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Caribou distribution during calving in the northeast National Petroleum Reserve–Alaska, June 1998 to 2000

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Abstract: Barren ground caribou (Rangifer tarandus granti) of the Teshekpuk Caribou Herd (TCH) inhabit the western portion of Alaska's Arctic Coastal Plain within the National Petroleum Reserve–Alaska (NPR-A). Alaska's North Slope communities, management agencies, and private industry are interested in this herd because of its importance as a subsistence resource and location relative to potential petroleum development. From 1998 through 2000, we monitored caribou distribution during the calving period within the Northeast Planning Area of the NPR-A using systematic strip-transect aerial surveys, as well as VHF and satellite telemetry for cow caribou. Aerial survey and telemetry data indicated cows with calves were distributed around Teshekpuk Lake, with a concentration south of the lake in 1999 and 2000. Inconsistencies in weather conditions, survey timing (both strip-transect and VHF surveys), 100% coverage survey areas, and small sample sizes confound interpretations of our results. However, several patterns were apparent. Later transect survey timing (7–12 June versus 4–7 and 5–8 June) resulted in more cow/calf pairs recorded. Our 18% coverage area, originally based on VHF telemetry data for the extent of TCH calving, covered a consistently high proportion (95% to 100%) of the annual calving ranges (95% kernel utilization distributions), but accounted for only 24% to 46% of the adult cows in the TCH based on the current Alaska Department of Fish and Game population estimate (1999) and average 1998-2000 herd composition. It appears that either our transect survey methodology significantly underestimated the true number of caribou cows in the study area, many cows calved outside the area or moved into the area and calved after our surveys, or we have over estimated the number of reproductive cows in the herd. Our 100% coverage transect areas covering oil and gas lease areas, contained 38% of the calving range with 23% of TCH cows in 1999; and 18% of the calving range with 8% of TCH cows in 2000. Based on 95% minimum convex polygon ranges, satellite collared cow/calf pairs were not stationary during either our survey period (14.7 ± 6.56 km^2; mean ± standard error of the mean; 4–12 June) or during the calving period (86.9 ± 72.30 km^2; 1–20 June) during 1998–2000. Site specific pre-development data on caribou distribution during calving in NPR-A will be useful for assessing the importance of specific areas to caribou during calving and for designing oilfields that minimize impacts should oil development occur.

Key words: Arctic Coastal Plain, barren ground caribou, oil and gas development, oilfield, Rangifer tarandus, Teshekpuk Caribou Herd.

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Introduction

Barren ground caribou (Rangifer tarandus granti) of the Teshekpuk Caribou Herd (TCH) inhabit the western portion of Alaska's Arctic Coastal Plain and range primarily within the National Petroleum Reserve–Alaska (NPR-A; U. S. Department of the Interior [USDI], 1998). North Slope communities, management agencies, and private industry are particularly interested in this herd because of its importance as a subsistence resource and location relative to potential oilfield development and existing oil and gas exploration.

The TCH was recognized as a separate herd from the Central Arctic (CAH) and Western Arctic (WAH) herds, which also range within NPR-A, in the mid 1970s (Davis & Valkenburg, 1978). Since

Table 1. Caribou number, density (caribou/km²), and mean group size (± standard error of the mean) recorded on 6 systematic aerial strip-transect surveys during calving in the National Petroleum Reserve–Alaska, 4–12 June 1998–2000. A sightability correction factor was applied to 18% and 100% coverage surveys during 1999 and 2000 to correct for poor sightability due to patchy snow cover (Lawhead et al., 1994).

Year	Area coverage	Survey dates	Cows	Calves	Total Caribou	Density (No./km²)	Number of Groups	Mean group size
1998	18% of 6509 km²	4–5 June	848	24	1062	0.91	246	4.3 ± 0.32
1999	18% of 7250 km²	7–11 June	455	169	662	0.51	119	3.0 ± 0.24
2000	18% of 7250 km²	6 June	551	19	624	0.48	128	2.6 ± 0.22
1998	100% of 1401 km²	5 and 7 June	1965	540	2668	1.90	501	5.3 ± 0.41
1999	100% of 2327 km²	9–12 June	2312	882	3369	1.45	444	4.0 ± 0.20
2000	100% of 2327 km²	5–8 June	837	55	1040	0.45	257	2.2 ± 0.08

1978, the Alaska Department of Fish and Game (ADFG), North Slope Borough Department of Wildlife Management (NSB), and Bureau of Land Management (BLM) have attempted to estimate the population size of the TCH through visual estimates and more recently through photocensus techniques. Visual survey estimates of the TCH were recorded in 1978 (3000–4000 caribou; Davis & Valkenburg, 1979), 1982 (4000 caribou; BLM, unpublished data), and 1985 (13 406 caribou; Philo et al., 1993). In 1984 the first photocensus of the TCH was completed and 11 822 caribou were counted (Silva, 1985). Additional photocensus estimates conducted in 1989 (16 649 caribou) and 1993 (27 686 caribou) documented increases in the TCH during the period 1984–1993 (Carroll, 1992; 1995), which was followed by a decrease in the herd in 1995 (25 076 caribou; Carroll, 1997). The exponential growth rate for this herd from the 1970s through the early 1990s (0.152 ± 0.087 [± 95% confidence interval]) was most similar to the WAH (0.116 ± 0.020) among Arctic Coastal Plain herds (Cronin et al., 1998). The most recent photocensus was conducted in 1999 where 28 627 caribou were counted (Carroll, 2001). Herd composition in 1998 and 2000 was, on average, 44% cows with 20% yearlings (Carroll, 2001) for about 10 077 adult cows in 1999.

Most TCH cows begin migrating to the Teshekpuk Lake area in May, and by early June most of the cows have moved into the calving area surrounding the lake (Carroll, 1999). Changes in the location of the calving area for the TCH have been documented since this herd was identified. During the mid 1970s, calving was reported on the west side of Teshekpuk Lake (Davis & Valkenberg, 1979; Silva, 1985). Since the mid 1990s, however, calving has been northeast, east, and southeast of Teshekpuk Lake (Carroll, 2001).

Although there has been oil and gas winter exploration within the Teshekpuk Lake area since the late 1940s (Silva, 1985), currently the TCH has no regular contact with industrial development (Murphy & Lawhead, 2000). Davis & Valkenburg (1978) recognized the importance of obtaining baseline data on the TCH prior to development of the NPR–A. Baseline data on herd size, distribution, and seasonal habitat use will be useful for planning to minimize impacts of likely future petroleum exploration and development on the TCH. Current abundance and distribution data will allow resource managers to make informed decisions regarding management of the herd's habitat.

The objectives of this study were to: (1) determine the current (1998–2000) number, sex/age composition, and distribution of caribou during the calving period near Teshekpuk Lake and within areas of potential oil and gas development and, (2) to investigate the importance of these areas of potential oil and gas development to the calving range for the TCH as defined by VHF calving sites. VHF telemetry data describe the extent of calving for each year of our transect surveys. Satellite telemetry data describe the potential for movement of cows with and without calves during both our transect survey period (2–14 June) and the calving period (1–20 June).

Study Area

The Teshekpuk Lake area of the NPR-A is west of the Colville River delta on Alaska's Arctic Coastal Plain (Fig. 1). We conducted surveys in the NPR-A at two effort levels covering approximately 18% and 100% of the areas (Figs. 2, 3). The 18% coverage survey area (6509 km²) in 1998 was roughly a rectangular block east of the Ikpikpuk River (northwest corner T17N, R11W, Teshekpuk quadrangle) to Atigaru Point (7250 km², southeast corner T10N,

R12E, Harrison Bay quadrangle) and 50 miles inland, during the 1999 and 2000 surveys. This study area was designed to cover the documented extent of TCH caribou calving distribution based on VHF telemetry data (Carroll, 2001). The 100% coverage survey area (1401 km²) in 1998 extended north to the Beaufort Sea coast and was concentrated on the area east of Teshekpuk Lake. This survey area was designed to include documented concentrations of calving caribou (Carroll, 2001). In 1999 and 2000, the 100% coverage survey area was truncated north of Teshekpuk Lake and extended east to the Fish Creek delta and south to the Pik Dunes and Fish Creek areas covering 2327 km². This survey area focused on areas of potential oil and gas lease development where caribou calving had been documented (Carroll, 2001; USDI, 1997; Davis & Valkenberg, 1979; Reynolds, 1982; USDI unpublished data in Silva, 1985).

The composition of our 18% coverage survey transects in 1999 and 2000 was: 35% water (lakes and streams), 18% aquatic tundra, 6% wet tundra, 16% sedge/grass meadow, 17% tussock tundra, 3% moss/lichen tundra, 2% dwarf shrub tundra, and 3% sand dunes/barrens (Kempka et al., 1995; Pacific Meridian Resources, 1996). Our 100% coverage survey area in 1999 and 2000 were 27% water, 17% aquatic tundra, 8% wet tundra, 21% sedge/grass meadow, 21% tussock tundra, 1% moss lichen tundra, 2% dwarf shrub tundra, and 3% sand dunes/barrens (Kempka et al., 1995; Pacific Meridian Resources, 1996).

Methods

Aerial Surveys

Between 4–12 June 1998–2000, we conducted systematic, strip-transect aerial surveys (Caughley, 1977b) during the calving period from fixed-wing aircraft (Cessna 206). Transect centerlines were spaced at 9.6-km and 1.6-km intervals, using a 1.6-km transect width, resulting in 18% and 100% coverage of the survey areas, respectively. All transects were oriented north–south and centered on township and section lines mapped on 1:63 360-scale U.S. Geological Survey (USGS) topographic maps. Systematic surveys were flown 90 m

Table 2. Estimated number of cow caribou for strip-transect surveys, proportion of calving range covered by transect survey areas, and the proportion of the estimated number of Teshekpuk Caribou Herd (TCH) cows within the transect survey area for 6 systematic aerial strip-transect surveys on 4–12 June 1998–2000, National Petroleum Reserve–Alaska. VHF calving range was modeled as the 95% fixed kernel utilization distribution for all calving locations recorded for each survey year (Fig. 3). The number and percent of cows were extrapolated from a sample of 11 transects covering 18% of the total survey area are reported with ± standard error of the mean (Caughley, 1977a). A sightability correction factor was applied to 18% and 100% coverage surveys during 1999 and 2000 to correct for poor sightability due to patchy snow cover (Lawhead et al., 1994).

Year	Area Coverage	Transect survey dates	Estimated number of cows	VHF calving range within transect area	VHF–TCH cow range within transect area	Proportion of cows in TCH[1]	VHF telemetry survey dates	Transect and VHF date comparison
1998	18% of 6509 km²	4–5 June	4649 ± 942	100%	67%	46% ± 9%	11–15 June	Earlier
1999	18% of 6509 km²	7–11 June	2463 ± 481	96%	80%	24% ± 5%	4–12 June	Within
2000	18% of 6509 km²	6 June	2968 ± 637	95%	67%	29% ± 6%	5–14 June	Within
1998	100% of 1401 km²	5 and 7 June	1965	45%	14%	19%	11–15 June	Earlier
1999	100% of 2327 km²	9–12 June	2312	38%	28%	23%	4–12 June	Within
2000	100% of 2327 km²	5–8 June	837	18%	15%	8%	5–14 June	Within

[1] Calculated as the per cent of the number of adult cows (10 077) based on the 1999 TCH census results (28 627 caribou) and average 1998- 2000 herd composition (44% cows with 20% yearlings; Carroll, 2001).

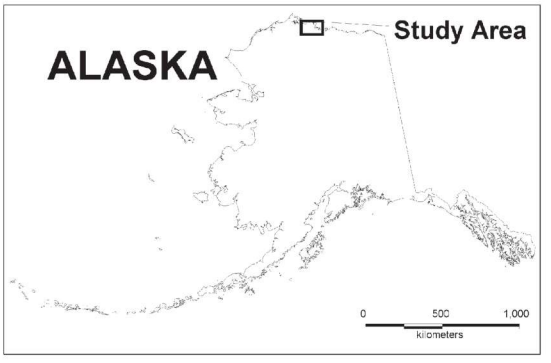

Fig. 1. Study area.

above ground level at 185–200 km/h airspeed. During surveys, two observers searched an 800-m wide area on each side of the transect centerline. A third observer entered data into a computer and assisted with spotting caribou during 1999 and 2000 surveys. Aircraft wing struts were marked with tape to enable visual control of transect strip-width (Pennycuick & Western, 1972) and estimation of group distances perpendicular from the transect centerline. Transect widths were also checked periodically with inclinometers and maps to assist in training observers.

As with previous aerial surveys in the Prudhoe Bay oilfield (Pollard et al., 1992; 1996), global positioning system receivers (GPS) were used to navigate the aircraft and provide position records during systematic surveys. Locations of animals were estimated by using the GPS in combination with visual estimates of their perpendicular distance to the transect centerline. At the time of sighting, all data were entered directly into a notebook computer that was linked to the GPS receiver (Geolink version 6.1, Michael Baker Jr., Inc., Jackson, MS). The computer software associates a real–time GPS position (latitude and longitude of the survey aircraft) for each animal sighting entered with related attributes (e.g., number of individuals in the group and sex/age classification). When possible, behavior and habitat types, along with the group attributes and time of sighting, were recorded into the computer or an audio recorder.

We counted and classified caribou as bulls, cows, calves, or unclassified, based on body size, antler development, pelage, and calf presence. Unclassified caribou were adults or yearlings that couldn't be classified with confidence. Caribou near the outer margin of transect strips were most difficult to classify. During patchy snow cover sightability of caribou was diminished and a sightability correction factor (SCF=1.88) developed for 20-70% snow cover on Alaska's North Slope (Lawhead et al., 1994) was applied to survey results. The total number of cows within the 18% coverage survey area was extrapolated and the variance was calculated based on the sample of 11 transects within the 6509 km^2 area (Caughley, 1977a). June weather data was obtained from National Oceanic and Atmospheric Administration weather stations at Deadhorse, Alaska for 1998 and Nuiqsut, Alaska for 1999 and 2000. Data were unavailable for the Nuiqsut station for June 1998.

Satellite and VHF Telemetry

Through a cooperative project involving ADFG, NSB, and BLM, caribou were captured using a skid-mounted net gun from a Hughes 500 helicopter (Carroll, 2001). Platform Transmitter Terminal (satellite radio collar transmitters or PTTs) or VHF (Very High Frequency) collars were attached to captured caribou; and satellite collars were programmed to transmit on a 6-h per 48-h cycle (Carroll, 2001). Data were received from 6 collared animals by downloading satellite location data (monthly summaries) from the Argos Data Collection and Location System (ARGOS) in Landover, Maryland. VHF radiotracking flights collected information on 27–36 animals year^{-1} between 2–16 June to determine caribou movements, distribution, and reproductive status (Carrol, 2001).

VHF calving locations defined as the first sighting of an individual cow with a calf (Carroll, 2001) were used to calculate "calving ranges" as the fixed kernel utilization distribution (Worton, 1989) with least squares cross validation (Silverman, 1986) using the Animal Movements extension (Hooge and Eichenlaub, 1997) for ArcView® Geographic Information System. Calving ranges for cow caribou based on VHF telemetry from 2–16 June were calculated separately for cows with (n = 16–23 cows year^{-1}) and cows without (n = 4–14 cows year^{-1}) calves.

Satellite-collared cow ranges were calculated as 95% minimum convex polygons (MCP, Range Manager© v. 1.0.1, Data Solutions, Topsail, Newfoundland, Canada, for MapInfo Professional®). These MCP ranges for satellite-collared cows were based on movements of 6 individual cows during 1–20 June (calving period, n = 28–58 locations per cow) and during our transect survey period from 4–12 June (n = 6–22 locations per cow).

All mean values are reported with the standard error (SE) of the mean. Spatial comparison of calving ranges and study area coverages was completed using MapInfo Professional®. Mean range values were compared using 2-sample t-tests without the assumption of equal variance (Snedecor & Cochran, 1980).

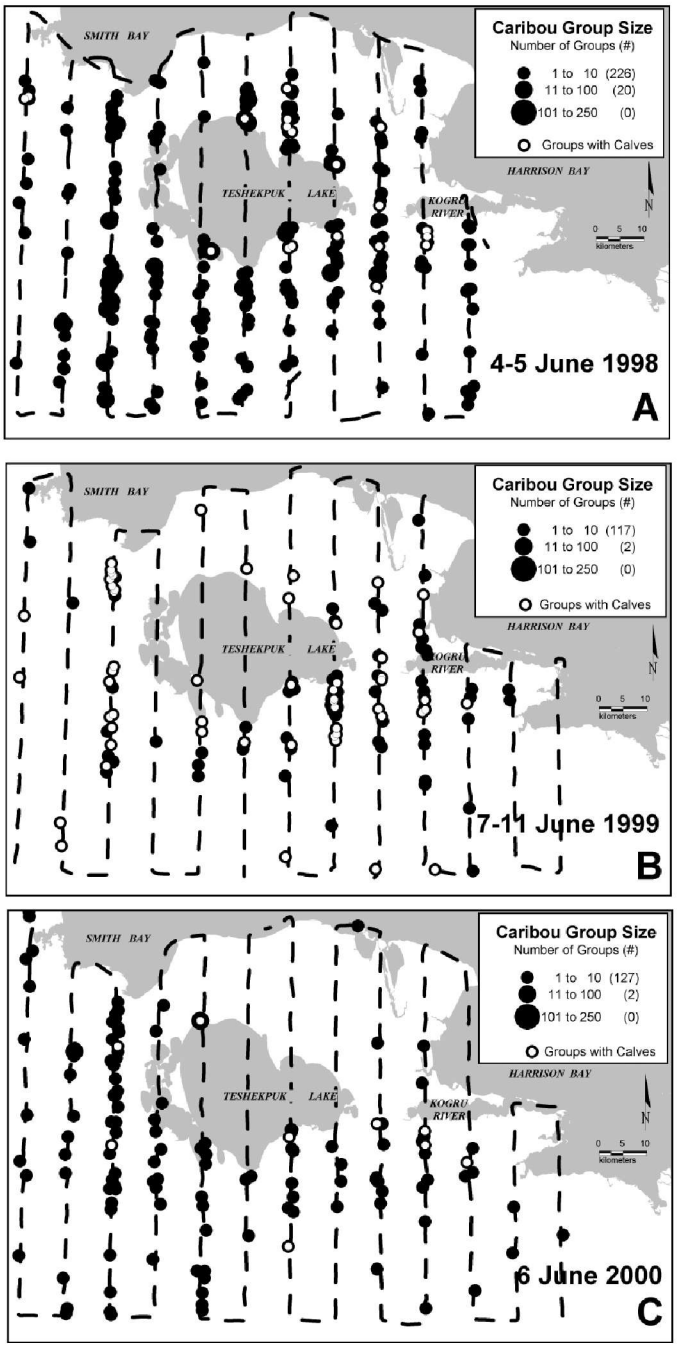

Fig. 2. Caribou groups located during 18% coverage systematic aerial strip-transect surveys in the National Petroleum Reserve–Alaska, June 1998–2000.

Results

Aerial Surveys

We completed 3 aerial surveys at 18% coverage and 3 aerial surveys at 100% coverage in the Teshekpuk Lake area during the caribou calving period between 4–12 June 1998–2000. Snow melt was nearly complete during the survey in 1998, but patchy snow cover leading to poor sighting conditions occurred in 1999 and 2000. Areas north of Teshekpuk Lake were 80% to 100% snow covered while areas south of the lake were 30% to 70% snow covered during surveys in 1999 and 2000. Mean daily temperature during 1–15 June declined steadily over our surveys during 1998–2000: 4.26 ± 0.57 °C in 1998, 3.04 ± 0.90 °C in 1999, and 2.04 ± 0.99 °C in 2000.

18% coverage area

We observed fewer total caribou of all classes and lower caribou density in the 18% coverage area in 1999 and 2000 than in 1998, even after application of the SCF (Table 1). However, more cow/calf pairs were recorded in 1999 (Table 1). In general, cow/calf pairs were closer to Teshekpuk Lake in 1998 and 2000 than in 1999 when survey timing was later (Fig. 2). In 1999, more cow/calf pairs were west of Teshekpuk Lake and at the southern border of the study area than in the eastern study area (Fig. 2). In the 18% coverage area, cows without calves generally occurred over a larger area than cow/calf pairs during 1998 and 2000, with more cows without calves occurring west and southwest of Teshekpuk Lake (Fig. 2).

Based on the 11 transects sampled consistently during 1998–2000 in the 18% coverage area, the estimated number of cows declined from the number observed in 1998 by 47% in 1999, and 36% in 2000 (Table 2). Our estimated number of cows within this area ranged from 24% to 46% of the estimated total of 10 077 cows in the TCH, based on the 1999 ADFG population estimate (Table 2).

100% survey area

In 1998, cow/calf pairs occurred throughout the 100% coverage area centered on the area northeast and southeast of Teshekpuk Lake (Fig. 3). In 1999 and 2000, cow/calf pairs were concentrated in the northwestern half of the survey area, southeast of Teshekpuk Lake and south of the Kogru River (Fig. 3). In 2000, we

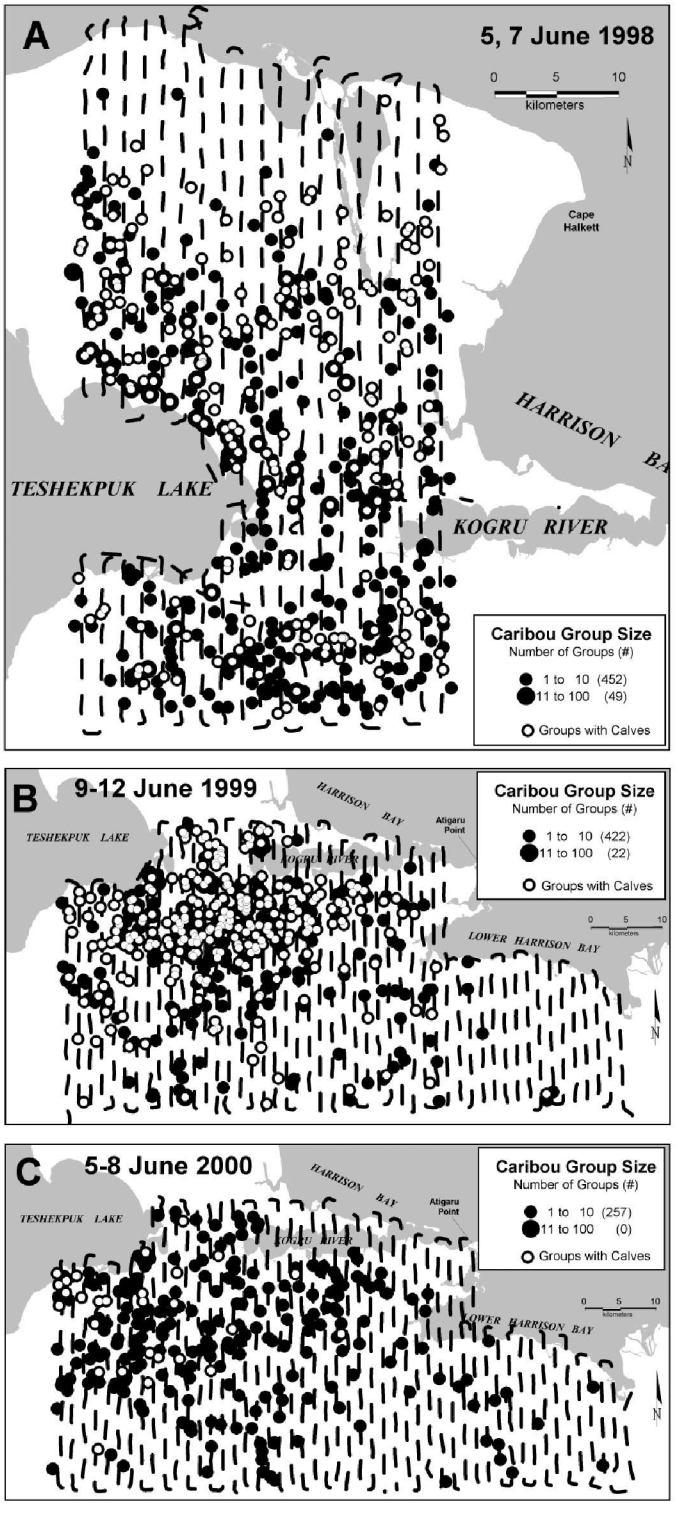

Fig. 3. Caribou groups located during 100% coverage systematic aerial strip-transect surveys in the National Petroleum Reserve–Alaska, June 1998–2000.

observed lower caribou densities, fewer total caribou, and fewer cow/calf pairs within the 100% coverage survey area than in the same area in 1999 (Table 1). Survey timing in 1999 was later (9–12 June) than in 2000 (5–8 June). Mean group size declined steadily during the 1998–2000 survey period (Table 1). The eastern extent of calving in the 100% coverage area appears to be Atigaru Point; only 1 cow/calf pair was sighted east of Atigaru Point (Fig. 3).

The 100% coverage area during 1998 included 19% of TCH cows. Survey coverage, focused on areas of potential oil and gas development, included 23% of TCH cows in 1999 and 8% in 2000 (Table 2). As in the 18% coverage area, a higher proportion of cow/calf pairs was recorded during 1999 than in either 1998 or 2000.

VHF and Satellite Telemetry

During early June 1998–2000 radio-collared caribou calving locations (n=63 locations) were distributed around Teshekpuk Lake, within 97 km of the lake shoreline (Carroll, 2001). Cows without calves (n=30 locations) were generally located west of Teshekpuk Lake within 123 km of the lake (Fig. 4; Carroll, 2001). During the 3 years of surveys, cows without calves occurred over a wider area (15 210 ± 2080.0 km^2) than cow/calf pairs (3874 ± 1221.1 km^2, t=-4.70, P=0.02, df=3). Radio-collared cows with calves during the 3 years of surveys were also closer together (mean distance = 32.9 ± 8.21 km) than cows without calves (mean distance = 65.9 ± 2.58 km; t=-3.51, P=0.04, df=3). Calving ranges appeared more concentrated in 1998 (2210 km^2) and 1999 (3158 km^2) than in 2000 (6254 km^2, Fig. 4). This was consistent with group size observations for both the 18% and 100% coverage survey areas which indicated mean group sizes declined from 1998–2000 (Table 1).

Based on the limited data available for this period, satellite-collared cows with calves (n=4 caribou) during 1–20 June 1998–2000 were generally south and southeast of Teshekpuk Lake and cows without calves (n=2 caribou) were

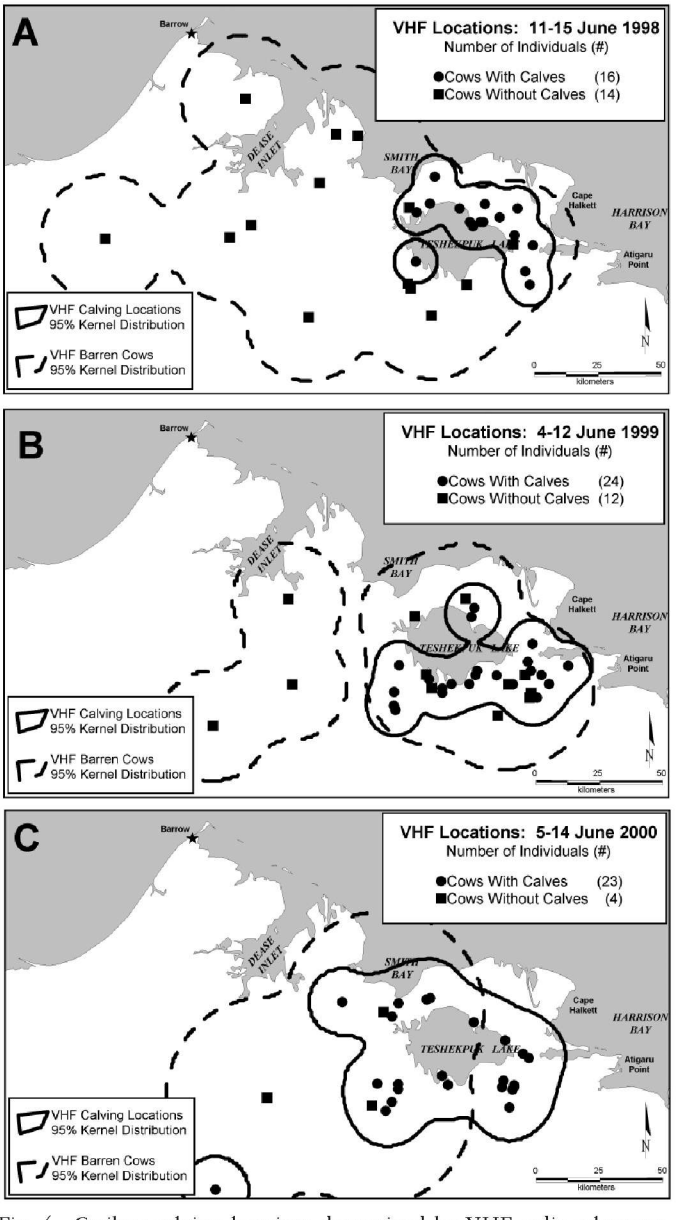

Fig. 4. Caribou calving locations determined by VHF radio telemetry from 4–15 June 1998–2000 (Carroll, 2001) and fixed kernel utilization distributions for calving locations and for cows without calves in the National Petroleum Reserve–Alaska.

west of the lake. Cow caribou MCP ranges between 1–20 June (28–58 locations per cow, n=6 cows) were similar for cow/calf pairs (621 ± 524.3 km^2, n=4 cows) and cows without calves (468 ± 303.3 km^2, n=2 cows). MCP ranges for satellite-collared cows during our 4–12 June survey period (6–22 locations per cow, n=6 cows) were smaller and less variable for cow/calf pairs (15 ± 6.6 km^2, n=4 cows) than for cows without calves (87 ± 72.3 km^2, n=2), although this difference was not statistically significant.

Mean distances traveled per day during 1–20 June were similar for cows with and without calves (2.5 ± 0.69 km/d and 3.7 ± 1.56 km/d, respectively). Mean distances traveled per day during our 4–12 June survey period were also similar to movement rates during the calving period (2.5 ± 0.85 km/d with calf, and 3.3 ± 0.50 km/d without calf). Total distance traveled during our 4–12 June survey period showed an increasing trend across years from 23 km in 1998, 37 km in 1999, to 45 km in 2000. This trend was inconsistent during the 1–20 June calving period with 155 km in 1998, 101 km in 1999, and 183 km in 2000.

Discussion

The TCH calved southwest of Teshekpuk Lake in 1976 and 1977, and northeast of the lake in 1978 (Davis & Valkenburg, 1979). Since the mid 1990s, calving has been northeast, east, and southeast of the lake (Carroll, 2001). Philo et al. (1993) reported that 3 out of 5 collared cows calved southeast of Teshekpuk Lake. Aerial survey and telemetry data suggest that the entire area surrounding Teshekpuk Lake is used by caribou during calving.

In general, calving dates for the TCH range from 2–16 June, with most cows moving into the area in early June (Carroll, 2001). When our strip-transect surveys were initiated, we focused on the distribution of calving locations, believing that the peak of calving, near 5 June, would be similar to the Central Arctic Caribou Herd. We considered that after this date most cows would have moved into the Teshekpuk Lake area and would have calved.

Carroll (2001) noted that most calves were located during VHF telemetry surveys after 7 June 2000, which he indicated was slightly later than normal. During surveys for waterfowl in the 100% coverage survey area on 15–19 June 2000, Noel et al. (2001) recorded nearly 3 times the total number of caribou and a much higher proportion of cows with calves (61 calves:100 cows) than during our 5–8 June 2000 survey (Table 1). Apparently cows moved into this

area after our survey on 5–8 June, either before or after parturition.

More cow/calf pairs were observed on our transect surveys in 1999 than in either 1998 or 2000 apparently because survey dates in 1998 and 2000 were before most cows had calved. Patchy snow conditions and cooler temperature from 1–15 June were likely responsible for the decreased numbers of caribou recorded within our 18% coverage survey area in 1999 and 2000 (Table 2). Calving ranges were larger in 1999 and 2000 than in 1998, indicating that cows/calf pairs were spread across a larger area in these years. VHF determined calving ranges during 1998–2000 were potentially influenced by (1) survey timing, (2) small sample sizes, and (3) weather conditions.

We recommend that calving period transect surveys be flown after 15 June, when most calves have been born, and the ADFG VFH calving surveys have been completed. This later timing may be less disruptive to pre-parturient and parturient cows and should allow documentation of a higher proportion of cow/calf pairs. Also, because VHF determined calving ranges will already be established, this may allow a more accurate comparison between the proportion of TCH cows and the proportion of the TCH calving range represented by the area of interest for potential development.

Annual variation in calving distributions is evident from the few years of survey data presented here, and is potentially influenced by snow cover, weather conditions, survey timing, and possibly sample size. Comparing the proportion of the calving range within a particular transect survey area should indicate how important any particular area is for the calving period during a given year. Our comparison of calving ranges based on VHF surveys to estimates for the number of TCH cows within the 18% coverage transect survey area suggests that the VHF determined calving ranges may underestimate the calving range of the TCH, for these years. Satellite telemetry data for 1998–2000 indicate cows were not static either during our survey period or during the calving period.

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