the role of nature in managing salmon and the existential nature of salmon.

Proposition 15: "Nature manages salmon."

There was a high degree of consensus between all 3 groups on Proposition 15: 73% of Ahtna, 87% of commercial fishers, and 81% of fishery scientists/managers agreed. Respondents from all 3 groups qualified their answers with statements pertaining to the role played by people in managing and caring for salmon stocks.

Ahtna respondents specifically noted that humans had to take care of salmon and help nature by removing beaver dams that block salmon streams, monitoring consumption, and having respect for the fish.

- "People got to take care of the fish. Sometimes though, nature does things, like the river will change."
- "It's up to people to take care of salmon."
- "Nature provides salmon, but sometimes beaver dam up the creek and people got to take it out."

Commercial fishers generally agreed that nature manages salmon, a perspective consistent with other research about the role of nature in a commercial fishery (Paolisso 2002). However, some commercial fishers pointed out that nature does not manage salmon: rather, management plays a role in salmon survival by making sure that salmon escape to the spawning grounds:

- "To a point [nature manages salmon]. We still need escapement."
- "Not necessarily true. Nature can't manage a resource. Conditions of nature can dictate how big or small the runs are with inriver and ocean survival but [the salmon are] not managed by nature. People manage a fishery."
- "Man manages salmon; nature plays a part in their survival."

Over 80% of fishery scientists/managers agreed with this proposition, although their comments showed a variety of opinions. One fishery scientist/manager thought nature had only a modest impact, while another commented that nature could hinder management:

- "Catastrophic floods could override human activity. We can help fish. Mother Nature can undo right decisions."

Proposition 22: "Salmon have a spirit."

Eighty-seven percent of Ahtna respondents agreed that salmon had a spirit while 61% of commercial fishers and 54% of fishery scientists/managers agreed. Although there was strong agreement among Ahtna respondents, some commented that this was a traditional or old belief. They said that they were concerned that their responses would be misinterpreted and that others would think they were "nature worshippers" or that they "believed in fish ghosts."

Several Ahtna elders lamented that traditional protocols governing the handling of salmon were no longer being followed. In the traditional Ahtna belief system, fish are sentient beings (de Laguna 1969/70; de Laguna and McClellan 1981). Because they are sentient, salmon can respond negatively or positively to humans. If humans do not treat salmon properly, the salmon can make themselves scarce and difficult to catch. To placate the salmon, Ahtna have developed a large number of protocols associated with every aspect of salmon fishing, from building a fish rack to handling of dried salmon (Simeone and Kari 2002). Ahtna comments about Proposition 22 seemed to reflect these traditional ideas about the human's relationship with salmon.

- "I know they say to be real careful when you handle fish ... keep your mind on what you're doing ... don't drop them."
- "Yeah ... there must be [a salmon spirit] ... There's a Fish Song [sung to the fish in order to please them and ensure their return]."
- "You have to take really good care of the fish … [in] all we do ... we sit by the creek and clean fish, and then we put everything back in the water. Them old people who live before us ... they knew lotsy. We don't do like them anymore. Them old people knew. My mother ... she died too young. I like to go back so I can see them old people ... how they do things."
- "I heard a story about that when I was a kid. Some people was hungry and they tell him to eat fish. The man act like he don't like fish ... that man kick the fish that was on the ground and said 'That's nothing.' Then he try to eat it, but it turned to dust."
- "You got to be careful with this question. The ones who make this survey, you got to explain to them to make this question different. If you ask the elders this they won't know what you mean. It's not like we think the salmon have a soul ... if so, there would be a lot of ghost fish around! But we do believe in spiritual. We have lots of stories about that. You got to be careful how you ask the old people about this question ... they might not understand what you're trying to say. It's got to be asked in a different way."

Over one-half of commercial fishers and fishery scientists/managers agreed that salmon had a spirit, although their comments revealed various attitudes and beliefs. Some characterized their understanding of salmon as possessing a drive. Two comments by fishery scientists/managers described this drive as the urge to spawn; one fishery scientist/manager distinguished between this drive and the ability of salmon to make choices:

- "Are you asking in a religious sense? Or a drive? Some kind of drive? Not in the sense that they can alter what they do in life, cannot make choices like humans, [the] drive to spawn is independent of anything."
- "They have an urge to spawn. I am not a spiritual person."

The most consistent theme among commercial fishers and fishery scientists/managers appeared to be that every living thing has a spirit. This belief seemed to be motivated by the extraordinary drive fishers observed in salmon migrating upriver to spawn:

- "It's a perception question. Livelihood and culture perceptions. Spirit, having watched a salmon with half of its back eaten by a bear, they continue to spawn. If people have a spirit, then salmon do, too."
- "Every animal has a spirit; otherwise they would never make it to the spawning grounds."
- "Salmon do not have a spirit per individual fish, but salmon as a species has a spirit. 'If salmon have an individual spirit, what does that make of me?'"

Code Hierarchy: Management

Comments pertaining to overfishing, escapement, politics, and fish of hatchery origin were coded under the rubric of management issues. In general, commercial fishers and fishery scientists/managers tended to agree with each another on issues of Copper River fisheries management while the Ahtna did not agree with the other 2 groups.

Proposition 10: "Hatchery salmon is necessary to support fisheries in the Copper River."

More than 80% of fishery scientists/managers disagreed with this proposition. Fishery scientists/managers who commented, however, also said that although hatchery fish were not necessary, overall harvests would be lower without them:

- "I said no, but looking at overall returns, maybe fewer fish for the commercial fishery or upriver fisher, but it's not necessary for the fishery. Hatchery production dampens the natural lows. Hatchery fish cannot be harvested in great numbers because they mix with all other stocks. In the personal use fishery this year, hatchery fish made up only 16% of the harvest, and some years it's much smaller. In Prince William Sound, the pink salmon hatcheries work because fishers harvest mainly the hatchery production ... can develop an industry around that. But not the case in the Copper River."

Seventy percent of commercial fishers agreed with the proposition. They commented that hatchery fish increase commercial harvests, and in some years may make the fishery more lucrative or simply just possible.

- "It helps. Last year [2008], there were no spring reds [sockeye salmon], and then Gulkana came through."
- "Last year [2008] would have made a major difference in the commercial fishing sector had there not been a hatchery. [This was] evident in the [20]08 season."

Some commercial fishers pointed out that hatchery fish provide opportunity for other fisheries and thus they were not the only user group to benefit:

- "Agree, both for subsistence and commercial. Commercial fish tax money to support the hatchery."
- "No one would be fishing without them."
- "Because all of the different users that are harvesting the resource. Upriver users take a lot more of the enhanced stock than they realize."

A majority of Ahtna respondents (60%) disagreed with Proposition 10, although those who commented realized that without hatchery fish harvests would be lower and wild salmon might be endangered:

- "I don't like it about hatcheries ... but maybe too many people want to take fish from the river."
- "This question is a trap, because on one hand I don't think that hatcheries are good for our fisheries, but on the other hand there might be more demand than the wild can provide for. I

want to say let the sport fisherman go to hatcheries, and leave the wild fish for subsistence users."

- "There is more demand than wild salmon can provide for. We don't want the wild salmon to go extinct, so we need to farm fish to meet the demand."

Proposition 18: "Copper River sockeye salmon should be managed for each different stream rather than as a whole group."

Ahtna respondents generally agreed with Proposition 18, but commercial fishers and fishery scientists/managers disagreed. Their responses to this proposition revealed the Ahtna's strong concerns about a perceived loss of diversity of salmon stocks within the watershed. Ahtna familiarity with stocks and streams of the watershed is evident by their inventory of names for every spawning stream on the Copper River upstream of the mouth of the Sanford River (Kari 1986; Simeone and Kari 2002). These names often reflect either a morphological aspect of the salmon that spawn in these streams or a characteristic of the stream. Although Ahtna now fish primarily in the mainstream of the Copper River, in the past they fished and monitored the abundance of salmon in these tributary streams. In their comments on the propositions, Ahtna were able to describe conditions in specific streams, such as Sinona or Tanada creeks.

Commercial fishers and fishery scientists/managers disagreed with this proposition, and many commented on the logistical and financial infeasibility of stream-by-stream management. Perhaps because of their location at the mouth of the river, commercial fisher responses showed that they tended to view Copper River salmon as an aggregate. Two commercial fishers said that current conditions and technological limitations prevented single-stock management and one characterized it as micromanagement. Another commercial fisher voiced similar concerns, but also observed that maintaining the health of all stocks would benefit commercial fishers:

- "Tough proposition. ADFG is barely hanging onto funding. We need to increase the money exponentially. Separate stocks need to be monitored, but I don't know if they can be accurately measured. Commercial fishermen are concerned with separate socks. Nice to target a few more systems [while commercial fishing], without breaking the bank [i.e., overfishing]."

Another commercial fisher respondent said that more damage could be done if each stream were managed separately. The respondent described the impacts of closures in the commercial fishery during the 2008 fishing season because of low returns to the Copper River Delta and the Gulkana River. The respondent said that commercial fishers then went to Prince William Sound in order to make money, and that only about 25 boats remained in Cordova. When the Copper River finally reopened for commercial fishing, he said, the inefficiency in the commercial fleet enabled a large number of fish to escape, or perhaps overescape, into the Copper River. The respondent thus concluded that single-stream management could cause more harm than good.

Fishery scientists/managers were split on this proposition. Most of their comments focused on technological and logistical problems of single-stream management, as well as the enormous expense required to monitor each spawning stream. Several fishery scientists/managers believed this would be ideal, but it was currently impossible:

- "If I could wish for something, this is something that I'd wish for. I don't think it's possible though. We [would] need to recognize that particular stream and start monitoring it [if there were a problem]."

- "[This would be] a challenge and [I] recognize that we are going away from that. But [I] fear that the Copper River could suffer the same fate as Northwest fisheries if we don't. [I] fear

that we will lose stocks and suffer the Northwest's fate. Diversity is a major asset to the Copper."

- "Ideally, yes; but in reality, currently not possible."
- "Would be nice, but cannot be done."
- "Agree, but it's not possible; don't have info to tell them apart … $5 billion wouldn't even be enough."

Proposition 9: "Current fisheries management in the Copper River provides healthy fisheries for now and for future generations."

Only 50% of Ahtna agreed with this proposition, while 90% of commercial fishers and 88% of fishery scientists/managers agreed. Ahtna comments reflected various viewpoints:

- "If I have to choose between 'agree' or 'disagree,' I would have to say 'disagree'."
- "They're doing pretty good, but they got to be careful with hatchery fish .... that's not too good."
- "We needed more management 25 years ago. Bristol Bay run was damn near slaughtered 25 years ago ... they are just now starting to see a return. If management wouldn't have come in they might be gone."
- "Them managers might not know enough. I mean ... they think they know ... they might know a lot of things ... but I don't think they really KNOW them fish."
- "They need more management, more oversight. Management of people, not management of fish."
- "Maybe they are doing their job good but some things we don't like. That fish weir by Batzulnetas ... Grandma doesn't like it ... it seems to be disturbing the fish. A long time ago people would make a weir across to get fish ... but they would take the fish and then move the weir and stay out of the water. Not stay in all the time."
- "We are not looking far enough ahead."
- "I think the Copper River Watershed Project is doing a good job ... we need more organizations who will work to protect the salmon and educate the people."
- "Management could be better ... but what we have is better than nothing."

Comments from commercial fishers also seemed to vary widely:

- "Current fisheries management is quite conservative."
- "Pretty conservative now."
- "Sustainability—ADFG is [managing/doing] better than the national average."
- "Mostly agree. [Managers] do make mistakes—human error—i.e., fish too much, let too many pass."
- "Don't know how it's managed upriver, so I dunno. Lots of escapement by us. Escapement is our future, we gotta have it."
- "For the most part."
- "More enforcement upriver is needed to provide healthy fisheries now and for future generations."

- "Comm Fish [division, in ADF&G] is doing its part. Ironic [that] the ADFG Sport Fish [Division] and ADFG Comm Fish [Division] do not have the same mission statement. They should have the same mission statement."
- "Varies from year to year. One problem is the revolving managers. One manager learn enough to effectively manage the fishery but then he moves on. Agree with statement but the flux in changes in management is a negative. Not that the managers are not trying to do a good job. Funding and the reduction in retirement benefits is not attracting managers to take the job or keep the job. The benefit situation is at a point where the good people can't afford to stay in those jobs. ADFG has its hands tied with the amount of money, spending, and what's available (dollar) is thinner and [they end] up having less to spend while having to do more."

The comments from fishery scientists/managers were fairly consistent:

- "[I] think with management now [we] will have healthy populations in the future, but not the diversity of salmon. 120 stocks now, not as many in the future … loss of abundance, meaning lower escapement. We will have subsistence fish, but won't catch as many and will have to work harder to do that."
- "I don't agree with the allocation, or management decisions, but I do not think managers have made any mistakes."
- "Coordination between [Division of] Sport Fish and [Division of] Commercial Fish needs improvement. Sport fishers say there is a 2 week delay from Miles Lake to Wood Canyon, [but] this is not consistent with tagging [or other research]. 6 weeks would be better. Room for improvement for management of inriver fisheries."
- "Got to be better than when I was there."
- "It has a few problems, but generally agree. Could do better for some stocks."
- "We need to keep a good handle on it and work together."
- "That was our goal, what we were trying to do, ever since I worked there."

DISCUSSION

Based on earlier research on Copper River salmon fisheries (Simeone and Kari 2002; Simeone et al. 2007) and recent literature on LTK (Berkes 1999; Ferguson and Messier 1997), researchers hypothesized that Ahtna's and commercial fishers' understanding of the fisheries would resemble scientific knowledge but that long term experience on the water, cultural backgrounds, academic training, and spatial/temporal foci would affect each group's knowledge and opinions about the fisheries. This discussion examines different interpretations of the data and is organized around the 4 hypotheses.

HYPOTHESIS 1: LONG TERM EXPERIENCE ON THE WATER PROVIDES COMMON GROUND

The first hypothesis was that Ahtna and commercial fishers would share opinions about the fisheries based on their long term experience on the water. The demographic data showed that both Ahtna and the commercial fishers had considerable experience in the fishery. However, the consensus analysis showed that Ahtna and the commercial fishers agreed on only 2 of 22 propositions. One interpretation is that long term experience on the water has little or no bearing on how fishers view the fisheries. The lack of agreement between Ahtna and commercial fishers could be the result of other factors, such as the kinds of propositions asked. Ahtna and commercial fishers agreed on the proposition that winter and spring environmental conditions could be used to predict salmon abundance. Agreement on this proposition may indicate that both groups share similar views about value of experience in predicting salmon returns.

HYPOTHESIS 2: FORMAL EDUCATION AND PROFESSIONAL EXPERIENCE ENCOURAGES DIFFERENCES

Hypothesis 2 was that fishery scientists/managers are distinct from Ahtna and commercial fishers because of their academic training and professional status. Of the 3 groups interviewed for this study, the fishery scientists/managers had the highest levels of education and demonstrated the most cohesion represented by higher average respondent knowledge scores and the absence of negative knowledge scores. Education, especially at the graduate level, provides fishery scientists/managers with a more uniform model for understanding the fisheries. Most fisheries scientists/managers are trained in the scientific method and the use of quantitative data. They generally also share an agency perspective. The following comment by a fishery scientist/manager characterizes the managers' point of view on the importance of quantitative data:

> Management is quantitative. If I knew, or had quantitative data or new information, I would have agreed with more propositions. Management is not historical; history is discounted to a degree. People focus on the anomalies, so they don't see the pattern or trend, just [the] anomaly. Managers could manage historically if they saw that what they had been doing for 25 years was working—that is, they would not need data if they saw consistent success. Managers consistently question the validity of data, but don't question science. But managers are willing to change their ideas if the data changes. For example, I could not accept an observation that salmon are smaller without data, couldn't accept the observation without validation from other sources.

Results from the consensus analysis supported hypothesis 2, but there is a caveat. Although the demographic profile showed that commercial fishers did not generally have the same level of academic and professional training as fishery scientists/managers, there was a relatively strong consensus between these 2 groups evidenced by their agreement on 10 of 22 propositions. These 2 groups draw from overlapping cultural models on the subject of Copper River salmon. For example, both commercial fishers and fishery scientists/managers agreed that there are more than 50 spawning groups; that too many spawning salmon in a stream can reduce salmon abundance; that current fisheries management is providing for a healthy fisheries; that the size of salmon varies from year to year; that fisheries at both ends of the river have an effect on each other; that nature manages salmon; that salmon diversity is important; and that sockeye salmon are not smaller now than in the past.

If commercial fishers had become thoroughly acquainted with agencies' fisheries management principles, their congruence on the majority of the propositions could be explained. The economic success of commercial fishers probably depends not only on their knowing how to catch fish, but also on their understanding of agency fisheries management. Commercial fishers also seem to approve of the agency's management actions;90% of commercial fishers agreed with the proposition that current fisheries management provided healthy fisheries and the comments from commercial fishers reflected a generally positive feeling toward agency management. Over the past 20 years, salmon abundance as measured by commercial harvests has been high, which perhaps led one commercial fisher to comment that "ADF&G is [managing/doing] better than the national average."

Another comment alluded to the close relationship between commercial fishers and fishery scientists/managers, some of whom live year round in Cordova and thus are easily accessible to commercial fishers during the long winter months and during the fishing season. This comment illustrates the depth of knowledge about ADF&G that some commercial fishers have:

> [Management] varies from year to year. One problem is the revolving managers. One manager learns enough to effectively manage the fishery but then he moves on… but the flux in changes in management is a negative. Not that the managers are not trying to do a good job. Funding and the reduction in retirement benefits is not attracting managers to

> take the job or keep the job. The benefit situation is at a point where the good people can't afford to stay in those jobs. ADF&G has its hands tied with the amount of money, spending, and what's available (dollar) is thinner and [they] end up having less to spend while having to do more.

While commercial fishers in this study generally agreed with fisheries management, anthropological studies of commercial fishers suggest that they view nature as dynamic, not necessarily in equilibrium, and that it is sensitive to small initial perturbations (Brakel 2001; Smith 1996). Research on hunter-gatherer cultures also suggests that hunters view nature in a similar way and that they are especially skilled at fine tuning their perceptions in order to act appropriately to survive (Ingold 1996). In other words, those involved in making their living from fishing and hunting learn to observe the fine details while they engage with the environment. This attention to detail is apparent in the high level of consensus between commercial fishers and Ahtna on Proposition 2, that environmental conditions can be used to predict salmon abundance.

Fishery scientists/managers, on the other hand, are trained to look at the big picture and to observe nature through the lenses of statistics and predictive models. Their job is to level the variations in nature and maintain consistent harvests. Most fishery scientists/managers disagreed with Proposition 2. One fishery scientist/manager explained that seasonal environmental indicators were not good predictors of abundance. He said that managers "would never use just one factor to predict abundance, they would use several," and concluded that "managers would not manage based on these predictors."

The difference in focus may also explain why Ahtna and fishery scientists/managers disagreed on propositions including whether hatchery fish look different from wild salmon (Proposition 7), or whether sockeye salmon were now smaller than 25 years ago (Proposition 11). In each case, Ahtna agreed with the proposition and could provide specific details based on their observations of the differences in the meat or the fat content of the salmon they had harvested. Fishery scientists/managers, on the other hand, focused on whether there were data to support agreement with the proposition.

The consensus analysis suggests that most Ahtna have little knowledge of the technical aspects of fisheries management compared to commercial fishers. Formal and informal interviews with Ahtna in the context of other studies support this view. Ahtna's lack of knowledge about fisheries management is reflected in their disagreement with Proposition 8 ("Too many spawning salmon in a stream can reduce future salmon abundance"), which is a central tenet of agency fisheries management used to set escapement goals. Although Ahtna respondents did not express a thorough knowledge of the principles of modern fisheries management, the Ahtna as a group has a long history of confronting fisheries management, and they do engage with management through the public process by submitting proposals to change regulations and by testifying before the BOF (Simeone et al. 2007; Simeone *Unpublished* [13]).

HYPOTHESIS 3: AHTNA AND COMMERCIAL FISHERS SHARE A WORLDVIEW

Hypothesis 3 was that Ahtna and commercial fishers would share similar opinions because their knowledge is more localized than that of fishery scientists/managers, who tend to adopt broad scale approaches. Results of consensus analysis showed that there was no agreement between Ahtna and commercial fishers and so in this respect the data did not support the hypothesis. There are at least 2 ways to interpret this result. First, because commercial fishers were familiar with fisheries management, they tended to adopt management's broad scale approach. A second interpretation is that Ahtna and commercial fishers did not share similar opinions because their knowledge was very localized, so their dissimilar views on the fisheries were largely the result of their different geospatial orientations. The

[13] Simeone, W. E. *Unpublished*. Engaging government: the Ahtna and the Upper Copper River salmon fishery 1915–1990. Unpublished paper in possession of the author. Alaska Department of Fish and Game Division of Subsistence, Anchorage.

geospatial data showed that Ahtna and commercial fishers fished and lived at opposite ends of the river. This upriver/downriver dynamic was also reported for the Kuskokwim and Skeena rivers (Pinkerton 2009:904; Butler 2005). Analysis of several propositions supports this interpretation of the data.

Ninety percent of commercial fishers supported the proposition that sockeye salmon are more abundant now than 25 years ago while over 90% of Ahtna did not. Abundance is a relative term (Escobar 1998) and how fishers view abundance may depend on where they fish. Commercial fishers, who fish at the mouth of the Copper River, measure abundance in terms of their harvests, which have remained high since the 1980s (Hollowell and Taube 2005; Lewis et al. 2008). Ahtna fishers, who fish on the upper Copper River, measure abundance in terms of the number of salmon in their fish wheels. While harvest data and escapement show that Copper River salmon have been abundant over the last 20 years, Ahtna respondents who fish on the upper Copper River said they saw declining numbers of sockeye salmon.

Responding to Proposition 14, most Ahtna thought fisheries on the upper river had no effect on those on the lower river. Comments showed that some Ahtna thought their fisheries too small to have any effect on fisheries in the lower river. Commercial fishers saw the situation in reverse: any activity on the upper river, such as sport fishing on or near the spawning grounds, would affect future abundance and subsequent opportunity to harvest salmon. Interestingly, both groups agreed with Proposition 13, that fisheries on the lower river do affect those on the upper river. Some Ahtna commented that fishers on the lower river were overharvesting salmon, while commercial fishers who commented on this proposition thought that tight regulations on their harvests would mitigate any effect the commercial fishery would have on the upper river.

Commercial fishers and Ahtna disagreed with each other regarding the proposition that each stock of sockeye salmon should be managed individually (Proposition 18). Commercial fisher respondents tended to view salmon populations in large aggregates. Attempting to manage each stock would, in the view of some commercial fishers, be micromanagement, or worse, would result in damage to the commercial fishery. Ahtna who commented on this proposition expressed concern for specific streams and the health of salmon in those streams. This attention to specific streams reflects the Ahtna tradition of fishing on tributary streams and their intimate knowledge of the local environment.

Location also seemed to be a factor in how respondents viewed the effects of human activity on the fisheries (Proposition 16). A majority of Ahtna agreed with this proposition while just over one-half of the commercial fishers agreed and just 40% of fishery scientists/managers agreed. Ahtna interviewed for this study live and fish on the upper Copper River where most of the noncommercial fishing takes place and which is accessible by road to the larger urban centers. The Copper River Delta is inaccessible by road and can be reached only by airplane or boat, which led one commercial fisher to comment that "most of the human activities throughout the delta in particular have remained neutral, or have had no impact."

HYPOTHESIS 4: ALL GROUPS ARE CULTURALLY DISTINCT

Hypothesis 4 was that the opinions and beliefs of Ahtna, commercial fishers, and fishery scientists/managers would be culturally distinct. Analysis of answers to the propositions demonstrates that there was no overall consensus between the 3 groups, which supports this hypothesis by indicating that respondents may be using more than one cultural model to assess the fisheries. Ahtna perspectives of the fisheries are based on cultural models of nature and temporal and spatial scales that differ from those of fishery scientists/managers (Simeone and Kari 2002; Simeone et al. 2007).

In terms of models of nature, the Ahtna ecological model assumes that humans, plants, fish, and animals live in one world and that these entities are intelligent, moral beings (de Laguna 1969/70; Simeone and Kari 2002). Fish in particular are to be treated with respect because they travel long distances and they permit human beings to use their bodies. This view also was revealed in comments Ahtna made when asked if salmon had a spirit. Ahtna said that respect for salmon was demonstrated by the care fishers give them and by gentle handling (see Wolfe 1988 for similar views among the Yup'ik).

While many commercial fishers and fishery scientists/managers agreed that salmon had a sprit, their responses revealed various attitudes and beliefs. None characterized salmon as sentient or aware; instead, most characterized them as possessing a drive. The most consistent theme among commercial fishers and fishery scientists/managers was that every living thing has a spirit, a belief inspired by their observations of the extraordinary drive of migrating fish.

There was general agreement among all 3 groups that nature manages salmon, but most respondents qualified their answers by saying that people also play a role in managing and caring for salmon stocks. Ahtna respondents generally viewed the relationship between nature and humans as a partnership, in which humans help take care of salmon by removing beaver dams that block salmon streams, monitoring their consumption of fish, and having respect for the fish. Commercial fishers generally agreed that nature manages salmon, a finding consistent with other research about the role of nature in a commercial fishery (Paolisso 2002). However, some commercial fishers disagreed that nature manages salmon, believing instead that management plays an important role in salmon survival by ensuring adequate escapement to the spawning grounds. Comments made by fishery scientists/managers varied from the opinion that nature does manage salmon, to that it has a modest impact, and to that it can actually hinder management.

CONCLUSIONS

This study assessed the similarities and differences between scientific knowledge and local and traditional knowledge of Copper River salmon. The project had 4 objectives:

1. Formally assess different cultural models or perspectives on Copper River salmon fisheries using consensus analysis, a formal mathematical model;
2. Understand where the knowledge and opinions of Ahtna, commercial fishers, and fishery scientists/managers converge or diverge on the subject of the Copper River salmon fisheries;
3. Find common ground between major stakeholders and fishery management on the subject of the management of Copper River salmon fisheries; and
4. Initiate a process that includes user knowledge as a tool that can be used by fishery scientists/managers to maintain the health of the Copper River salmon fisheries.

Researchers developed a set of 22 propositions with the help of consultants from each of the 3 study groups. A total of 86 respondents were interviewed: 30 Ahtna, 30 commercial fishers, and 26 fishery scientists/managers. The interview data included respondents' yes/no answers to the propositions, as well as qualitative data in the form of respondent comments, demographic data, and geographic data. Propositions related to the level of agreement between Ahtna, commercial fishers, and fishery scientists/managers on salmon biology, including stock structure, fish movement, abundance, stock condition, and the effect of management in commercial and subsistence fishing areas. Findings were drawn from the analysis of 5 data sets: consensus analysis, demographic characteristics of the study populations, geospatial data, qualitative coding of respondent comments, and organization of respondent comments.

Researchers found common ground between commercial fishery stakeholders and fishery scientists/managers on the subject of management of Copper River salmon fisheries.[14] Despite

[14] When researchers began this project, they contacted CDFU and the Ahtna Tene Nene′ Customary and Traditional Use Committee to obtain both groups' approval for the project and to ask for their participation. The CDFU expressed concern that the project might undermine their position at an upcoming meeting of the BOF. They were also concerned that Ahtna participation on the study team might somehow bias the results of the survey. After several discussions with CDFU, the project team agreed to postpone the survey until after the BOF meeting. At the time of these discussions, members of the public, including some who were members of CDFU, submitted proposals to the BOF that, if

differences in education levels, fishery scientists/managers and commercial fishers largely shared similar views about the fisheries, agreeing on issues of management and the existential nature of salmon. Unlike scientists/managers, however, commercial fishers and Ahtna seemed comfortable with using experience as a way to gauge the fisheries.

The data did not support the hypothesis that Ahtna and commercial fishers share common opinions about the fisheries because of their long term experience on the water. Nor did the data support the hypothesis that Ahtna and commercial fishers share similar opinions because their knowledge is more localized than that of fishery scientists/managers. Researchers determined that a respondent's geospatial orientation, defined by his/her upriver or downriver location, is a main point of difference between Ahtna and commercial fishers. It seems that geospatial orientation or "place" is less significant to fishery scientists/managers, who view the fisheries in terms of the entire watershed.

The data demonstrated that Ahtna generally have very different views of the fisheries, which researchers attribute to differences in cultural models and geospatial and temporal orientations. The data showed that Ahtna, fishery scientists/managers, and commercial fishers have different views on the existential nature of salmon. The upriver–downriver dynamic between commercial fishers and Ahtna seems to be pronounced and appears to affect how each group views aspects of the fisheries.

Compared to the other 2 groups, Ahtna have a pessimistic view of the fisheries. Researchers attributed this pessimism to the effects of history (temporal orientation), ethnicity, and culture (Nazarea 1999). The entire length of the Copper River has experienced many developments including the gold rush of 1898, the development of a large scale copper mine and attendant railroad, the construction and dismantling of World War II military bases, the construction of the Trans-Alaska Pipeline, and the development of a highway system that links the Copper River Basin to other parts of the state.

Commercial fishers and fishery scientists/managers said they saw no evidence that these developments had an effect on Copper River salmon. While members of these groups did express concerns about habitat, they acknowledge that available data show the fisheries to be thriving and, in contrast to salmon streams in the western United States, there are no major industrial developments on the Copper River. Ahtna, however, have described these developments as a threat to salmon (Simeone and Kari 2002; Simeone et al. 2007). This perspective is based largely on personal experience. Almost every middle-aged and elderly Ahtna has observed and directly experienced the developments mentioned above and noticed subsequent changes in the fisheries. Their experiences are reflected in the Ahtna consensus that habitat is being compromised (Proposition 3), that salmon in the Copper River are being overfished (Proposition 4), that sockeye salmon are not as abundant as they once were (Proposition 6), and that the timing of the salmon runs has changed (Proposition 21). Ahtna view habitat compromise not only as a physical risk to salmon, but also as an existential threat to humans because it threatens the human–animal relationship, which is crucial to human survival. About Proposition 21, one Ahtna commented: "People used to know how to take care of things: We learn about *'engii* [traditional rules] … we should never bother the animals. … We gone too far away … nobody cares anymore."

The last objective was to initiate a process that included user knowledge as a tool that could be used by fishery scientists/managers to maintain the health of the Copper River salmon fisheries. This objective was not fully met through this study, though the study did contribute to ongoing efforts to develop communications between managers and users. Currently, these efforts include the Salmon Harvest Task Force composed of commercial fishers (Prince William Sound seiners and Copper River/ Prince William

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adopted, would have changed regulations governing the Copper River salmon fisheries. Several of these proposals, if adopted, would have resulted in restrictions to the upriver fisheries. After the proposals were published, the Ahtna Tene Nene′ Customary and Traditional Use Committee invited members of the CDFU to a meeting in Glennallen to discuss the proposals. Members of the project team attended the meeting, and Ahtna and commercial fishers exchanged views about the fisheries. Ahtna also described how the proposals would hurt their participation in the fisheries. At the end of the meeting, the proposer agreed to withdraw several of the proposals.

Sound gill netters) and ADF&G managers. This group meets before the harvest season to discuss harvest management issues related to forecasted returns. Additional meetings may be held when unforeseen events occur during the harvest season. The Copper River strategy group started by Ecotrust is another example of managers working with traditional users on watershed issues.

A formal management working group could be formed for integrating local knowledge into management of the Copper River salmon fishery. This working group could be modeled after the Kuskokwim River Salmon Management Working Group, which includes stakeholders and managers. The new working group could meet once to discuss management objectives before the onset of the harvest season, once during the season, and once after the end of the season to assess current management and to develop future management objectives. The working group should also include personal use dipnetters and the sport fishers, who were not included in this study.

Because LTK tends to be localized, additional studies on more specific ecological questions should be conducted to complement this study, which had a general scope. Studies focused on specific tasks such as identifying critical habitat areas or assessing the health of small salmon stocks are necessary. To provide information useful for management, these studies should include local experts, natural scientists, and social scientists collaborating directly in all phases, especially in the field while collecting data (Wolfe and Spaeder 2009).

In conclusion, analysis of the data showed no general consensus among fishery scientists/managers, commercial fishers, and Ahtna on Copper River salmon, although agreement was observed within each of the 3 groups. Fishery scientists/managers were the most cohesive group, likely because of their similar training and education. There was agreement between commercial fishers and fishery scientists/managers regarding management of the fisheries. Ahtna were distinct from the other 2 groups in demographics, geospatial orientation, and culture. A likely major distinction between the views of fishery scientists/managers and Ahtna (and commercial fishers, to some extent) is that management is concerned with biological facts regarding the resource itself, whereas LTK is much broader and more inclusive of experiential and contextual information, all of which facilitates a fisher's ability to harvest fish (Paolisso 2002; Butler 2005). As we have seen, the local knowledge of commercial fishers includes an understanding of management and the larger context of their fishing activities. This also seems to hold true for Ahtna, who gauge the fisheries through the lens of their long term and accumulated knowledge of the fisheries. In sum, a local fisher's view of the fisheries is frequently shaped by a wide variety of factors, including the circumstances of competition, regulation, history, and politics. Fishers are as attentive to those factors as they are to the technical aspects of catching fish.

PUBLICATIONS

A journal article coauthored by members of the study team is currently in preparation. Journals considered for submittal include the *Journal of Society* and *Natural Resources*.

OUTREACH

Before data collection, much communication with the 3 study groups was necessary to ensure their participation in this study. The research team worked closely with the CDFU and the Ahtna Tene Nene′ Customary and Traditional Use Committee. Members of the research team held several formal and informal meetings with CDFU board members to discuss the scope and potential implications of the project. Team members also discussed the project with staff of the ADF&G Division of Commercial Fisheries.

The research team sent a draft report to the Ahtna communities and the CDFU, and made it available for fishery scientists/managers. The final report will be sent to CDFU, the Ahtna Tene Nene′ Customary and Traditional Use Committee, and to the ADF&G offices in Anchorage, Glennallen, Fairbanks, and Cordova.

Results of the study will be presented at a future meeting of the Ahtna Tene Nene′ Customary and Traditional Use Committee.

CONFERENCE PRESENTATIONS

Copper River Strategy Group Meeting, June 4–5, 2009, Gakona, Alaska. Presentation of preliminary results by W. E. Simeone.

Alaska Chapter of the American Fisheries Society, November 3–5, 2010, Juneau, Alaska. Presentation of "Cultural Models of Copper River Salmon Fisheries" by W. E. Simeone, L.C. Naves, M.E. Lowe, G. Stickman, E. McCall-Valentine, and J. Brady.

Alaska Marine Science Symposium, January 16–20, 2012, Anchorage, Alaska. Upcoming poster presentation of "Cultural Models of Copper River Salmon Fisheries" by W. E. Simeone, L.C. Naves, M.E. Lowe, G. Stickman, E. McCall-Valentine, and J. Brady.

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APPENDICES

Appendix A.–Letter of Invitation to potential respondents.

STATE OF ALASKA

SARAH PALIN, GOVERNOR

DEPARTMENT OF FISH AND GAME

SUBSISTENCE DIVISION

333 Raspberry Road
Anchorage,, AK 998518
PHONE: (907) 267-2309
FAX: (907)267-2450

Invitation to Participate in a Study of Copper River Salmon

You are invited to participate in a study investigating the knowledge Ahtna fishers, Cordova commercial fishers, and fisheries managers have about Copper River salmon. This study is being conducted by researchers from the Alaska Department of Fish and Game – Division of Subsistence, Ahtna Inc., Ecotrust, University of Alaska Anchorage, and North Cape Fisheries Consulting with funding from the North Pacific Research Board.

Here in Alaska we often hear about the need to consider "local knowledge" in resource management. We feel that local knowledge is not something that is the property of a single population. People who have spent their lives either using or studying natural resources, such as fisheries, have a specialized knowledge about them. We are inviting people who are considered experts on the subject of Copper River salmon to participate in this study to help us understand how different groups of people might agree or disagree on the subject of salmon ecology.

We are asking these experts to participate in a survey which resembles a test, but this test has no right or wrong answers. You will be asked to answer 25 propositions about Copper River salmon ecology and whether you agree or disagree with these statements. The propositions refer to salmon ecology, stock structure, fish movement, abundance, and fisheries management. For example, a proposition could be: "Salmon in the Copper River prefer cold water." In addition to answering the proposition, participants will also be encouraged to offer reasons for their answers. Using this type of a survey, we can measure how much particular groups of people agree or disagree on a specific topic.

To develop the survey, we have depended upon the consultation and collaboration of the Cordova District Fishermen United (CDFU) and two experts from each study group (Ahtna fishers, commercial fishers, and fisheries managers).We hope the outcome of this study will help identify common ground and improve communication between resource users and fishery managers and contribute to the long-term sustainability of the Copper River salmon fisheries.

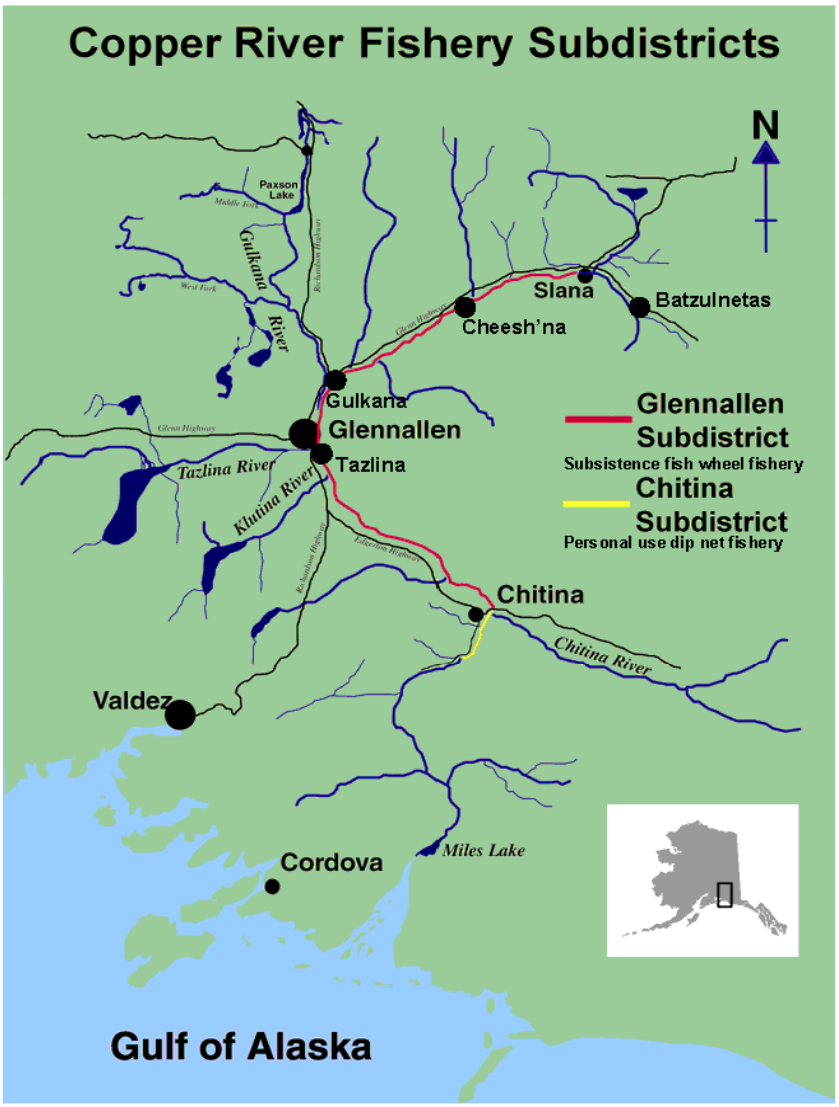
The interviews will last about one hour. We are contacting you because of your long term experience with the Copper River salmon fishery and value your input. This letter will be followed by a phone call to see if you are interested in participating in the study and if so, when we could arrange a time to come and speak with you. Respondents will receive an honorarium of $20.

Thank you very much!
Bill Simeone
ADFG – Division of Subsistence
bill.simeone@alaska.gov

Appendix B.–Interview instrument.

Cultural Models of Copper River Salmon Ecology
ADF&G, UAA, Ecotrust, Ahtna Inc., North Cape Fisheries Consulting, NPRB

1. Name: _____
2. Date of interview: _____ Start: _____ Finish: _____
3. Group: Ahtna ( ) Commercial fisher ( ) Fisheries biologist ( ) Fisheries manager ( )
4. Address_____
5. City: _____ State: _____ Zip: _____
6. Age: _____
7. Gender: Male ( ) Female ( )
8. How many years have you lived in area?_____
9. How many years have you fished for salmon and/or worked as a salmon biologist/manager in the Copper River drainage? _____
10. Do you currently fish for salmon in the Copper River? Yes ( ) No ( )
11. Do/did your parents fish for salmon in the Copper River? Yes ( ) No ( )
12. Education:
    - High school or GED ( )
    - Some college ( )
    - College ( )
    - Masters ( )
    - PhD ( )
    - Other ( ) _____
13. Please circle on the map (see back) the area or areas of the Copper River drainage that represent your area of expertise.
14. Mark with an "X" individual locations where you have fished or collected field data on Copper River salmon.


Copper River Fishery Subdistricts
N
Paxson Lake
Gulkana River
Slana
Batzulnetas
Cheesh'na
Gulkana
Glennallen
Tazlina
Tazlina River
Klutina River
Glennallen Subdistrict
Subsistence fish wheel fishery
Chitina Subdistrict
Personal use dip net fishery
Chitina
Chitina River
Valdez
Cordova
Miles Lake
Gulf of Alaska

Cultural Models of Copper River Salmon Ecology

ADF&G, UAA, Ecotrust, Ahtna Inc., North Cape Fisheries Consulting, NPRB

Propositions

1. There are more than 50 different sockeye salmon spawning groups in the Copper River.

Agree Disagree

2. Winter and spring environmental conditions (amount of snow, budding, temperature, etc.) can be used to predict salmon abundance.

Agree Disagree

3. The loss of habitat is the greatest threat to salmon abundance.

Agree Disagree

4. Salmon in the Copper River drainage are being overfished.

Agree Disagree

5. King salmon are more abundant now than they were 25 years ago.

Agree Disagree

6. Sockeye salmon are more abundant now than they were 25 years ago.

Agree Disagree

7. Hatchery sockeye salmon look different from wild sockeye salmon.

Agree Disagree

8. Too many spawning salmon in a stream can reduce future salmon abundance.

Agree Disagree

9. Current fisheries management in the Copper River provides healthy fisheries now and for future generations.

Agree Disagree

10. Hatchery salmon are necessary to support fisheries in the Copper River.

Agree Disagree

11. Sockeye salmon are smaller in size now than they were 25 years ago.

Agree Disagree

12. The size of salmon varies from year to year.

Agree Disagree

Informant Number:_____

Cultural Models of Copper River Salmon Ecology

ADF&G, UAA, Ecotrust, Ahtna Inc., North Cape Fisheries Consulting, NPRB

Propositions continued…

13. Fisheries in the lower Copper River affect fisheries in the upper river.

Agree Disagree

14. Fisheries in the upper Copper River affect fisheries in the lower river.

Agree Disagree

15. Nature manages salmon.

Agree Disagree

16. Human activity over the past 25 years has reduced the number of different sockeye spawning groups in the Copper River.

Agree Disagree

17. Fishing on the spawning grounds is bad for that that particular spawning group of salmon.

Agree Disagree

18. Copper River sockeye salmon should be managed for each different stream rather than as a whole group.

Agree Disagree

19. Salmon diversity is important to maintain overall salmon abundance.

Agree Disagree

20. The Copper River floods more now than 25 years ago.

Agree Disagree

21. Run timing of salmon has changed over the last 30 years.

Agree Disagree

22. Salmon have a spirit.

Agree Disagree

Informant Number:_____