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Exploring stakeholder communication within a caribou hunting system of Arctic Alaska

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ABSTRACT

The Central Arctic Caribou (*Rangifer tarandus*) Herd (CACH) of Arctic Alaska rapidly declined (approximately 70%) between 2010–2016, which has generated hunter concerns and more conservative hunting regulations. Stakeholders expressed interest in exploring opportunities for a more effective exchange of information to facilitate management. We conducted a survey to identify hunters' insights into CACH dynamics and to estimate the extent and effectiveness of stakeholder communication channels. Most hunters (69%) perceived a decline in caribou numbers where they hunt because of shifts in caribou movement. Approximately half of hunters (46%) communicated with other stakeholders and primarily shared their thoughts through solely informal (29%) rather than formal (2%) communication channels. Informal channels were perceived as equally or more effective than formal channels for influencing management. We provided a revised model of hunter engagement in the regulatory process. Our research contributes to knowledge on stakeholder communication channels, an understudied topic within wildlife management.

KEYWORDS

Co-production; focus groups; hunting regulations; reindeer; survey research

Introduction

Effective management of a public trust resource (e.g., wildlife in North America) requires meaningful engagement of relevant stakeholders and reciprocal dialogue among resource users and managers (Lauber, Decker, & Pomeranz, 2014). Communication among stakeholders such as hunters, wildlife managers, and policy decision-makers can add transparency to the management process and help facilitate the alignment of management decisions with hunters' interests (Lute & Gore, 2014). For hunters, this can lead to a better understanding of why certain management strategies are chosen and fosters public acceptance of, and compliance with, management decisions (Cornicelli, Fulton, Grund, & Fieberg, 2011; Jacobs, Vaske, & Sijtsma, 2014). Stakeholder engagement, along with an open exchange of information, provides the opportunity for all stakeholders to gain new insights and perspectives on the resource of interest. For example, integration of hunters' knowledge and understanding can provide wildlife managers with contextual information that complements instrument-based data and monitoring efforts (i.e., population surveys) (Huntington, Callaghan, Fox, & Krupnik, 2004).

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Critical evaluation of communication channels is important because sufficient opportunities for and performance of communication can ensure accurate representation and interpretation of hunters' knowledge and maximize hunters' contribution to wildlife management and conservation (Campbell & Mackay, 2009; Huntington et al., 2002). Most wildlife management agencies in the USA recognize the value of hunters' knowledge and have created communication channels to gather hunters' opinions and insights to inform management decisions (Lord & Cheng, 2006), yet contention and confusion over management decisions continues to be a common problem (Brinkman, 2018; Urbanek, Nielsen, Davenport, & Woodson, 2015). Effective communication among stakeholders has often been reported as key to resolving this issue (Kruse, Klein, Braund, Moorehead, & Simeone, 1998; Talley, Schneider, & Lindquist, 2016; Triezenberg, Riley, & Gore, 2016). Public users (i.e., hunters) in our study raised concerns about the effectiveness of their communication with managers and about how their insights were used to inform policy decisions (see *Exploratory Stakeholder Focus Groups* for details). We explored channels used by hunters to communicate their insights on the dynamics and management of caribou (*Rangifer tarandus*) in Alaska. We also sought to inform opportunities for building effective communication strategies among stakeholders.

Stakeholders and the Regulatory Process

Caribou in the State of Alaska are primarily managed through hunting regulations set by the Board of Game (BOG) in accordance with Alaska Statute 16.05.255 that put restrictions on the location, season, bag limit, and sex of caribou that can be harvested and who can hunt them (e.g., general harvest, registration, drawing permits, residents, nonresidents). Alaska's regulatory process used to set hunting regulations involves participation from the general public (including hunters and non-governmental interest groups), Local Advisory Committees (LAC), and the Alaska Department of Fish & Game (ADF&G). Any person or group has the opportunity to submit proposals to the BOG regarding changes to hunting regulations and can provide comments on proposals submitted before they are considered by the BOG.

There are 84 LACs authorized by Alaska Statute 16.05.260 distributed across Alaska that represent public opinion on local fish and wildlife conservation issues. These LACs provide recommendations to the BOG on proposals regarding their local area. LAC meetings are open to the public and focus on developing and evaluating regulatory proposals and provide a forum for discussion among individuals, organizations, and agencies. The ADF&G Division of Wildlife Conservation (DWC) is the state agency tasked with managing and monitoring caribou in Alaska. ADF&G prepares analyses of wildlife population demographics and harvest trends and provides the BOG with their recommendations on all proposals submitted based on biological information. The BOG consists of seven members intended to represent diverse stakeholder views who are appointed by the governor and confirmed by the legislator. The BOG meets two to three times a year and is the authority that ultimately makes decisions on hunting regulations in Alaska. Further description of the BOG is discussed in detail in Alaska Statute 16.05.221 (b) and (c). The ADF&G is responsible for implementing management based on BOG decisions.

The ADF&G developed a conceptual model that describes formally recognized communication channels among stakeholders which is frequently presented in outreach materials to educate the public on how to contribute their opinions and insights to inform

wildlife management and policy decisions (e.g., McCarthy & Taras, 2011; McFarland & Taras, 2016; Nedwick, 2012). Currently, this model does not include a communication pathway directly from the public to the ADF&G and all communication channels are represented with unidirectional arrows (Figure 1a). We focused on the role of hunters in this process and described how they were communicating with other stakeholders in the context of ADF&G's model and management of the Central Arctic Caribou Herd (CACH) in Alaska. We broadly define *hunters* as Alaskan residents that have participated in hunting under State regulations.

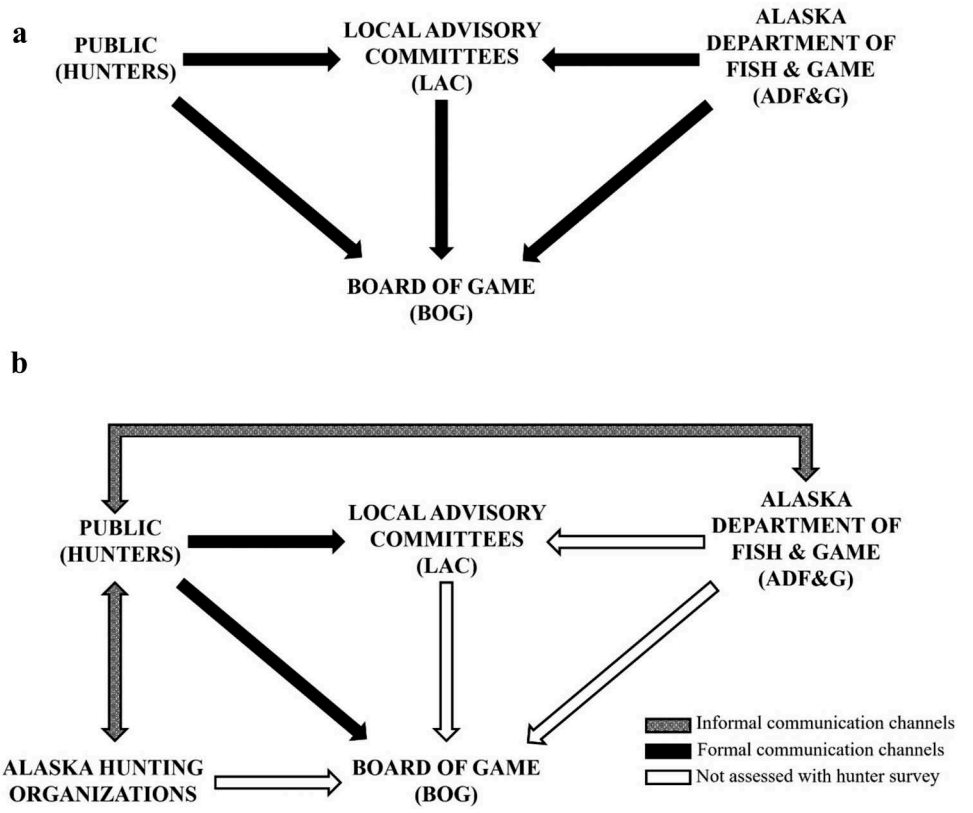

Figure 1. Formally recognized (Panel A) and revised (Panel B) conceptual models of stakeholder communication channels for the regulatory process for the management of wildlife in Alaska. Arrows represent pathways of communication. Panel A is a summary of conceptual models presented in Alaska Department of Fish & Game (ADF&G) public outreach materials (e.g., McCarthy & Taras, 2011; McFarland & Taras, 2016; Nedwick, 2012). Panel B is revised based on hunter survey results. *Note*: Informal communication channels identified with our hunter survey are represented with two-way arrows to signify hunters both sharing information with and receiving information from those groups.

Central Arctic Caribou Herd

There are four large barren-ground caribou herds in Northern Alaska that comprise more than 75% of all caribou in the state: the Western Arctic Caribou Herd (WACH), Porcupine Caribou Herd (PCH), Central Arctic Caribou Herd (CACH), and Teshekpuk

Caribou Herd (TCH). Mixing between herds does occur, particularly when seasonal ranges of adjacent herds overlap, and can lead to shifts in individual herd population estimates (Parrett, Dau, & Nedwick, 2014). Among these herds, the CACH's range has the most overlap with areas of current oil development and receives the most hunting pressure due to relatively good access provided by the Dalton Highway which bisects the CACH's range. During 2001–2015, most of the CACH overwintered on the south side of the Brooks Range between Coldfoot and Arctic Village, migrated north during spring to their calving grounds east of Nuiqsut, spent the summer on the Arctic Coastal Plain between Prudhoe Bay and Kaktovik, and then migrated south to their wintering grounds during the fall (Figure 2).

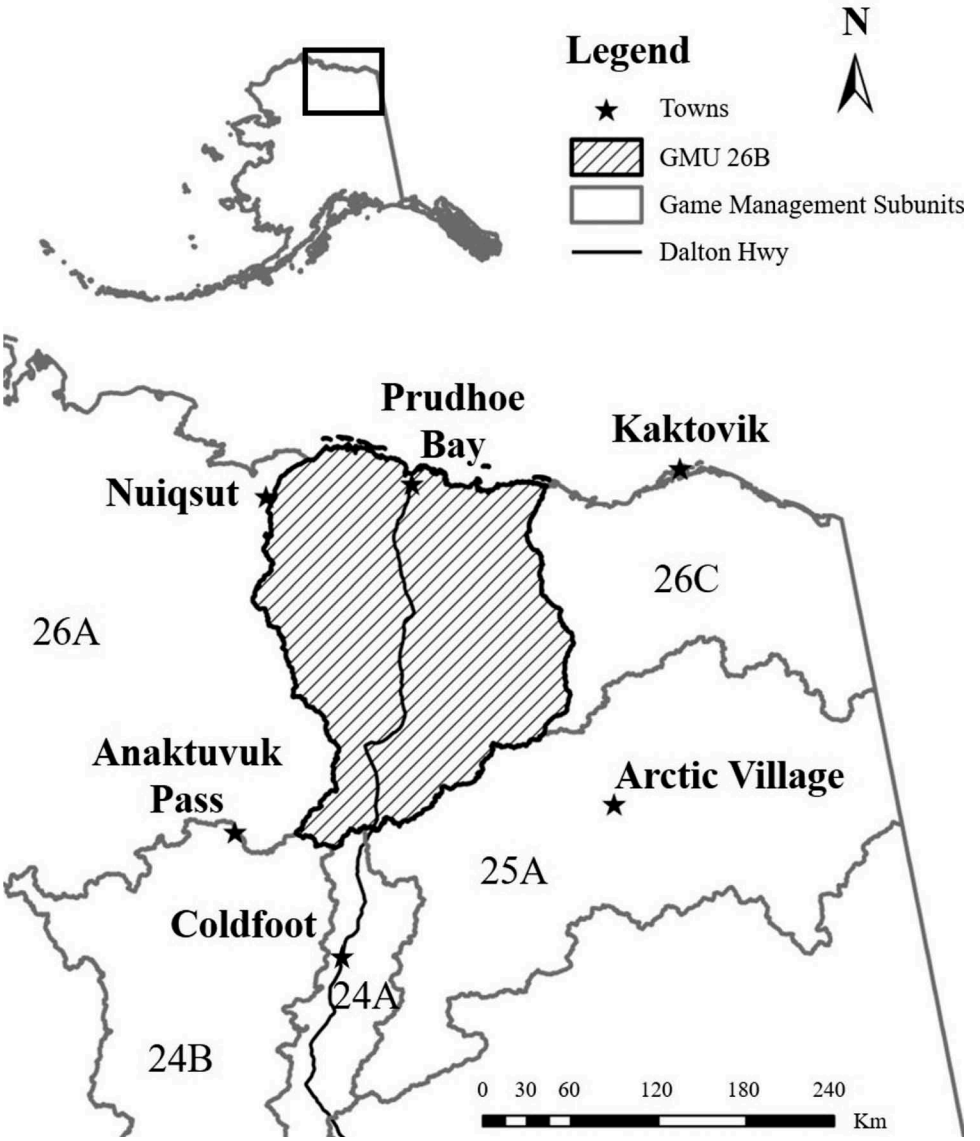

Figure 2. Location of Game Management Subunit (GMU) 26B in Alaska, USA. Our hunter survey included resident hunters who have hunted caribou in GMU 26B at least once between 2008 and 2012 and at least once between 2013 and 2017. This GMU captures the majority of the Central Arctic Caribou Herd's (CACH) range and receives the most hunting pressure compared to surrounding units.

Managers began monitoring the CACH in the late 1970s following construction of the Dalton Highway and oil development on the North Slope (Cameron & Whitten, 1979; Lenart, 2015). Generally, the CACH increased between 1978 and 2010, when it peaked at roughly 70,000 animals. Since 2010, the population rapidly declined by approximately 70% and was estimated at roughly 22,000 animals in 2016 (the most recent estimate available at the time our study was implemented). The ADF&G identified high adult female mortality between 2013 and 2016 due to population age distributions and late springs as the leading factor contributing to the decline, along with herd switching of the CACH with the TCH to the west, and PCH to the east, as indicated by CACH radio-collars being present in adjacent herd's photocensus counts. However, the impact of other factors, including range quality, parturition rates, sex ratios, predation, and disease remains unclear (Lenart, 2015; McFarland & Taras, 2016).

Between 2016 and 2017, the ADF&G distributed newsletters to hunters in response to the decline, sharing the status of the herd and current agency understanding of factors contributing to its decline. The ADF&G also increased the frequency of population photocensus counts to more closely monitor herd trends. Although hunter harvest was not thought to have contributed to the dramatic population decline, in 2017, the BOG responded by shortening the season length and reducing hunting bag limits in Game Management Subunit (GMU) 26B from five caribou regardless of sex to two bulls for residents and one bull for nonresidents. GMU 26B encompasses a large portion of the CACH's annual range and has been the area where most hunting activity occurred. During 2010–2015, roughly 1,400 people hunted the CACH each year, harvesting around 800 caribou annually, though these numbers have been slowly declining (McFarland & Taras, 2016). Although there were hunting opportunities throughout most of the year, the majority of harvest occurred between mid-August and early-September. Approximately two-thirds of these hunters were Alaskan residents, most of whom did not reside in this area but accessed it using highway vehicles (Lenart, 2015). ADF&G management reports provide further description of this area, CACH population dynamics, and harvest trends (Lenart, 2015).

Given the complexity of the issues involved (i.e., dramatic population decline, uncertainties about contributing factors, changes to hunting regulations that reduced hunting opportunities, and concerns for continued consumptive use of this resource), we sought to understand how hunters communicate their knowledge and opinions regarding management of this resource with other stakeholders in this system. Informally, both hunters and the ADF&G expressed interest in exploring the benefits of a more effective exchange of knowledge.

Exploratory Stakeholder Focus Groups

To identify important concerns and questions related to changes in the CACH population, its management, and the exchange of information among stakeholders, we convened semi-structured focus groups (n = 10) between February and April 2017 with representatives from key stakeholder groups. These exploratory focus groups helped us better understand the hunting system and aided in study design and development of a more structured survey. A facilitator led discussions with open-ended questions intended to elicit conversations on the topics of interest. Stakeholder groups included GMU 26B ADF&G caribou managers, members of hunting organizations (e.g., Resident Hunters of Alaska), commercial hunting guides and transporters, and hunters with multiple years of caribou hunting experience in GMU 26B over the last decade.

Stakeholder groups were represented by 2–4 individuals. Discussions took place at the University of Alaska Fairbanks campus in person or through conference calls and included 2–4 focus group discussions with each stakeholder group. These focus groups captured insight from both hunter and management stakeholder groups and identified key themes to formulate future questions and were not quantified (Nyumba, Wilson, Derrick, & Mukherjee, 2018).

Caribou managers noted that several hunters and commercial operators (e.g., guides, pilots transporting hunters) reported in 2015 and 2016 that the CACH declined before managers identified the extent of this change in 2016 (B. Lenart, ADF&G Wildlife Biologist, pers comm). Managers expressed interest in understanding what information hunters used to assess changes in CACH population trends. Hunters and commercial operators demonstrated strong interest and enthusiasm about sharing their knowledge of the CACH and opinions about caribou management. These groups expressed uncertainty about whether their insights were being heard by managers or used to inform policy decisions. They believed that management regulations did not respond to their concerns quickly enough to appropriately address the rapid population decline. In response to unchanging hunting regulations between 2010 and 2016, some hunters shared that they were implementing their own conservation policies; for example, some were not harvesting cows and some commercial operators restricted their clients to one or two caribou. During this time, however, regulations allowed for the harvest of five caribou regardless of sex in GMU 26B. These users sought to know how to effectively communicate their knowledge and concerns with caribou managers and how to meaningfully participate in and affect caribou management decisions. Based on focus group discussions, the question we addressed from a manager's perspective was: "What cues were hunters using to assess changes in the CACH population and what are their thoughts on why the CACH declined?" and from the hunters' perspective: "How do we more effectively influence management and policy decisions?".

To address these questions, and to inform future management of wildlife in Alaska, we implemented a structured survey with the following objectives: (a) document hunters' insights into recent changes in the CACH population, (b) describe the extent of use and perceived effectiveness of channels used by hunters to communicate with other stakeholders, and (c) compare characteristics of groups of hunters who have and have not communicated with other stakeholders to inform representation and interpretation of hunters' communication.

Methods

Study Population

Our study included Alaskan residents over the age of 18 who have hunted the Central Arctic Caribou Herd (CACH) within Game Management Subunit (GMU) 26B at least once between 2008 and 2012 and once between 2013 and 2017. These criteria ensured that participants' hunting experience aligned with a period of reported population change. Our target population excluded Alaskan residents who hunted the CACH under Federal subsistence hunting regulations because of differences in bag limits, harvest reporting requirements, and regulatory processes (Federal Subsistence Management Program, 2019). Our target population also excluded nonresident hunters because they are unlikely to participate in the regulatory process through Local Advisory Committee (LAC) or Board of Game (BOG) meetings. ADF&G provided harvest records through a data sharing agreement that included contact information for each hunter, age, years they hunted,

and whether they harvested a caribou. Based on complete records, our target population was the 804 hunters who were eligible to participate in our survey. To obtain a sampling error of 5% with a 95% confidence level (CL), we needed approximately 261 completed surveys. Anticipating a response rate of 30%, we surveyed our entire population.

Survey Development

Based on qualitative information gathered during exploratory focus group discussions with stakeholders, we designed a survey that assessed hunters' insights into recent changes in the CACH population (Obj. a), the extent to which hunters communicate with other stakeholders and the perceived effectiveness of these communication channels (Obj. b), and characteristics of groups of hunters who have and have not communicated with other stakeholders (Obj. c). The final survey (https://humanwildliferesearch.com/survey) was pre-tested with exploratory focus group participants to ensure questions were clear and addressed our objectives, and that close-ended questions included a comprehensive set of response options.

Survey Implementation

Between June and September 2018, we conducted a mixed-mode survey (online SurveyMonkey; mailed hard copy) [IRB# 1097621]. The first solicitation (June 12, 2018) for participation was an emailed e-postcard (PaperlessPost) and a mailed postcard which included a brief description of our study and a link to our online survey. For the second solicitation (July 1, 2018), we mailed a hardcopy of our survey with a postage-paid return envelope to those who had not yet responded. Follow-up reminders via an e-postcard were sent 2 weeks after the first and second solicitations. Our survey was open for a total of 3 months.

We assessed potential nonresponse bias on questions relating to hunters' communication with other stakeholders (Obj. b) and characteristics of communication groups (Obj. c) by randomly surveying hunters within the target population who did not respond by the survey deadline (Sept. 10, 2018). Participants in the nonresponse survey completed an abbreviated survey online after receiving an e-mail invitation. We also compared hunter age and harvest success rate between respondents and our target population using ADF&G harvest records.

Data Analysis

We used descriptive statistics to summarize hunters' insights on how the CACH population changed over the last decade, potential contributing factors accounting for these changes (Obj. a), and to describe the extent to which hunters communicated with other stakeholders and the perceived effectiveness of these communication channels, as well as which sources they used to obtain information on caribou (Obj. b). Responses to survey questions on stakeholder communication were used to construct a revised conceptual model of stakeholder communication channels that reflected actual hunter behavior. To compare characteristics of groups of hunters who have and have not communicated with other stakeholders (Obj. c), we compared mean responses between groups using a non-parametric Mann–Whitney U test. We compared means between groups for nine questions related to hunters' satisfaction with their hunting experiences, opinions of management, and hunters' influence in decisions. Questions used five-point response categories (e.g., 1 = very satisfied, 5 = very dissatisfied).

Within the context of the survey, the term *management* explicitly referred to the State's regulatory and decision-making process related to the CACH.

Results

After accounting for undeliverable mailings (n = 26), 778 surveys were sent to caribou hunters. We received 278 surveys (82 mailed in, 196 completed online) which provided an overall response rate of 36% and a survey sampling error of ±5% with a 95% CL. The completion rate of our survey was 95%, and the average time spent was approximately 10 min. We found hunter age to be similar between the target population (47 years, SD = 12.8, n = 804) and the sample population (49 years, SD = 13.0, n = 272), as well as harvest success rate between the target population (45%, SD = 34.0, n = 804) and the sample population (47%, SD = 33.4, n = 272). For our non-response bias test, 45 hunters completed the abbreviated survey. We detected no differences ($p > .05$) between respondents and non-respondents, or between respondents and our target population, and therefore, did not weight responses.

Hunters' Insights into Caribou Population Dynamics (Obj. A)

The majority of hunters (69%) reported that the number of caribou in areas they hunted most in Game Management Subunit (GMU) 26B had declined over the last 10 years, 15% reported that numbers stayed the same, 3% reported an increase, and 13% indicated that they did not know how the number of caribou had changed. The top three factors (i.e., cues) hunters used as their basis for perceived changes in caribou numbers were a change in the number of caribou seen (75%), a change in caribou movement (66%), and a change in effort needed to harvest a caribou (54%). Out of 10 potential factors that influenced changes in caribou numbers in areas hunters used, a majority of hunters (51%) reported that a shift in caribou movement contributed to a decrease in caribou numbers but that human development and/or infrastructure (65%), hunter harvest (49%), and weather conditions (45%) had no effect on the number of caribou. "I don't know" was the most common response for the remaining factors including disease (78%), change in calf:cow ratios (66%), change in bull:cow ratios (65%), change in range quality (54%), caribou body condition (52%), and predation (49%) (Table 1).

Table 1. Hunters insights into factors that influenced changes in caribou numbers.

Factor	n	Contributed to an increase	Contributed to a decrease	No effect	I don't know
Shift in caribou movement	277	5%	**51%**	10%	34%
Human development and/or infrastructure	273	1%	10%	**65%**	24%
Hunter harvest	273	2%	11%	**49%**	38%
Weather conditions	274	1%	14%	**45%**	40%
Disease	275	0%	7%	16%	**78%**
Change in calf:cow ratios	273	3%	13%	18%	**66%**
Change in bull:cow ratios	274	2%	10%	23%	**65%**
Change in range quality	272	1%	8%	37%	**54%**
Caribou body condition	270	3%	6%	39%	**52%**
Predation	274	2%	24%	25%	**49%**

Responses were based on areas hunters used most in Game Management Subunit (GMU) 26B over the last 10 years. Values represent the percent of respondents who selected the corresponding response category for each factor. The most common response category for each factor is shown in bold.

Hunters' Communication with Stakeholders (Obj. B)

Roughly half of hunters (46%) reported that they communicated their thoughts about caribou populations with at least one stakeholder group and the other half (55%) reported that they did not communicate with any group. From most to least, hunters were sharing their thoughts with the Alaska Department of Fish & Game (ADF&G) (31%), Alaska hunting organizations (22%), the Board of Game (BOG) (13%), and Local Advisory Committees (LAC) (8%) (Figure 3). Only 2% of hunters solely used formally recognized communication channels (BOG, LAC), 29% solely used informal channels (ADF&G, Alaska hunting organizations), and 14% used a combination of formal and informal channels. The groups that hunters frequently or occasionally used to acquire information about the CACH, from most used to least, were other hunters/organizations/media (97%), the ADF&G (90%), the BOG (38%), and LACs (21%). Approximately half of hunters (51%) indicated that sharing information with ADF&G caribou biologists was very or somewhat effective for influencing management decisions, followed by sharing information with other hunters (42%), providing testimony at LAC meetings (39%), and providing testimony at BOG meetings (37%) (Figure 3). Based on these results, a revised conceptual model of stakeholder communication identifying both formal and informal communication channels is presented in Figure 1b.

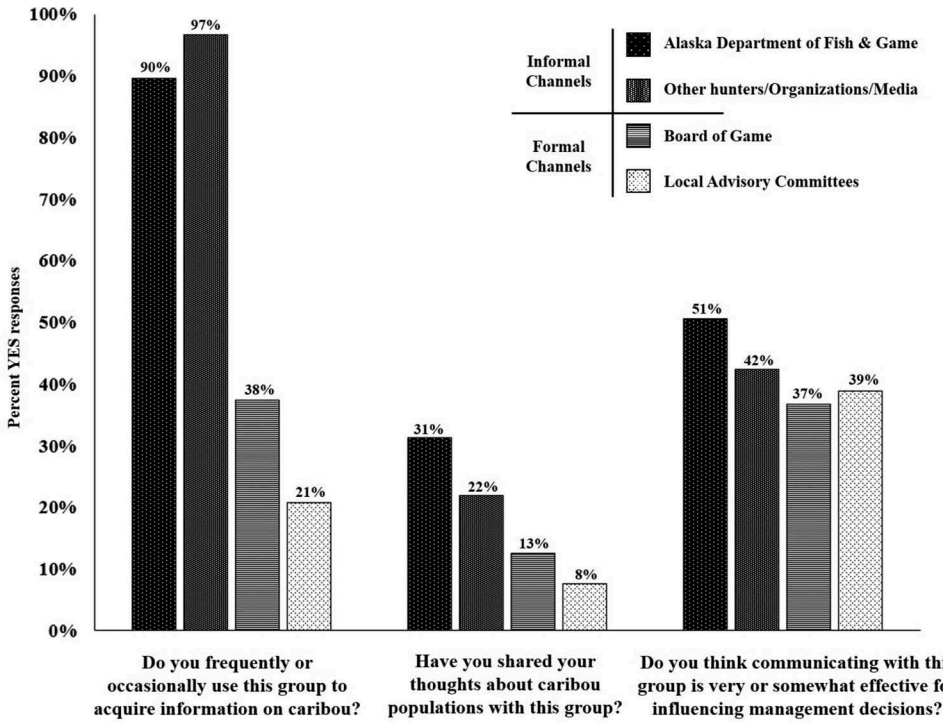

Figure 3. Hunters' use of communication channels and their perceived effectiveness. Bar heights represent the percent "Yes" responses out of the total number of responses for each survey question. Respondents could select more than one group for each survey question.

Comparison between Communication Groups (Obj. C)

Hunters who communicated with stakeholders were consistently more dissatisfied and in more disagreement on survey questions than those who have not communicated (Table 2). Hunters who communicated with stakeholders were more dissatisfied with current management of the CACH ($p = .002$) and with their most recent caribou hunts in GMU 26B ($p = .040$), as well as in more disagreement with the following statements: hunters' concerns influence the data collected on caribou ($p = .002$), and hunters have sufficient opportunities to affect management decisions for the CACH ($p = .007$) (Table 2). There were no differences between hunters who have and have not communicated in the extent of agreement that changes to hunting regulations have been appropriate responses to changes in the CACH population ($p = .053$), trust in the data ADF&G uses to inform caribou management decisions ($p = .423$), agreement that decision-makers have enough information to make well-informed management decisions ($p = .461$), that management quickly responds to changes in caribou populations ($p = .729$), and extent of satisfaction with their caribou hunts over the last 10 years in GMU 26B ($p = .978$) (Table 2).

Table 2. Comparing characteristics of hunters who have and have not communicated with stakeholders.

	Have communicated with stakeholders			Have not communicated with stakeholders				
Question	*n*	*M*	*SD*	*n*	*M*	*SD*	*U*	*p*
To what extent are you satisfied or dissatisfied with current management of the CACH?	114	**3.18**	1.29	127	**2.67**	1.16	5628	**.002**
To what extent do you agree or disagree that hunters' concerns influence the data collected on caribou?	109	**3.35**	1.11	107	**2.89**	1.03	4472	**.002**
To what extent do you agree or disagree that hunters have sufficient opportunities to affect management decisions for the CACH?	115	**3.44**	1.27	113	**3.01**	1.12	5198	**.007**
To what extent are you satisfied or dissatisfied with your most recent caribou hunt in GMU 26B?	117	**3.01**	1.47	140	**2.62**	1.42	7008	**.040**
To what extent do you agree or disagree that changes to hunting regulations have been appropriate responses to changes in the CACH population?	114	3.04	1.35	120	2.70	1.28	5882	.053
To what extent do you trust or distrust the data the Alaska Department of Fish & Game uses to inform caribou management decisions?	119	2.49	1.21	128	2.34	1.10	7190	.423
To what extent do you agree or disagree that decision makers have enough information to make well-informed management decisions?	109	2.90	1.28	105	2.73	1.18	5401	.461
To what extent do you agree or disagree that management quickly responds to changes in caribou populations?	112	2.79	1.16	114	2.84	1.09	6221	.729
To what extent are you satisfied or dissatisfied with your caribou hunts over the last 10 years in GMU 26B?	109	1.88	1.04	139	1.85	0.99	7561	.978

Mean response scores on survey questions relating to satisfaction with management or hunters' influence in informing decisions. All questions used five-point response categories (e.g., 1 = strongly agree, 5 = strongly disagree). Significant differences between groups (in bold) were determined using a Mann–Whitney *U* test ($\alpha = .05$).

Discussion

Hunters' Insights into Caribou Population Dynamics (Obj. A)

The majority of hunters (69%) reported the number of caribou declined in the areas they hunt most in Game Management Subunit (GMU) 26B over the last decade, supporting

changes in Central Arctic Caribou Herd (CACH) population estimates reported in Alaska Department of Fish & Game (ADF&G) newsletters (McFarland & Taras, 2016). Additionally, the majority of hunters (51%) reported the only factor that contributed to this decline in their hunting areas was a shift in caribou movement (Table 1). Hunters' insights may have been affected by newsletters the ADF&G distributed between 2016 and 2017 prior to our survey. ADF&G's newsletter reported that caribou were switching herds during the decline, moving primarily from the CACH to the Teshekpuk Caribou Herd and Porcupine Caribou Herd (McFarland & Taras, 2016). Therefore, our findings suggest that hunters either perceived a change in spatial distribution of caribou within the CACH or agreed with ADF&G reports that herd switching had occurred.

The cues hunters used to assess changes in the CACH population (i.e., change in number of caribou seen (75%), change in caribou movement (66%), and change in effort needed to harvest a caribou (54%)) were likely based on their direct observations of caribou during their hunting activities and their interaction with this resource. Although the CACH has a large range and individual hunters only interact with a very small area within this range, these findings indicate that the collective local observations of hunters may provide a good indicator of population-level wildlife dynamics and highlights the importance of conducting scientific human dimensions of wildlife surveys (Berkes, Colding, & Folke, 2007; Kofinas et al., 2003; Tomaselli, Kutz, Gerlach, & Checkley, 2018). Routine and systematic surveys that gather hunters' knowledge of the wildlife they interact with may provide a useful management tool for early detection of changes in wildlife populations and information that is complementary to managers' monitoring efforts (Huntington et al., 2002, 2004; Klein, Moorehead, Kruse, & Braund, 1999).

This article demonstrated that hunters are able and willing to contribute their understanding of this resource and want opportunities to share their knowledge. Hunters' insights into wildlife populations have been shown to be informative and help guide management and policy decisions in other systems (Chase, Siemer, & Decker, 2002; Fleegle, Rosenberry, & Wallingford, 2013; Holmgaard, Eythórsson, & Tombre, 2018; Riley et al., 2003), and despite the challenges of conducting scientific human dimensions of wildlife surveys, managers should be aware of and receptive to the notion that hunters' knowledge could be used to inform monitoring and research on wildlife in Alaska (Lauber et al., 2014; Sexton, Miller, & Dietsch, 2011).

Hunters' Communication with Stakeholders (Obj. B)

We found hunters' communication strategies were largely inconsistent with conceptual models of formally recognized communication channels for the management of wildlife in Alaska (Figures 1 and 3). A minority of hunters (2%) exclusively shared information with Local Advisory Committees (LAC) and the Board of Game (BOG), which are the groups these conceptual models suggest hunters should use to inform decisions. However, a greater proportion of hunters (29%) solely used informal communication channels including sharing information with the ADF&G and Alaska hunting organizations (Figure 3). Hunters reported that sharing information through informal channels was more (ADF&G) or equally (Other hunters) as effective as formal channels (BOG, LAC) at influencing management decisions. Hunters reported that they primarily acquired

information about the CACH through other hunters/organizations/media, followed by the ADF&G, the BOG, and LACs. This suggests that reciprocal dialogue (i.e., two-way exchange of information) may have played a role in how hunters chose to engage in the management process (Talley et al., 2016): the groups hunters primarily received information from were the same groups they primarily shared their thoughts with. These results showed that the groups formally recognized as being responsible for representing public opinion were not actually receiving the majority of hunters' opinions. This may lead to unintentional misrepresentation or a perceived lack of consideration of hunters' opinions, which hunters expressed as their main concern in our exploratory focus group discussions. Other studies have suggested that LACs and the BOG may poorly represent the opinions of all hunters because there are generally differences in attitudes and opinions between those who speak up and those who do not (Brinkman, 2018). Since most hunters of the CACH did not reside in this area, it is unlikely that many participate in the LAC in this geographic area (i.e., North Slope Advisory Committee). However, LACs in other geographic areas can and do provide comments and submit proposals for areas where they are not located. Lastly, the groups who received the majority of hunters' input (i.e., ADF&G caribou managers) may not be equipped or prepared to accurately document and disseminate hunters' collective voice. The established conceptual models of stakeholder communication are consistently excluding the channels of communication hunters used most, as well as do not indicate where reciprocal dialogue was taking place (Figure 1).

We identified a substantial proportion of hunters (55%) that have not communicated with any stakeholders. This missing input suggests the potential for improving hunter engagement, thereby maximizing hunters' contribution to wildlife management and facilitating a more representative voice. We acknowledge this article primarily focused on hunters' opinions of and participation in the regulatory process. Hence, we encourage future research to explore stakeholder communication and engagement from different group perspectives, leading to a more comprehensive evaluation of dialogue among multiple stakeholders and of the performance of the regulatory process for wildlife management in Alaska.

Comparison between Communication Groups (Obj. C)

Our survey identified differences in characteristics of groups of hunters who have and have not communicated with other stakeholders, indicating that groups receiving communication from hunters may not be receiving a representative voice of all hunters and should interpret their communication with caution. We found hunters who had not communicated were generally satisfied, whereas those who communicated were generally dissatisfied with current management of the CACH (Table 2). Other studies have shown that hunters who have not attempted to engage in management and policy decision-making either were satisfied with current management of the resource or felt their opinions would not influence decisions (Brinkman, 2018). The two statements that received the most disagreement from both hunters who have and have not communicated were *hunters have sufficient opportunities to affect management decisions for the CACH* and *hunter concerns influence the data collected on caribou* (Table 2). These findings highlight the importance of providing and informing hunters of opportunities to communicate their opinions about management and insights on the resource through channels they feel comfortable and confident in using.

In exploratory focus group discussions conducted prior to our survey, a concern was raised that management regulations did not respond quickly enough to appropriately address the CACH population decline. We explored this concern in our survey and found that both hunters who have and have not communicated were generally in agreement that management quickly responds to changes in caribou populations, had trust in the data ADF&G uses to inform caribou management decisions, and were in agreement that decision-makers have enough information to make well-informed management decisions (Table 2). However, hunters who communicated with stakeholders slightly disagreed, whereas hunters who had not communicated slightly agreed, that changes to hunting regulations have been appropriate responses to changes in the CACH population. By exploring this concern further with a structured survey, the concern raised may have been more attributed to the perceived appropriateness of the BOG decision made in response to the CACH decline, rather than the time it took to respond to caribou population change or information used to inform the decision. These results suggest that both hunter groups generally feel that managers and decision-makers have the capacity to respond appropriately, but in this instance, hunters who communicated with stakeholders thought the decision made was not appropriate. These results demonstrate how focus groups can help guide researchers toward important topics that warrant further investigation (Minnis, Holsman, Grice, & Payton, 1997; Nyumba et al., 2018). However, the differences between focus group and survey results with regards to management responsiveness emphasizes the importance of acquiring a representative sample.

Hunters' satisfaction with their caribou hunting experiences in GMU 26B over the last 10 years received the highest satisfaction from both groups of hunters who have and have not communicated with stakeholders. However, satisfaction declined for both groups with their most recent hunt in GMU 26B (Table 2). This may be attributed to declining harvest opportunities due to a decline in the CACH population and reduced hunting opportunities due to recent BOG changes to hunting regulations.

Implications and Recommendations

We demonstrated that hunters who were communicating were primarily using communication channels that are different from those that the Alaska wildlife management system and regulatory process is predicated on (Figures 1 and 3). To effectively manage a public trust resource such as caribou in Alaska, managers and decision-makers must be acutely aware of public opinions, attitudes, and behaviors so that their management actions can appropriately account for public interests and conservation (Lauber et al., 2014; Organ, Decker, Stevens, Lama, & Doyle-Capitman, 2014). In some cases, failure to do so has led to conflict among the public and wildlife managers and reduced the public's trust in management agencies (Brinkman, 2018; Rudolph & Riley, 2014). Not accounting for public interests in decisions can lead to reduced public compliance with management regulations, as indicated by users in our focus groups who shared they were implementing their own conservation policies in response to being unable to influence regulations they felt were too liberal during a period of perceived caribou population decline. Focus group discussions indicated that these users were using informal communication channels to voice their concerns. We were unable to identify any BOG proposal submitted between 2010 and 2017 by hunters that proposed more conservative hunting regulations because of the perceived decline in the CACH. The hunter

proposals that were submitted requesting more conservative regulations suggested that current harvest bag limits of five caribou were excessive and caused unethical hunter behavior such as wanton waste (Board of Game, 2017).

Our survey results indicated that hunters were not using formally recognized communication channels because they thought they were equally as or less effective than other strategies. However, using formal channels is necessary for ensuring that hunters' concerns are documented within public record. Also, we identified that a substantial proportion of hunters (55%) have not communicated their thoughts about caribou with any stakeholders. To maximize hunters' influence in BOG decisions, future efforts may consider enhancing and advocating for engagement from this group. We identified important differences between groups of hunters who have and have not communicated with stakeholders (Table 2), highlighting the importance of enhancing hunter engagement to ensure balanced representation of all hunters' opinions.

We identified that the current conceptual model of the regulatory process for wildlife management in Alaska did not accurately represent how hunters were actually engaging. To advance opportunities for building more robust engagement and communication strategies among stakeholders in this system, we provided a revised conceptual model of stakeholder communication based on our survey results (Figure 1b) and provided information to aid managers and decision-makers in the interpretation of hunters' communication. To improve hunters' contribution to management and conservation of this resource, and to improve stakeholder relationships in this system, future efforts may benefit from utilization of alternative communication channels and may consider further exploration and revision of the current model for hunter engagement in Alaska. Ultimately, effective wildlife management requires that decisions be made that appropriately account for both biological and social perspectives. To aid in a comprehensive understanding of the social perspective, optimizing theoretical frameworks that foster communication among stakeholders is paramount.

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