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Cultural Consensus on Salmon Fisheries and Ecology in the Copper River, Alaska

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ABSTRACT. This study assessed levels of agreement in knowledge and opinions about salmon fisheries and ecology of the Copper River, Alaska, in three user groups: the Ahtna, an Alaska Native people indigenous to the upper river; commercial fishers who fish at the mouth of the river; and fishery managers and biologists with jurisdiction over the entire watershed. We anticipated that cultural background, academic training, long-term experience on the water, and spatial focus would be reflected in each group's knowledge and opinions. Cultural consensus analysis showed agreement within each group, similar opinions between commercial fishers and managers and biologists, and distinct Ahtna opinions. Managers and biologists were the most cohesive group; they related to the entire watershed and relied on quantitative information as the basis for fisheries management. Ahtna focused on the upper river and incorporated observed long-term sociocultural, economic, and environmental changes into their opinions about the fisheries. Commercial fishers focused on the lower river and had strong familiarity with scientific principles of fisheries management. The similar views of commercial fishers and managers and biologists may result from the fact that commercial fishers' economic success also depends on their understanding of fisheries management. To respond to socioeconomic and ecological sustainability issues, fisheries management would benefit from recognizing these perspectives and promoting participation of all stakeholder groups and effective communication among them.

Key words: Alaska; Copper River; Pacific salmon; commercial fishing; subsistence fishing; cultural consensus analysis; Ahtna; local and traditional knowledge; fisheries management

RÉSUMÉ. Cette étude a permis d'évaluer les degrés d'accord en matière de connaissances et d'opinions sur l'écologie et la pêche au saumon de la rivière Copper, en Alaska, chez trois groupes d'utilisateurs : les Ahtna, peuple autochtone de l'Alaska natif du haut de la rivière; les pêcheurs commerciaux qui pêchent à l'embouchure de la rivière; et les gestionnaires et biologistes des pêches qui ont compétence sur l'ensemble du bassin versant. Nous nous attendions à ce que les connaissances et les opinions de chaque groupe soient rattachées aux antécédents culturels, à l'expérience académique, à l'expérience à long terme de la pêche et l'orientation spatiale. L'analyse du consensus culturel a permis de démontrer un accord au sein de chaque groupe, des opinions similaires entre les pêcheurs commerciaux et les biologistes-gestionnaires, et des opinions distinctes chez les Ahtna. Les biologistes-gestionnaires ont constitué le groupe le plus cohérent. Ils comprenaient l'ensemble du bassin versant et s'appuyaient sur des données quantitatives pour gérer les pêches. Pour leur part, les Ahtna se concentraient sur le haut de la rivière et tenaient compte, dans leurs opinions au sujet des pêches, des changements socioculturels, économiques et environnementaux observés à long terme. Les pêcheurs commerciaux se concentraient sur le bas de la rivière et connaissaient bien les principes scientifiques de la gestion des pêches. Les points de vue similaires des pêcheurs commerciaux et des biologistes-gestionnaires peuvent découler du fait que la réussite financière des pêcheurs commerciaux dépend aussi de leur compréhension de la gestion des pêches. Pour répondre aux questions de durabilité écologique et socioéconomique, la gestion des pêches pourrait bénéficier de la reconnaissance de ces perspectives, puis promouvoir la participation de tous les groupes d'intervenants de même que des communications efficaces entre eux.

Mots clés : Alaska; rivière Copper; saumon du Pacifique; pêche commerciale; pêche de subsistance; analyse du consensus culturel; Ahtna; connaissances locales et traditionnelles; gestion des pêches

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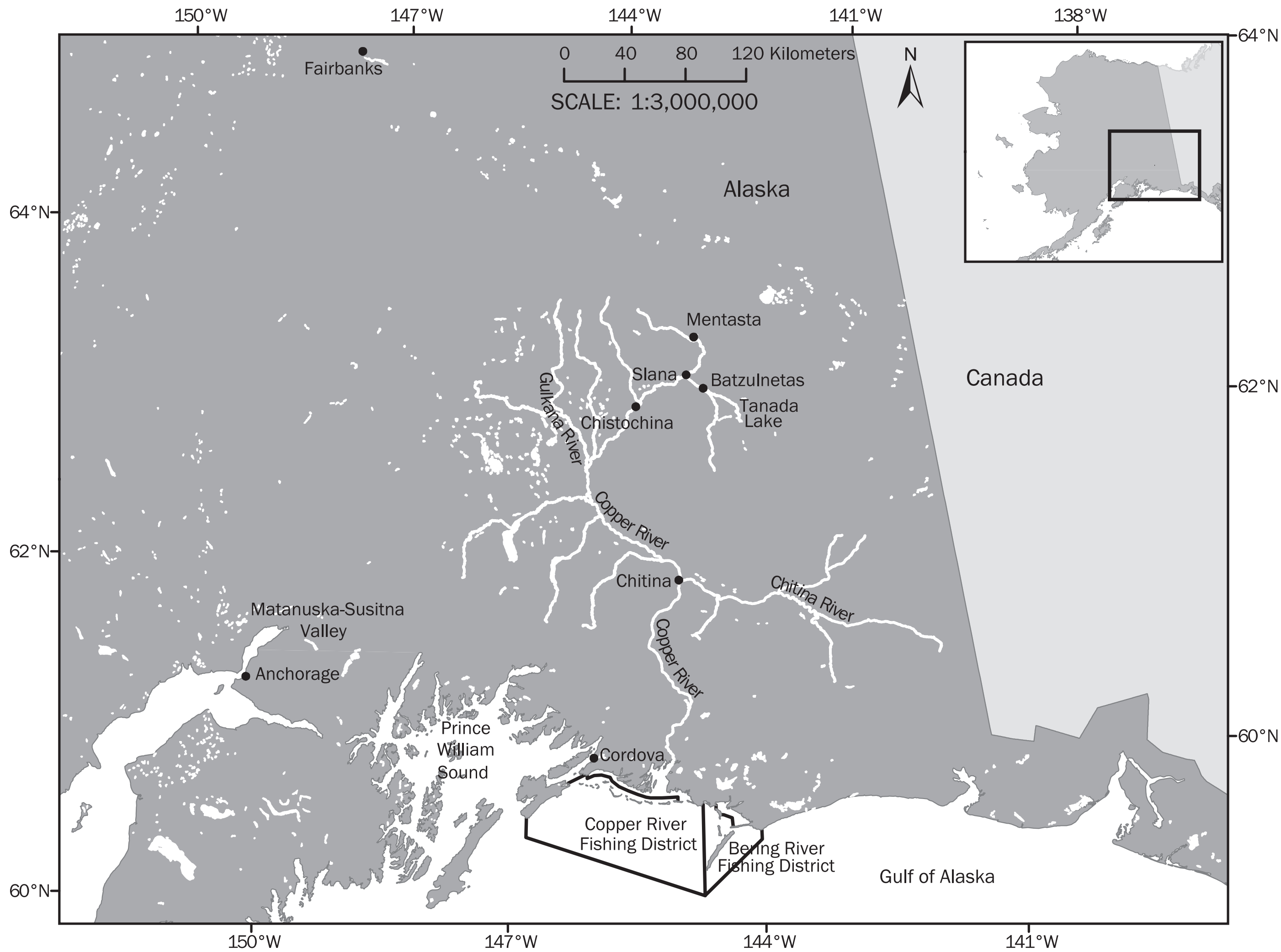

FIG. 1. The Copper River watershed and adjacent areas, Alaska. Rivers of other watersheds in adjacent areas are not represented in this map. Map prepared by the Alaska Department of Fish and Game, Division of Subsistence, July 2014. North American Datum 1983.

INTRODUCTION

Copper River Salmon Fisheries, User Groups, and Study Objectives

This study assessed similarities and differences in knowledge (understanding gained through experience or academic study) and opinions (what people believe to be true or false in the course of their daily lives) of subsistence fishers, commercial fishers, and fishery managers and biologists on the subject of salmon fisheries and ecology of the Copper River, Alaska. This study also aimed to promote integration of user knowledge and communication as useful tools in fisheries management. The need for such efforts in the Copper River fisheries was recognized in a letter of support for this study from the Cheesh'na Tribal Council: "This documentation is a collaborative effort that will ascertain and facilitate communication between stakeholder groups by sharing knowledge and opinions where otherwise there is none." Cultural models are conceptual frameworks or "pre-supposed, taken-for-granted models of the world that are widely shared (although not to the exclusion of other, alternative models) by members of a society and that play an enormous role in their understanding of that world and their behavior in it" (Quinn and Holland, 1987:4). Understanding of cultural models may help user groups, managers, and biologists to better frame perspectives, facilitate negotiation, and foster collective action to support management actions responsive to socioeconomic and ecological sustainability issues (Huntington et al., 2002; Paolisso, 2002; Stone-Jovicich et al., 2011). Findings of this study were originally reported in detail in Simeone et al. (2011).

In the Copper River watershed (Fig. 1), an extensive complex of tributaries and lakes provides spawning grounds for king salmon *Oncorhynchus tshawytscha*, sockeye salmon *O. nerka*, and coho salmon *O. kisutch*, while chum salmon *O. keta* and pink salmon *O. gorbuscha* spawn in the estuaries. These salmon support four main fisheries:

(1) the commercial gillnet fishery in estuarine and marine waters at the river mouth; (2) the personal-use dip net fishery near the town of Chitina; (3) the upper river subsistence fish wheel and dip net fishery upstream of Chitina; and (4) the sport rod and reel fishery on several tributaries in the mid and upper watershed.

In 2001–10, the Copper River commercial fishery harvest averaged 1.6 million salmon per year, of which 75% were sockeye salmon. Unlike the other fisheries, the commercial fishery has limited entry: the number of permits is fixed at about 500 and no new permits are issued. The personal-use dip net fishery (about 8000 household permits per year) averaged about 114 000 salmon annually. Most personal-use dip net permits are issued to residents of urban centers outside the Copper River watershed (Fairbanks, Anchorage, and the Matanuska-Susitna Valley). The subsistence dip net and fish wheel fisheries (about 1100 annual household permits) averaged 80 000 salmon per year. An upper river subsistence fishery operates along the main stem between the communities of Chitina and Slana. Smaller subsistence fisheries operate at the traditional site of Batzulnetas (in the headwaters) and also in estuarine and marine waters at the river mouth (Botz and Somerville, 2011; Botz et al., 2012). The sport rod and reel fishery averages about 15 000 salmon per year and targets king salmon, accounting for the second-largest harvest component for this species after the commercial fishery (Somerville, 2011). This sport fishery is the only fishery allowed in tributaries and lakes where salmon spawn. Participation in all upper river fisheries will likely continue to grow as the state's population grows.

This study used cultural consensus analysis (Romney et al., 1986; Weller, 2007) to assess similarities and differences in knowledge and opinions of (1) Ahtna involved in upper river subsistence fisheries; (2) commercial fishers fishing at the river mouth; and (3) fishery managers and biologists with jurisdiction over the entire watershed. Stakeholders involved in the sport and the personal-use dip net fisheries were not included in this study because their livelihoods are not intrinsically reliant on Copper River fisheries. Although sport and personal-use dip net fishers may participate in management and have their own opinions on the fisheries, these fishers generally have a looser connection with the Copper River watershed, where their presence may be limited to one or a few trips per summer.

The Ahtna are Alaska Native, Athabascan-speaking people indigenous to the upper Copper River watershed. In 2010, the Ahtna population in the Copper River area was about 900 people living in several communities. An unknown number of Ahtna live outside the Copper River area (U.S. Census Bureau, 2011). Contemporary Ahtna communities maintain a lifestyle centered on their customary and traditional uses of fish and wildlife and have a mixed cash-subsistence economy. Salmon is a main subsistence resource for these communities while diverse other resources, such as moose, berries, and small land mammals, are also harvested (Kukkonen and Zimpelman, 2012; La Vine et al., 2013). Ahtna relations with salmon date back more than 2000 years. Over this time, they developed sophisticated methods for harvesting and processing salmon, protocols governing the treatment and use of salmon, and an oral tradition on the origin of Copper River salmon (de Laguna, 1969; Workman, 1977; de Laguna and McClellan, 1981; Kari, 1986). Since the 1920s, Ahtna have experienced increased competition for salmon, the development of fully allocated fisheries, environmental changes, and changes in their traditional harvest and use patterns (Simeone and Kari, 2002; Simeone and Fall, 2003; Simeone and McCall Valentine, 2007).

Commercial fishing began in the Copper River delta region in 1889, and since then it has been the mainstay of the economy and culture of the city of Cordova (population of 2239 in 2010; U.S. Census Bureau, 2011). Almost half of Cordova's households have at least one member working in fish harvesting or processing. In 2008, 347 commercial salmon permits (out of a total of 500) were issued to Cordova residents, leading to local earnings of about 29 million dollars (Alaska Commercial Fisheries Entry Commission, 2008a). Alaska Native groups, particularly the Eyak, have inhabited the delta for thousands of years, but today they represent only about 15% of Cordova's population, which is predominately of Euro-American descent (70%; U.S. Census Bureau, 2011). The *Exxon Valdez* oil spill in 1989 severely impaired Cordova's fishing-based economy, and its lingering effects, together with competition from international salmon farming, still present local fishers with considerable economic challenges.

In the Copper River fisheries management system (see below), managers and biologists conduct research on salmon population dynamics, including assessments of salmon abundance and timing of migrations, characterization of stocks, genetic and ecological interactions between hatchery and wild stocks, and monitoring of wild stock productivity. The data generated are used to inform policies and actions for fisheries management. Some managers and biologists have authority to open and close fisheries on the basis of the regular management calendar and on emergency orders.

Previous research found that Ahtna fishers and fishery managers and biologists hold differing views on the long-term sustainability of Copper River fisheries (Simeone and Kari, 2002; Simeone and McCall Valentine, 2007). Ahtna local and traditional knowledge (LTK) focuses on specific streams and fishing sites, while managers and biologists usually relate to the entire watershed and fisheries. The Ahtna believe salmon to be sentient, moral beings that give themselves to people as long as they are treated with respect and users are not wasteful. They have reported declines in salmon spawning in the headwaters and the possible extirpation of one type of sockeye salmon that spawns in Tanada Lake and attribute these changes to increased noise, water pollution, and other changes in spawning areas caused by human activities. Fishery managers and biologists report that the abundance of upper river salmon stocks naturally fluctuates over time and that there is no evidence of stock extirpation (Simeone and Kari, 2002; Simeone and Fall, 2003; Simeone and McCall Valentine, 2007). Managers and biologists, basing their view on drainage-wide harvest and escapement data from the last 20 years, perceive the management of the Copper River fisheries as successful (Botz et al., 2012).

Copper River Fisheries Management

The Copper River salmon fisheries are largely managed by the State of Alaska, although federal subsistence regulations also play a role (U.S. National Archives and Records Administration, 2014a, b). Under state laws and regulations, all Alaskans regardless of place of residence or ethnicity may participate in authorized subsistence fisheries. Participation in federally authorized subsistence fisheries is limited to residents of rural communities with recognized customary and traditional uses. All Ahtna communities have federally recognized customary and traditional uses of Copper River salmon. Harvestable amounts of salmon consistent with sustainable yields are fully allocated, and increasing the allocation of one group would require decreasing that of one or more other groups (State of Alaska, 2013:5 AAC 24.360 and 5 AAC 24.361). With current salmon returns, providing for the subsistence allocation (61 000 – 82 500 salmon) is not resulting in substantial restrictions on other Copper River fisheries. If harvestable returns drop below management goals, other fisheries would need to be restricted to provide for the subsistence fisheries (State of Alaska, 2013:SEC 16.05.258).

In the Copper River, each salmon species has a number of stocks differentiated by genetics and by spawning location (tributaries have specific natal stocks). The abundance and timing of migration of individual stocks vary annually. While stocks are mixed at the delta region and in the main stem, fisheries management initiatives apply to all stocks. To avoid overharvest of individual stocks, managers and biologists regulate the commercial fishery through openings and closures timed throughout the salmon migration. A sonar device located about 45 km upstream of the commercial fishing district provides data on the number of salmon migrating upriver. The sonar passage goal is set to provide for diversification of spawning stocks and for upper river harvest allocations to the subsistence, personal use, and sport fisheries. Unlike the other fisheries, the subsistence fishery is continuously open through the entire salmon migration and rarely experiences in-season management adjustments (Botz and Somerville, 2011; Somerville, 2011; Botz et al., 2012).

Copper River fisheries management is based in part on the principle that optimal salmon productivity is related to an optimum number of fish on the spawning grounds. While a minimum number of spawning salmon (360 000 for sockeye salmon and 17 500 for other salmon; State of Alaska, 2013:5 AAC 24.360) is necessary to ensure smolt production, too many salmon can result in reduced productivity because of excessive competition among spawning salmon, disturbance of spawning beds, and competition among emerging smolt. Salmon returning to the Copper River in excess of amounts necessary to ensure sustainable spawning stocks are allocated to user groups on the basis of management plans (State of Alaska, 2013:5 AAC 24.360 and 5 AAC 24.361).

Supplementing wild salmon returns with hatchery fish is another management tool used in the Copper River. In the early 1970s, a hatchery was established in the headwaters of the Gulkana River to mitigate loss of spawning habitat due to road construction. Fertilized eggs are produced from local wild salmon and released as juvenile fish. In 2002 – 11, the estimated average return of hatchery sockeye salmon was 300 000 fish/year and represented 5% – 29% of the total returns (Stopha, 2013). Returns added by hatchery fish and escapement goals attempt to reduce annual variation in salmon abundance and harvests amounts.

METHODS

Extensive communication with the three stakeholder groups was necessary to ensure their participation in this study. We worked closely with the Cordova District Fishermen United (CDFU), a nonprofit commercial fishing organization; the tribal councils of Chistochina (Cheesh'na) and Mentasta; and the Ahtna Tene Nene' Customary and Traditional Use Committee during all phases of this study. In the early stages, these organizations provided letters supporting the study and voluntary participation of the communities. Participation of individual respondents was also voluntary. Several formal and informal meetings with CDFU board members were held to discuss the study scope and potential implications. We also discussed the study plan with staff of the Alaska Department of Fish and Game (ADF&G) Division of Commercial Fisheries. Preliminary results were presented to Ahtna tribal councils, the CDFU, and fishery managers and biologists for comment.

We used cultural consensus analysis (Romney et al., 1986; Weller, 2007) to assess similarities and differences in knowledge (understanding gained through experience or academic study) and opinions (what people have realized to be true or false in the course of their daily lives) of Ahtna, commercial fishers, and managers and biologists. We asked respondents considered to be experts on Copper River salmon fisheries to respond to a set of propositions, allowing two categorical answers (agree or disagree). Consensus analysis has been applied in cross-cultural studies in various fields such as medicine, business, tourism, and natural resources management (Miller et al., 2004; Wilson et al., 2006; Medin et al., 2007; Stone-Jovicich et al., 2011). The benefit of this method is that it allows us to quantify levels of agreement on a cultural domain (concepts about a theme) within and among defined cultural groups while simultaneously assessing patterns of answers across a set of propositions.

TABLE 1. Set of answers estimated by consensus analysis ("agree" or "disagree" for each proposition and group) and percentage of respondents in each group answering "agree" to individual propositions (in parentheses).

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

Collectively, our research team represented decades of work experience and research on ethnography and fisheries and wildlife management in the Copper River basin (e.g., Simeone and Kari, 2002; Simeone and Fall, 2003; Simeone and McCall Valentine, 2007). On the basis of this experience and broad-scope LTK literature (e.g., Brakel, 2001; Paolisso, 2002; Fraser et al., 2006), we anticipated some factors that could be reflected in perspectives about the fisheries. (1) Knowledge and opinions might differ because of different cultural backgrounds. (2) The academic training of managers and biologists might result in opinions different from those of Ahtna and commercial fishers, who tend to draw knowledge from diverse sources (e.g., formal and informal teaching and learning systems, personal and group experience, media). (3) Ahtna and commercial fishers might share perspectives because both have long-term field experience on the water. (4) Knowledge and opinions of Ahtna and commercial fishers might be more spatially localized than that of managers and biologists, who tend to adopt watershed-wide approaches.

We developed 45 preliminary propositions referring to salmon ecology, human activities, environmental conditions, and fisheries management. Two consultants with long-term experience in the Copper River fisheries and fisheries management were identified in each group to help fine-tune the preliminary propositions. Some CDFU members were concerned that individual views of an Ahtna researcher in this study could lead to biased findings. Therefore, to facilitate participation of commercial fishers in the study, the CDFU executive director was also invited to assist as a consultant. All consultants helped us to identify propositions more likely to capture important perspectives of each study group, to refine wording to clarify meaning, and to avoid preferences or value judgements (Weller, 1998). The number of propositions in the final set was reduced to 22 to keep interview duration to one hour or less (Table 1). The seven consultants did not participate as respondents. Respondents had no access to propositions beforehand and were interviewed individually to minimize the opportunity for collusion.

Potential respondents were identified on the basis of their long-term experience with Copper River salmon and the fact that they made their living in the fisheries at the time of this study or had done so for a period of their lives. The local tribal councils helped identify potential Ahtna respondents living in the communities of Mentasta and Chistochina who were aged 40 years and older (n = 30). Active and former fishery managers and biologists directly involved in the Copper River salmon fisheries were identified from state and federal agencies' staff directories and by recommendation from professionals in the area (n = 26). Active commercial fishers living in Cordova who had been fishing in the area for at least 20 years (n = 155) were identified from 1988–2008 annual lists of drift gillnet permit holders (Alaska Commercial Fisheries Entry Commission, 2008b). From this pool, the CDFU executive director helped to identify fishers that were permanent residents of Cordova and potentially available for an in-person interview. A random sample of 50 commercial fishers was drawn to allow for 30 respondents and 20 alternates to replace initially selected respondents who had moved from Cordova, declined to participate, or were unavailable for an interview. A letter of invitation was mailed to all potential respondents to introduce the study goals, methods, and expected outcomes.

Data were collected in structured, in-person interviews guided by a form specifying demographic information (name, gender, age, stakeholder group, education, length of residence in the area, length of participation in the fisheries, and whether the respondent's parents fished in the Copper River), geographic area of expertise, and the set of propositions. On a map of the watershed, respondents circled their area(s) of expertise and pinpointed locations where they had fished or collected data. These location responses were standardized through assignment to 10 drainage units (Ecotrust, 2005). Respondents were considered to be familiar with a drainage unit if one or more of their circles or locations included any portion of it. The interviews were conducted in January – April 2009.

Interviewers explained to respondents that there were no right or wrong answers to propositions. Some respondents, not being able to agree or disagree with a proposition, responded "I don't know," and these answers were treated as missing data. Commercial fishers had seven missing answers; managers and biologists, 10 missing answers; and Ahtna, no missing answers. Respondents were encouraged to comment on their answers to provide context for consensus analysis results and to help identify underlying processes related to agreement or disagreement. Comments were recorded as field notes with the intent of being close but not literal transcriptions and were published in Simeone et al. (2011).

Analyses were conducted with the software Anthropac 4.98 using the covariance method (Borgatti, 1996; Weller, 2007). Four sets of results are discussed: (1) eigenvalues for each factor (vectors representing the percentage of the variance in responses that each factor accounted for) and the ratio of the first eigenvalue (the largest) to the others; (2) loadings on the first factor ("knowledge scores" of each respondent, which is a measure of how well each individual represents the entire sample); (3) loadings on the second factor ("disagreement scores" of each respondent; relatively high disagreement scores indicate that knowledge scores do not account for a significant proportion of the variance in responses); and (4) an estimated set of answers based on individual knowledge scores and the proportion of respondents that concurred in their responses to propositions (Table 1).

If the first factor represents a large percentage of the variance, there may be a significant level of agreement among respondents. In general, a ratio of at least 3:1 between the first and second factors is provisional evidence that the data fit the consensus model (there is consensus among respondents). A ratio smaller than three between the first and second factors and low (< 0.5) or negative individual knowledge scores indicate that (1) there is a low level of agreement among respondents; (2) a few respondents do not fit the general cultural model; (3) there are sub-populations representing different cultural models; (4) sub-populations differ in their level of agreement; or (5) a significant proportion of propositions within the set failed to capture perspectives and worldviews (Borgatti, 1996; Weller, 2007; Gatewood and Cameron, 2009).

RESULTS

The duration of involvement in the salmon fishery was longer for the Ahtna (average = 51.6 years) than for the commercial fishers (average = 36.2 years) and the managers and biologists (average = 10.9 years) interviewed (Table 2). Age and years involved in the fishery were more strongly correlated for Ahtna ($R^2 = 0.71$) than for commercial fishers ($R^2 = 0.48$) and managers and biologists ($R^2 = 0.17$). Managers and biologists reported the highest levels of formal education. On average, Ahtna were familiar with 1.5 drainage units, commercial fishers with 1.0 unit, and managers and biologists with 7.0 units. Ahtna were familiar with the Mentasta-Chistochina and Mount Sanford units, both located at the headwaters (Fig. 2). All commercial fishers interviewed indicated experience in the Copper River Delta unit, which closely corresponds with the Copper River commercial fishing district. Collectively, managers and biologists indicated experience across all drainage units.

A first round of consensus analysis considered all respondents together to assess whether the three groups had a single pattern of responses. A low first-to-second eigenvalue ratio and a relatively high proportion of low (< 0.5) and negative knowledge scores (loadings on the first factor) indicated lack of agreement among all respondents (Tables 3 and 4). When contrasting knowledge scores (loadings on the first factor) and disagreement scores (loadings on the second factor), the smaller the distance between groups, the closer the similarity in their responses to propositions: commercial fishers and managers and biologists had similar response patterns while Ahtna were distinct from the two other groups (Fig. 3).

A second round of analysis was performed considering the three groups individually. First-to-second eigenvalue ratios larger than three indicated higher within-group agreement than in the first analysis (Table 3). Low individual knowledge scores still occurred in the three groups and negative scores occurred for Ahtna (3% of respondents) and commercial fishers (7% of respondents) (Table 4). The highest level of within-group agreement occurred in managers and biologists, as indicated by its highest average first-to-second factor ratio and absence of negative knowledge scores (Tables 4 and 5).

Because of the closer proximity between commercial fishers and managers and biologists than between other groups (Fig. 3), a third round of analysis was done combining these two groups. Although the first-to-second factor ratio was larger than three (Table 3), the average knowledge score was lower than for each group individually (Tables 4 and 5).

Characteristics of respondent profiles (age, gender, years lived in the area, years fishing or working in the area, and

TABLE 2. Profiles of the three respondent groups (Simeone et al., 2011: Table 2).

	Ahtna (n = 30)	Commercial fishers (n = 30)	Fishery managers and biologists (n = 26)
Interview duration (minutes)[1]	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)[1]	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[2]			
Female	14	1	2
Male	16	29	24
Years living in the watershed[1]	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 watershed[1]	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 watershed?[2]			
Yes	29	28	17
No	1	1	9
Did/do parents fish in the watershed?[2]			
Yes	30	18	3
No	0	12	23
Education[2]			
High school or GED[3]	14	15	0
Some college	6	5	1
College degree	0	7	12
Graduate degree	0	0	13
Other	10	2	0

[1] Average ± SD (range; sample size).
[2] Number of cases.
[3] GED = General Educational Development.

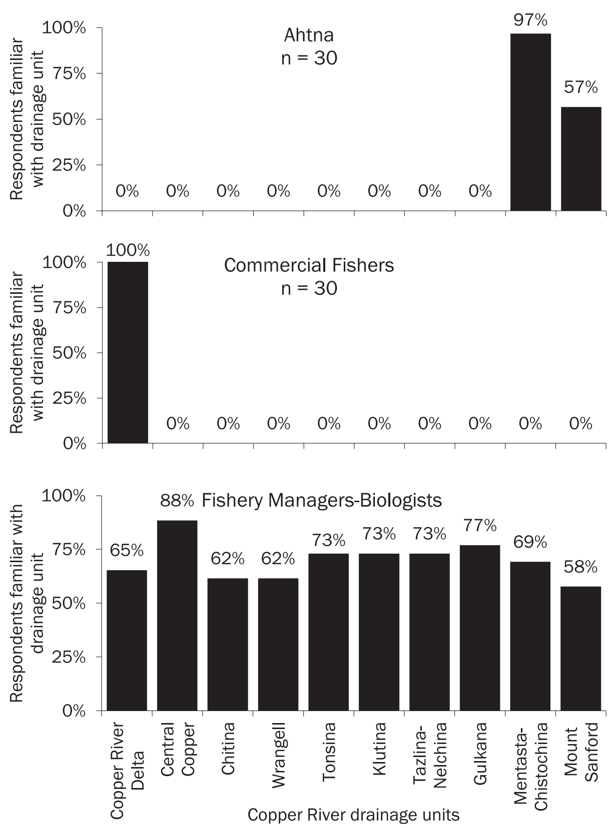

FIG. 2. Geographic areas (drainage units) in the Copper River familiar to Ahtna, commercial fishers, and fishery managers and biologists. Drainage units are listed (left to right) from the lower river to the upper river. Drainage units are based on Ecotrust (2005). Source: Simeone et al. (2011: Fig. 3).

education) were contrasted with individual knowledge scores to assess factors related to agreement levels within and among groups. When considering individual groups, Ahtna presented a tendency for higher knowledge scores in respondents of intermediary age (about 50–70 years old) than in those younger and older (Fig. 4). No relationships were observed between knowledge scores and other demographic characteristics (results not presented here). Effects of gender were not assessed for commercial fishers and managers and biologists because of low female representation among respondents, which reflects a male majority in these professional fields (Table 2).

All three groups were estimated to concur on nine of the 22 propositions (Table 1). Besides the propositions on which all groups concurred, commercial fishers and managers and biologists were estimated to concur on 10 other propositions, Ahtna and commercial fishers were estimated to concur on only two other propositions, and Ahtna and managers and biologists were estimated to concur on only one other proposition.

DISCUSSION

Cultural consensus analysis based on our set of propositions indicated higher within-group agreement among managers and biologists than among Ahtna and commercial fishers. A tendency for higher knowledge scores in Ahtna respondents of intermediary age (about 50–70 years old) than in those younger and older indicated that age-related

TABLE 3. Eigenvalues indicating goodness of fit to the consensus model (Simeone et al., 2011: Table 3).

Factor	Eigenvalue	% of variance explained	Ratio
Three groups together:			
1st	21.15	55.9	1.94
2nd	10.88	28.8	1.88
3rd	5.78	15.3	
Ahtna:			
1st	9.46	69.7	4.18
2nd	2.26	16.7	1.23
3rd	1.84	13.6	
Commercial fishers:			
1st	10.88	68.2	3.48
2nd	3.12	19.6	1.59
3rd	1.96	12.3	
Fishery managers and biologists:			
1st	10.07	70.6	4.25
2nd	2.37	16.6	1.30
3rd	1.82	12.8	
Commercial fishers and fishery managers and biologists:			
1st	19.01	67.3	3.93
2nd	4.83	17.1	1.09
3rd	4.42	15.7	

TABLE 4. Proportion of low and negative individual knowledge scores for groups of respondents (Simeone et al., 2011: Table 4).

Group	Low knowledge scores (> 0.5)	Negative knowledge scores
Three groups together	63%	34%
Ahtna	40%	3%
Commercial fishers	37%	7%
Fishery managers and biologists	35%	0%
Commercial fishers and fishery managers and biologists	40%	5%

processes may partly explain the heterogeneity within this group. Low within-group agreement may be related to the existence of different views within groups or to agreement on only a sub-set of the propositions (Gatewood and Cameron, 2009). Although our interview team included an Ahtna Native and speaker, some of the eldest Ahtna were less fluent in English and may have had difficulty understanding some propositions. Also, older Ahtna may have experienced more cultural, environmental, and social change in their lifetime as compared to younger Ahtna (see below), which may be reflected in their perspectives. Ahtna of younger and intermediary age usually have more formal education and are fluent in English. We found no factors that could help explain a relatively low level of agreement among commercial fishers. Although much effort was devoted to develop propositions that were clear and properly worded, differences in communication styles and language barriers may have affected how some respondents understood some propositions.

Stakeholders Have Diverse Cultural Backgrounds

Among the studied groups, Ahtna perspectives were singular in many aspects. In the Ahtna model of nature, humans, plants, and animals are all sentient, moral beings. If not treated properly, salmon can make themselves scarce and difficult to catch. To show respect for and placate salmon, Ahtna have developed protocols for diverse aspects of salmon fishing such as building a fish rack, handling and processing the catch, and sharing salmon foods (Workman, 1977; de Laguna and McClellan, 1981; Simeone and Kari, 2002). Similar views have been documented among Yup'ik people in western Alaska (Wolfe, 1988).

TABLE 5. Average knowledge scores of individual respondents (Simeone et al., 2011: Table 5 modified).

Group	Average	SD
Three groups together	0.26	0.42
Ahtna	0.53	0.19
Commercial fishers	0.53	0.29
Fishery managers and biologists	0.57	0.25
Commercial fishers and fishery managers and biologists	0.52	0.26

Different interpretations of proposition 22 ("Salmon have a spirit") seem to derive from distinct cultural backgrounds. Some Ahtna comments referred to relationships between people and salmon (e.g., "I know they say to be real careful when you handle fish, keep your mind on what you're doing, don't drop them" and "We have to take really good care of the fish in all we do. The old people who lived before us knew lots. We don't do like them anymore. I would like to go back so I can see the old people, how they do things"). On the other hand, commercial fishers and managers and biologists characterized salmon as possessing a drive, and none characterized them as sentient (e.g., "Are you asking in a religious sense or 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"). It seems this

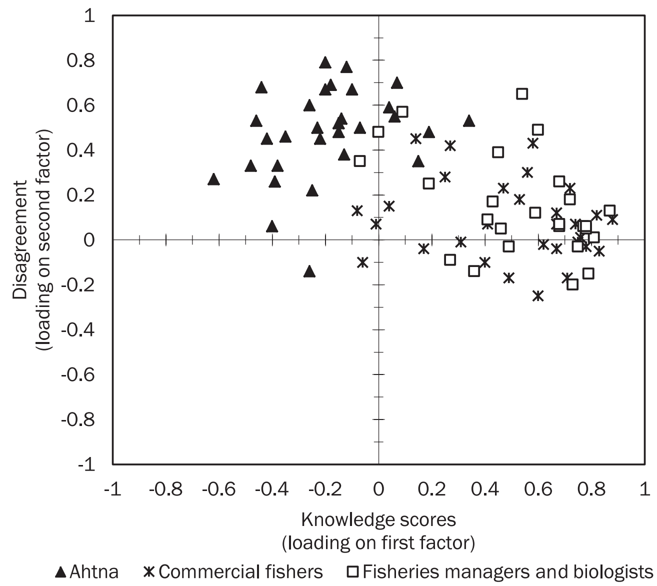

FIG. 3. Individual knowledge scores (loadings on first factor) and disagreement scores (loadings on second factor) for Ahtna, commercial fishers, and fishery managers and biologists (three groups considered together). Source: Simeone et al. (2011: Fig. 4).

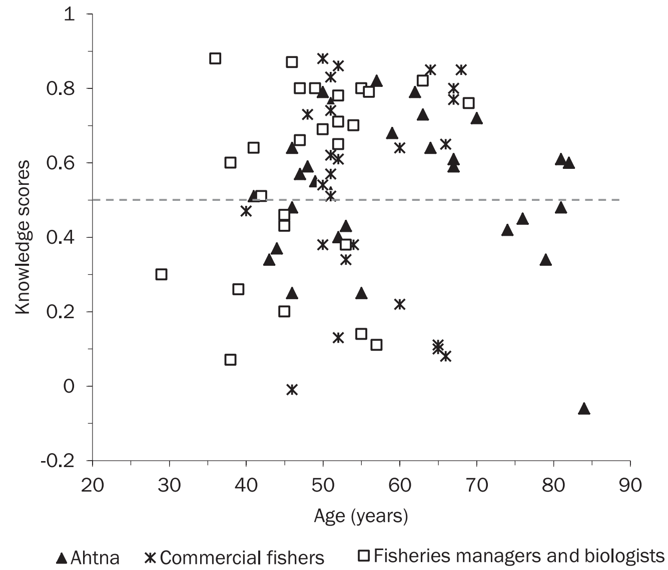

FIG. 4. Relationship between age of respondents and individual knowledge scores (loadings on first factor) for Ahtna, commercial fishers, and fishery managers and biologists (groups considered individually). Dashed line indicates threshold for low knowledge scores (< 0.5). Source: Simeone et al. (2011: Fig. 5 modified).

proposition was interpreted by some commercial fishers and managers and biologists as "salmon have an instinct" rather than "salmon have a spirit."

Ahtna had a pessimistic view of the fisheries, which may be related to history and culture. Ahtna experiences are reflected in the opinions that salmon are being overfished (proposition 4), sockeye salmon are not as abundant as before (proposition 6), and that salmon diversity has been reduced (proposition 16). The Copper River basin has experienced many developments including the 1898 gold rush, a large-scale copper mine and attendant railroad, construction and dismantling of World War II military bases, the Trans-Alaska Pipeline, and highways linking the Copper River basin to other parts of the state. Ahtna have described these developments as a threat to salmon (Simeone and Kari, 2002; Simeone and McCall Valentine, 2007). Most middle-aged and elderly Ahtna have directly experienced these developments and noticed changes in the fisheries. On the other hand, commercial fishers and managers and biologists did not refer to effects of these developments on salmon. These groups referred to data that show the Copper River fisheries are thriving and, compared to salmon streams in other states, the Copper River has no major industrial developments or dams.

Ahtna attention to small-scale processes and long tradition in depending on salmon for food may explain why they agreed that hatchery fish look different from wild salmon (proposition 7). Ahtna provided details on their observations of differences in the meat and fat content of hatchery salmon (e.g., "Them kind fish don't have grease in the head, it's just like water" and "The color of the meat is different"). Some Ahtna perceive hatchery salmon as a threat to wild salmon. Metaphysically, the Ahtna may perceive hatchery salmon as intrinsically different from wild salmon.

Ahtna have a long history of discussing and challenging practices and decisions in fisheries management and they testify before the Board of Fisheries and submit proposals to change regulations (Simeone and McCall Valentine, 2007). However, it seems Ahtna respondents had less connection with some scientific principles of fisheries management. The idea that too many spawning salmon may have adverse impacts on productivity plays an important role in escapement goals used in Alaska fisheries management. In contrast to the majority of commercial fishers and managers and biologists, Ahtna did not agree that too many spawning salmon can reduce future salmon abundance (proposition 8).

Only Ahtna agreed that salmon should be managed for individual stocks (proposition 18). Currently Ahtna primarily fish the main stem, but in the past they fished and observed salmon abundance in tributaries. Ahtna familiarity with individual salmon stocks is demonstrated by many traditional place names for upper-river spawning streams, which often refer to a stream's characteristics or morphological aspects of its salmon (Kari and Tuttle, 2005). Although managers and biologists and commercial fishers disagreed with proposition 18, they frequently explained that they agreed with the concept, but did not think that stock-specific management was feasible (e.g., "This is a challenge and I recognize we are going away from that. I fear we will lose stocks and suffer the Pacific Northwest's fate. Diversity is a major asset to the Copper River"). In fact, all groups agreed that salmon diversity is important to support overall salmon abundance (proposition 19).

All groups agreed that nature manages salmon (proposition 15). One difficulty with this proposition was the interpretation of management. Several respondents qualified their answers explaining management related to control of salmon abundance or to control of human activities. However, some Ahtna comments revealed a particular perspective according to which humans are responsible for helping and caring for salmon if natural conditions become unfavorable (e.g., "People got to take care of the fish. Sometimes though, nature does things, like the river will change" and "Nature provides salmon, but sometimes beaver dam up the creek and people got to take it out [so salmon can reach spawning grounds]").

A likely distinction between the views of fishery managers and biologists and those of Ahtna and commercial fishers is that management is concerned with quantifiable biological and ecological facts, whereas LTK is broader in scope and more inclusive of experiential and contextual information that facilitates fishers' ability to harvest fish (Paolisso, 2002; Butler, 2005). The following comment by a manager-biologist respondent illustrates this perspective: "Management is quantitative. Management is not historical. People focus on the anomalies, so they don't see the pattern or trend, just the anomaly." Local fishers' views of the fisheries are frequently shaped by a wide variety of factors, including the technical aspects of catching fish and also circumstances of competition, regulation, history, and politics.

Different Views Based on Quantitative Information and LTK

Fishery managers and biologists had the highest level of within-group agreement. Formal education, especially at the graduate level, likely provided managers and biologists with a uniform framework to understand fisheries based on quantitative data and to use statistics and predictive models to provide a watershed-wide perspective. The value of quantitative information in fisheries management is formally recognized and incorporated in federal policy by the Magnuson-Stevens Fishery Conservation and Management Act of 1976 and its associated legislation (Miller et al., 2004; North Pacific Research Board, 2005).

While fishers integrate factors likely to affect harvest success within their fishing ranges, managers and biologists address processes at much larger geographic scales, which can be achieved only through mathematical approaches based on systematic data collection. Mathematical models are simplifications of nature because they can incorporate a limited number of factors and are constrained in their ability to address interactions among factors. Fishers and hunters deal with an extremely diverse set of factors in their continuous quest to understand circumstances that favor harvest success (e.g., weather, currents, animal abundance and behavior, tide, precipitation amount and timing). Because of inherent difficulties in integrating these many factors and their interactions, fishers and hunters may find it intrinsically difficult to predict the occurrence and abundance of biological resources. Because LTK is often based on the principle that nature is unpredictable, hunters and fishers may also find it difficult to embrace the models of managers and biologists, which rely on simplifications of nature to forecast resource abundance (Berkes, 1999; Brakel, 2001; Paolisso, 2002).

On the other hand, managers and biologists find it difficult to integrate LTK into management because LTK usually is qualitative. Considerable effort has been made to document Alaska Native LTK and to make it available and usable for broad purposes (e.g., Huntington et al., 1999; Andersen and Fleener, 2001; Coiley-Kenner et al., 2003; Langdon, 2006). However, the integration of LTK into resource management remains challenging (Van Daele et al., 2001; Wheeler and Craver, 2005; Brelsford, 2009).

Different Views Based on Spatial Orientation

Opinions of Ahtna and commercial fishers tend to focus on a relatively small geographic scale and specific places, while fishery managers and biologists adopt broad-scale approaches, viewing the fisheries in terms of the entire watershed. Commercial fishers perceive nature as a complex, dynamic system not necessarily in equilibrium and sensitive to small perturbations (Smith, 1996; Brakel, 2001). Hunters and gatherers have a similar view and are especially skilled at fine-tuning their observations to respond to variations (Ingold, 1996). People making a living from fishing and hunting may develop the habit of observing details of environmental, biological, and ecological conditions in their continuous quest to understand circumstances that favor harvest success.

Maybe as a consequence of their focused spatial orientation, Ahtna and commercial fishers were largely polarized by the fact that they fish and live at opposite ends of the river (propositions 4, 9, 13, 14, 16). This upriver-downriver dynamic was also documented in the Kuskokwim and Skeena Rivers (Butler, 2005; Pinkerton, 2009:904). Commercial fishers largely agreed that sockeye salmon are more abundant now than 25 years ago (proposition 6), while Ahtna largely disagreed. However, fishers' perception of abundance may depend on where they fish (Escobar, 1998). Commercial fishers fish a large, mixed-stock fishery in the delta region and measure salmon abundance by their harvests, which have remained high. While harvest and escapement data show that sockeye salmon have been abundant over the last 20 years (Botz and Somerville, 2011; Botz et al., 2012), Ahtna fishing the upper river report declining salmon numbers.

In contrast to commercial fishers and managers and biologists, Ahtna largely disagreed that fisheries in the upper river affect fisheries in the lower river (proposition 14). In fact, the majority of harvests take place downstream of the two Ahtna communities included in this study. Although some Ahtna perceived that headwaters are important for the health of salmon populations, they thought upper river fisheries were small in volume. Some managers and biologists commented that upper river allocations could affect fisheries in the lower river because subsistence users have priority over other user groups.

In contrast to commercial fishers and managers and biologists, Ahtna largely agreed that human activity has reduced the number of sockeye salmon stocks (proposition 16). Ahtna believe that noise, air and water pollution, and disrespectful salmon treatment by casual fishers have reduced the abundance of salmon (Simeone and McCall Valentine, 2007). Because the upper river is accessible by road to residents of the large urban centers, Ahtna have directly experienced increased human activities, including a substantial increase in competition for fish and wildlife resources. On the other hand, the presence of outsiders in the delta region is very limited because this area can be reached only by airplane or boat. This fact may contribute to the view of some commercial fishers that the impact of human activities on salmon abundance is minimal. Managers and biologists see human activity as a negligible factor when they compare the relatively pristine environment of the Copper River to other areas in the United States and abroad, such as the Columbia River.

Shared Views of Commercial Fishers and Fishery Managers and Biologists

Consensus analysis revealed shared opinions between managers and biologists and commercial fishers. These two groups agreed that too many spawning salmon can reduce salmon productivity (proposition 8), that current management is providing for healthy fisheries (proposition 9), and that salmon are not being overfished (propositions 4, 6, 11, and 16). When agreeing on absence of overfishing (proposition 4), some respondents from both groups explained that their answers referred to the whole watershed rather than to individual stocks (e.g., "Not consistently overfished. There might be some years and stocks when overharvest occurs but looking at the aggregate, no"). However, only commercial fishers agreed that hatchery salmon are necessary to the fisheries (proposition 10) (e.g., "No one would be fishing without them"). Managers and biologists and Ahtna disagreed with this proposition but tended to believe that overall harvests would be lower without hatchery fish.

The economic success of commercial fishers likely depends not only on their ability to catch fish, but also on their understanding of fisheries management. It seems that commercial fishers' opinions are related to perceived impacts of fisheries management on their activities. Commercial fishers perceive that their fishery is tightly regulated and that regulations are conservative. However, it also seems they have a generally positive view of the management system (e.g., "ADF&G is doing better than the national average"). This positive view may be related to the fact that commercial harvests have been high over the past 20 years (Botz et al., 2012).

Managers and biologists and commercial fishers (Prince William Sound seiners and Copper River and Prince William Sound gill netters) interact directly through the Prince William Sound Salmon Harvest Task Force. This group meets before the harvest season to discuss management issues related to forecasted salmon returns, and other meetings may occur to address emerging topics. The participation of commercial fishers in this task force may also help to explain why their views are more similar to those of managers and biologists (as compared to Ahtna, who do not participate in the task force).

Knowledge and Communication as Management Tools

This study quantified levels of agreement among three stakeholder groups, demonstrated their different perspectives, and explored possible reasons for these differences. Cultural consensus analysis was an effective tool to capture, summarize, and visually present patterns of agreement for practical uses. With a blend of qualitative and quantitative information, cultural consensus analysis has great potential to facilitate communication in resource management systems.

In fisheries and wildlife management, issues related to knowledge, communication, equitable distribution of decision-making power, and resource allocation are intertwined and dynamic (Wilson et al., 2006). Future Copper River fishery management efforts would benefit from (1) recognizing different perspectives, cultural backgrounds, and styles of communication; (2) developing long-term, non-adversarial relationships among stakeholder groups; and (3) implementing processes and mechanisms through which all stakeholders are able to participate and contribute to policy and decision making. Some efforts to foster communication among resource users, managers, and researchers have included the Copper River strategy group (Ecotrust, 2011a), workshop series (Ecotrust, 2006), and knowledge system (Ecotrust, 2011b). Such approaches could also help to formulate specific research questions on topics such as identifying critical salmon spawning areas and assessing the sustainability of small salmon stocks. Direct collaboration between local experts and natural and social scientists is needed for research to provide the most useful information for management.

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