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Use of satellite telemetry to evaluate movements of caribou within subsistence hunting areas in northern Alaska

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Abstract: Caribou from the Teshekpuk Herd (TH) are an important subsistence resource for residents of Iñupiaq villages in northern Alaska. In recent years the use of satellite telemetry has increased the understanding of the herd's annual movements and interactions with other herds. Most caribou of the TH are within the National Petroleum Reserve–Alaska (NPRA) throughout the year. The northeastern portion of NPRA has undergone two lease sales for oil and gas exploration, and lease sales are tentatively scheduled for the central/northwest portion of the NPRA in 2004. During 1990–1999, the movements of 27 caribou from the TH were tracked using satellite collars. We evaluated the proportion of time caribou were available to Iñupiaq hunters by incorporating maps depicting subsistence-use areas for each of seven Iñupiaq villages, and then examining seasonal and annual movements of caribou relative to those areas. By combining caribou locations with subsistence hunting areas, we were able to explore spatial and temporal patterns in caribou availability to subsistence hunters. This information is useful for managers to set appropriate hunting regulations and for devising sensible alternatives and mitigation of likely petroleum development in NPRA.

Key words: Alaska, GIS, Rangifer tarandus, Teshekpuk Herd.

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Introduction

Barren-ground caribou (Rangifer tarandus granti) of the Teshekpuk Herd (TH) typically calve in the vicinity of Teshekpuk Lake in the north-central part of the North Slope of Alaska (Philo et al., 1993; Kelleyhouse, 2001; Prichard et al., 2001; Fig. 1). Most TH caribou stay north of the Brooks Range throughout the year, but a portion of the herd winters south of the Brooks Range in some years (Philo et al., 1993; Prichard et al., 2001). The range of the TH overlaps with the range of the Central Arctic Herd (CAH) to the east and the Western Arctic Herd (WAH) to the west. The population of the TH has been increasing since it was first recognized as a herd in the early 1970s (Davis & Valkenburg, 1978). A photocensus in 1999 enumerated 28 627 caribou in the herd (Carroll, 2001).

The TH is an important subsistence resource for local residents (BLM, 1998). A number of Alaskan villages are within the peripheral range of the TH (Fig. 1), but seven villages comprise the majority of the harvest in most years. The population in these villages is predominantly Iñupiat (Table 1), although non-native rural residents also hunt caribou under the same state and federal regulations. In Alaska, the Alaska Board of Game issues caribou hunting regulations that cover all people and all lands in the state, but simultaneously the Federal Subsistence Board issues caribou hunting regulations that cover only rural Alaskan residents on federal public lands. Throughout the western portion of the North Slope,

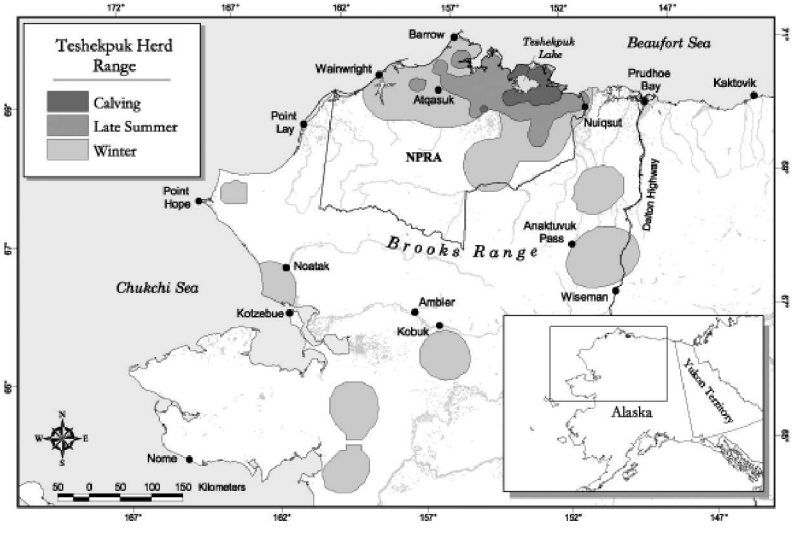

Fig. 1. Seasonal range of Teshekpuk Herd caribou based on satellite collar locations 1990–1999. Ranges represent 95% utilization distributions based on fixed-kernel analysis of one location per transmitting day (Calving=1-15 Jun; Late Summer=8 Aug-15 Sep; Winter=1 Dec-30 Apr; after Prichard et al., 2001).

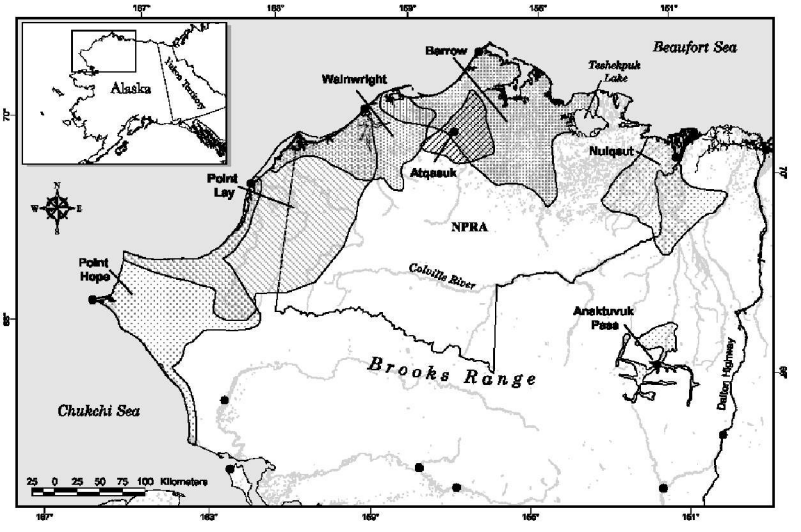

Fig. 2. Approximate subsistence hunting areas for seven villages within the range of Teshekpuk Herd caribou.

caribou of both sexes may be harvested during most times of the year (the season for cows is closed during calving, 16 May–30 June), but the majority of the harvest generally occurs in summer and fall (Fuller & George, 1997; BLM, 1998). Due to the remote location of the TH, sport harvest of the herd is minimal (Carroll, 2001).

It is currently difficult to accurately estimate TH harvest because residents of each of the North Slope villages harvest caribou from more than one herd. In addition, fall movements and winter locations of the herd are quite variable among years, and harvest levels are influenced by the proximity of caribou to villages. Based on subsistence surveys and approximate herd locations, the subsistence harvest of TH caribou in three North Slope villages was estimated at 808–1084 during 1989–1990 (Carroll, 1992) and 2500 per year in all North Slope Villages in 1994–1996 (Carroll, 1997).

Other than several villages, there currently is little development in the core of the TH range (Fig. 1). However, most of the herd's annual range is within the National Petroleum Reserve–Alaska (NPRA). The northeastern portion of NPRA has undergone two lease sales for oil and gas exploration in 1999 and 2002. These areas currently are under exploration and one development has already been proposed. Additional lease sales are tentatively scheduled for the central/northwest portion of the NPRA in 2004. Comments from local residents during the Environmental Impact Statement process indicated that local residents were concerned that oil and gas development would lead to a decrease in subsistence species, decreased access to subsistence areas, and changing movement patterns of subsistence species (BLM, 1998). Such a conflict already is perceived by villagers of Nuiqsut with current oil developments to the east and north of the village (Lawhead et al., 2002; NRC 2003), and residents of Nuiqsut generally avoid the oilfields while hunting (Brower & Hepa, 1997; NRC, 2003).

In this paper, we attempt to integrate the distribution of TH caribou based on the year-round location of satellite-collared caribou with results of sub-

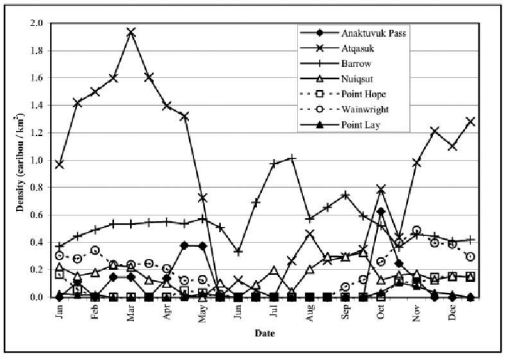

Fig. 3. Estimated density (animals/km^2) of Teshekpuk Herd caribou (proportion × 28 000/area) within the village subsistence hunting areas during 24 time periods, based on locations of 27 caribou outfitted with satellite collars, 1990–1999.

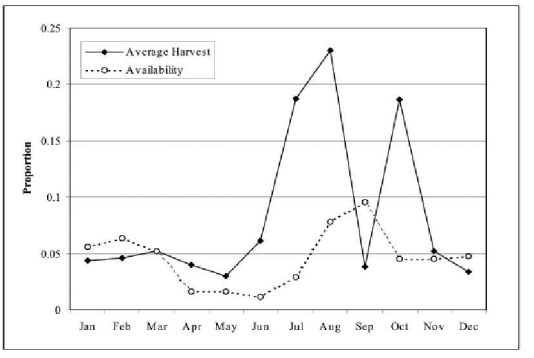

Fig. 4. Comparison of proportion of annual caribou harvest in each month in Nuiqsut (1992 and 1994–1995; Brower & Opie, 1997, Fuller & George, 1997) with availability of Teshekpuk Herd caribou as estimated by the proportion of locations of caribou outfitted with satellite collars within the area used for subsistence hunting, 1990–1999.

sistence surveys in seven villages to explore temporal and spatial patterns of caribou availability to local hunters. This information may be useful in planning development projects as well as assessing impacts of future development on subsistence hunting opportunities.

Methods

In 1990, a cooperative satellite radio-collar caribou-tracking project was initiated by the North Slope Borough Department of Wildlife Management, the Alaska Department of Fish and Game, and the U.S. Bureau of Land Management. From 1990 through 1999, 28 female and one male caribou were captured and outfitted with satellite collars near Teshekpuk Lake in June and July. Two female caribou displayed movements more typical of the WAH and did not return to Teshekpuk Lake during subsequent calving periods. For this paper, we analyzed the distribution of the 27 remaining caribou thought to be from the TH.

Satellite Telemetry

In 1990 and 1991, caribou were captured using a dart containing carfentanil and xylazine fired from a tranquilizer gun from a helicopter. After 1991, in response to concerns of subsistence users, caribou were captured using a helicopter and a skid-mounted net gun (Philo et al., 1993; Carroll, 1999). All caribou were fitted with a satellite transmitter and a conventional VHF radio-transmitter attached to a collar produced by Telonics, Inc. (Mesa, AZ). Data were retrieved using Service Argos (Landover, Maryland). The collars were programmed to transmit location data for 6 hours every 2 days in most cases and 6 hours every day for one caribou. Collars transmitted locations for an average length of 427 days (min=94, max=789). Location data included a location quality score (NQ) of 0 to 3 calculated by Service Argos based on six criteria corresponding to estimated spatial accuracy (Service Argos, 1988; Keating et al., 1991).

Data Screening

Data were screened to remove duplicate records, locations acquired prior to collaring, locations acquired after mortality, and locations that were obviously wrong (e.g., far offshore). In addition, we analyzed each combination of two successive vectors of movement to identify suspect locations based on rate of travel and the angle of change between three successive locations. Locations were removed if three successive locations formed an angle of less than 20 degrees and both vectors of the angle had speeds of greater than 10 km/h (indicating rapid movement and an abrupt change of direction). After screening data, one location of the best NQ score was selected for each transmitting day. This screened set of point locations was used to create a linear route track for each caribou using ArcView GIS 3.2a software (ESRI Inc., Redlands, CA).

Subsistence Areas

Village subsistence areas were identified for seven villages based on previous studies. Information on caribou hunting locations for North Slope villages was used for Barrow and Wainwright (Braund, 1993a; Braund, 1993b). For the other villages, cari-

Table 1. Human population data (2000 census) and the approximate size of subsistence hunting areas, as well as the estimated annual caribou density and average distance of Teshekpuk Herd caribou within the subsistence hunting areas for the seven villages that regularly harvest caribou from the Teshekpuk Herd. Density and distance were calculated based on 27 satellite-collared caribou 1990–1999.

	Population (2000)	Alaskan Native (%)	Subsistence Hunting Area (km^2)	Estimated Caribou Density (Caribou/km^2)	Average Distance (km)
Anaktuvuk Pass	282	88.3	2026	0.07	36.7
Atqasuk	228	94.3	3520	0.62	21.2
Barrow	4581	64.0	18013	0.61	90.8
Nuiqsut	433	89.1	8714	0.18	47.3
Point Hope	757	90.6	15589	0.05	98.1
Point Lay	247	88.3	24272	0.02	100.1
Wainwright	546	93.0	8728	0.16	43.7
Total	7074	73.4			

bou hunting areas were estimated based on data from North Slope Borough surveys for all terrestrial mammals, including furbearers. In most cases, these areas probably overestimate caribou hunting areas, but, because caribou are harvested throughout the year as part of other hunting activities, they are probably a reasonably accurate representation of potential harvest locations.

For Barrow and Wainwright, areas used for caribou hunting were available for the years 1987–1989 and 1988–1989, respectively (Braund, 1993a; Braund, 1993b). The subsistence hunting area was determined as a minimum convex polygon encompassing all harvest locations. This area then was "clipped" at the coast to exclude offshore areas (Fig. 2).

The Atqasuk caribou hunting area was estimated using the total harvest area for all species for the years 1994–1995 (Brower & Hepa, 1997). The hunting area was relatively small despite the fact that it probably overestimates the area used solely for caribou hunting.

No recent data were available for Point Hope or Point Lay caribou hunting areas, so we based the Point Hope and Point Lay caribou hunting area on data gathered for the North Slope Borough Coastal Management Program (North Slope Borough, 2000). Interviews were conducted with approximately 10 senior hunters in each village by staff from the North Slope Borough Planning Department and the Department of Wildlife Management. The perimeters of the subsistence hunting areas reflected hunting regions used over the previous decade and included both terrestrial and marine species. We used the total hunting area (marine areas excluded). This technique appears to have resulted in overestimates of the areas where caribou are actually harvested, particularly for Point Lay.

The caribou hunting area for Anaktuvuk Pass was determined from hunting areas reported in Brower & Opie (1996). Specific harvest locations for caribou were not reported, so the village harvest area was determined as the sum of all traditional hunting areas where successful harvests were made in 1994–1995. The hunting area excludes high mountain peaks and generally follows river and creek drainages. The Nuiqsut caribou hunting area was determined as a minimum convex polygon encompassing the terrestrial harvest area for the period July 1994 to June 1995 (Brower & Opie, 1997).

Spatial Analysis

By entering subsistence hunting areas and caribou routes as layers in ArcView GIS 3.2a, we were able to record each time a caribou was in a subsistence area. We calculated the proportion of locations within a subsistence area for each caribou for each of 24 time periods throughout the year (1–15 January, 16–31 January, 1–15 February, etc.). We then calculated the average of the proportions for all collared caribou during each time period. If a caribou was collared for more than a year, it could be counted more than once in a given time period. The average proportion of time satellite-collared caribou were within a subsistence hunting area was used as an estimate of the proportion of the herd within each hunting area per day for each of the 24 time periods. This assumes that collared caribou were randomly distributed throughout the herd. Proportions were converted to approximate caribou densities within a subsistence area by multiplying by 28 000 (approximate size of the herd in 1999; Carroll, 2001) and dividing by the area of the subsistence hunting area. In addition, we used collar locations to calculate the average distance from villages for all points within the subsistence area for the same 24 time periods.

Published accounts of caribou harvest exist at

Table 2. Average, minimum, and maximum percentage of time caribou spent in the Barrow subsistence hunting area each year based on satellite collar locations 1990–1999. Only months with 5 or more active collars were included in the analysis.

Month	Percent of time			
	Average	Minimum	Maximum	Number of years
Jan	23.2	0.0	42.9	4
Feb	39.0	33.3	44.8	2
Mar	43.6	38.6	48.6	2
Apr	41.1	25.0	57.1	2
May	40.4	37.3	43.5	2
Jun	48.0	48.0	48.0	1
Jul	63.7	29.9	96.9	5
Aug	35.7	6.8	53.3	4
Sep	40.4	3.8	64.4	4
Oct	25.3	6.4	46.5	4
Nov	23.6	0.0	49.0	4
Dec	20.0	0.0	42.9	4

varying levels of detail for all seven villages, enabling comparison of harvest levels with herd availability estimates. We compared harvest levels from Nuiqsut in 1994–1995 (Brower & Opie, 1997) and in 1992 (Fuller & George, 1997) to caribou locations. We compared the average proportion of caribou harvested monthly in Nuiqsut in the two studies to the estimated proportion available, based on satellite telemetry data

Results

The size of the seven village subsistence areas (Fig. 1; Table 1) varied greatly. Because the telemetry data set consists almost entirely of female caribou, our results may not accurately represent the probability of males being close to villages at times when males and females are spatially segregated, such as during calving.

The proportion of caribou encountering village subsistence hunting areas varied greatly from village to village. The Barrow hunting area had the highest overall proportion of satellite-collared caribou (65% in late July; 36% average of all time periods), however, the Barrow area also is the second largest hunting area. The approximate density of caribou (proportion of collared caribou × 28 000/area) was highest for Atqasuk, second highest for Barrow, and lowest for Point Lay (Table 1). There were large seasonal differences in densities of satellite-collared caribou present among villages (Fig. 3). Atqasuk, Wainwright, and Point Hope had their largest densities in the winter months, Barrow and Nuiqsut had higher proportions available in the summer than winter, and Anaktuvuk Pass had the highest densities available during spring and fall migration. Wainwright, Anaktuvuk Pass, Point Hope, and Point Lay had no satellite-collared caribou within the subsistence hunting areas during June, July, or August.

There were also large differences among villages in the average distance from the village of caribou that were within a subsistence hunting area (Table 1). These distances were, of course strongly affected by the size of the defined hunting areas, as well as the traditional range use of the TH. Average distances of caribou within a subsistence area did not fluctuate greatly throughout the year.

An estimate of the amount of time an individual caribou spent within any of the seven village hunting areas on the North Slope was generated for each two-week period in the annual cycle. The overall average percent of time an individual caribou spent in any of these seven hunting areas was 51.5% (SE=7.0%, n=51). The percentage was lowest in early June (21.9%, SE=8.4%, n=24) and highest in early July (68.9%, SE=8.1%, n=33). The percentage was fairly constant from November through April (min=45.7%, max=50.2%).

The proportion of time caribou were within subsistence hunting areas can also be used for determining the annual variation in caribou distribution within the village subsistence areas. The annual variability in time caribou spent in the Barrow hunting area each month varied (only months with at least 5 collared caribou were included) (Table 2). Some caribou, for example, were within the Barrow hunting area in all years and in all months except November, December, and January.

The caribou harvest in Nuiqsut was estimated at 249 caribou in 1994–1995 (Brower & Opie, 1997) and 278 in 1992 (Fuller & George, 1997). Both studies reported monthly harvest numbers. Caribou harvest was highest in July, August, and October, but was low in September. Caribou availability based on satellite collar locations, however was highest in August and September (Fig. 4).

Discussion

Determining baseline levels of herd availability and harvest provides a basis for quantifying the effects of

oil and gas development on herd movements and subsistence hunting. Because caribou movements are highly variable, seasonally and annually, long-term knowledge of movements is needed to determine if changes in herd distribution after development are unusual. Because of the large amount of overlap in herd ranges in this area, traditional ecological knowledge cannot always supply herd-specific information on past range use. The use of subsistence hunting areas and satellite telemetry may provide a framework for more accurately estimating subsistence harvest by herd. Accurate estimates of harvest of the TH would allow herd managers to make more effective hunting regulations in times of low herd productivity or abundance.

The pattern of average monthly harvest in Nuiqsut (1992 and 1994–1995) was fairly similar to the pattern of TH availability estimated using satellite collar locations (1990-1999; Fig. 4), except in September when the harvest level was low despite the highest proportion of TH animals available. This discrepancy may be because many hunters concentrate on whaling during that time of year (Brower & Opie, 1997) or because travel is difficult in years of early freeze-up. Nuiqsut hunters also have access to CAH caribou as well as TH caribou, and further study is needed to determine what percentage of the harvest comes from each herd.

In future studies, we hope to compare herd availability data for different North Slope herds with village monthly harvest numbers to estimate herd-specific harvest levels. If we assume that monthly harvest of each herd is proportional to the relative availability of each herd, harvest of TH caribou could be approximated by the number of TH caribou within the subsistence area divided by the total number of caribou of all herds within the subsistence area, multiplied by the number of caribou harvested in each month. Analysis of harvest of TH, CAH and WAH caribou is continuing.

Two current limitations of this approach are that sample sizes are generally small and, in this study, only one male was collared. In 2001, 10 satellite collars were attached to CAH caribou and 10 additional collars were attached to TH caribou. Six of the TH collars were attached to mature males. In addition, satellite collars can be used in conjunction with the VHF collars to provide a larger sample size. There are numerous VHF collars on all 3 herds, and radio-tracking surveys can be conducted to determine the relative proportion of caribou from the three herds that are in the hunting areas during times when caribou are being harvested.

Another limitation is the inconsistency of harvest data and hunting areas. The amount of information available varied greatly among villages. In addition, some hunting areas were delineated based on harvest locations, whereas others were based on areas used for hunting. In order to make accurate estimates of harvest among herds, current and accurate harvest data are needed for as many villages as possible. In order to be most useful, harvest data should include the time and place of harvest as well as a delineation of areas used for caribou hunting. Ideally, hunting patterns should be considered over multiple years to integrate the annual variability in caribou abundance and harvest locations. By integrating seasonal changes in hunting locations and some measure of hunting intensity into hunting area boundaries, a more accurate assessment of harvest potential can be conducted. For instance, the Barrow hunting area is so large that it encompasses much of the TH during most of the year. By differentiating high and low use areas, as well as winter and summer areas for Barrow, we could get a more detailed depiction of actual availability of TH caribou and harvest of the North Slope caribou herds.

Despite a number of limitations of this analysis, the approach seems quite sound. The combination of subsistence hunting areas, GIS, and satellite collar locations can provide managers with another tool to estimate and predict impacts of future development on subsistence users and set appropriate hunting regulations.

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