FINAL REPORT

SURVEYS OF CARIBOU AND MUSKOXEN IN THE KUPARUK-COLVILLE REGION, ALASKA, 2001

BRIAN E. LAWHEAD
AND
ALEXANDER K. PRICHARD

PREPARED FOR
PHILLIPS ALASKA, INC.
ANCHORAGE, ALASKA

PREPARED BY
ABR, INC.
FAIRBANKS, ALASKA

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Prepared for:

PHILLIPS Alaska, Inc.
Greater Kuparuk Area
P. O. Box 100360
Anchorage, AK 99510

Prepared by:

Brian E. Lawhead
and
Alexander K. Prichard

ABR, Inc.—Environmental Research & Services
P. O. Box 80410
Fairbanks, AK 99708

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EXECUTIVE SUMMARY

- We investigated the distribution, abundance, calf production, and movements of Central Arctic Herd (CAH) caribou in northern Alaska between the Colville River and the Prudhoe Bay Oilfield from early June through late October 2001. Muskoxen were recorded incidentally during these surveys.
- A fixed-wing airplane was used to survey caribou calving distribution and abundance during 5–7 June and 10–12 June. Summary maps of caribou density were prepared to compare the annual distribution with longer-term averages from regional calving surveys since 1993. A helicopter was used to sample sex and age composition on 14–15 June. We conducted surveys from a helicopter and truck during the insect season (26 June–27 July). In addition, we conducted six surveys of caribou distribution during late summer and fall (August–October).
- Snow melt was delayed in 2001. Snow was deeper than normal through May but melted rapidly in the first half of June. Few caribou were seen on the early June survey, so we applied a correction factor to adjust calving survey counts for low sightability. We observed 187 caribou, including 13 calves (7.0%), in the Colville East and Kuparuk South survey areas on 5–7 June, resulting in an expanded and sightability-corrected total estimate (± 80% confidence interval) of 653 ± 200 large caribou (adults and yearlings), and an average density of 0.31 ± 0.1 large caribou/km².
- During 10–12 June, we observed a total of 1973 caribou, including 484 calves (24.5%), in all three calving survey areas, resulting in an expanded estimate (± 80% C.I.) of 3946 ± 293 total caribou and an average density of 1.24 ± 0.1 caribou/km². Caribou density was lowest in the Kuparuk Field survey area and highest in the Kuparuk South survey area.
- In the Kuparuk Field calving survey area (including both sides of the Milne Point Road), over half of the caribou (65% of total, including 60% of calves) were located north of the Spine Road and east of the Oliktok Point Road, a proportion slightly lower than in most other years since 1993 (70–77%), except 2000 (43%) and 1998 (~50%).
- The area of greatest calving activity (in terms of distribution and density) was located south of the Kuparuk Oilfield, similar to the pattern observed in 1993 and 1995–2000. Calf production by the western segment of the CAH was high in 2001 for the sixth consecutive year, estimated at 79 calves: 100 cows (n = 3049 caribou) on 14–15 June.
- Insect harassment was monitored during 28 days between 26 June and 27 July 2001. Late June and early July were cooler than average and late July was warmer than average. Insect harassment in 2001 began on 2 July and resulted in a northward movement of caribou to the coast. Temperatures cooled on 4 July and stayed cool until 15–16 July, when warming temperatures triggered the second major insect-induced movement of caribou to the coast. Prolonged westerly winds and warm temperatures in the third week of July caused an unusual large-scale movement of most of the western segment of the CAH onto the Colville River delta, with many continuing west of the Colville River into NPRA.
- Caribou densities were low in the Colville East survey area during August–October 2001. In that period, densities tended to be higher nearer the coast in September and October than in August, although they were much lower than during the insect season. Average group size was lowest in August (1.2–2.8 caribou/group), increased by late September (6.3 caribou/group), and then decreased again.
- Muskoxen were widely dispersed throughout the region. We recorded 37 sightings between mid-May and late October 2001. At least 151 different muskoxen (including at least 28 calves) were observed between the eastern portion of the National Petroleum Reserve–Alaska (NPRA) and the Sagavanirktok River.

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ACKNOWLEDGMENTS

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INTRODUCTION

The Central Arctic Herd (CAH) of barren-ground caribou (*Rangifer tarandus granti*) inhabits the central Arctic Coastal Plain of northern Alaska, ranging from the Brooks Range north to the Beaufort Sea. The CAH grew rapidly during the late 1970s and 1980s, reaching a peak count of 23,444 caribou in July 1992 (Taylor 1993) before declining 23% to 18,093 caribou in July 1995 (Woolington 1995). On 19–20 July 1997, the herd was estimated to number 19,730 animals (Lenart 1999), a 9% increase over the 1995 census. The most recent photocensus on 21 July 2000 revealed that the CAH had increased further to at least 27,128 caribou, the maximum size recorded thus far for the herd (E. Lenart, Alaska Department of Fish and Game [ADFG], pers. comm.).

The Kuparuk Oilfield, located on the outer coastal plain, is within the summer range of the CAH (Lawhead 1988). Since 1978, shortly before development of the Kuparuk Oilfield began, considerable interest has focused on the use of the oilfield and surrounding area (particularly the Milne Point Unit) by the CAH during calving. The Kuparuk–Milne Point area is one of two locales (the other being the Bullen Point–Staines River area, east of the Prudhoe Bay Oilfield) that consistently received concentrated use during the calving season from the late 1970s to the late 1980s, as determined by systematic aerial surveys beginning in 1978 (Whitten and Cameron 1985, Lawhead and Cameron 1988). Studies by ADFG (Dau and Cameron 1986, Cameron et al. 1992) reported local avoidance of oilfield facilities and human activities by cows with young calves in this general concentration area during the calving season. From 1978 through 1992, ADFG conducted aerial transect surveys of caribou distribution annually during the latter portion of the calving season (usually 10–15 June). After 1992, however, that annual effort was cut back because of budget constraints; ADFG's next transect survey was conducted in June 1997 and another was conducted in June 2000. ABR has conducted similar calving surveys of the western segment of the CAH every year since 1993 (except 1994), as well as conducting calving surveys in several earlier years (1983, 1984, 1987) in the region.

Since 1992, ADFG survey efforts have focused primarily on tracking radio-collared female caribou, with 80–100 collars potentially transmitting in summer 2001 (E. Lenart, ADFG, pers. comm.). In early June 2001, 60 newborn calves were outfitted with conventional VHF radio-collars by ADFG (with funding from PHILLIPS Alaska, Inc. [PAI]) to study calf mortality and growth. During late July 2001, 10 female CAH caribou were outfitted with satellite collars by ADFG, in a cooperative study with the North Slope Borough (NSB) Department of Wildlife Management and the U.S. Bureau of Land Management (BLM), to study distribution and movements of the herd throughout the year. The transect and reconnaissance surveys reported herein complement the data from those telemetry studies.

To help fulfill the mandate for ongoing caribou research in the Kuparuk River Unit Agreement, the study reported here was conducted under contract to PAI to monitor the use of the Kuparuk Oilfield in 2001 during the calving and insect seasons and in late summer through fall.

This study had five objectives in 2001:

- Document the distribution and abundance of caribou using the region between the Kuparuk and Colville rivers, including the Meltwater (Drill Site 2P) Project area, during the calving season (early to mid-June);
- Sample the sex and age composition of caribou in the region in mid-June to quantify initial calf production;
- Document the distribution and movements of caribou in the region during the insect season in midsummer (late June through July);
- Document the distribution and abundance of caribou east of the Colville and Itkillik rivers, including the Meltwater Project area, during late summer and fall (August–October); and
- Assess the summer distribution and abundance of muskoxen in the region between the Colville and Kuparuk rivers.

STUDY AREA

The study area extended west from the Kuparuk River to the Colville River, and north from about latitude 70º N to the Beaufort Sea coast (Figure 1). This area encompassed the entire Kuparuk Oilfield; the Alpine Project pipeline corridor between the Kuparuk Oilfield and Colville River; the Milne Point Oilfield; and the westernmost portion of the Prudhoe Bay Oilfield (west of the Kuparuk River). Aerial surveys of caribou calving were conducted in three survey areas, as described by Lawhead et al. (1998) and Johnson et al. (1998): (1) the Kuparuk Field survey area (1107 km²), including the Kuparuk and Milne Point oilfields from Kalubik Creek to the Kuparuk River; (2) the Kuparuk South survey area (603 km²), located south of the Kuparuk Field; and (3) the Colville East survey area (1478 km²), located between the Colville River and the western Kuparuk field (including the recently permitted DS-3S project area), and extended inland in 1999 to incorporate the Meltwater South exploration area. Observations of caribou on the Colville River delta were limited to incidental sightings; caribou survey efforts were curtailed there in July 1998 at the request of representatives of the village of Nuiqsut.

The landscape in the region slopes gently from upland, moist tussock tundra in the upper reaches of the Sakonowyak, Ugnuravik, Kalubik, Miluveach, and Kachemach drainages, down to moist and wet coastal tundra communities nearer the coast. The study area is characterized by permafrost-related features such as oriented thaw-lakes, beaded streams, and pingos. The physiography, vegetation, and climate of the central Arctic Coastal Plain were described by Walker et al. (1980).

METHODS

CARIBOU CALVING SEASON

We conducted aerial surveys of caribou distribution and numbers during calving in three survey areas (Kuparuk Field, Kuparuk South, Colville East; Figure 1) during 5–7 June and 10–12 June 2001. The surveys were scheduled to coincide with the timing of previous years' surveys in early and mid-June (1–8 and 9–15 June, respectively, in 1993 and 1995–2000). During systematic surveys, caribou were counted by two observers looking on opposite sides of a Cessna 206 airplane. During most surveys a third biologist recorded data for the observers, thereby reducing the need for observers to look away from the transect strip. In each survey area, the pilot navigated along north–south-oriented transect lines using coordinates programmed into a global positioning system (GPS) receiver; navigation was checked periodically on U.S. Geological Survey (USGS) topographic maps. The pilot maintained the aircraft speed at ~150 km/h and the altitude at ~90 m above ground level (agl) using a radar altimeter. Transect lines were spaced at intervals of ~1.6 km, following section lines on USGS maps (Figure 1).

Observers counted caribou within a 400-m-wide strip on each side of the transect centerline, for a sampling intensity of ~50% (0.8 km of each 1.6 km). The strip width was delimited visually using tape markers on the struts and windows of the aircraft, following the method of Pennycuick and Western (1972). Tape markers were positioned to indicate strip widths of 200 and 400 m. When a caribou group was observed within the 400 m strip the location was recorded using a GPS receiver, the number of adults and calves was recorded, and the group was assigned to a distance category (one of four 100-m zones). For production of color maps depicting calving distribution and density, caribou groups were pooled into the same 3.2-km-long transect segments used in previous years (Lawhead and Prichard 2001) for comparative purposes.

The percentage of ground surface covered by snow was estimated visually in the survey area as an index to survey conditions. The patchy visual image of broken snow cover during spring snowmelt drastically reduces an observer's ability to detect caribou. Patchy snow cover is the most important factor diminishing sightability (defined as "the probability that an animal within the observer's field of search will be seen by that observer" [Caughley 1974: 923]) of caribou during the calving season (Lawhead and Cameron 1988). One way to adjust counts made during poor viewing conditions is to estimate sightability using a double-survey technique and then calculate a sightability correction factor (SCF) for post-survey

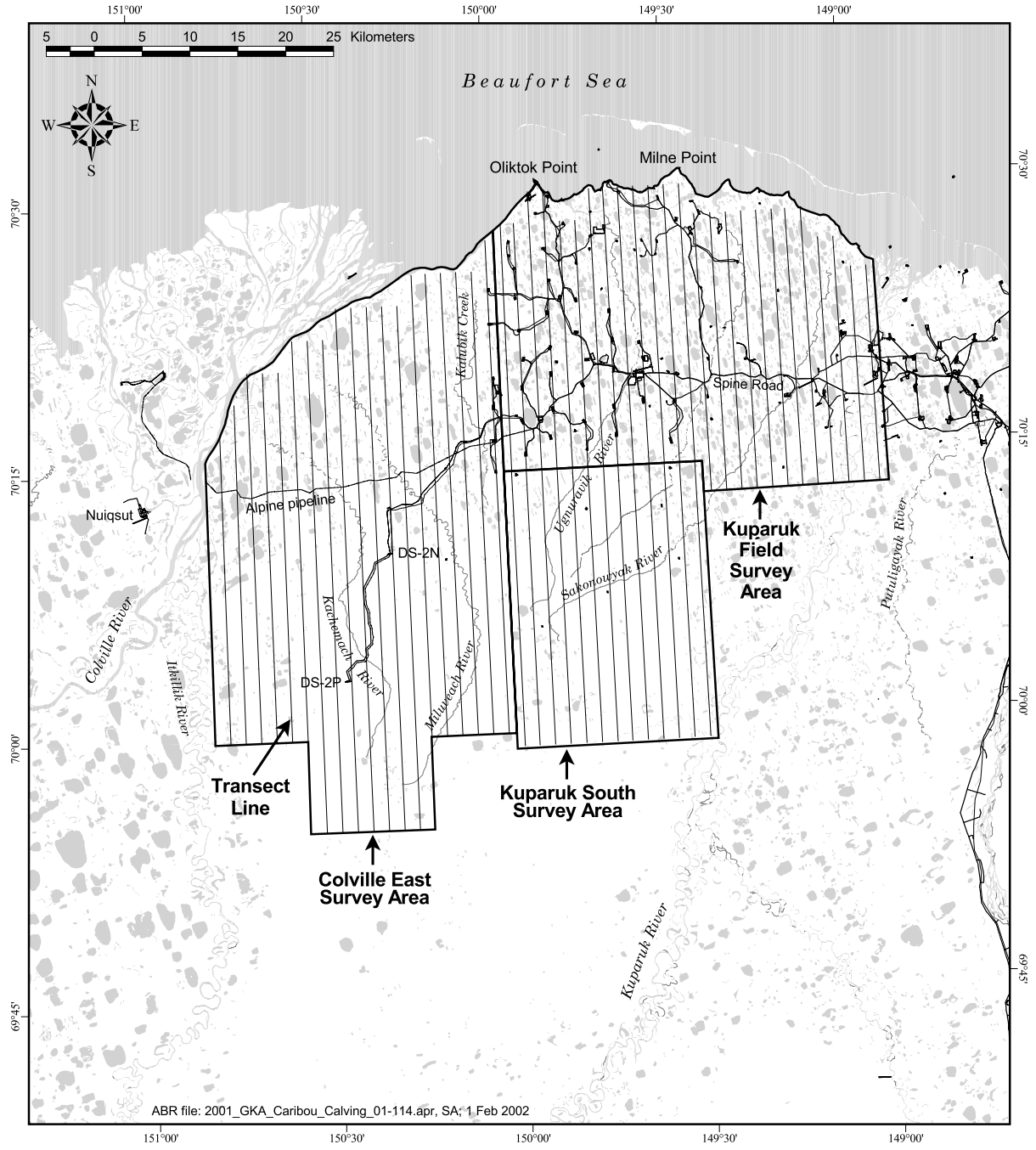

Figure 1. Survey areas and transect lines for systematic aerial surveys of caribou in the Kuparuk–Colville region, northern Alaska, during the 2001 calving season.

adjustment of counts (Gasaway et al. 1986). In 1993, an SCF (1.88) was calculated for patchy 20–70% snow cover during calving season surveys in the Colville and Kuparuk survey areas (Smith et al. 1994, Lawhead et al. 1994) and was available for correction of counts. We extrapolated population estimates for total caribou and for calves from their respective counts and standard errors using formulas modified from Gasaway et al. (1986). Because our surveys had 50% coverage of the study area, we estimated the "observable population" (i.e., the estimated number of caribou in the entire survey area, unadjusted for sightability), by doubling the number of caribou observed. In text, these estimates are followed by the 80% confidence interval (CI); for example, an observable population estimate of 70 ± 30 caribou means that the 80% CI ranges from 40 to 100 caribou.

We used a Bell 206-B "Jet Ranger" helicopter to sample the sex and age composition (cows, calves, yearlings, and bulls) of caribou groups in portions of all three survey areas on 14–15 June 2001. Helicopter speed ranged from 40 to 125 km/h (slowing frequently to observe groups closely) and altitude ranged from 30–50 m agl to facilitate accurate identification of sex and age classes. We followed a nonsystematic survey path on this survey to maximize the number of groups encountered, using a GPS receiver to avoid duplicate counts. We included areas of both high-density (concentrated) calving and low-density peripheral areas, based on the preceding distribution surveys.

To summarize the calving distribution and abundance data for each year of surveys (1993 and 1995–2001), we applied the Inverse Distance-Weighted (IDW) interpolation technique of the *Spatial Analyst* extension of *ArcView* GIS software to the transect data from early and mid-June (1–8 and 9–15 June) surveys for each year, as well as to the mean value for each transect segment over all years surveyed. This analysis was conducted on total caribou numbers and number of calves pooled over 3.2-km segments along the length of transects. The IDW interpolator calculated a density surface using each segment centroid and the distance-weighted values for the 14 nearest centroids. This analysis produced color maps showing surface models of the density of all caribou (large caribou + calves) and all calves observed over the entire survey area, to create an easily understood visual portrayal of the data. The resulting color map plots are visual depictions of distribution and relative abundance within each year.

CARIBOU INSECT SEASON

We conducted surveys during the insect season (the time of year when mosquitoes and oestrid flies harass caribou) to document the abundance, distribution, and movements of caribou between the east (main) channel of the Colville River and the east side of the Kuparuk River, thus encompassing both the Kuparuk and Milne Point oilfields. A single observer was based at the Kuparuk Operations Center (KOC) facility during 26–27 June and 1–27 July 2001. In addition, a second observer from the Kuukpik Subsistence Oversight Panel (KSOP) conducted road surveys independently in mid-July (which are not reported here). Incidental observations were provided by researchers surveying other species or working on other projects in the region. Daily observations included weather conditions, levels of insect harassment, and caribou movements, which were monitored primarily by aerial surveys. Supplemental observations from a truck were used to monitor the general movements of caribou in the vicinity of the oilfield road system when the survey helicopter was not available.

Insect-season surveys consisted of nonsystematic reconnaissance flights specifically for caribou, as well as incidental observations during other wildlife surveys (e.g., for fox dens and waterbird broods). The aerial surveys used a helicopter (Bell 206-B or -LIII) on an opportunistic basis. A broad search path (~3 km wide) was employed on reconnaissance surveys over larger areas, with the observer using 10 × 30 image-stabilizing binoculars to scan ahead and to the sides of the aircraft. Survey intensity varied among surveys according to the prior distribution and movements of caribou in the study area, but daily observations allowed close tracking of large-scale caribou movements. We mapped the locations and number of caribou groups and recorded group type (cow/calf-dominated, bull-dominated, mixed). When possible, the age

and sex composition of groups (bull, cow, yearling, calf, and unknown) were recorded.

LATE SUMMER–FALL SURVEYS

Aerial transect surveys were conducted over the Colville East survey area (Figure 1) in late summer and fall, the time when most of the subsistence harvest of caribou by local residents occurs. Surveys followed the same protocol as calving surveys, but because visibility was generally good (either no snow cover or 100% snow cover), surveys were flown at ~150 m (500 ft) agl and caribou were recorded within 800 m of the plane. Transects were spaced at 3.2-km intervals to maintain ~50% coverage. Surveys were conducted three times in August, once in September, and twice in October.

MUSKOXEN

Locations and numbers of muskoxen were noted and mapped during aerial surveys for caribou in the three calving survey areas and throughout the survey region during the summer insect-season surveys. A number of sightings in May and June were incidental observations during reconnaissance surveys for the Meltwater caribou monitoring study (Lawhead et al., in prep.) and others were reported by observers conducting surveys for other species.

RESULTS AND DISCUSSION

CARIBOU CALVING SEASON

HABITAT AND SURVEY CONDITIONS

Snow melt in the Kuparuk–Colville region was delayed in 2001. Snow depth and cover were high in May, but snowmelt progressed relatively quickly in early June (Figure 2). The mean daily temperature was below average in May but higher than average in early June (Figure 2, Appendix A). Despite the early June warming trend, snow cover did not disappear completely until mid-June, similar to the other late springs of 1997, 1999, and 2000, and the average daily temperature remained below freezing in May and early June (Appendix A). In years of early snowmelt, such as 1996 and 1998, snow cover disappeared by the end of May, and even in years of intermediate snow melt, snow cover typically is gone by the time of the mid-June calving surveys.

Snow cover was extensive during the surveys of the Kuparuk South and Colville East areas on 5–7 June (the Kuparuk Field area was not surveyed due to poor weather) (Table 1). Therefore, we applied the sightability correction factor, developed in 1993 for patchy snow cover conditions ranging from 20 to 70% cover (Lawhead et al. 1994), to the early June survey counts.

During the mid-June surveys (10–12 June), snow cover persisted in relatively small amounts in the three calving survey areas (mostly 10% or less; Table 1). Because of the generally low snow cover, we did not apply the sightability correction to the mid-June counts, but sightability was depressed in several areas on the mid-June surveys. The highest cover remaining in the Colville East area was near the coast. The snow cover remaining in the Kuparuk South area consisted mainly of persistent seismic survey lines from winter exploration, which introduced a grid pattern that probably lowered our counts. Similarly, sightability of caribou was lower in some parts of the Kuparuk Field survey area because of extensive seasonal flooding in low, wet habitats and the complex

Table 1. Estimated snow cover (%) among survey areas during caribou calving surveys, June 2001.

Survey Area	Date	Mean %	*n*	Minimum %	Maximum %
Colville East	5–6 June	54	142	10	90
	10–11 June	11	18	<5	30
Kuparuk South	7 June	40	1 (summary)	5–10	90
	11 June	6	5	<5	10
Kuparuk Field	12 June	1	23	1	<5

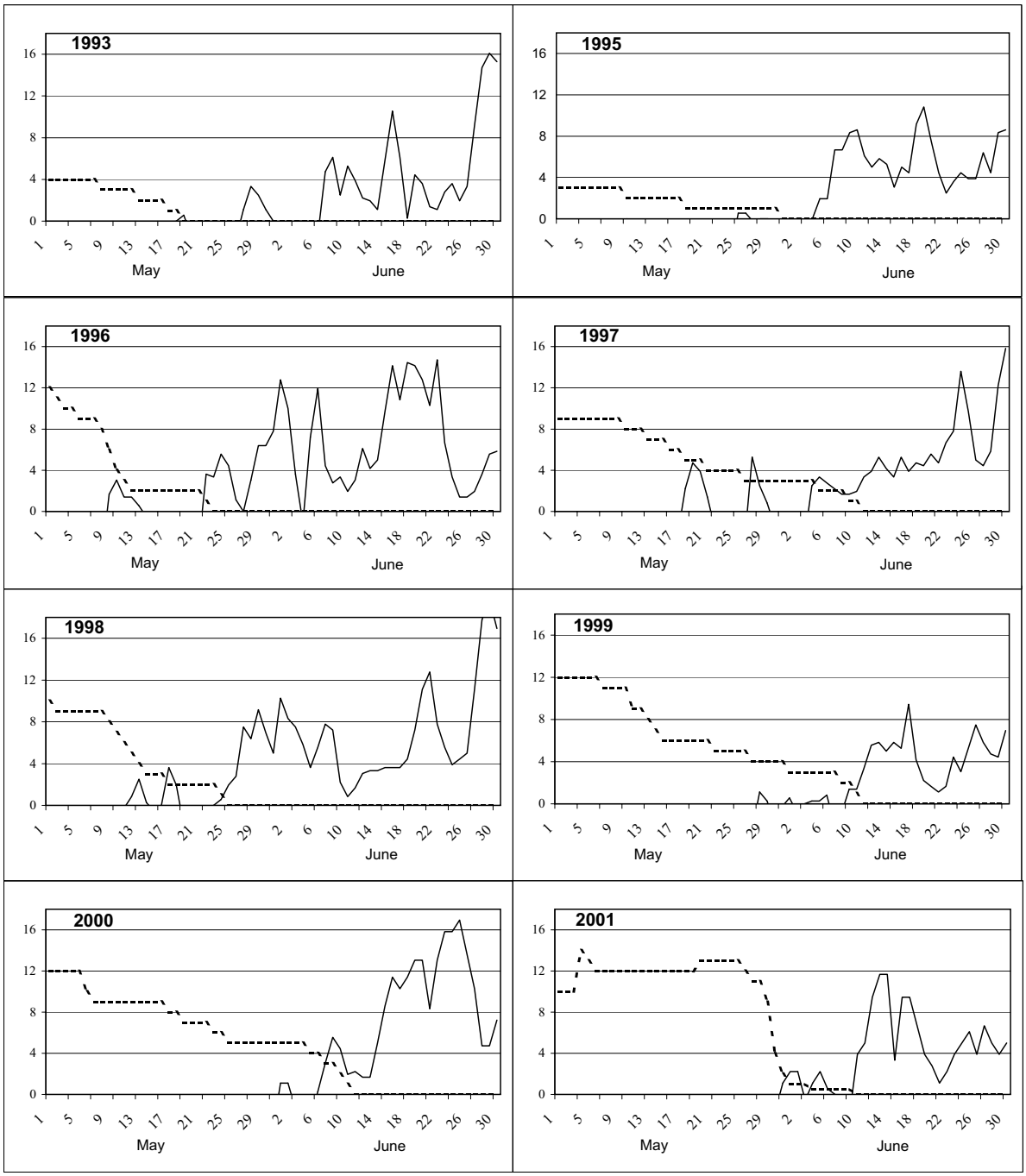

Figure 2. Snow depth (inches; dashed lines) and average daily temperature (º C; solid lines) at the Kuparuk airstrip, May–June 1993–2001.

visual background resulting from the interspersion of snow, ice, meltwater, and bare ground.

DISTRIBUTION AND ABUNDANCE IN 2001

The number of caribou in the three calving survey areas increased substantially between our two surveys; a similar increase was noted in the same period (4–13 June) on calving surveys conducted for the Meltwater monitoring study (Lawhead et al., in prep.). During 5–7 June, we observed 187 caribou, including 13 calves (7%), in the Colville East and Kuparuk South survey areas; the Kuparuk Field area could not be surveyed in early June (Figures 3 and 4). In contrast, a total of 1973 caribou, including 484 calves (25%), were seen during one complete round of surveys in all three areas during 10–12 June (Figures 5 and 6).

Expansion of these counts, which sampled 50% of the total area, gave estimates (not adjusted for sightability) of 374 ± 59 total caribou, including 26 ± 7 calves, in the Kuparuk South and Colville East areas in early June and 3946 ± 293 total caribou, including 968 ± 89 calves, in mid-June in all three areas (Table 2). Due to patchy snow cover on the early June surveys, the SCF was applied to arrive at an estimate of 653 ± 200 large caribou (adults + yearlings) in the two survey areas (Table 2), for an adjusted average density in early June of 0.31 ± 0.10 large caribou/km² in the Colville East and Kuparuk South survey areas combined (Table 3). The SCF was not used for the mid-June counts, and the overall density estimate was 0.93 ± 0.07 large caribou/km² among all three survey areas.

The density of caribou in mid-June was lowest in the Kuparuk Field survey area and highest in the Kuparuk South area (Figure 7), as was the case in most previous years (Table 4, Figure 8). The mid-June density in 2001 was lower than average in all three survey areas, reflecting the late snowmelt and greater inland distribution of caribou at calving. The total density in 2001 was the second lowest in 8 years of mid-June surveys in Colville East and was the third and fourth lowest densities recorded in 7 years of surveys in the Kuparuk Field and Kuparuk South areas, respectively (Table 4).

In the Kuparuk Field survey area, 217 of the animals counted on 12 June (65% of the total caribou and 60% of the calves seen in the area) were located north of the Spine Road and east of the Oliktok Point Road, an area containing approximately half of the Kuparuk Field survey area. This proportion is higher than in 2000 (43% of total, 44% of calves; Lawhead and Prichard 2001) and 1998 (~50% of total; Lawhead 1999), but is lower than in most other recent years (70–77% in 1993, 1996, 1997, 1999; Lawhead and Johnson 2000). The results of composition surveys in the Kuparuk Field area indicate that the area receives consistent annual use by several hundred cows exhibiting a high level of calf production.

Table 2. Counts and population estimates of caribou (± 80% confidence interval [CI]) during the 2001 calving season in the Colville East, Kuparuk South, and Kuparuk Field survey areas, Alaska.

Survey Area	Date	Area (km²)	Unadjusted Estimate			SCF-Adjusted [a]
			Total	Large	Calves	(Large Only)
Colville East	5–6 June	1478	90 ± 46	90 ± 46	0	169 ± 96
	10–11 June	1478	1148 ± 122	956 ± 101	192 ± 28	
Kuparuk South	7 June	603	284 ± 33	258 ± 30	26 ± 7	484 ± 137
	11 June	603	2132 ± 202	1524 ± 138	608 ± 69	
Kuparuk Field	12 June	1107	666 ± 119	498 ± 193	168 ± 29	
Total	5–7 June	2081	374 ± 59	348 ± 57	26 ± 7	653 ± 200
	10–12 June	3188	3946 ± 293	2979 ± 214	968 ± 89	

[a] Sightability Correction Factor (1.88) applied to adjust estimates of large caribou (no SCF was available for calves) due to patchy snow cover (Lawhead et al. 1994).

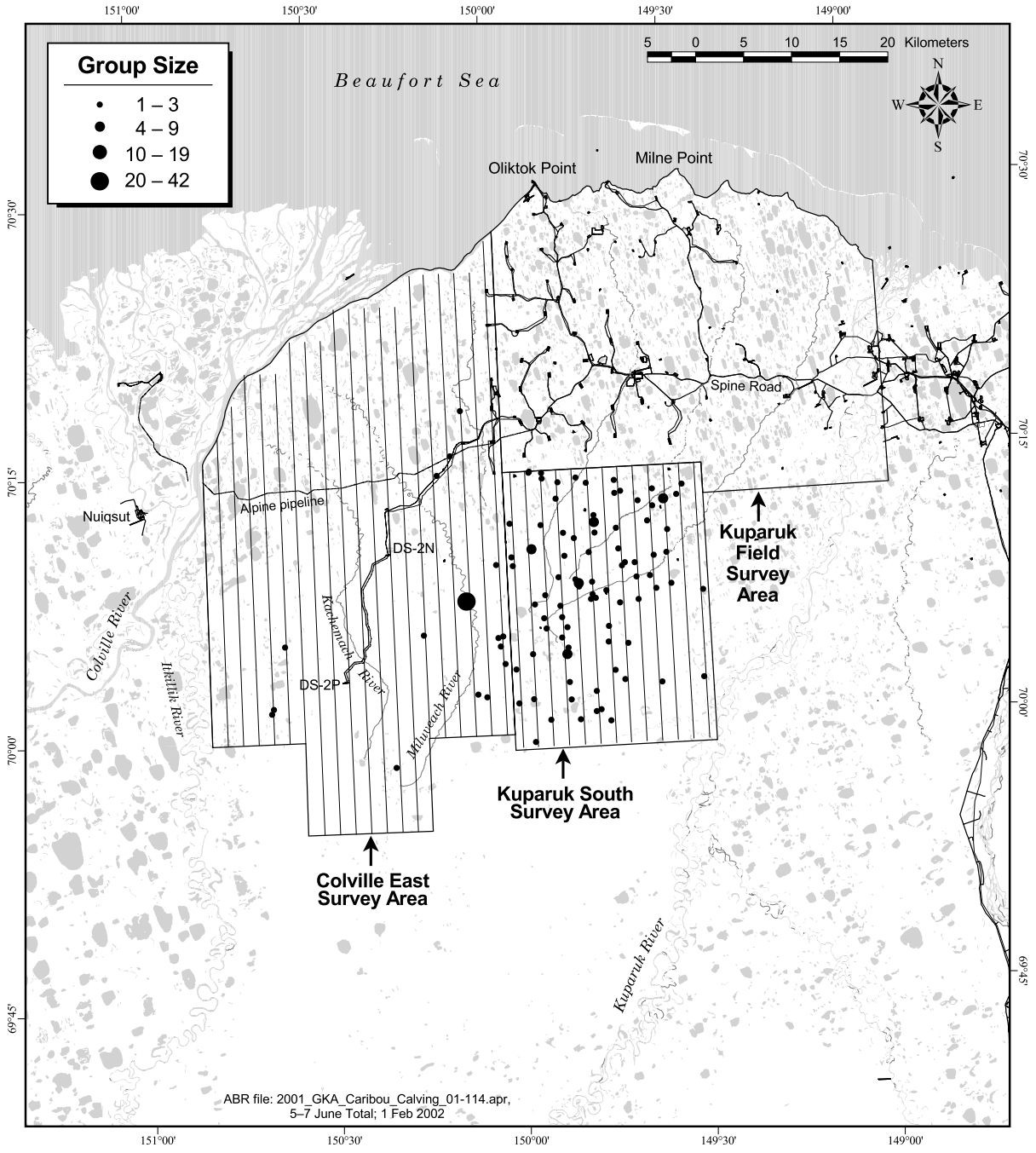

Figure 3. Distribution and number of all caribou (adults and calves) in the Kuparuk South and Colville East calving survey areas, 5–7 June 2001.

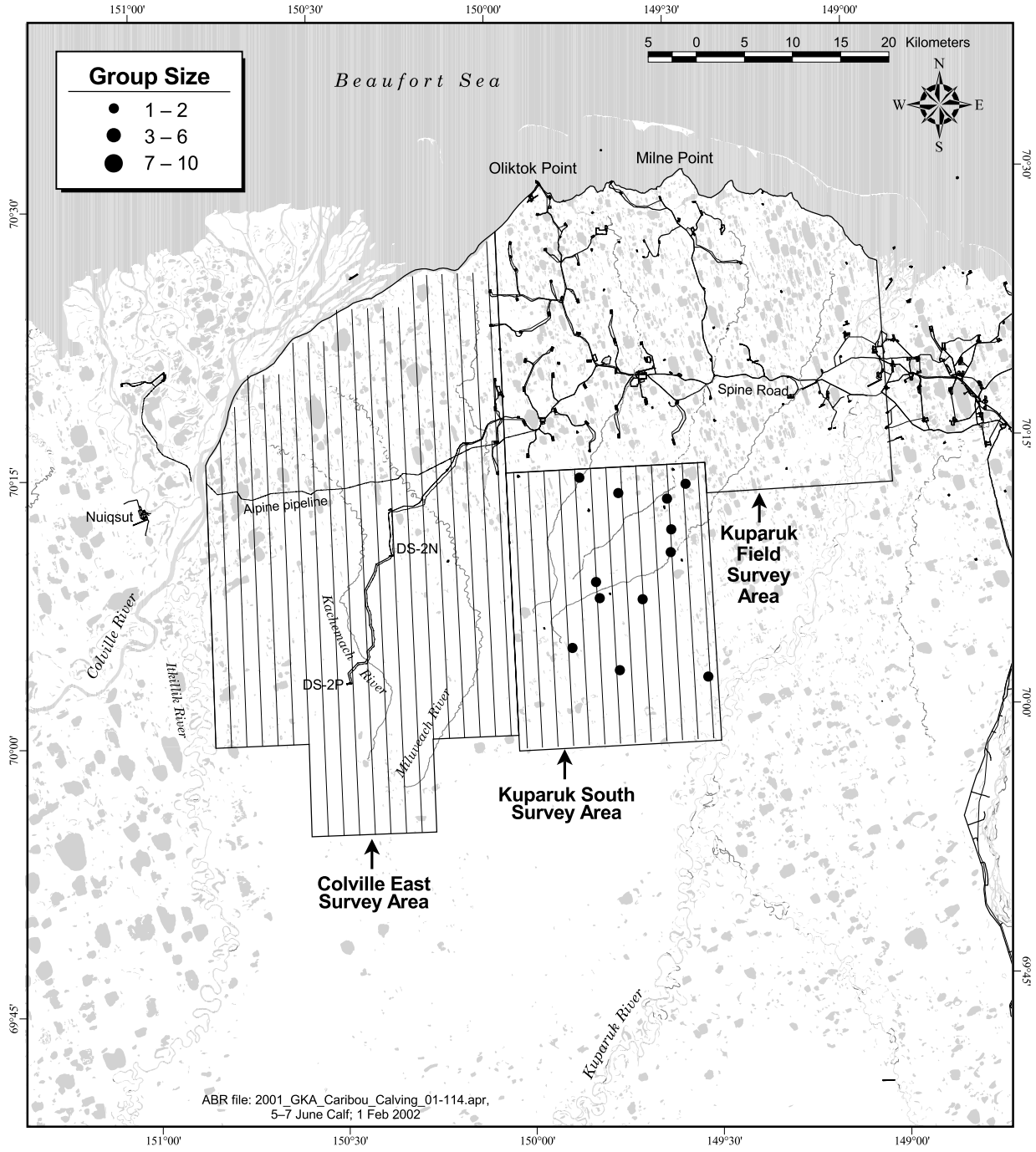

Figure 4. Distribution and number of calf caribou in the Kuparuk South and Colville East calving survey areas, 5–7 June 2001.

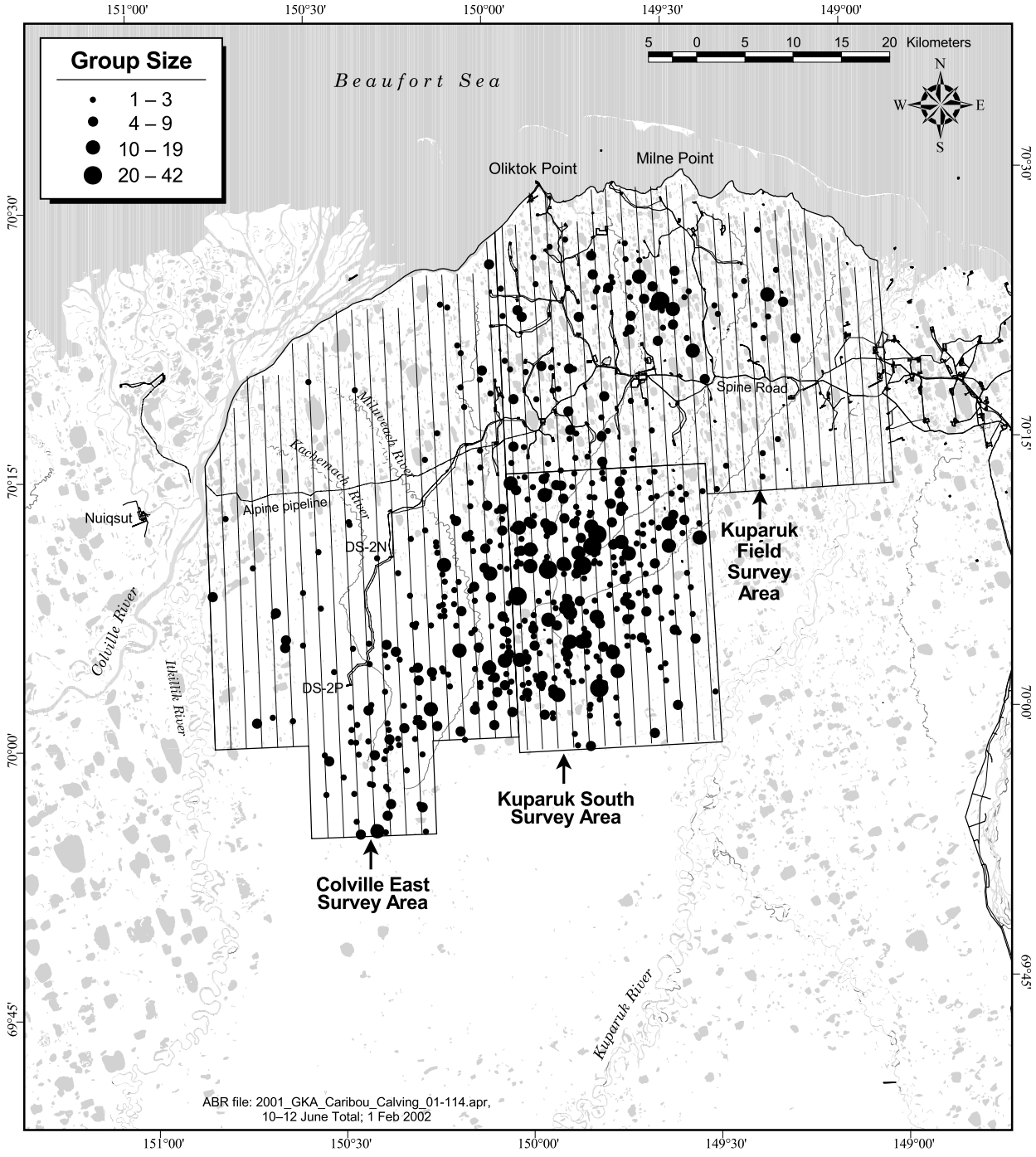

Figure 5. Distribution and number of all caribou (adults and calves) in the Kuparuk and Colville calving survey areas, 10–12 June 2001.

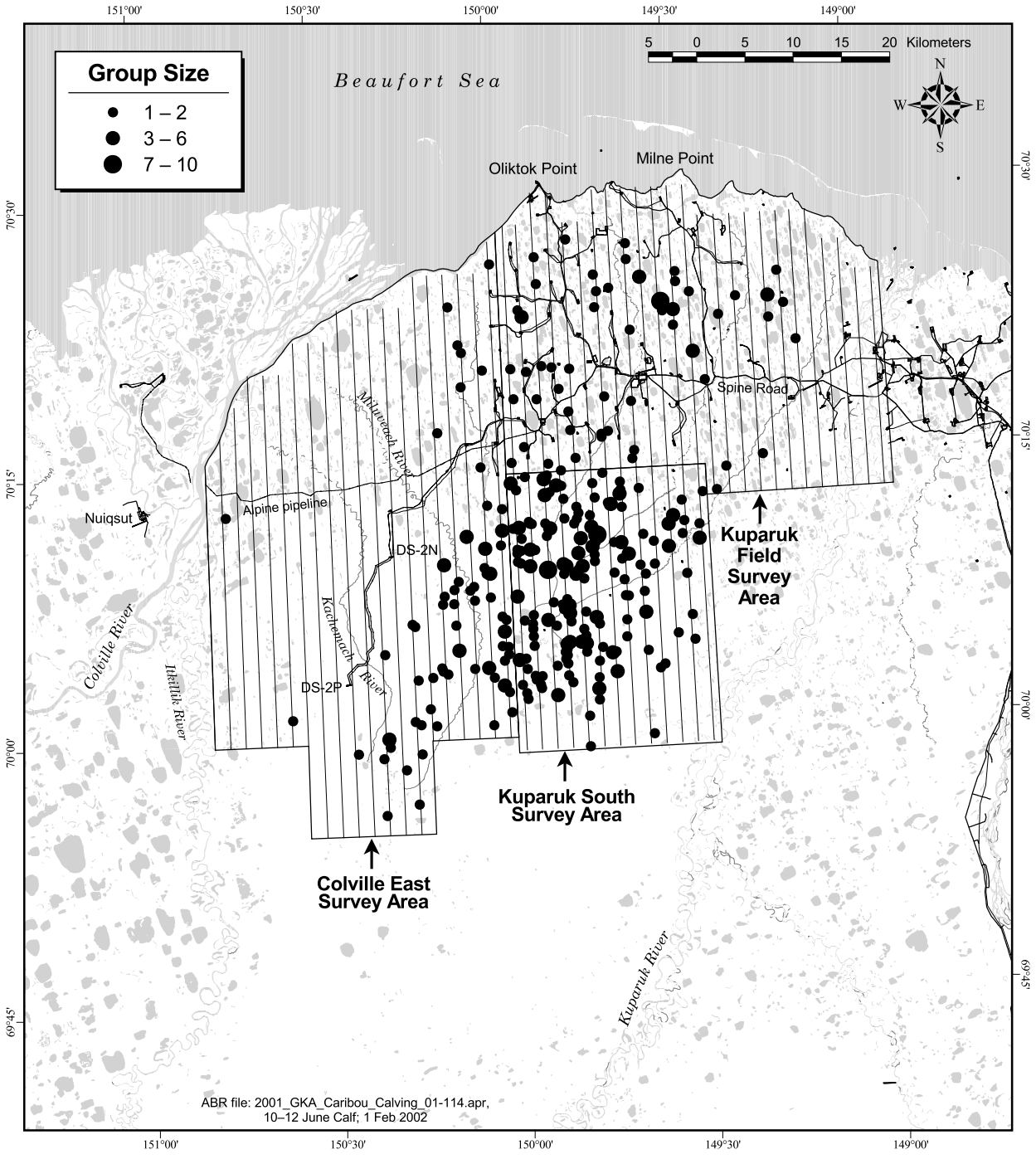

Figure 6. Distribution and number of calf caribou in the Kuparuk and Colville calving survey areas, 10–12 June 2001.

Table 3. Population density (number per km² ± 80% C.I.) of caribou in the Colville East, Kuparuk Field, and Kuparuk South calving survey areas, June 2001.

		Unadjusted Estimate			SCF-Adjusted [a]
Survey Area	Date	Total	Large	Calves	(Large Only)
Colville East	5–6 June	0.06 ± 0.03	0.06 ± 0.03	0	0.11 ± 0.07
	10–11 June	0.78 ± 0.08	0.65 ± 0.07	0.13 ± 0.02	
Kuparuk South	7 June	0.47 ± 0.55	0.43 ± 0.05	0.04 ± 0.01	0.80 ± 0.23
	11 June	3.54 ± 0.34	2.53 ± 0.23	1.01 ± 0.11	
Kuparuk Field	12 June	0.60 ± 0.117	0.45 ± 0.17	0.15 ± 0.03	
Total	5–7 June	0.18 ± 0.28	0.17 ± 0.03	0.01 ± 0.003	0.31 ± 0.10
	10–12 June	1.24 ± 0.09	0.93 ± 0.07	0.30 ± 0.03	

[a] Sightability Correction Factor (1.88) applied to adjust estimates of large caribou (no SCF was available for calves) due to patchy snow cover (Lawhead et al. 1994).

Table 4. Estimated densities (number per km²) of caribou among calving survey areas in mid-June 1993–2001.

	Colville East		Kuparuk Field		Kuparuk South		
Year	Total	Calf	Total	Calf	Total	Calf	Snow Melt
1993	2.40	0.61	0.65	0.16	–	–	Intermediate
1995	1.52	0.23	–	–	5.05	0.97	Intermediate
1996	1.97	0.58	2.16	0.79	7.25	2.62	Early
1997 [a]	3.05	0.92	0.28	0.07	2.40	0.69	Late
1998	1.39	0.23	0.62	0.18	10.22	3.68	Early
1999	1.47	0.37	1.17	0.41	3.26	1.03	Late
2000 [a]	0.65	0.13	0.36	0.09	0.53	0.14	Late
2001	0.78	0.13	0.60	0.15	3.54	1.01	Late
Mean	1.65	0.40	0.83	0.26	4.61	1.45	

[a] Applied Sightability Correction Factor of 1.88 (Lawhead et al. 1994)

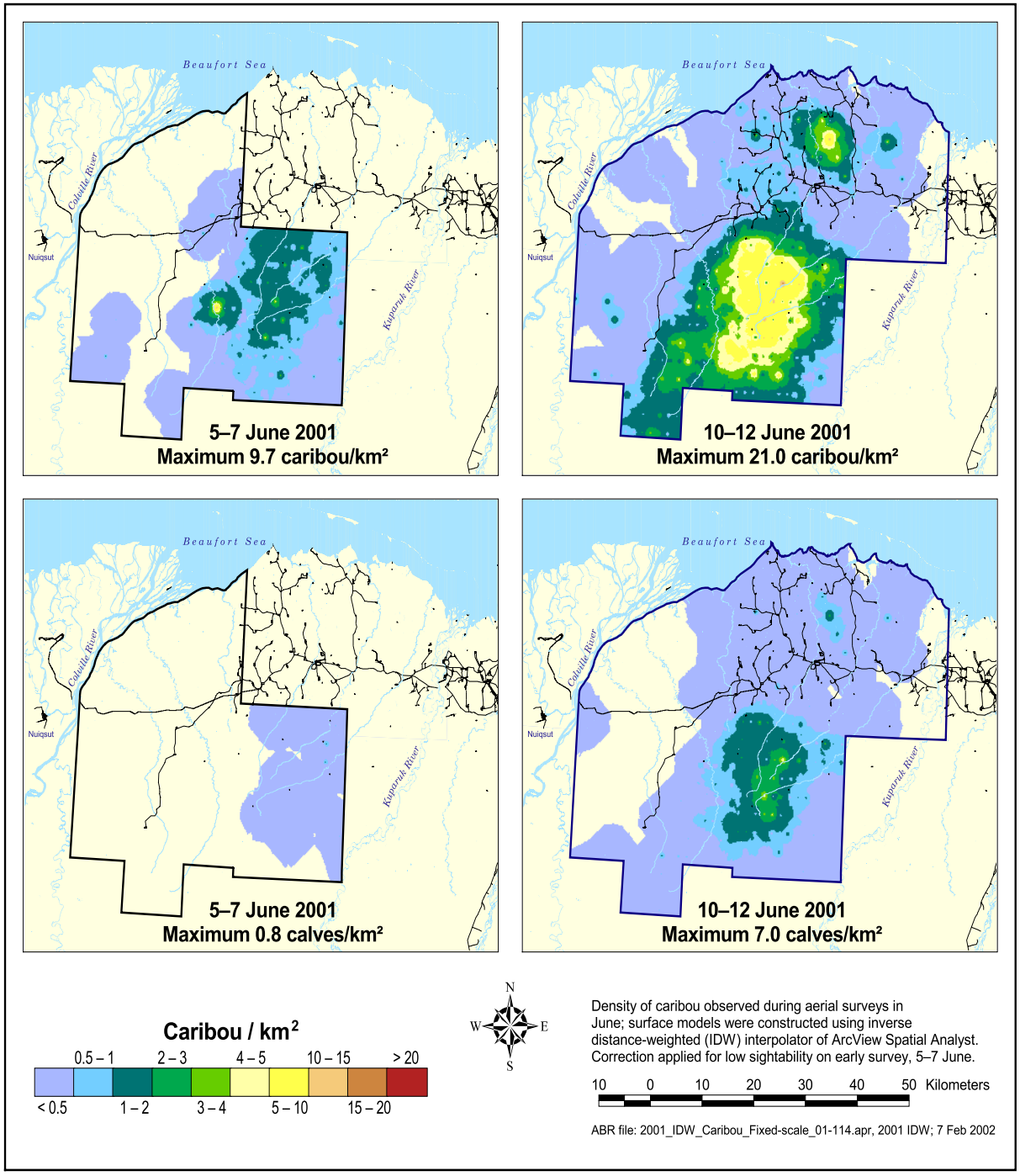

Figure 7. Distribution and density of all caribou (adults and calves; top) and calf caribou (bottom) observed during 5–7 June (left side) and 10–12 June (right side) 2001 calving surveys in the Kuparuk and Colville calving survey areas.

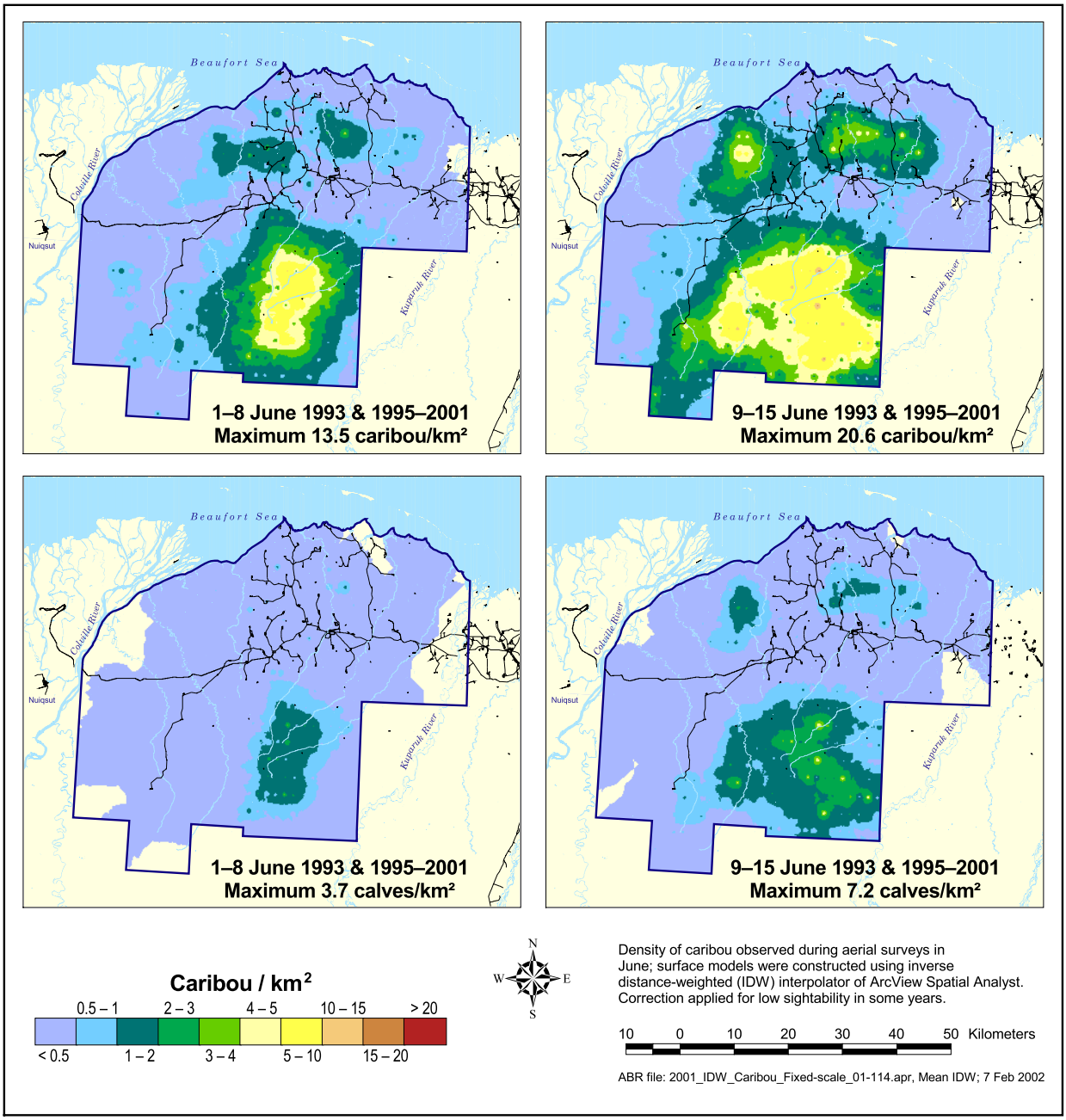

Figure 8. Distribution and mean density of all caribou (adults and calves; top) and calf caribou (bottom) observed during early June (left side) and mid-June (right side) calving surveys in the Kuparuk and Colville survey areas, 1993 and 1995–2001.

CALVING DISTRIBUTION AND DENSITY, 1993 AND 1995–2001

For comparative purposes, annual data from our calving surveys in 1993 (Lawhead et al. 1994, Smith et al. 1994), 1995 (Johnson et al. 1996), 1996 (Johnson et al. 1997, Lawhead et al. 1997), 1997 (Johnson et al. 1998, Lawhead et al. 1998), 1998 (Lawhead 1999), 1999 (Lawhead and Johnson 2000), 2000 (Lawhead and Prichard 2001), and 2001 (this study) are summarized in Appendix B. The annual data were used to generate mean values for each transect segment over the entire 8-year period (note that some portions of the area portrayed only had 7 years of data) (Figure 8). The corresponding observable population estimates and calculations of density in each area depict the variation in numbers and densities within and among areas and years (Appendix B). The historically used Kuparuk–Milne concentration area has continued to be used at levels within the range observed during 1979–1987 (~300–2100 caribou north of the Spine Road; Figure 6 in Cameron 1994). The estimated numbers in the Kuparuk Field survey area during our mid-June surveys in 1993–2001 ranged from 320 to 2458 caribou (Appendix B), with most of those being north of the Spine Road. The summary data clearly show, however, that the area of greatest calving activity (in terms of distribution and density) during each of those years was located south or southwest of the Kuparuk Oilfield.

This pattern of the highest density of calving being located south of the Kuparuk–Milne Point area persisted in 2001, even though the densities of caribou observed were lower than average throughout the three survey areas. The relative abundance and density of caribou varied annually between the Colville East and Kuparuk South areas during 1993–2001, but on average was highest in Kuparuk South (Appendix B). The Kuparuk South (and earlier, Kuparuk Inland) survey area—the smallest of the three—consistently contained the highest densities of caribou (2.4–10.2 caribou/km² and 0.7–3.7 calves/km²). The densities were lower and generally similar between the larger Colville East (0.7–3.1 caribou/km² and 0.1–0.9 calves/km²) and Kuparuk Field (0.3–2.2 caribou/km² and 0.1–0.8 calves/km²) survey areas (Appendix B), and the southeastern portion of Colville East received high levels of use in most years. The densities of caribou in the Kuparuk South and Colville East study areas in 2000 were by far the lowest of the period 1993–2001, although the densities in the Kuparuk Field area were slightly lower in 1997, another year of delayed snowmelt.

SEX AND AGE COMPOSITION AT CALVING

On the sex and age composition survey (Figure 9), we counted 2946 caribou on 14 June in the Kuparuk Field, southern Colville East, and Kuparuk South areas, and 103 caribou on 15 June in the northern Colville East and western Kuparuk Field areas. The total sample of 3049 caribou comprised 1581 cows, 1247 calves, 219 yearlings, and 2 bulls (Table 5). Based on this composition count, our estimate of the standard ratio used to assess calf production—the number of calves per 100 cows—was 78.9 calves:100 cows for the western segment of the CAH in 2001. The calf:cow ratio in the Kuparuk Field survey area (82.1 calves:100 cows) did not differ significantly from that south of the field (79.3 calves:100 cows; P = 0.697, Fisher's Exact Test). Yearlings constituted 7.2% of the total composition sample, for an overall ratio of 17.6 yearlings:100 cows (Table 5). The yearling ratio in the Kuparuk Field survey area (8.7:100) was significantly lower than the areas farther south (13.7 yearlings:100 cows; P = 0.049, Fisher's Exact Test). At 79 calves: 100 cows, calf production by the western segment of the Central Arctic Herd in 2001 exceeded the long-term average (72:100 for the period 1978–2001, using the data portrayed in Figure 10) for the sixth year in a row. The high calf production ratios (77–87 calves:100 cows) obtained from our composition surveys in 1996–2001 are comparable with those observed in the early 1980s, a period of rapid herd growth. ADFG estimated a parturition rate of 83% in a sample of 48 radio-collared females in the CAH on 3–5 June 2001 (E. Lenart, in prep.). Tracking of radio-collared cows ≥3 years and older in the western segment of the CAH (n = 11–17 per year) by ADFG confirmed generally high parturition rates in 1996–2001 (61–94%, increasing after 1996) (Lenart 1999; E. Lenart, pers. comm.).

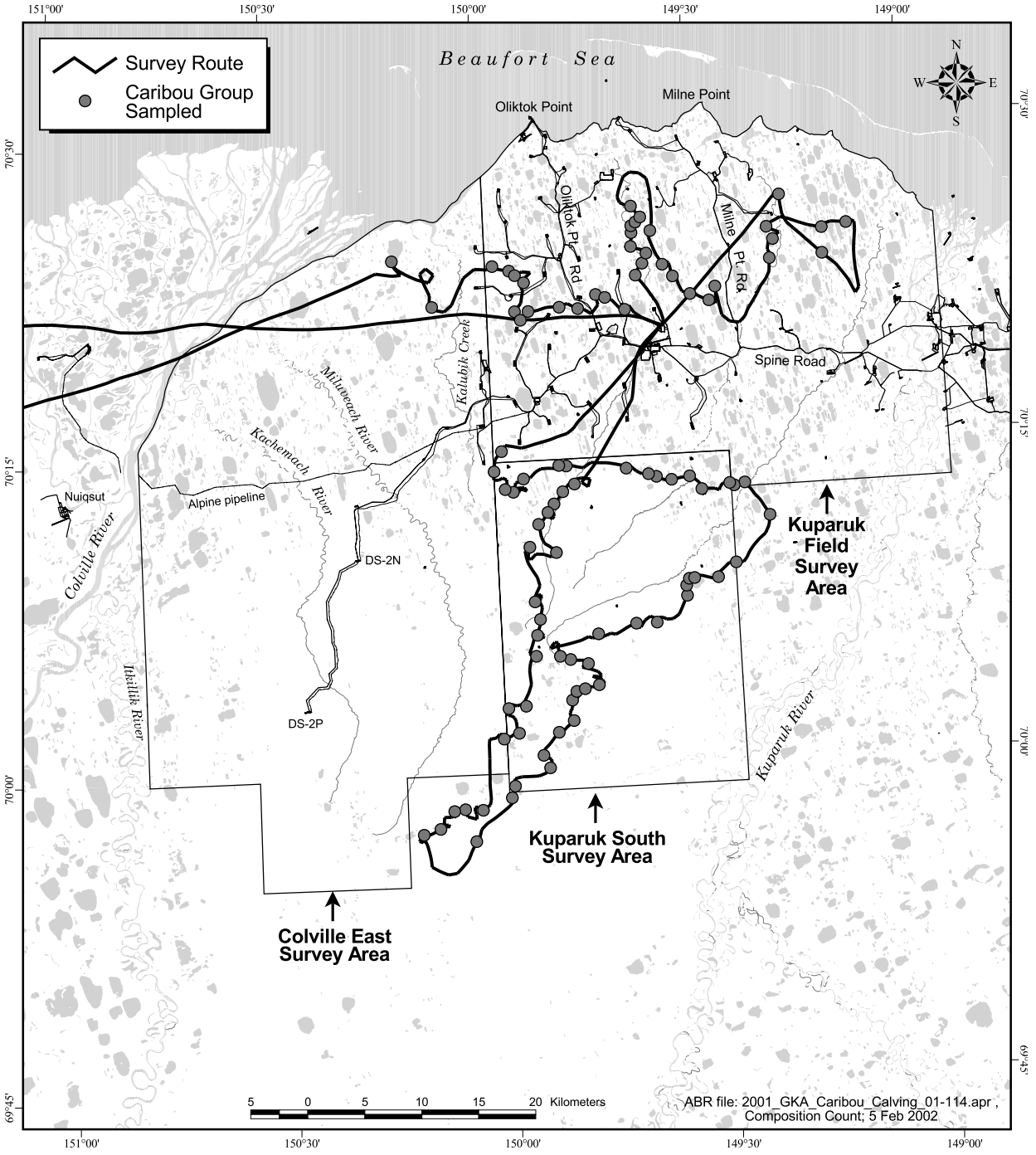

Figure 9. Route of aerial survey to quantify sex and age composition of caribou groups and locations of groups sampled in the Kuparuk and Colville calving survey areas, 14–15 June 2001.

Table 5. Sex and age composition of caribou groups observed in the Kuparuk South–Colville East (combined sample) and Kuparuk Field calving survey areas during a helicopter survey on 14–15 June 2001.

		Total	Cows		Calves		Yearlings		Bulls		Calf	Yrlg.
Date	Survey Area	No.	No.	%	No.	%	No.	%	No.	%	Ratio [a]	Ratio [b]
14 June	Kuparuk South – Colville East	2550	1316	51.6	1043	40.9	191	7.5	0	0	79.3	13.7
	Kuparuk Field	396	207	52.3	170	42.9	18	4.5	1	0.3	82.1	8.7
15 June	Kuparuk Field (NW portion)	103	58	56.3	34	33.0	10	9.7	1	1.0	58.6	17.2
Overall		3049	1581	51.9	1247	40.9	219	7.2	2	0.1	78.9	17.6

[a] Calves:100 cows

[b] Yearlings:100 cows

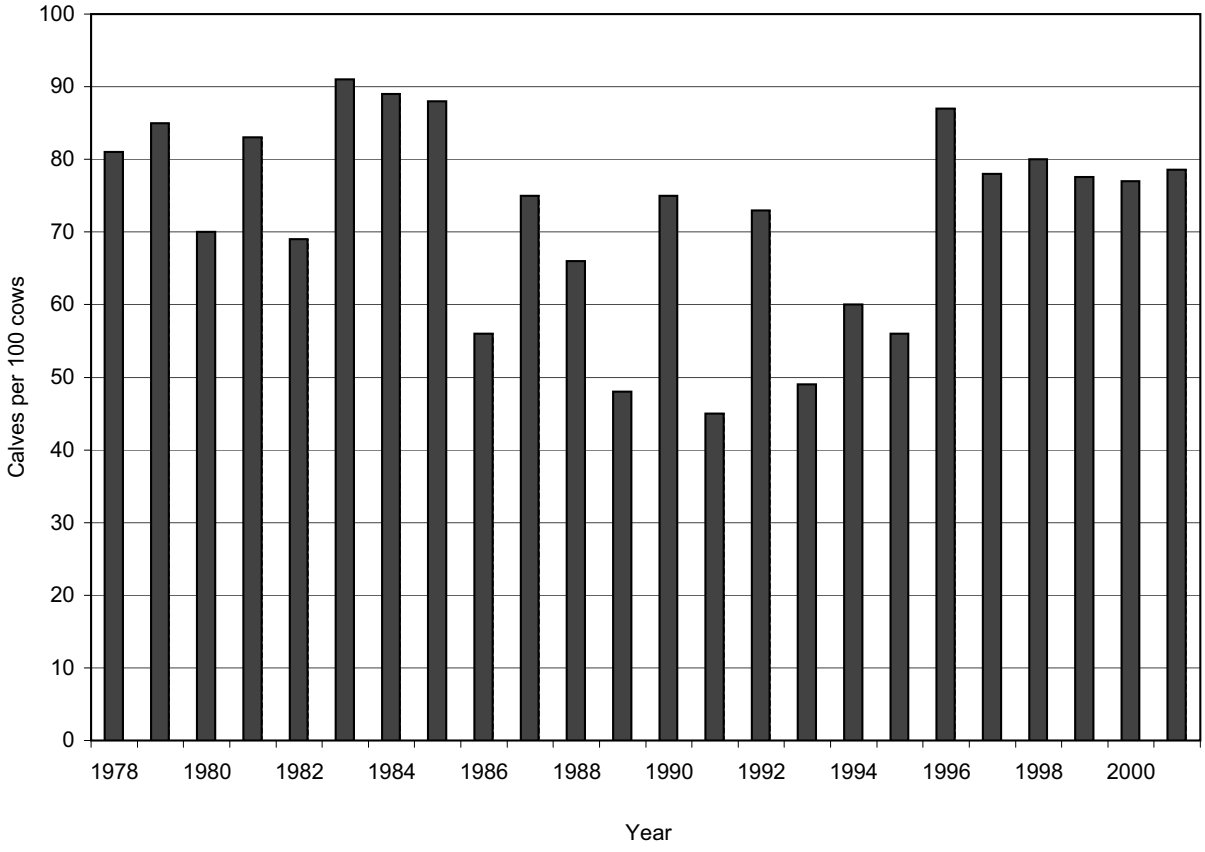

Figure 10. Estimated production of calf caribou (calf:cow ratio) by the Central Arctic Herd, based on aerial composition surveys in mid-June, 1978–2001.

CARIBOU INSECT SEASON

Field observations of caribou during the insect season were recorded from 26 June through 27 July 2001. The distribution and movements of caribou in the study area were surveyed and mapped on 28 days in this period (no observations were conducted on 28–30 June or 24 July), using a combination of broad-scale aerial reconnaissance surveys and road surveys by truck on the oilfield road system (Table 6). The reconnaissance nature of our aerial survey effort needs to be considered when reviewing the distribution data during the insect season because the entire area was surveyed selectively, not systematically. This approach allowed us to use limited helicopter time most efficiently to track large-scale movements sequentially on a daily basis, enabling observation of the major patterns of distribution and movements of caribou in the western segment of the CAH during the insect season. In addition, coverage of the Colville River delta was limited because of the concerns of local residents about helicopter traffic in that subsistence use area; thus, movements on the delta were recorded only sporadically.

Aerial surveys were conducted on 24 days and road surveys on 15 days (Table 6). Overall, data were recorded on 591 groups totaling 86,390 caribou (including repeated observations of the same animals among successive days) (Table 7). Aerial surveys were more efficient for locating large numbers of animals over broad areas, totaling 76% of the groups and 80% of the total number of caribou observed.

The second half of June and first half of July 2001 were cooler than average and the second half of July was warmer than average (Figure 11, Appendix C). The overall sum of Thawing Degree-Days (TDD; average daily temperature >0° C) at the Kuparuk airstrip between mid-June and the end of July was very close to the long-term average for 1983–2001 (Figure 11, Appendix C). The occurrence of weather conducive to insect harassment (as indicated by Mörschel's [1999] index of fly harassment) was low in the first half of July and increased substantially in the second half of the month (Figure 12, Appendix D).

Before mosquitoes emerged, small bands of caribou were distributed widely inland (Figure 13). Mosquito harassment occurred on most days in the study period, peaking at only mild levels (typically

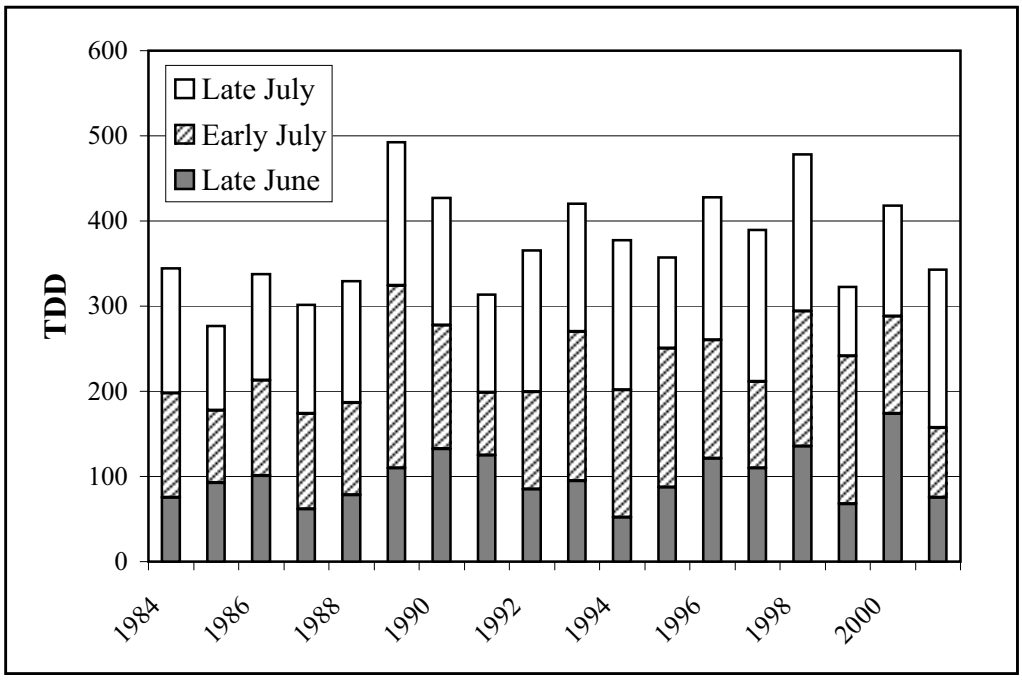

Figure 11. Index of annual insect-season severity (expressed as cumulative thawing degree-days in º C above freezing) from mid-June through July, 1983–2001.

Table 6. Daily summary of weather conditions, insect activity, and caribou movements in the Kuparuk–Colville region during 26 June–27 July 2001.

	Survey Type[a]		Number of Caribou		Temp. (° C) [at Kuparuk]		Wind Direction (degrees) & Speed (knots) [at Alpine]		Mosquitoes[b]		Oestrid Flies[c]		Direction of Movement		
Date	A.M.	P.M.	Road	Aerial	Min	Max	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	Location / Notes
26 June		R	553		1	7	050@7	Var.@4		1		0		0	Scattered in small groups throughout CPF-2 area
27 June		A		427	4	9	320@10	340@8	0	0	0	0		0	Scattered inland in small groups
1 July	A	A		535	2	14	060@10	070@14	0	0	0	0	0	0	Scattered inland in small groups
2 July	A	R	2562	301	4	26	200@2	230@9	2	2	0	0	NE	NE	First day of widespread mosquito harassment; caribou headed north & east to coast. Large numbers crossed Spine Rd. near Kuparuk River bridge.
3 July	R	A	6	5800	7	27	VRB@2	270@12	2	2	0	0	N,E	0	Most caribou on the coast; large numbers near Beechey Point.
4 July	A	R	1624	1940	1	16	060@5	040@12	0	0	0	0	S	S,0	Caribou scattering inland, most north of Spine Rd. and east of CPF-2
5 July	R	A	1198	2819	–2	7	060@15	040@18	0	1	0	0	W, SW	0	Caribou widely scattered inland as far southwest as DS-2L.
6 July		A		5257	–1	4	300@7	360@11	0	1	0	0		0	Spread out inland, large numbers along Kachemach and Miluveach rivers.
7 July		A		2256	0	5	000@0	050@5	1	0	0	0		0,S	Many groups along Kuparuk River.
8 July		A		2747	–2	4	030@13	060@13	0	0	0	0		0	Many groups south of DS-2P along Kachemach and Miluveach rivers.
9 July		A		74	–1	3	060@9	050@16	0	0	0	0		0	Caribou far inland, few remain in the Kuparuk Field area.
10 July	R	A	132	3540	0	4	060@12	060@12	0	0	0	0	0	0	Caribou far inland, few remain in the Kuparuk Field area.
11 July		B	8	735	0	4	060@8	060@13	0	0	0	0		0	Still in scattered groups inland.
12 July		R	111		0	6	080@16	070@16	0	0	0	0		Var	Still in scattered groups inland.
13 July		A		2030	0	8	060@16	060@18	0	0	0	0	0	0	Still in scattered groups inland.
14 July		A		1495	0	9	070@18	070@16	0	1	0	0		N,0	Still in scattered groups inland; some northward drift in afternoon.

Table 6. (Continued).

	Survey Type[a]		Number of Caribou		Temp. (° C) [at Kuparuk]		Wind Direction (degrees) & Speed (knots) [at Alpine]		Mosquitoes[b]		Oestrid Flies[c]		Direction of Movement		
Date	A.M.	P.M.	Road	Aerial	Min	Max	A.M.	P.M.	A.M.	P.M.	A..	P.M.	A.M.	P.M.	Location / Notes
15 July		A		2282	1	14	070@16	090@20	0	2		9		NE,0	Scattered groups inland in morning, but moving rapidly toward coast in afternoon.
16 July		A		8220	5	28	090@10	070@10	3	3	1	1		E,NE	Large groups moving east along coast, many crossing Kuparuk River by early afternoon.
17 July	R	B	10,694	4523	9	26	150@5	300@10	3	2	9	0	N,W	W	Wind shifted to west, causing major westward movement; 4000–5000 caribou observed crossing Oliktok Point Rd. from east to west near coast.
18 July	R	A	0	9842	8	20	230@10	090@10	2	2	0	0		W	Large numbers between Kalubik Creek and Colville River.
19 July	R	B	6	3537	4	15	100@10	200@10	1	3	0	9	0, NE	N	Many caribou observed on eastern Colville Delta., few in Kuparuk Field.
20 July	R	R	139		14	18	260@6	210@11	3	3	0	1	NW	N,W	Helicopter pilots reported large numbers between Nuiqsut and Alpine.
21 July	R		4		12	20	240@12	240@10	1	1	1	1		Unk	Many caribou reported near Alpine and along the Nigliq channel.
22 July	R	B	4	0	9	21	030@8	360@6	1	2	9	1	Unk	Unk	Few caribou seen in Kuparuk Field or eastern NPRA; reports of large numbers of caribou on the Colville Delta.
23 July		A		7389	7	23	190@7	300@14	2	3	1	1		W	Fairly large groups in Colville Delta also 5000–7000 caribou seen in NPRA, west of Ublutuoch River and along Judy Creek, moving west.
25 July	R	A	180	710	2	10	240@7	010@7	0	2	0	9	0,S	0,E	Some large groups on Colville Delta; ADFG reported ~6000 near Fish Creek. Few between Colville and Kuparuk rivers.
26 July		A		1183	3	12	000@0	090@4	0	2	0	1		0,E	Large groups on outer Colville Delta.
27 July	A			1527	7	16	200@8	230@10	2		1		var		A few groups seen on or east of Colville Delta; only one caribou seen in eastern NPRA area.

[a] Survey type: A = aerial survey, R = road survey, B = both.

[b] Mosquitoes: 0 = none, 1 = mild, 2 = moderate, 3 = severe.

[c] Oestrid flies: 0 = not active, 1 = active, 9 = unknown.

Table 7. Numbers of caribou groups and individuals mapped (see Figure 14) and levels of insect harassment recorded on aerial and road surveys in the Kuparuk Oilfield region during 26 June–27 July 2001.

	Road Survey			Aerial Survey			Total			Insect Harassment	
Date	No. of Groups	No. of Caribou	Av. Group Size	No. of Groups	No. of Caribou	Av. Group Size	No. of Groups	No. of Caribou	Av. Group Size	Mosquitoes	Flies
June 26	41	553	14				41	553	14	mild	none
27				37	427	12	37	427	12	none	none
July 1				34	535	16	34	535	16	none	none
2	9	2562	285	4	301	75	13	2863	220	moderate	none
3	2	6	3	2	5800	2900	4	5806	1452	moderate	none
4	20	1624	81	6	1940	323	26	3564	137	none	none
5	18	1198	67	22	2819	128	40	4017	100	mild	none
6				37	5257	142	37	5257	142	mild	none
7				38	2256	59	38	2256	59	mild	none
8				35	2747	79	35	2747	79	none	none
9				8	74	9	8	74	9	none	none
10	8	132	17	49	3540	72	57	3672	64	none	none
11	3	8	3	17	735	43	20	743	37	none	none
12	8	111	14				8	111	14	none	none
13				44	2030	46	44	2030	46	none	none
14				40	1495	37	40	1495	37	mild	none
15				13	2282	176	13	2282	176	moderate	unknown
16				13	8220	632	13	8220	632	severe	active
17	10	10,694	1069	3	4523	1508	13	15,217	1171	severe	unknown
18	0	0	0	15	9842	656	15	9842	656	moderate	none?
19	3	6	2	7	3537	505	10	3543	354	severe	unknown
20	4	139	35				4	139	35	severe	active
21	3	4	1				3	4	1	mild	active
22	3	4	1	0	0	0	3	4	1	moderate	active
23				15	7389	493	15	7389	493	severe	active
25	8	180	23	1	710	710	9	890	99	moderate	unknown
26				5	1183	237	5	1183	237	moderate	active
27				6	1527	255	6	1527	255	moderate	active
Total	140	17,221	123	451	69,169	153	591	86,390	146		

resulting in upwind movements) on 6 days (21% of the 28 days recorded) and at moderate or severe levels (typically resulting in movements to coastal relief habitat) on another 13 days (46%) (Table 6). Major mosquito-induced movements to the coast occurred on 2–3 July and 15–16 July. In the first instance, the duration of harassment was relatively brief (Figure 12) and caribou rapidly returned inland when mosquito activity subsided, dispersing relatively far inland during the cold weather of most the first half of July. The greatest extent of inland movement occurred during the extended period of cool weather in the first half of July (Figure 13). The inland extent of movements by caribou in July 2001 (up to 60 km) was greater than expected from past telemetry studies (30–35 km; Lawhead and Curatolo 1984, Curatolo 1986, Cameron et al. 1989), but was similar to July 2000 (Lawhead and Prichard 2001). Oestrid fly harassment was confirmed by behavioral observations of caribou on 7 days and suspected on another 4 days in July, although this is probably an underestimate, judging from the occurrence of weather conditions conducive to fly activity (Figure 12).

The most intensive insect harassment in the 2001 season occurred in the second half of July. The largest mass movement of caribou observed in summer 2001 occurred on 17–18 July, when at least 10,700 caribou (and probably more, comprising the majority of the western segment of the CAH) moved west from the Kuparuk River delta through the Milne Point and northern Kuparuk oilfields and across Kalubik Creek.

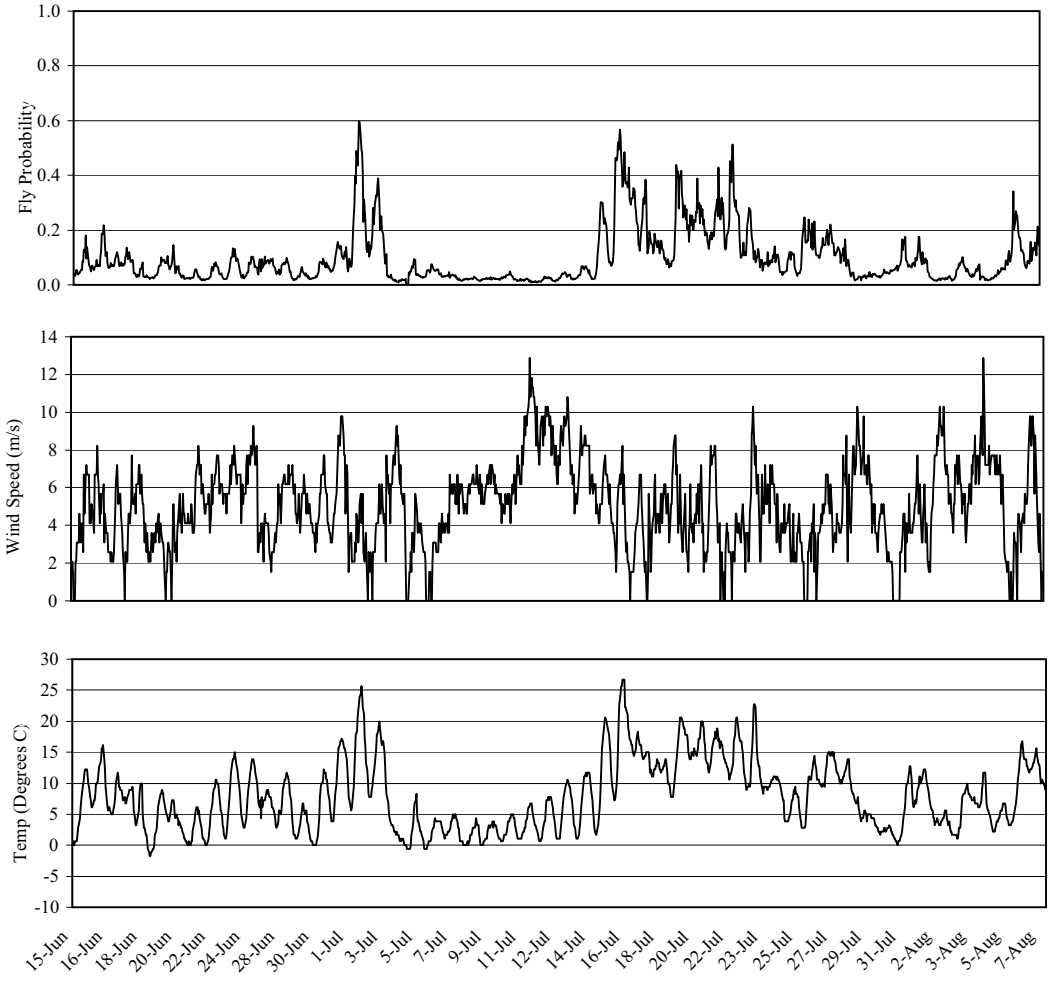

Figure 12. Probability of oestrid fly activity (index developed by Mörschel 1999) in summer 2001, based on wind speed and temperature recorded at Nuiqsut.

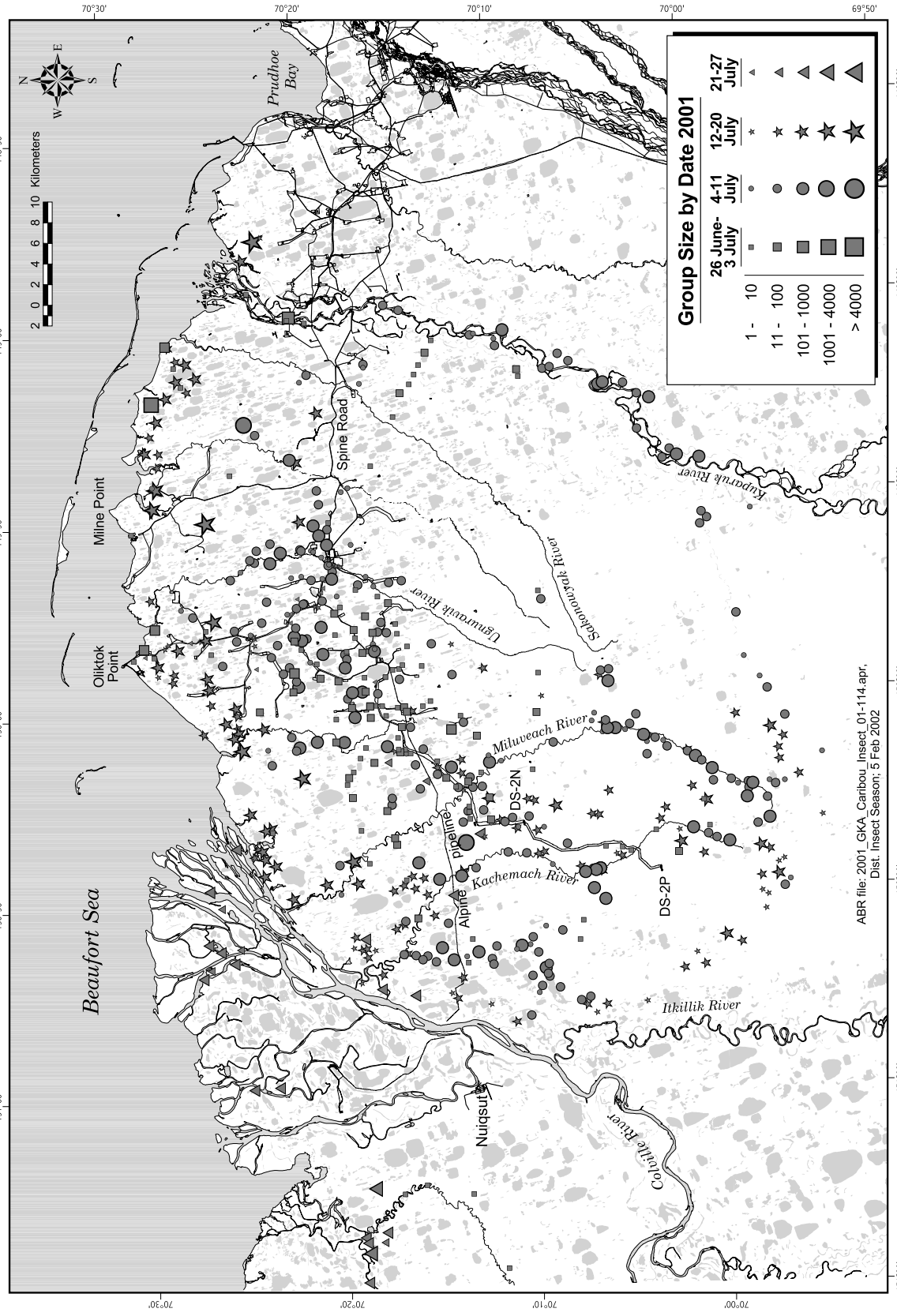

Figure 13. Distribution and sizes of caribou groups observed on systematic and reconnaissance aerial surveys of the Kuparuk–Colville region during the insect season, 26 June–27 July 2001. Survey coverage was not uniform over the entire area portrayed.

During the following week, those animals subsequently continued west onto the Colville River delta north of Nuiqsut, , constituting the largest recorded movement onto the delta by the CAH during the last two decades. Many of those caribou continued west into the National Petroleum Reserve–Alaska (NPRA).

After the large-scale movement of caribou to the west of the Kuparuk field and into NPRA in mid-July 2001, caribou numbers were low in the study area. By mid-July in most years, oestrid flies strongly affect caribou movements and behavior (Dau 1986, Murphy and Curatolo 1987), and a variety of unvegetated and elevated sites (river bars, mud flats, dunes, pingos, gravel pads and roads) become important as fly-relief habitat. Fly-harassed caribou often seek relief in the shade of elevated pipelines, buildings, and even parked vehicles. Although fly harassment typically continues into August, mosquito harassment declines markedly by the end of July, signaling the end of use of coastal mosquito-relief habitats (Lawhead and Curatolo 1984, Dau 1986). Fly harassment tends to fragment aggregations, resulting in small groups and single caribou being dispersed widely across the coastal plain (Roby 1978, Lawhead 1988).

The overall pattern of movements exhibited by the western segment of the Central Arctic Herd in the 2001 insect season was generally consistent with that seen in other recent years, except for the major westward movement across the Colville River in late July. The apparent lack of use of the Colville River delta by caribou in July 2001 is due to the fact that the area was not surveyed often. Since 1998, we have ended our insect-season surveys at the east channel of the Colville River to minimize aircraft activity in that subsistence hunting area; consequently, we cannot compare the distribution pattern for 1998–2001 with that observed during 1992–1993 and 1995–1997 (Appendices E and F) due to differences in survey effort. Therefore, coverage of the unusually large movement of CAH caribou onto the Colville delta in the third week of July 2001 is not well-represented on our maps.

LATE SUMMER–FALL SURVEYS

Caribou densities were low in the Colville East survey area during the six aerial surveys conducted between 4 August and 26 October (mean = 0.09 caribou/km²; range = 0.01–0.17; Table 8). Within the survey area, caribou tended to occur inland in the Itkillik hills in August and closer to the coast in late September and October (Figure 14). Warm temperatures in early September coincided with a tendency for caribou to move north toward the coast (J. Hamilton, pers. comm.), but it is unknown if any insects were active that late in the season. Caribou were widely scattered in small groups. Group size was lowest in August (1.2–2.8 caribou/group), peaked on 30 September prior to the rut (6.3 caribou/group), and then decreased slightly in October (Table 8).

The number of caribou seen east of the Colville River was low in late summer and fall, with most animals occurring west of the Meltwater and Tarn roads in the southwestern Kuparuk field.

Table 8. Number and density of caribou observed in late summer and fall in the Colville East survey area, 4 August–26 October 2001.

Date	Area Surveyed (km²)	No. of Caribou	Density (caribou/km²)	No. of Groups	Average Group Size
Aug. 4–5	849.7	11	0.01	4	2.75
Aug. 15	849.7	7	0.01	6	1.17
Aug. 28, 30	849.7	135	0.16	52	2.60
Sep. 30	746.7*	69	0.09	11	6.27
Oct. 12–13	849.7	77	0.09	15	5.13
Oct. 24, 26	849.7	147	0.17	29	5.07
Total		446	0.09	117	3.81

* Part of area not flown due to fog.

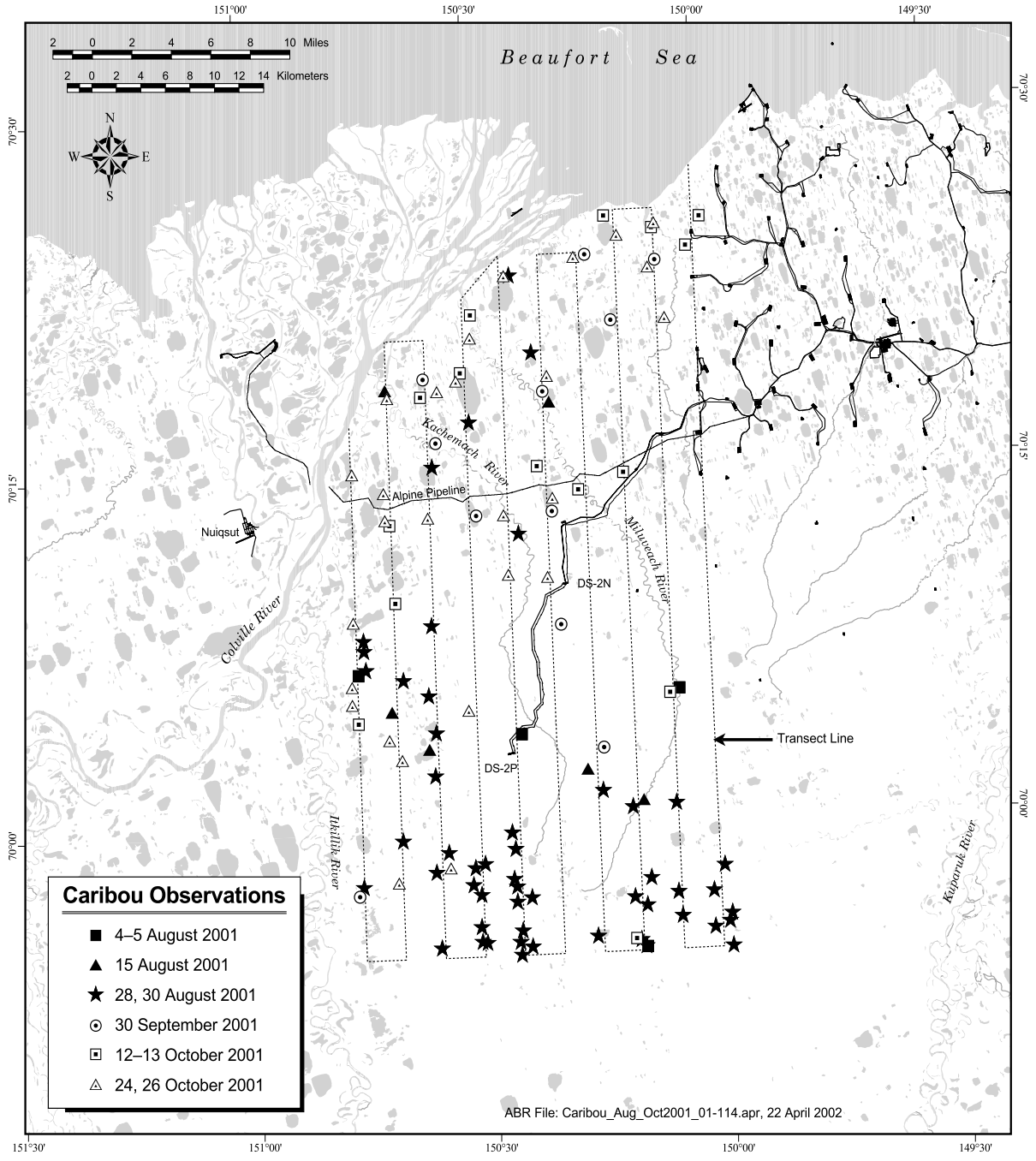

Figure 14. Location of caribou groups observed in late summer and fall in the Colville East survey area, 4 August–26 October 2001.

Caribou were more numerous west of the Colville River in northeastern NPRA during the same period (Burgess et al., in prep.). The herd affinities of the caribou west of the Colville River in the fall were uncertain. The range of the Teshekpuk Herd typically extends east to the Colville River (Prichard et al. 2001), but more CAH animals than normal may have been west of the Colville River in late summer and fall 2001 due to the unusual westward movement across the Colville delta in mid-July.

MUSKOXEN

Muskoxen were seen in widely dispersed locations throughout the Kuparuk–Colville region in summer 2001 (Figure 15); we recorded 37 sightings from mid-May to late October (Table 9). The distribution of groups observed incidentally in 2001 was greater than in recent years because of more extensive reconnaissance surveys early in the season for the Meltwater caribou mitigation monitoring study (Lawhead et al., in prep.) and

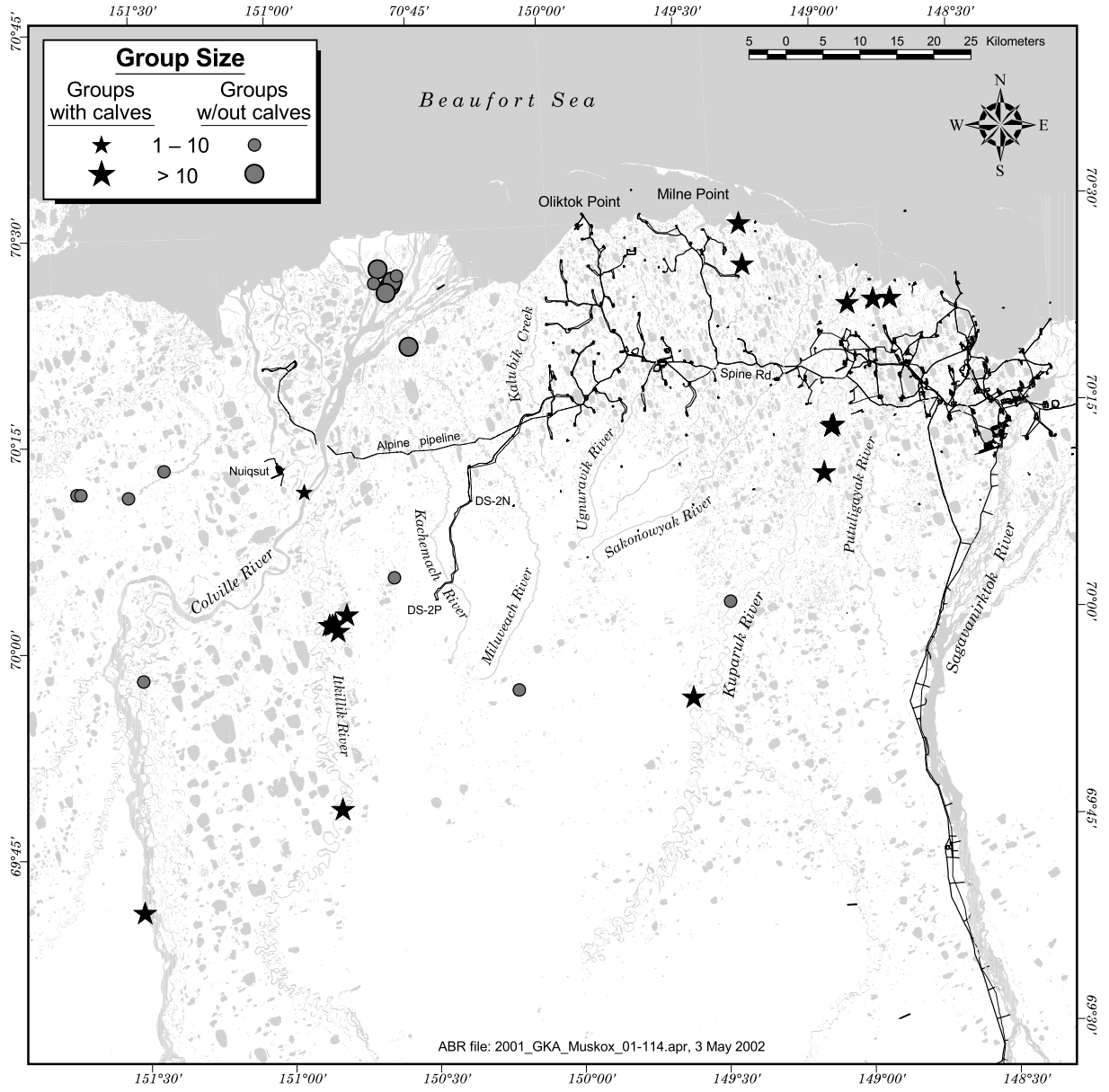

Figure 15. Distribution of muskoxen observed on aerial surveys of the Kuparuk–Colville region, May–October 2001. Survey coverage was not uniform over the entire area portrayed.

Table 9. Group size, number of calves, and general location of muskoxen observed in the Kuparuk–Colville region, May–October 2001 (nr = not recorded).

Sighting No.	Date	Total	Large	Calves	General Location
1	May 18	19	16	3	Milne Point
2	19	19	16	3	Itkillik River
3	21	21	16	5	Itkillik River
4	23	22	18	4	Upper Itkillik River
5	23	12	10	2	Upper Colville River
6	23	9	9	0	Upper Colville River
7	27	5	5	0	West of Nuiqsut
8	29	54	44	10	Ribdon River (not shown in Fig. 15)
9	29	5	5	0	Sagavanirktok R. (not in Fig. 15)
10	29	22	19	3	Upper Kuparuk River
11	June 5	25	nr	nr	Itkillik River
12	10	21	nr	nr	Itkillik River
13	11	21	15	6	Kuparuk River south of bridge
14	11	5	5	0	NPRA
15	12	23	17	6	Kuparuk River south of bridge
16	12	11	11	0	Colville River delta
17	13	21	nr	nr	Itkillik River
18	14	25	17	8	South of Milne Point
19	16	1	1	0	Kavik River (not in Fig. 15)
20	17	6	6	0	NPRA
21	23	6	6	0	NPRA
22	23	10	10	0	Colville River delta
23	24	1	1	0	‘Rubar Fork’ of Kuparuk River
24	July 7	23	16	7	Kuparuk River south of bridge
25	10	1	1	0	‘Rubar Fork’ of Kuparuk River
26	15	25	nr	nr	Kuparuk River delta
27	16	25	nr	nr	Kuparuk River delta
28	23	11	11	0	Colville River delta
29	25	11	11	0	Colville River delta
30	26	11	11	0	Colville River delta
31	27	11	11	0	Colville River delta
32	Aug. 16	25	20	5	Kuparuk River delta
33	17	8	8	0	Colville River delta
34	18	18	15	3	Kuparuk River south of bridge
35	20	5	3	2	Southeast of Nuiqsut
36	Oct. 12	1	1	0	West of Meltwater
37	24	13	13	0	Colville River delta

because of surveys in the eastern portion of NPRA. We were unable to identify individuals marked by ADFG in their ongoing telemetry study; consequently it was difficult to identify specific groups because of the duration of the period and the wide area within which observations were conducted. In some locations, groups were relatively sedentary, however, and we were fairly confident of group identity among surveys. Over the entire season, we recorded at least 151 muskoxen in at least 9 different groups between eastern NPRA and the Sagavanirktok River, of which 5 were mixed-sex groups containing at least 28 calves (Figure 15). These totals for our general study area do not include a large group of 54 animals well to the southeast in the Ribdon River drainage or two bull groups, totaling 6 animals, in the upper Sagavanirktok and Kavik river drainages (Table 9). The extensive distribution and the widespread occurrence of reproductive groups underscores the success of repopulation of formerly occupied areas of range of this native species.

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Appendix A. Snow depth (inches on ground) and thawing degree-days (TDD; sum in º C) at the Kuparuk airstrip, April–June 1983–2001.

	Snow Depth (in.)			Sum of TDD (º C)		
Year	1 April	15 May	31 May	1–15 May	16–31 May	1–15 June
1983	4	2	0	0	3.6	53.8
1984	7	6	0	0	0	55.6
1985	4	3	0	0	10.3	18.6
1986	13	8	4	0	0	5.0
1987	6	3	1	0	0.6	6.7
1988	4	2	2	0	0	16.7
1989	13	–	4*	0	5.6	20.6
1990	3	1	0	0	16.1	39.7
1991	9	3	1	0	7.8	14.4
1992	5	3	0	0.3	20.3	55.0
1993	5	2	0	0	8.6	33.6
1994	8	7	3	0	4.4	49.2
1995	7	2	0	0	1.1	59.4
1996	9	2	0	8.1	41.7	86.1
1997	11	7	3	0	20.8	36.1
1998	10	3	0	3.6	45.8	74.2
1999	11	6	4	0	1.4	30.3
2000	12	9	5	0	0	36.7
2001	9	12	2	0	1.1	53.3
Average	7.9	4.5	1.4	0.6	10.0	39.2

* Value for June 1

Appendix B. Estimated numbers and densities of caribou in the Kuparuk Field, Kuparuk South, Colville East, and Colville Inland survey areas during calving surveys in 1993 and 1995–2001.

Survey Area	Date	Total Area (km²)	Estimated Total Caribou [a]	Total Density (per km²)	Estimated Total Calves [a]	Calf Density (per km²)	Snow Cover
Kuparuk Field	4 June 1993	850	155	0.18	23	0.03	Patchy; SCF used
	15 June 1993	1202	786	0.65	188	0.16	None
	11 June 1996	1137	2458	2.16	897	0.79	None
	3 June 1997	1137	421	0.37	33	0.03	High; SCF not used
	11 June 1997	1137	320	0.28	81	0.07	Patchy; SCF used
	4–5 June 1998	1097	862	0.76	300	0.27	None
	14 June 1998	1107	688	0.62	202	0.18	None
	12–13 June 1999	1102	1284	1.17	456	0.41	Patchy; SCF not used
	14–15 June 2000	1107	402	0.36	102	0.09	Patchy; SCF used
	12 June 2001	1107	666	0.60	168	0.15	Patchy; SCF not used
Kuparuk South [b, c]	2 June 1993	825	328	0.40	16	0.02	Patchy; SCF used
	13 June 1995	548	2769	5.05	531	0.97	None
	4 June 1996	599	3573	5.96	1044	1.74	None
	9–10 June 1996	599	4344	7.25	1572	2.62	None
	2 June 1997	599	286	0.48	42	0.07	High; SCF not used
	12 June 1997	599	1437	2.40	415	0.69	Patchy; SCF used
	4 June 1998	603	3160	5.24	812	1.35	None
	12–13 June 1998	603	6162	10.22	2222	3.68	None
	12 June 1999	603	1964	3.26	622	1.03	Low; SCF not used
	12–13 June 2000	603	320	0.53	83	0.14	Patchy; SCF used
	7 June 2001	603	534	0.89	49	0.08	Patchy; SCF used
	11 June 2001	603	2132	3.54	608	1.01	Patchy; SCF not used
Colville Inland [d]	23 May 1993	1107	8	0.01	0	0.00	High; SCF not used
	28 May 1993	1107	224	0.20	15	0.01	Patchy; SCF used
	7 June 1993	1107	1186	1.07	64	0.06	Low; SCF not used
	10 June 1993	1107	1249	1.13	127	0.11	None
	5 June 1995	1107	321	0.29	30	0.03	Patchy; SCF used
Colville East [e, f]	26 May 1993	650	60	0.09	0	0	High; SCF not used
	27 May 1993	1050	87	0.08	0	0	High; SCF not used
	3 June 1993	1050	542	0.52	0	0	Patchy; SCF used
	8 June 1993	709	914	1.29	148	0.21	Low; SCF not used
	11 June 1993	910	2181	2.40	558	0.61	None
	4–5 June 1995	1057	315	0.30	41	0.04	Patchy; SCF used
	12–13 June 1995	1349	2057	1.52	305	0.23	None
	3–4 June 1996	1362	800	0.59	159	0.12	None
	12–13 June 1996	1358	2670	1.97	786	0.58	None
	1–2 June 1997	1362	555	0.41	60	0.04	Patchy; SCF used
	10–12 June 1997	1321	4035	3.05	1214	0.92	Patchy; SCF used

Appendix B. (Continued).

Survey Area	Date	Total Area (km²)	Estimated Total Caribou [a]	Total Density (per km²)	Estimated Total Calves [a]	Calf Density (per km²)	Snow Cover
	3 June 1998	1370	1840	1.34	284	0.21	None
	11–12 June 1998	1370	1902	1.39	310	0.23	None
	11 June 1999	1478	2166	1.47	544	0.37	Low; SCF not used
	11–12 June 2000	1478	966	0.65	192	0.13	Patchy; SCF used
	5–6 June 2001	1478	169	0.11	0	0	Patchy; SCF used
	10–11 June 2001	1478	1148	0.78	192	0.13	Patchy; SCF not used
Colville Delta	28 May 1993	637	27	0.04	0	0	High; SCF not used
	10 June 1993	637	0	0.00	0	0	Low; SCF not used
	3 June 1995	637	18	0.03	0	0	Low; SCF not used
	2 June 1996	637	58	0.09	0	0	None
	13 June 1996	637	10	0.02	1	<0.01	None
	1 June 1997	636	0	0.00	0	0	High; SCF not used
	12 / 20 June 1997	636	0	0.00	0	0	Patchy; SCF used

[a] Incorporates Sightability Correction Factor (SCF) of 1.88 (Lawhead et al. 1994) where indicated.
[b] Kuparuk Inland survey area of 1993 and 1995.
[c] Shifted south 1.6 km in 1996 to eliminate overlap with Kuparuk Field survey area.
[d] Surveyed only in 1993; northern portion incorporated in Colville East survey area in 1995.
[e] Extended south to 70º N latitude in 1995, thus incorporating much of 1993 Colville Inland survey area.
[f] Extended south in 1999 to incorporate Meltwater South study area.

Appendix C. Sum of thawing degree-days (º C above freezing) at the Kuparuk airstrip during the insect season by year and month, mid-June–July 1983–2001.

	Thawing Degree-Days			
Year	16–30 June	1–15 July	16–31 July	July Total
1983*	73.4	74.7	103.8	178.5
1984	75.3	122.8	146.4	269.2
1985	92.8	84.7	99.4	184.2
1986	100.8	112.2	124.7	236.9
1987	61.4	112.2	127.8	240.0
1988	78.1	108.3	143.1	251.4
1989	109.4	214.7	168.1	382.8
1990	132.2	145.0	150.0	295.0
1991	125.0	73.3	115.0	188.3
1992	85.3	113.9	166.1	280.0
1993	94.4	175.8	149.7	325.6
1994	51.7	149.7	175.8	325.6
1995	87.5	162.8	106.9	269.7
1996	121.1	138.9	168.1	306.9
1997	109.7	101.7	177.8	279.4
1998	135.0	158.9	184.4	343.3
1999	67.8	173.3	81.1	254.4
2000	173.3	115.0	130.0	145.0
2001	75.0	82.2	185.6	267.9
Average	97.1	127.3	142.2	269.5

* Some values missing and estimated by interpolation

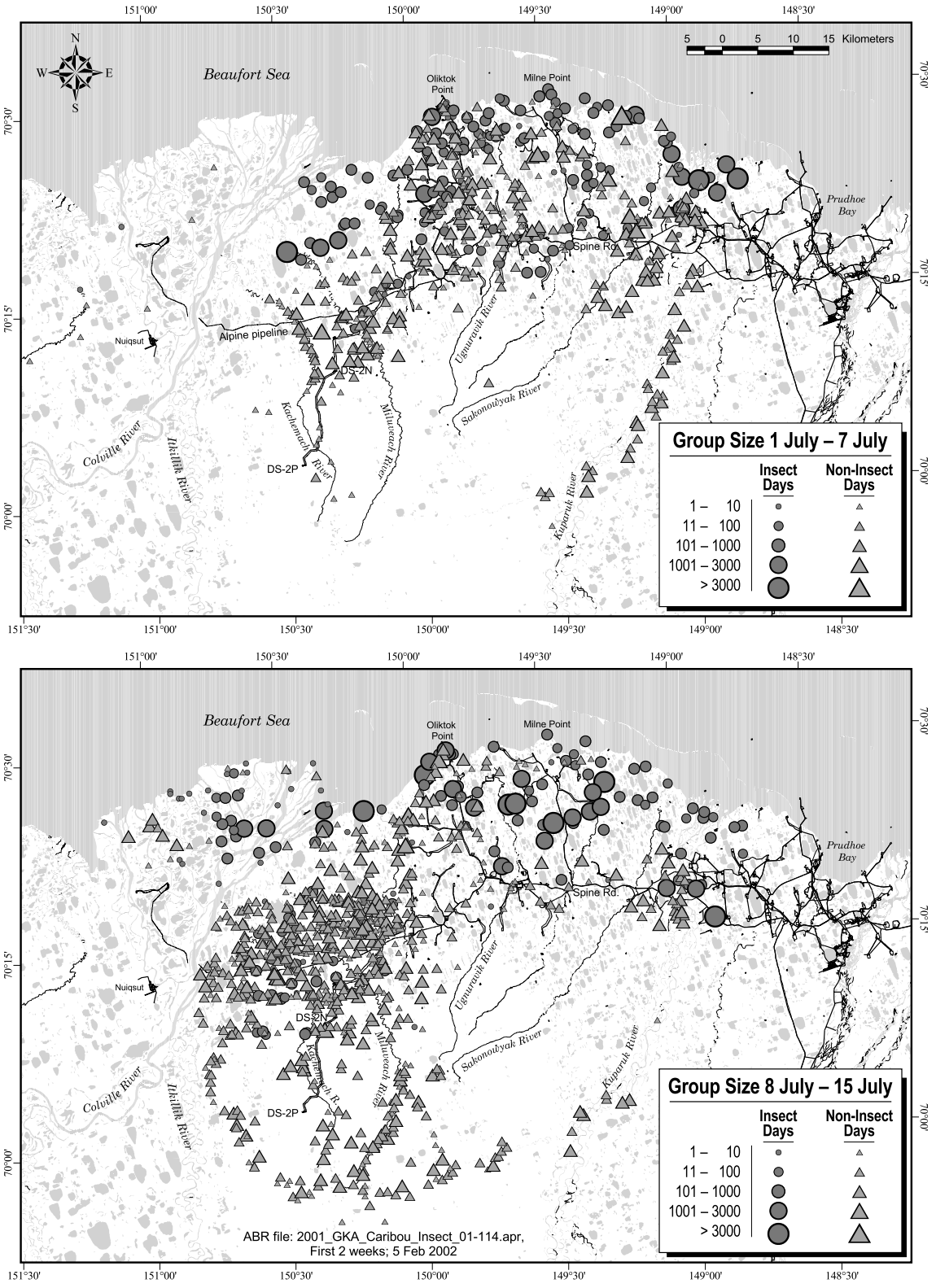
Appendix D. Average index values of oestrid fly and mosquito activity during June–August 1983–2001, based on daily maximum temperatures at the Kuparuk airstrip.

Average Fly Index = if daily Tmax <10 then zero; if Tmax >18 then 1; else 1–((18–Tmax)/8))

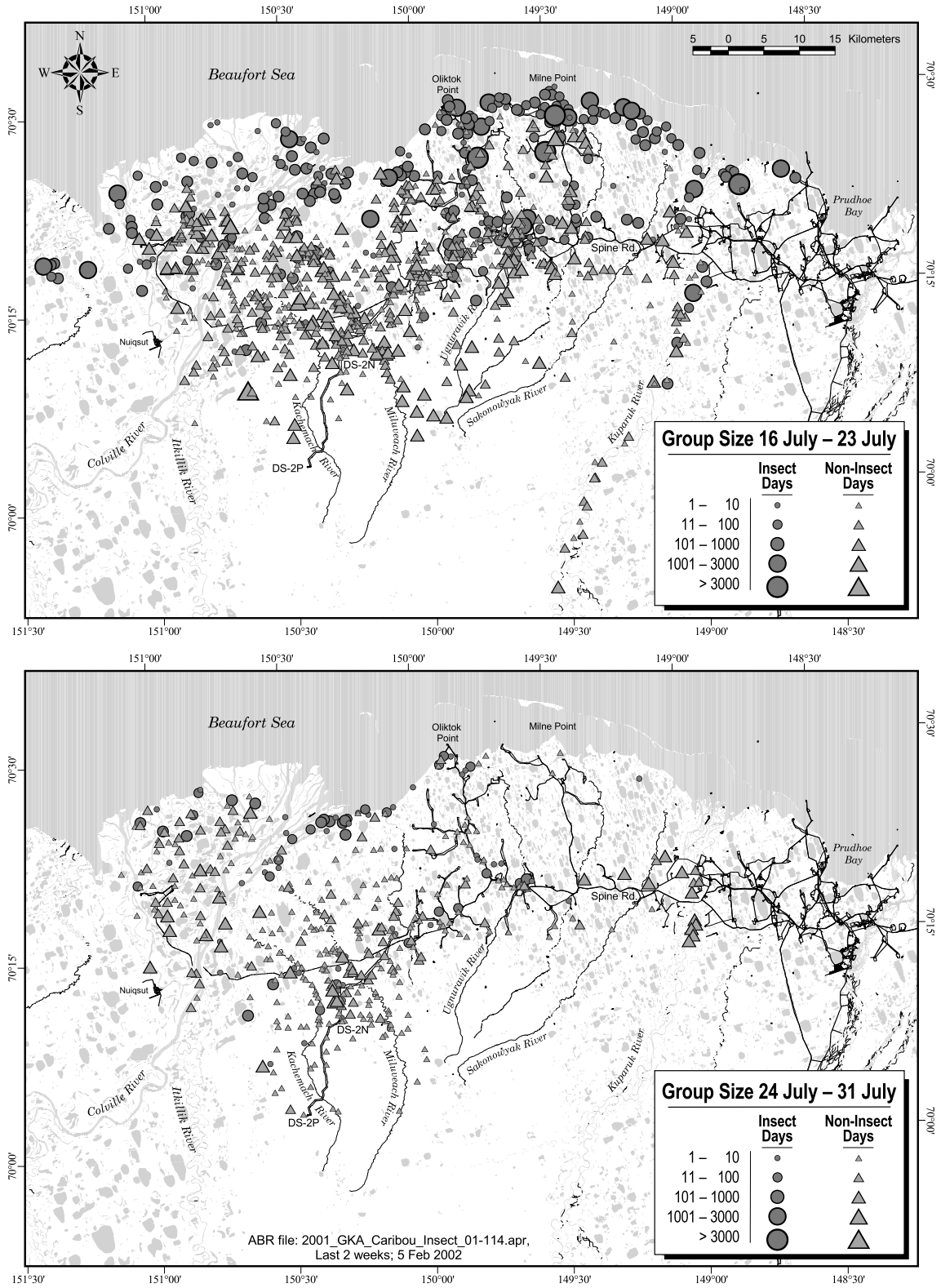
	June			July			August		
Year	Early	Late	Total	Early	Late	Total	Early	Late	Total
1983	0.10	0.15	0.12	0.04	0.33	0.19	0.25	0.02	0.13
1984	0.14	0.14	0.14	0.40	0.59	0.50	0.34	0.09	0.21
1985	0.03	0.26	0.15	0.29	0.27	0.28	0.36	0.21	0.28
1986	0.00	0.33	0.17	0.49	0.35	0.41	0.38	0.08	0.23
1987	0.00	0.05	0.03	0.29	0.33	0.31	0.09	0.23	0.16
1988	0.00	0.10	0.05	0.26	0.48	0.37	0.60	0.14	0.36
1989	0.00	0.40	0.20	0.85	0.63	0.74	0.75	0.49	0.62
1990	0.04	0.52	0.28	0.62	0.50	0.56	0.09	0.06	0.07
1991	0.00	0.49	0.24	0.21	0.32	0.27	0.17	0.14	0.16
1992	0.20	0.19	0.20	0.33	0.63	0.49	0.36	0.26	0.31
1993	0.02	0.35	0.18	0.69	0.47	0.58	0.24	0.16	0.20
1994	0.06	0.10	0.08	0.58	0.70	0.64	0.95	0.24	0.58
1995	0.16	0.18	0.17	0.73	0.24	0.48	0.11	0.21	0.16
1996	0.31	0.46	0.38	0.63	0.57	0.60	0.34	0.03	0.18
1997	0.00	0.28	0.14	0.32	0.72	0.53	0.74	0.16	0.44
1998	0.16	0.42	0.29	0.55	0.69	0.62	0.52	0.23	0.37
1999	0.01	0.10	0.06	0.74	0.17	0.44	0.70	0.08	0.38
2000	0.04	0.75	0.39	0.39	0.28	0.34	0.49	0.20	0.34
2001	0.19	0.10	0.15	0.24	0.63	0.44	0.41	0.01	0.20
1983–2001	0.08	0.28	0.18	0.46	0.47	0.46	0.42	0.16	0.28
1993–2001	0.11	0.30	0.20	0.54	0.50	0.52	0.50	0.15	0.32

Average Mosquito Index = if daily Tmax <6 then zero; if Tmax >18 then 1; else 1–((18–Tmax)/13))

	June			July			August		
Year	Early	Late	Total	Early	Late	Total	Early	Late	Total
1983	0.28	0.29	0.29	0.28	0.39	0.34	0.41	0.15	0.28
1984	0.26	0.37	0.31	0.60	0.68	0.64	0.46	0.20	0.32
1985	0.09	0.48	0.28	0.42	0.45	0.44	0.52	0.31	0.41
1986	0.01	0.46	0.24	0.62	0.54	0.58	0.53	0.21	0.36
1987	0.00	0.22	0.11	0.52	0.47	0.49	0.34	0.42	0.38
1988	0.04	0.32	0.18	0.50	0.64	0.57	0.73	0.19	0.45
1989	0.01	0.58	0.29	0.90	0.74	0.82	0.84	0.59	0.71
1990	0.17	0.69	0.43	0.68	0.62	0.65	0.30	0.21	0.25
1991	0.01	0.58	0.30	0.35	0.48	0.42	0.27	0.27	0.27
1992	0.29	0.36	0.33	0.49	0.77	0.64	0.48	0.42	0.45
1993	0.13	0.43	0.28	0.80	0.66	0.73	0.37	0.26	0.31
1994	0.23	0.18	0.21	0.73	0.77	0.75	0.97	0.37	0.66
1995	0.28	0.36	0.32	0.83	0.35	0.58	0.30	0.36	0.33
1996	0.44	0.55	0.49	0.72	0.69	0.70	0.46	0.14	0.30
1997	0.07	0.50	0.28	0.41	0.82	0.62	0.84	0.33	0.58
1998	0.30	0.55	0.43	0.72	0.81	0.77	0.71	0.46	0.58
1999	0.11	0.28	0.20	0.84	0.29	0.56	0.82	0.20	0.50
2000	0.11	0.82	0.47	0.50	0.47	0.49	0.59	0.27	0.42
2001	0.25	0.33	0.29	0.32	0.75	0.54	0.60	0.05	0.31
1983–2001	0.16	0.44	0.30	0.59	0.60	0.60	0.55	0.28	0.41
1993–2001	0.21	0.44	0.33	0.65	0.62	0.64	0.63	0.27	0.44



Appendix E. Distribution and sizes of caribou groups in relation to insect activity during the first two weeks of July 1992–1993 and 1995–2001, based on systematic and reconnaissance aerial surveys in the Kuparuk–Colville region. Survey coverage was not uniform over the entire area portrayed.



Appendix F. Distribution and sizes of caribou groups in relation to insect activity during the last two weeks of July 1992–1993 and 1995–2001, based on systematic and reconnaissance aerial surveys in the Kuparuk–Colville region. Survey coverage was not uniform over the entire area portrayed