SURVEYS OF CARIBOU AND MUSKOXEN IN THE KUPARUK–COLVILLE REGION, ALASKA, 2002

FINAL REPORT

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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 May through late October 2002. Muskoxen were recorded incidentally during these surveys.
- A fixed-wing airplane was used to survey caribou calving distribution and abundance during 6–8 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 June. We conducted surveys by helicopter and truck during the insect season (25 June–28 July). In addition, we conducted aerial surveys of caribou distribution during early May and late summer and fall (July–October) in the Colville East and Colville Delta areas.
- Snow melt was early in 2002. Snow cover was deep at the beginning of May but melted rapidly by mid-May. Most caribou had arrived in the study area by the time of our first calving surveys in early June. We observed 5482 caribou, including 1068 calves (19.4%), in the three survey areas on 6–8 June, resulting in an expanded total estimate (± 80% confidence interval) of 10,964 ± 761 caribou (adults and calves), and an average density of 3.37 ± 0.23 caribou/km².
- During 10–12 June, we observed a total of 5948 caribou, including 1212 calves (20.4%), in all three calving survey areas, resulting in an expanded total estimate (± 80% C.I.) of 11,896 ± 943 total caribou and an average density of 3.65 ± 0.29 caribou/km². Caribou density was lowest in the Kuparuk Field survey area and highest in the Kuparuk South survey area.
- Half of the caribou (49% of total and 50% of calves) in the Kuparuk Field calving survey area (including both sides of the Milne Point Road) were located north of the Spine Road and east of the Oliktok Point Road, a proportion lower than in most other years since 1993 (65–77%), except 2000 (43%) and 1998 (~50%).
- The area of greatest calving activity in 2002 (in terms of distribution and density) was located south of the Kuparuk Oilfield, continuing the pattern observed since at least 1993. Calf production by the western segment of the CAH was high in 2002 for the seventh consecutive year, estimated at 76 calves:100 cows (n = 4437 caribou) on 14 June.
- Caribou distribution and abundance during the insect-harassment season was monitored on 33 days between 25 June and 28 July 2002. Late June and early July were cooler than average. Insect harassment in 2002 began on 25 June and mosquito harassment levels were mild–moderate through the end of June. Major movements to the coast occurred during 7–10 July and again during 13–19 July. Due to prevailing easterly winds, many caribou crossed to the east side of the Kuparuk River in mid-July. After 19 July, caribou dispersed inland, with most remaining near the Kuparuk River and relatively few occurring in the western portion of the study area.
- Caribou densities were low in the Colville East survey area during early May and August–October 2002. Densities were also low on the Colville Delta during July, August and early September. The average group size was lowest in August (1.2–2.7 caribou/group) and increased in September and October (3.2–7.0 caribou/group).
- We observed fewer muskoxen (both groups and individuals) in the area than in 2001. Two large mixed-age groups were seen consistently in the study area. One group was usually seen on or near the Kuparuk Delta and another group was usually found along the eastern side of the main channel of the Colville River Delta.

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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. Since 1972, the herd has grown at an average of 7% per year. The CAH grew rapidly from the mid-1970s to the early 1990s, 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). In July 1997, the herd was estimated to number 19,730 animals (Lenart 1999). The herd has increased at an average annual rate of 8.5% since 1995, reaching at least 27,128 in July 2000 and 31,857 on 16 July 2002, the most recent photocensus (E. Lenart, Alaska Department of Fish and Game [ADFG], pers. comm.). The 2002 count is the maximum size recorded thus far for this herd.

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 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 the region in several earlier years (1983, 1984, 1987).

Since 1992, ADFG survey efforts have focused primarily on tracking radio-collared female caribou, with 85 VHF collars potentially transmitting in early summer 2002 (E. Lenart, in prep.). In both 2001 and 2002, ~60 newborn calves were outfitted with conventional VHF radio-collars by ADFG with funding from ConocoPhillips Alaska, Inc. (CPA; formerly PHILLIPS Alaska, Inc.) to study calf mortality and growth rates (Arthur 2002). In 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 (G. Carroll, ADFG, pers.comm.). The transect and reconnaissance surveys reported herein complement the data from those telemetry studies, which have not yet been reported in detail.

To help fulfill the mandate for ongoing caribou research in the Kuparuk River Unit Agreement, the study reported here was conducted under contract to CPA to monitor the use of the Kuparuk Oilfield and adjacent areas in 2002 during the calving season, period of insect harassment (insect season), and in late summer through fall. This study had five objectives:

- Document the distribution and abundance of caribou using the region between the Kuparuk and Colville rivers 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, including the Colville River Delta, during the insect season (late June through July);
- Document the distribution and abundance of caribou east of the Colville and Itkillik rivers, including the Colville River Delta, 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 Delta, 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 Delta; the Milne Point Oilfield; and the western Prudhoe Bay Oilfield (west of the Kuparuk River). Aerial surveys of caribou calving were conducted in three survey areas: (1) the Kuparuk Field survey area (1035 km²), including the Kuparuk and Milne Point oilfields from Kalubik Creek to the Kuparuk River; (2) the Kuparuk South survey area (788 km²), located south of the Kuparuk Field; and (3) the Colville East survey area (1432 km²), located between the Colville River and the western Kuparuk field (including the DS-3S project constructed in winter 2001–2002), and extended inland in 1999 to incorporate the Meltwater South exploration area. All three study areas were modified slightly in 2002 to better focus our survey effort on the areas of highest use. The westernmost transect of the Colville East survey area was dropped, the two easternmost transects of the Kuparuk Field survey area were dropped, and additional transects were added to the Kuparuk South survey area to extend eastward to the Kuparuk River. Surveys during the insect season covered the entire region between the western Prudhoe Bay Oilfield and the Colville River delta, and late summer–fall surveys covered the Colville East and Colville Delta areas.

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 near 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 the Kuparuk Field, Kuparuk South, and Colville East survey areas (Figure 1) during 6–8 June and 10–12 June 2002. 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 1995–2001). During systematic surveys, caribou were counted by two observers looking on opposite sides of a Cessna 206 airplane while a third biologist recorded data. 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.

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 distances of 200 m and 400 m from the inner edge of the strip. For each caribou group observed within the strip, the location was recorded using a GPS receiver, the number of adults and calves were recorded, and the group was assigned to a distance category (one of four 100-m zones). For production of map figures, caribou were assigned to the midpoint of the distance zone (i.e., 50, 150, 250, 350 m) in which they were seen. For color maps of calving density (described below), caribou groups were pooled into the same 3.2-km-long transect segments used in previous years (Lawhead and Prichard 2001) for comparative purposes.

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 snow cover was

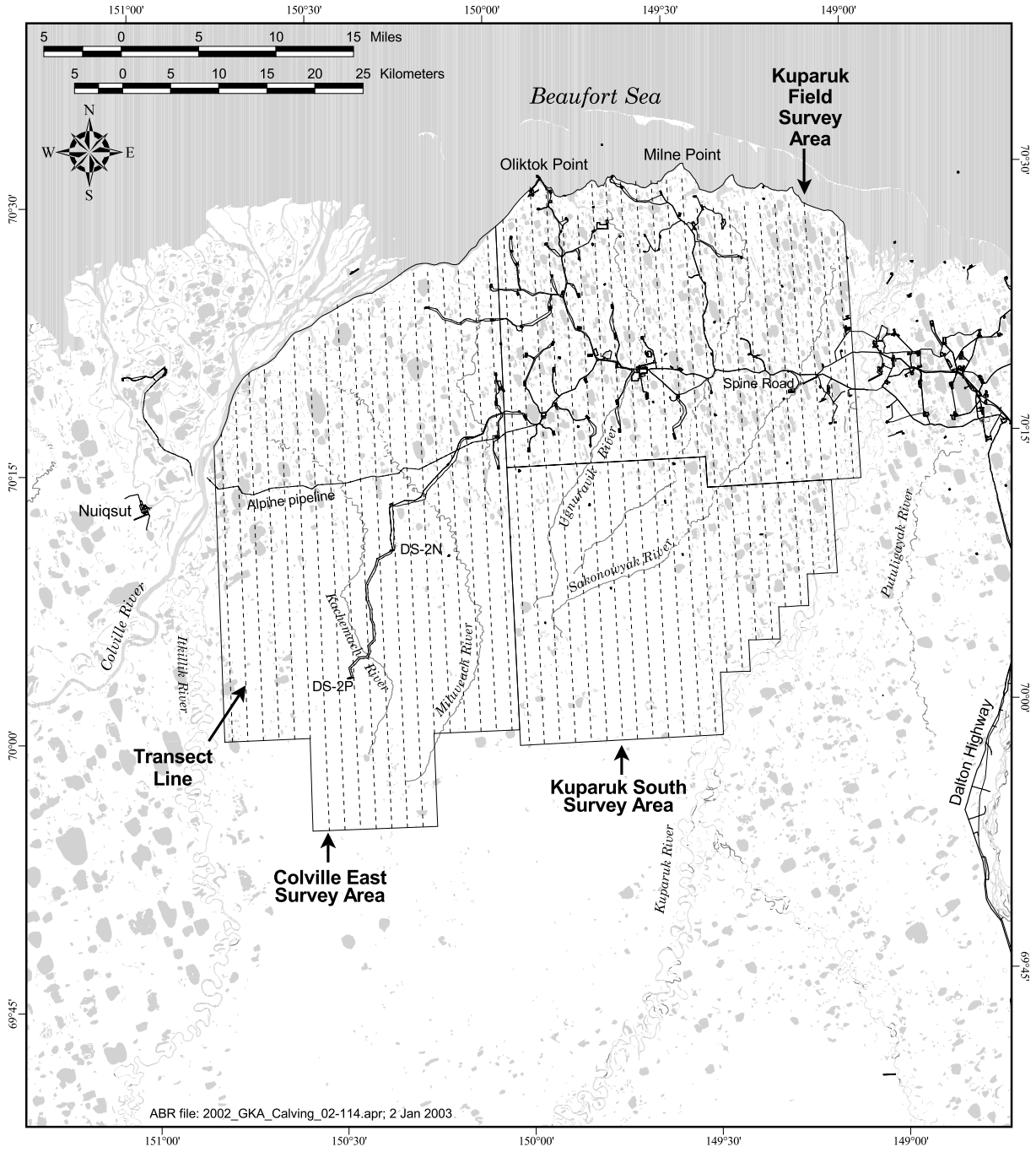

Figure 1. Survey areas and transect lines for systematic aerial surveys of caribou in the Kuparuk–Colville region, northern Alaska, during the 2002 calving season.

essentially gone during all surveys, we did not apply a sightability correction factor for patchy snow conditions, as has been done in some years (Lawhead et al. 1994, Lawhead and Prichard 2001). Because our surveys covered 50% of the study area, we estimated the "observable population" (i.e., the estimated number of caribou in the entire survey area) by doubling the number of caribou observed. In text, these estimates are followed by an 80% confidence interval (C.I.); for example, an observable population estimate of 70 ± 30 caribou means that the 80% C.I. ranges from 40 to 100 caribou.

We used a Bell 206-LIII 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 June 2002. Helicopter speed ranged from 40 to 125 km/h (slowing frequently to observe groups closely) and altitude ranged from 30 to 60 m (100–200 ft) 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 from early and mid-June (1–8 and 9–15 June) for each year of surveys (1993 and 1995–2002), we applied the Inverse Distance-Weighted (IDW) interpolation technique of the *Spatial Analyst* extension of *ArcView* GIS software to the transect data surveys for 2002, 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 provide visual depictions of caribou distribution and relative abundance within the study area.

On 20 June, we conducted a survey of the Kuparuk Field survey area and the area to the west (including the new DS-3S pad and road) to assess caribou distribution around the field prior to insect harassment. This survey was conducted in the same manner as the calving surveys, but was flown at higher altitude (~150 m, 500 ft agl) and caribou were recorded within 800 m of the airplane. Transects were spaced at 3.2-km intervals to maintain ~50% coverage of the survey area.

CARIBOU INSECT SEASON

We conducted aerial and ground surveys during the insect season (the time of year when mosquitoes and oestrid flies harass caribou) to track the abundance, distribution, and movements of caribou between the Colville River Delta and the Prudhoe Bay Oilfield, thus encompassing both the Kuparuk and Milne Point oilfields. Insect-season surveys were conducted during 25 June–28 July 2002. Two observers representing the Kuukpikmiut Subsistence Oversight Panel (KSOP) in Nuiqsut participated in a number of surveys in July. In addition, 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; the amount of available flight time typically was limited to 1–2 hours/day. A broad search path (~3 km wide) was employed on reconnaissance surveys over larger areas, with the observer using 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 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) and number or percentage of calves. When possible, the age and sex composition of groups (cow, calf, yearling, bull, and unclassified) were recorded.

CARIBOU LATE SUMMER–FALL SURVEYS

Aerial transect surveys were conducted in the Colville East and Colville Delta survey areas in late summer and fall (August–October), the time of year when most of the subsistence harvest of caribou by local residents occurs. An observer representing the Kuukpikmiut Subsistence Oversight Panel (KSOP) in Nuiqsut participated in most of the surveys during August–October. In addition, a spring (pre-calving) survey was conducted in Colville East on 3 May. Surveys followed the same protocol as calving surveys, but because visibility generally was better (either no snow cover or complete snow cover), surveys were flown at ~150 m (500 ft) agl and caribou were recorded within 800 m of the airplane. Transects were spaced at 3.2-km intervals to maintain ~50% coverage. Surveys of Colville East were conducted once in early May, three times in August, twice in September, and twice in October. Transect surveys of the Colville Delta began in July and continued into September. Three surveys were conducted in July, three in August, and one in September. As daylength waned in the fall, we ended surveys of the Colville Delta due to the very low numbers of caribou seen there in August and September, concentrating our survey effort instead on the Colville East (this study) and northeastern NPRA (Burgess et al. 2003) survey areas.

MUSKOX OBSERVATIONS

Locations and numbers of muskoxen were noted and mapped during aerial surveys for caribou in the three caribou calving survey areas and throughout the region during summer and fall. Additional observations of muskoxen 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 in 2002 was earlier than average and much earlier than in the late springs of 2000 and 2001. Snow cover was relatively deep in the beginning of May but melted rapidly, so that only trace amounts of snow were recorded at the Kuparuk airstrip after 12 May (Figure 2). The mean temperature was above freezing on 4 days in the first half of May and reached 9.4 ° C (49 ° F) in late May (Figure 2), resulting in the second highest average thawing degree-days (TDD) since 1983 during early May and the third highest during late May (Appendix A). Temperatures were only slightly above average during early June (Appendix A). The chronology of snow melt contrasted sharply with the previous 2 years, when snow cover persisted into mid-June and May temperatures were below average (Figure 2, Appendix A). The timing of calving in 2002 was earlier than in 2000 and 2001; we saw the first calves on 30 May 2002 in the Meltwater survey area (Lawhead et al., in prep.).

Snow cover was essentially gone by the time of the first calving surveys on 6–8 June. Therefore, it was not necessary to apply a sightability correction factor (Lawhead et al. 1994) to any 2002 survey data to adjust for low counts resulting from patchy snow cover.

DISTRIBUTION AND ABUNDANCE IN 2002

The number of caribou in the three calving survey areas was already high at the time of our first surveys (6–8 June; Figures 3 and 4) and increased only slightly during the mid-June surveys (10–12 June; Figures 5 and 6). During 6–8 June, we observed 5482 caribou, including 1068 calves (19%), in all three areas combined. During 10–12 June, we counted 5948 caribou, including 1212 calves (20%), in all three areas.

Expansion of these 50% sampling counts to the entire calving study area (all three survey areas combined) gave estimates of 10,964 ± 761 total caribou, including 2,136 ± 182 calves, in early June and 11,896 ± 943 total caribou, including 2,424 ± 219 calves, in mid-June (Table 1). The

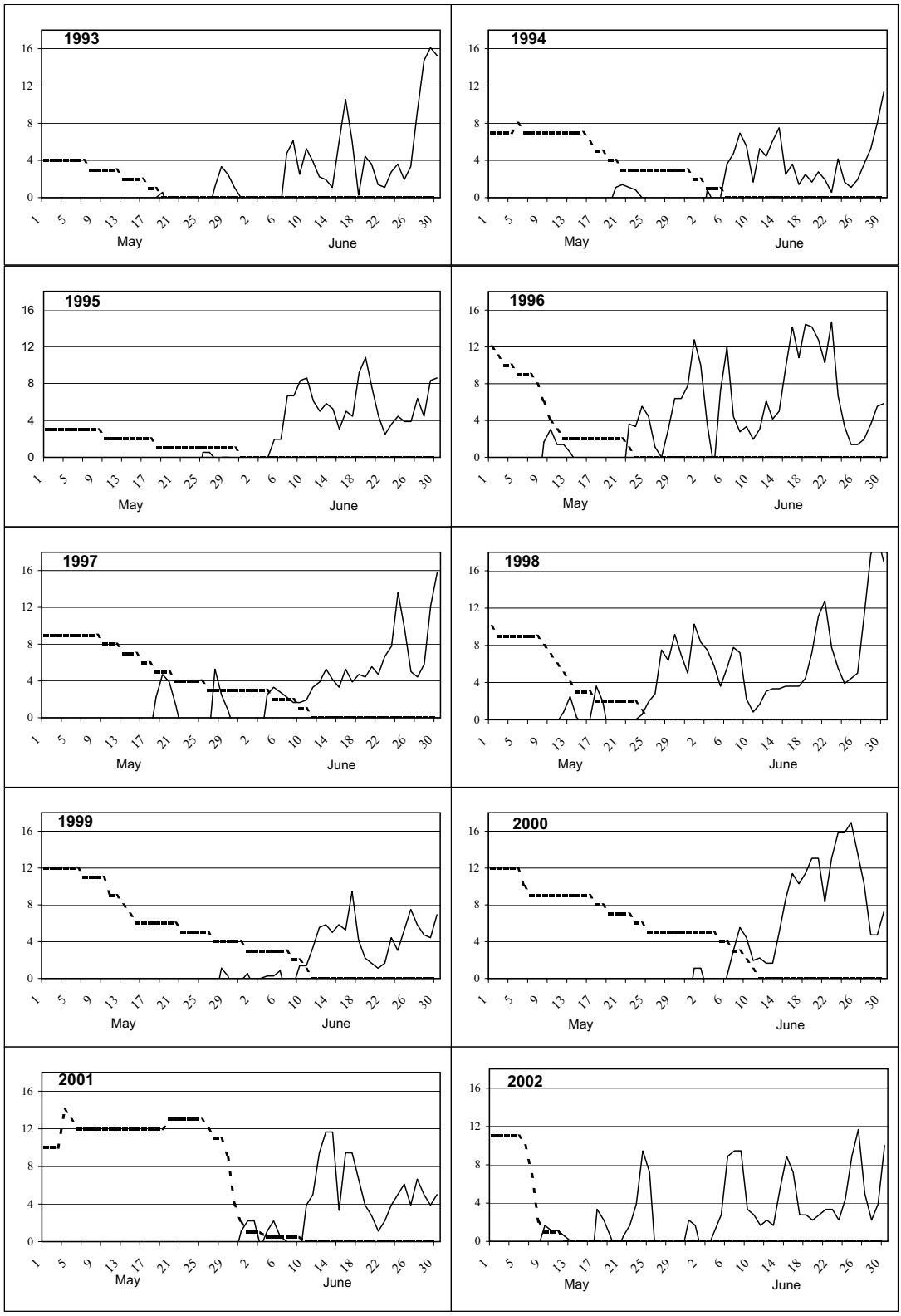

Figure 2. Snow depth (inches; dashed lines) and average daily temperature (º C; solid lines) at the Kuparuk airstrip, May–June 1993–2002.

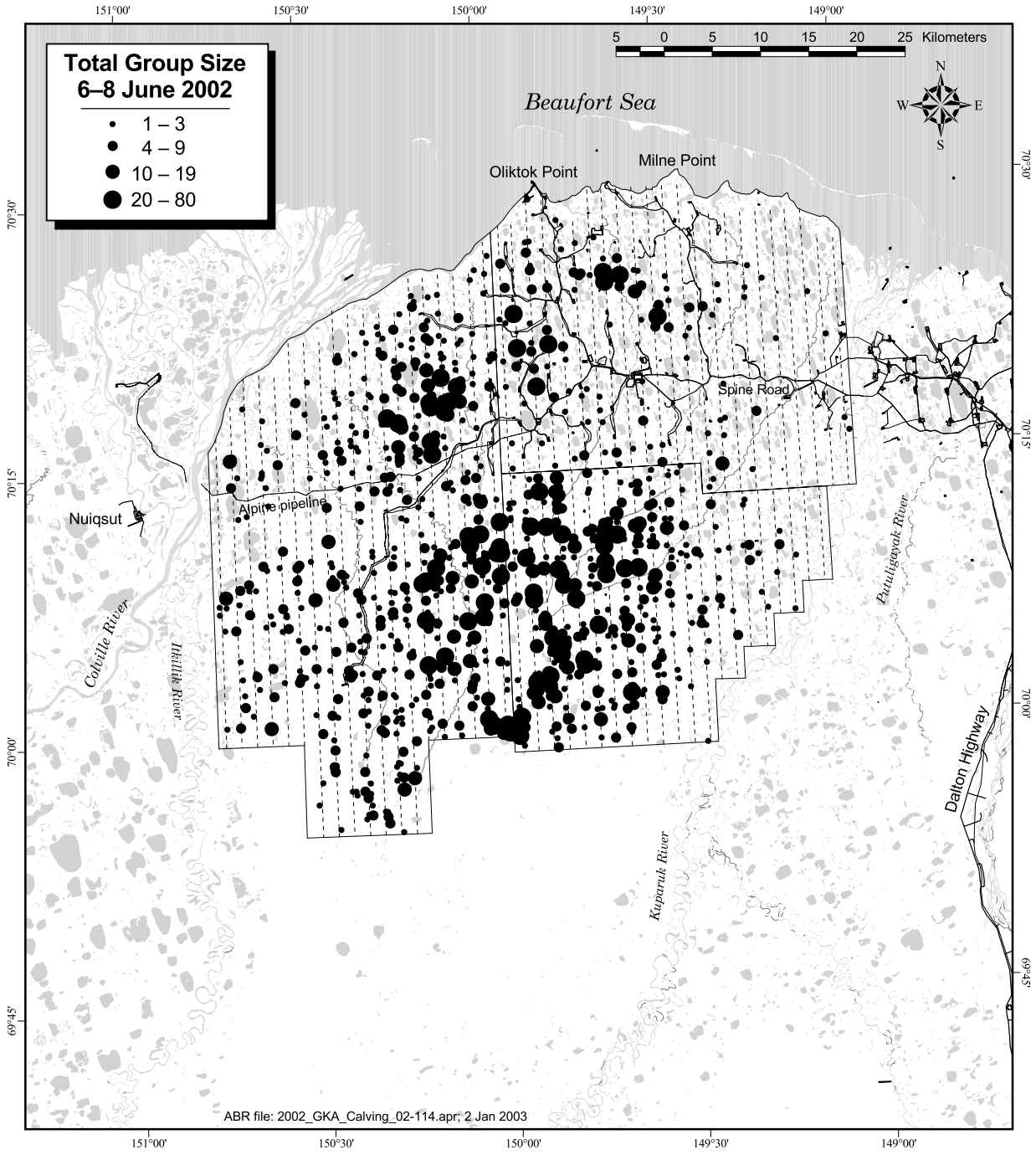

Figure 3. Distribution and number of all caribou (adults and calves) in the Kuparuk and Colville calving survey areas, 6–8 June 2002.

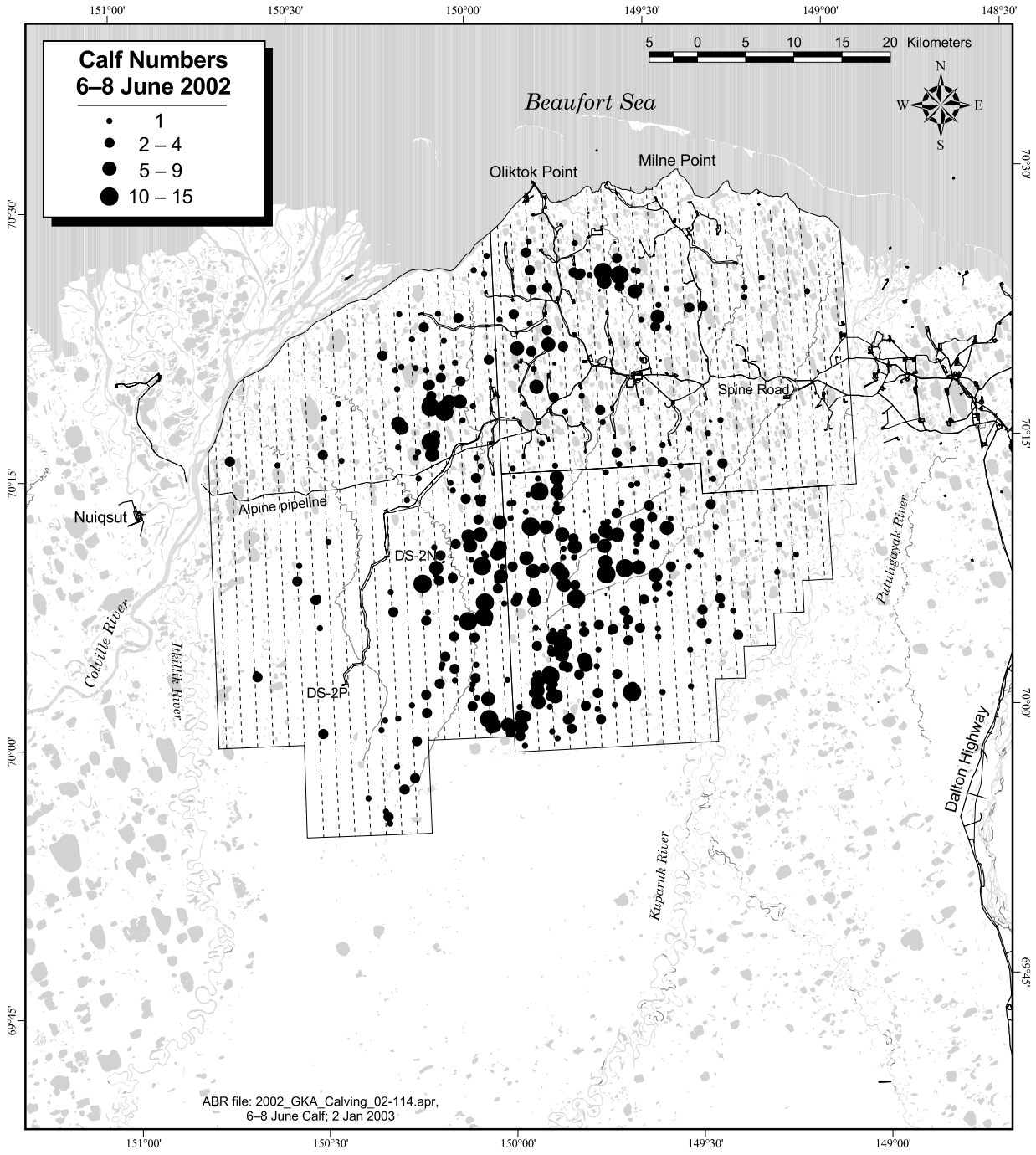

Figure 4. Distribution and number of calf caribou in the Kuparuk and Colville calving survey areas, 6–8 June 2002.

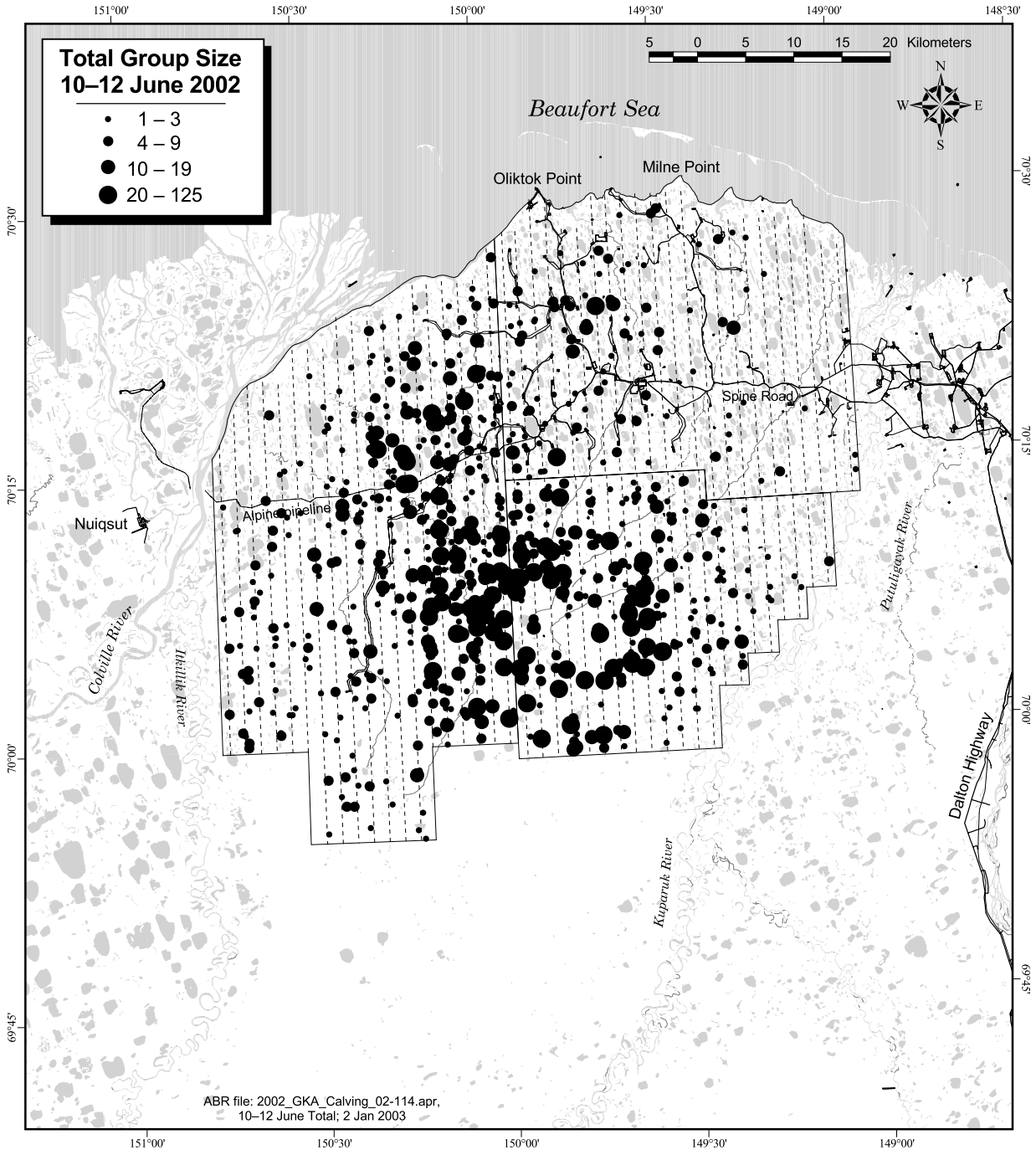

Figure 5. Distribution and number of all caribou (adults and calves) in the Kuparuk and Colville calving survey areas, 10–12 June 2002.

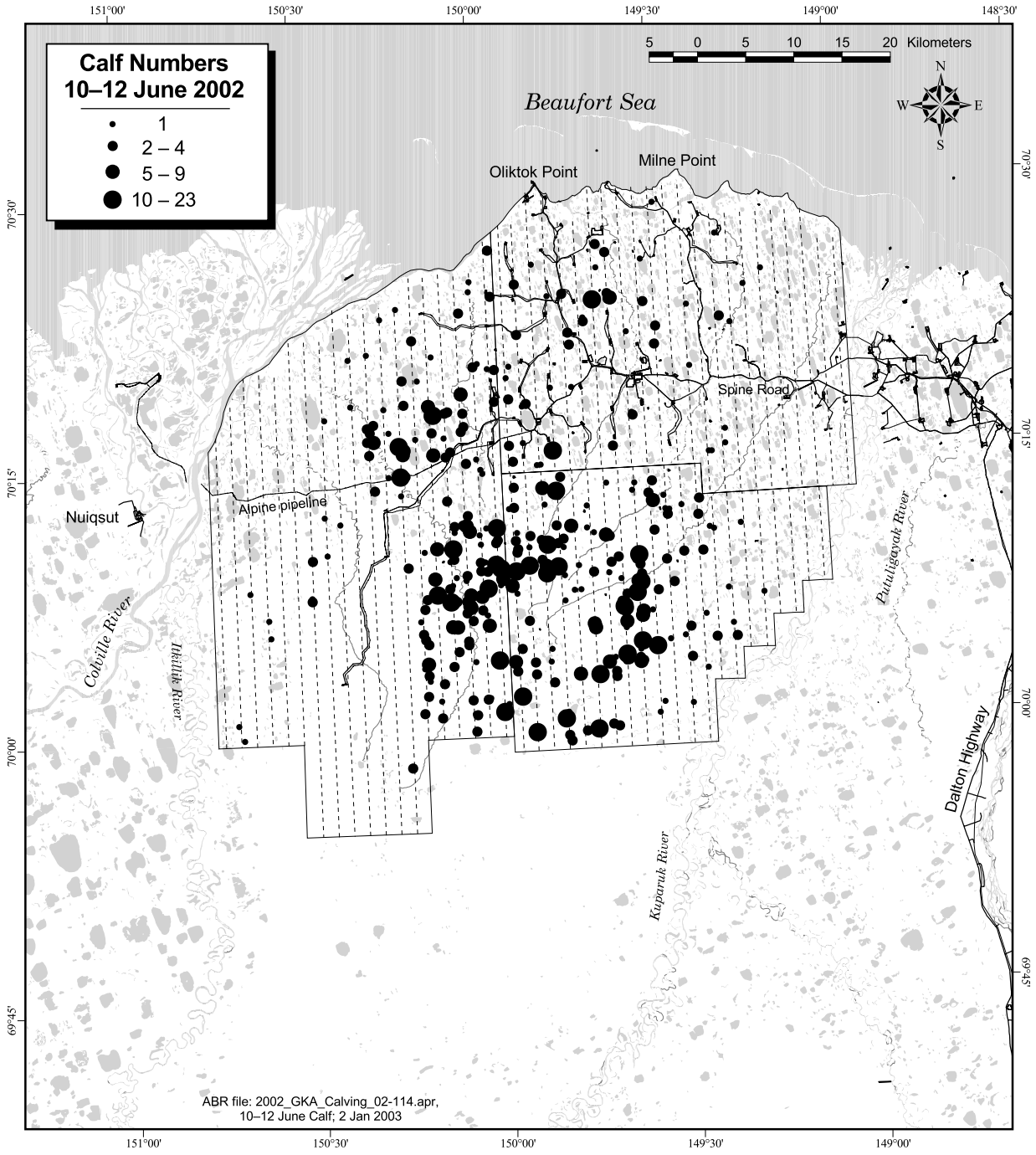

Figure 6. Distribution and number of calf caribou in the Kuparuk and Colville calving survey areas, 10–12 June 2002.

Table 1. Population estimates of caribou (± 80% C.I.) during the 2002 calving season in the Colville East, Kuparuk South, and Kuparuk Field survey areas, Alaska.

Survey Area	Date	Total Area (km²)	Estimated Number of Caribou		
			Total	Large	Calves
Colville East	June 6–7	1432	5584 ± 547	4754 ± 438	830 ± 123
	June 10–11	1432	6232 ± 675	5198 ± 569	1034 ± 140
Kuparuk South	June 7	788	4256 ± 451	3254 ± 345	1002 ± 115
	June 11	788	4778 ± 600	3614 ± 465	1164 ± 153
Kuparuk Field	June 6 & 8	1035	1124 ± 201	820 ± 152	304 ± 55
	June 12	1035	886 ± 136	660 ± 98	226 ± 45
Total	June 6–8	3255	10,964 ± 761	8828 ± 599	2136 ± 182
	June 10–12	3255	11,896 ± 943	9472 ± 763	2424 ± 219

average density in early June was 3.37 ± 0.23 large caribou/km² in all three survey areas combined (Table 2). The average density was 3.65 ± 0.29 large caribou/km² in mid-June. The overall number and density of caribou for all three calving survey areas combined was the highest we have observed since transect surveys began in 1993, reflecting the early spring and continuing increase in herd size (Appendix B). The number and density in Kuparuk South were exceeded only in 1998 and were similar in 1996.

Among the three survey areas, the density of caribou in mid-June was highest in the Kuparuk South area and lowest in the Kuparuk Field area (Table 2, Figure 7), as in most previous years (Table 3, Figure 8). Even so, the density in the Kuparuk Field area was the third highest observed since 1993 (Table 3, Appendix B). The mid-June density in 2002 was higher than average in all three survey areas, similar to other years of early snowmelt (e.g., 1996, 1998) and was substantially higher than in late springs (e.g., 1997, 2000, 2001) (Table 3, Appendix B). The number and total density in the Colville East survey area was the highest observed since we began these surveys in 1993, reflecting high use of the western portion of the area of most concentrated calving and the area north of the Tarn road and south of DS-3S (Figure 7).

In the Kuparuk Field survey area, the number of caribou decreased between the first and second surveys in June. On 12 June, 217 of the animals counted (49% of total caribou and 50% of calves) were located north of the Spine Road and east of the Oliktok Point Road, an area encompassing 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 about the same as 1998 (~50% of total; Lawhead 1999), but is lower than in most other recent years (65–77% in 1993, 1996, 1997, 1999, 2001; Lawhead and Johnson 2000, Lawhead and Prichard 2002). The results of mid-June composition surveys in the Kuparuk Field area in recent years indicate that the area receives consistent annual use by several hundred cows exhibiting a high level of calf production, with few yearlings or bulls using the area at that time of year.

CALVING DISTRIBUTION AND DENSITY, 1993 AND 1995–2002

For comparative purposes, annual data from our calving surveys in 1993 (Lawhead et al. 1994, Smith et al. 1994) and 1995–2002 (Johnson et al. 1996, 1997, 1998; Lawhead et al. 1997, 1998; Lawhead 1999; Lawhead and Johnson 2000; Lawhead and Prichard 2001, 2002, this study) are

Table 2. Population density (number per km² ± 80% C.I.) of caribou in the Colville East, Kuparuk South, and Kuparuk Field calving survey areas, June 2002.

		Estimated Density		
Survey Area	Date	Total	Large	Calves
Colville East	June 6–7	3.90 ± 0.38	3.32 ± 0.31	0.58 ± 0.09
	June 10–11	4.35 ± 0.47	3.63 ± 0.40	0.72 ± 0.10
Kuparuk South	June 7	5.40 ± 0.57	4.13 ± 0.44	1.27 ± 0.15
	June 11	6.06 ± 0.76	4.59 ± 0.59	1.48 ± 0.19
Kuparuk Field	June 6 & 8	1.09 ± 0.19	0.79 ± 0.15	0.29 ± 0.05
	June 12	0.86 ± 0.13	0.64 ± 0.09	0.22 ± 0.04
Total	June 6–8	3.37 ± 0.23	2.71 ± 0.18	0.66 ± 0.06
	June 10–12	3.65 ± 0.29	2.91 ± 0.23	0.74 ± 0.07

Table 3. Estimated density (number per km²) of caribou among calving survey areas in mid-June 1993–2002.

	Colville East		Kuparuk Field		Kuparuk South		Timing of
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*	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*	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
2002	4.35	0.72	0.86	0.22	6.06	1.48	Early
Mean	1.95	0.44	0.84	0.26	4.79	1.45	

* Applied Sightability Correction Factor of 1.88 (Lawhead et al. 1994)

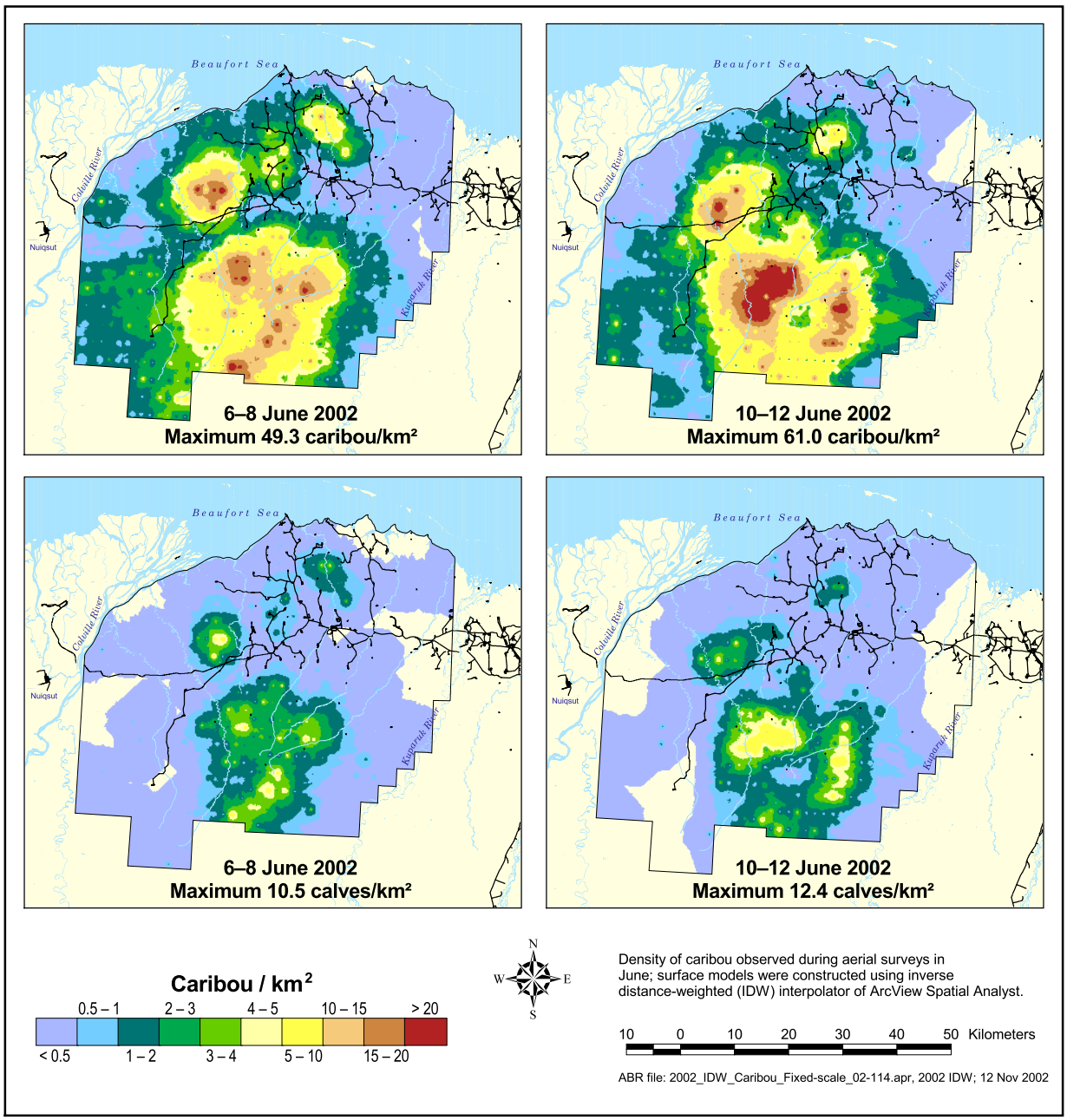

Figure 7. Distribution and density of all caribou (adults and calves; top) and calf caribou (bottom) observed during 6–8 June (left side) and 10–12 June (right side) 2002 calving surveys in the Kuparuk and Colville calving survey areas.

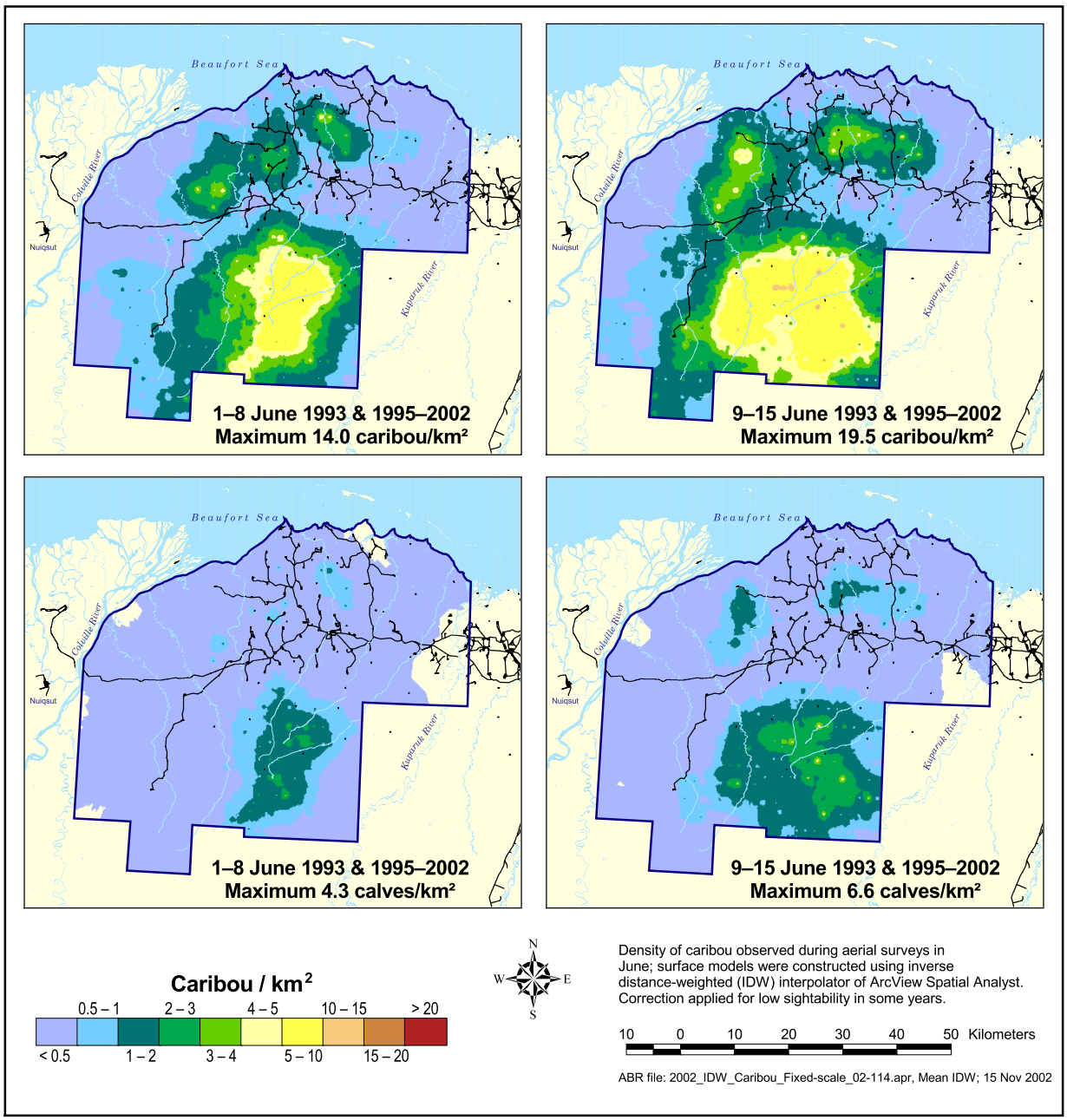

Figure 8. Distribution and mean density of all caribou (adults and calves; top) and calf caribou (bottom) observed during early June (left side) and mid-June (right side) calving surveys in the Kuparuk and Colville survey areas, 1993 and 1995–2002.

summarized in Appendix B. The annual data were used to generate mean values for each transect segment over the entire 9-year period (note that some portions of the area portrayed had fewer years of data) (Figure 8). The corresponding observable population estimates and calculations of density in each area depict the variation in numbers and densities 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 1993–2002 ranged from 320 to 2458 caribou (Appendix B), with most of those being north of the Spine Road. An additional area of generally high densities during 1993 and 1995–2002 was the area northwest of CPF-2 and south of the new Kuparuk drill site DS-3S (constructed in winter 2001–2002). Although caribou density in that area was low in the 2000 and 2001 calving seasons, it increased in 2002. Across the entire period of 1993–2002, the summary data clearly show that the area of greatest calving activity (in terms of distribution and density) was consistently located south or southwest of the Kuparuk Oilfield (Figure 8).

This pattern of high-density calving persisted in 2002. The relative abundance and density of caribou varied annually between the Colville East and Kuparuk South areas during 1993–2002, but on average was highest in Kuparuk South (Figure 8, Appendix B). In most years, the Kuparuk South (and earlier, Kuparuk Inland) survey area—the smallest of the three—consistently contained the highest densities of caribou, averaging 4.79 caribou/km² and 1.45 calves/km² (Table 3). The densities were lower in the larger Colville East (mean 1.95 caribou/km² and 0.44 calves/km²) and Kuparuk Field (0.84 caribou/km² and 0.26 calves/km²) survey areas (Table 3). 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 survey areas in 2000 were the lowest of the 1993–2002 period.

SEX AND AGE COMPOSITION AT CALVING

During the sex and age composition survey on 14 June (Figure 9), we counted 4437 caribou in portions of the Kuparuk Field, Colville East, and Kuparuk South survey areas. The sample comprised 2386 cows, 1806 calves, 236 yearlings, and 9 bulls (Table 4). Based on this count, our estimate of the standard ratio used to assess calf production—the number of calves per 100 cows—was 75.7 calves:100 cows for the western segment of the CAH in 2002. The calf:cow ratio north of the Spine Road and east of the Oliktok Point Road (70.3 calves:100 cows) did not differ significantly from that south of the Spine Road and west of the Oliktok Point Road (76.1 calves:100 cows; $P = 0.544$, Fisher's Exact Test). Yearlings constituted 5.3% of the total composition sample, for an overall ratio of 9.9 yearlings:100 cows (Table 4). The yearling ratio north of the Spine Road and east of the Oliktok Point Road (4.6:100) was significantly lower than in the other areas (10.3 yearlings: 100 cows; $P = 0.022$, Fisher's Exact Test).

At 76 calves:100 cows, calf production by the western segment of the Central Arctic Herd in 2002 exceeded the long-term average (73:100 for the period 1978–2002, Figure 10) for the seventh year in a row. The high calf production ratios (76–87 calves:100 cows) obtained from our composition surveys in 1996–2002 are comparable with those observed in the early 1980s, a period of rapid herd growth. ADFG estimated an overall parturition rate of 87% in a sample of 54 radio-collared females in both segments of the CAH on 4–7 June 2002; the rate for 29 cows west of the Sagavanirktok River was 83% (E. Lenart, in prep.). Tracking of radio-collared cows ≥4 years old in the western segment of the CAH ($n = 11–29$ per year) by ADFG confirmed generally high parturition rates in 1996–2001 (61–96%, increasing after 1996) (Lenart 1999; E. Lenart, pers. comm.).

PRE-INSECT SEASON SURVEY

We conducted a survey of the Kuparuk Field survey area and the area to the west around DS-3S (Figure 11) on 20 June 2002, as caribou gathered in larger groups and began drifting north into the oilfield before the emergence of mosquitoes. Visibility was poor during the survey due to light

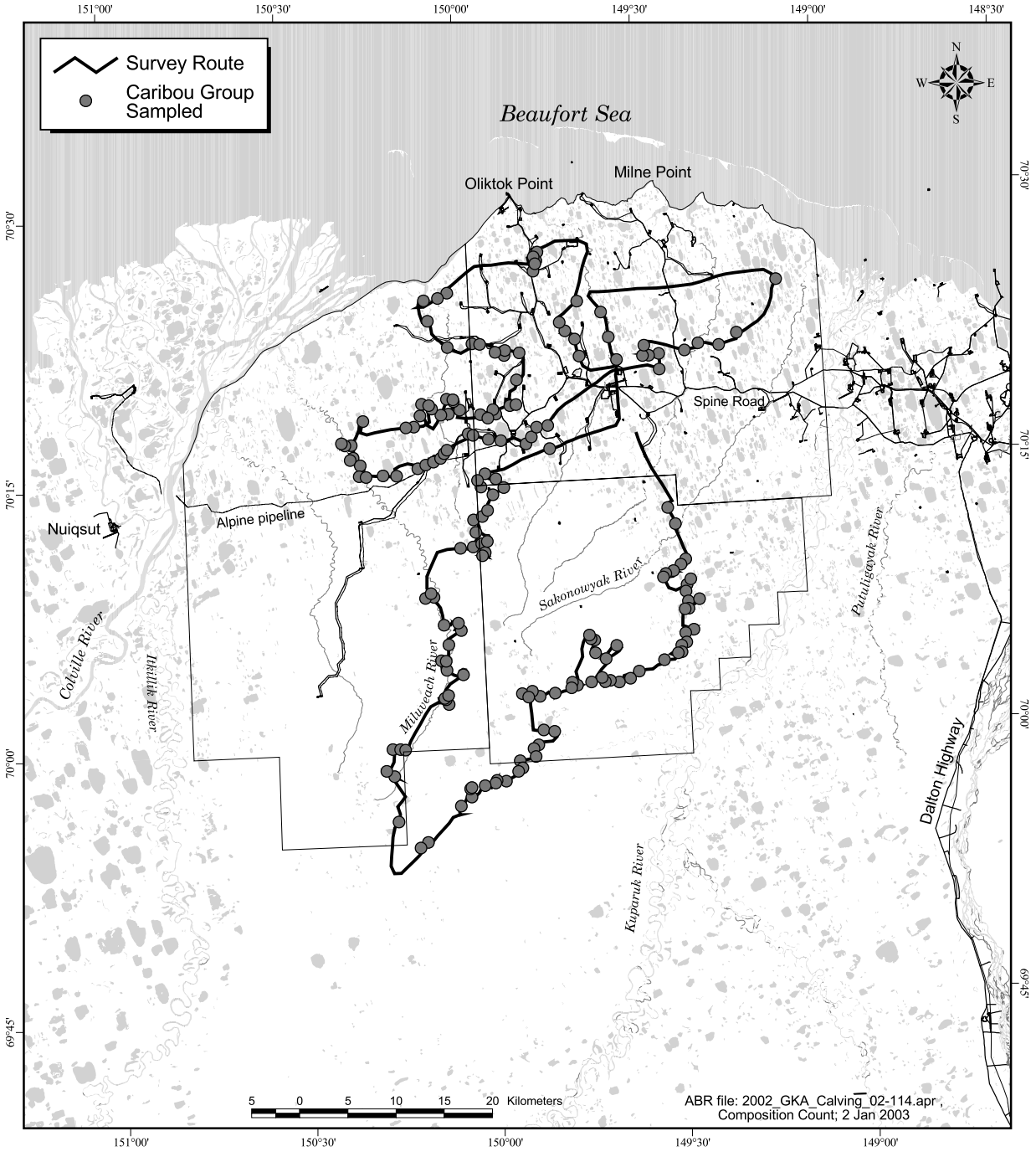

Figure 9. Route of aerial survey and location of groups sampled to quantify sex and age composition of caribou groups in the Kuparuk and Colville calving survey areas, 14 June 2002.

Table 4. Sex and age composition of caribou groups observed in the Kuparuk–Colville region during a helicopter survey on 14 June 2002.

Survey Area	Groups	Total No.	Cows		Calves		Yearlings		Bulls		Calf Ratio [a]	Yrlg. Ratio [b]
			No.	%	No.	%	No.	%	No.	%		
North of Spine Rd. / East of Oliktok Pt. Rd.	23	313	175	55.9	123	39.3	8	2.6	7	2.2	70.3	4.6
South of Spine Rd. / West of Oliktok Pt. Rd.	154	4124	2211	53.6	1683	40.8	228	5.5	2	0.05	76.1	10.3
Total	177	4437	2386	53.8	1806	40.7	236	5.3	9	0.2	75.7	9.9

[a] Calves:100 cows
[b] Yearlings:100 cows

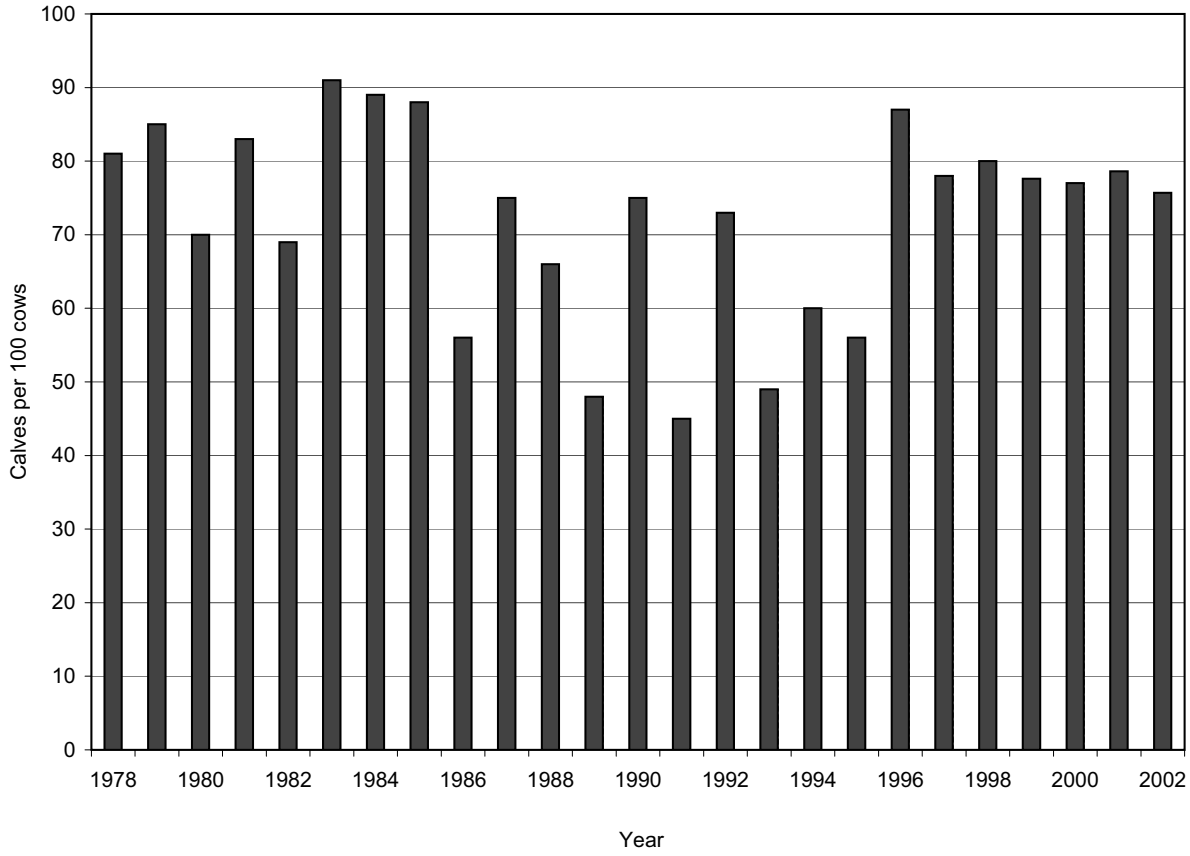

Figure 10. Estimated production of calf caribou (calf:cow ratio) by the western segment of the Central Arctic Herd, based on aerial composition surveys in mid-June 1978–2002. Data sources: Fancy et al. (1992) for 1978–1990; Woolington (1995) for 1991–1992; Smith et al. (1994) for 1993; Cameron (1994) for 1994; Cameron (pers. comm.) for 1995; Johnson et al. (1997, 1998) for 1996–1997; Lawhead (1999) for 1998; Lawhead and Johnson (2000) for 1999; Lawhead and Prichard (2001, 2002, this study) for 2000–2002.

snow and patchy fog. The greatest concentration of caribou occurred in the CPF-2 and CPF-3 areas, with few caribou in the eastern area of the Kuparuk Field. We saw a total of 730 caribou, including 147 calves, for estimated densities of 1.07 ± 0.43 total caribou/km^2 and 0.22 ± 0.10 calves/km^2. The average group size was 6.1 caribou (range 1–58).

Due to warm temperatures in mid-June, it appeared that mosquitoes would emerge early in 2002; however, temperatures decreased and the first large mosquito-induced movements were not observed until 24–25 June. Caribou appeared to move gradually north after calving and before the insect season, especially in the Meltwater and Tarn project areas (Lawhead et al., in prep.). During this survey we saw fairly high densities of caribou in the CPF-2 and CPF-3 areas, but over the entire area surveyed the density was similar to that in the Kuparuk Field during calving (Table 2).

CARIBOU INSECT SEASON

Field observations of caribou during the insect season were recorded from 25 June through 28 July 2002. The distribution and movements of caribou in the study area were surveyed and mapped on 33 days in this period (no observations were conducted on 28 June), using a combination of broad-scale aerial reconnaissance surveys and road surveys by truck on the oilfield road system (Table 5). The reconnaissance nature of our aerial survey effort needs to be considered when

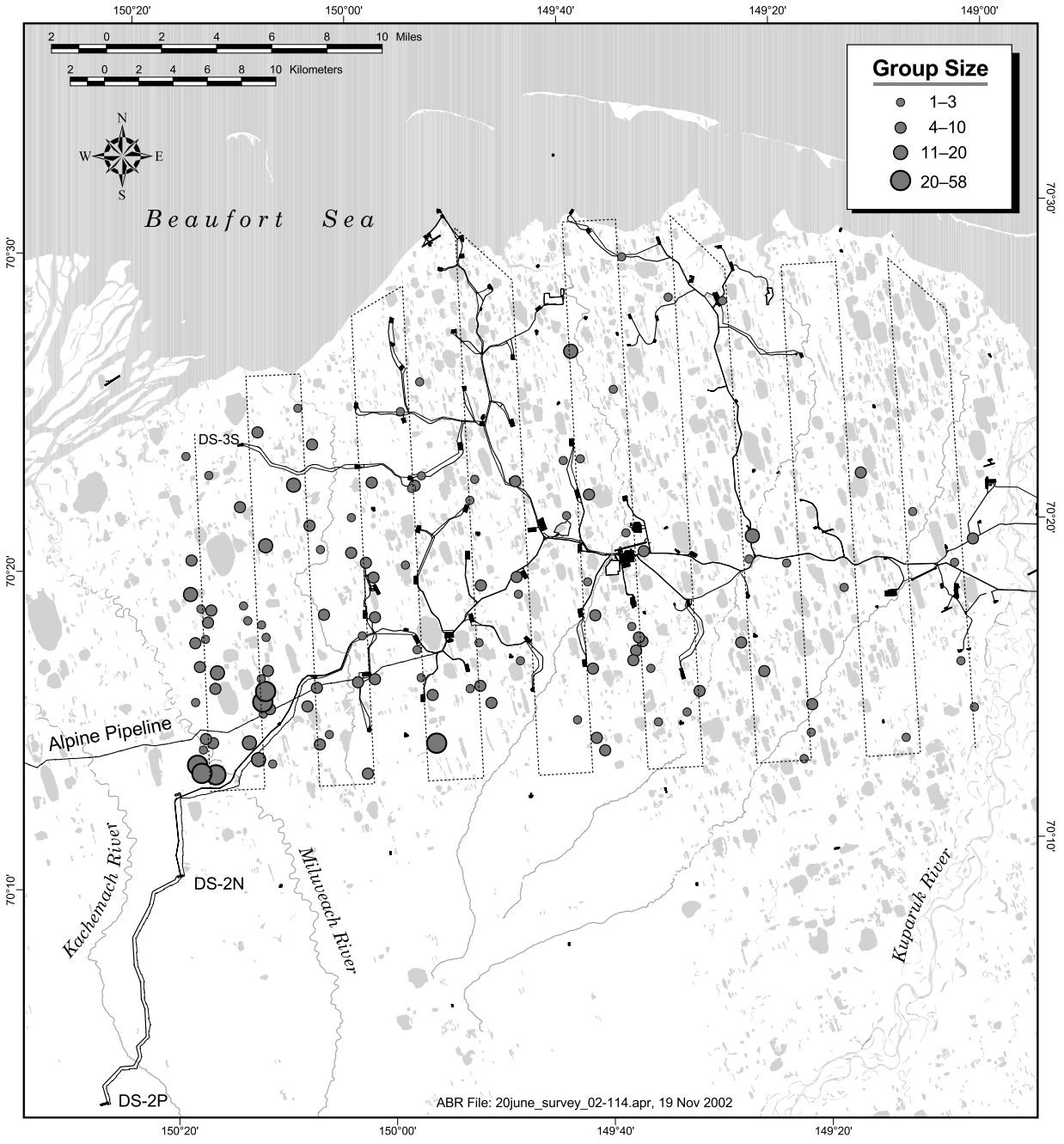

Figure 11. Distribution and number of all caribou (adults and calves) in the extended Kuparuk Field Survey area during a pre-insect season survey on 20 June 2002.

Table 5. Numbers of caribou groups and individuals mapped and levels of insect harassment recorded on aerial and road surveys in the Kuparuk Oilfield region during 25 June–28 July 2002.

	Road Survey			Aerial Survey			Total			Insect Harassment Level	
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	Oestrid Flies
June 25	12	3928	327.3				12	3928	327.3	moderate	none
26	13	3439	264.5	23	616	26.8	36	4055	112.6	moderate	none
27	2	34	17.0				2	34	17.0	mild	none
29				23	2845	123.7	23	2845	123.7	moderate	none
30				23	4020	174.8	23	4020	174.8	mild/moderate	none
July 1				24	982	40.9	24	982	40.9	mild	none
2	9	184	20.4	13	700	53.8	22	884	40.2	none	none
3	7	164	23.4	43	1748	40.7	50	1912	38.2	none	none
4	4	17	4.3	40	1310	32.8	44	1327	30.2	none	none
5	6	122	20.3	19	1237	65.1	25	1359	54.4	mild	unknown
6				24	9952	414.7	24	9952	414.7	moderate	active
7	13	408	31.4	28	1757	62.8	41	2165	52.8	moderate	active
8				23	1203	52.3	23	1203	52.3	mild	unknown
9	8	1606	200.8	23	2430	105.7	31	4036	130.2	moderate	unknown
10	1	400	400.0	25	6846	273.8	26	7246	278.7	moderate	unknown
11				63	3703	58.8	63	3703	58.8	none/mild	none
12				39	1610	41.3	39	1610	41.3	none	none
13				26	4640	178.5	26	4640	178.5	moderate	active
14				36	5785	160.7	36	5785	160.7	moderate	active
15				22	8127	369.4	22	8127	369.4	severe	active
16				4	5260	1315.0	4	5260	1315.0	severe	active
17				18	7104	394.7	18	7104	394.7	severe	active
18	1	1	1.0	8	1642	205.3	9	1643	182.6	moderate	active
19				5	829	165.8	5	829	165.8	severe	unknown
20				18	1568	87.1	18	1568	87.1	mild	unknown
21	1	3	3.0	14	1280	91.4	15	1283	85.5	mild	active
22				9	1948	216.4	9	1948	216.4	mild	unknown
23	1	2	2.0	22	1953	88.8	23	1955	85.0	none	active
24				21	1575	75.0	21	1575	75.0	none	unknown
25	1	2	2.0				1	2	2.0	none	unknown
26				12	585	48.8	12	585	48.8	none	active
27				3	10	3.3	3	10	3.3	none	none
28				1	4	4.0	1	4	4.0	mild	unknown
Total	79	10,310	130.5	652	83,269	127.7	731	93,579	128.0		

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.

Aerial surveys were conducted on 30 days and road surveys on 14 days. Overall, data were recorded on 731 groups totaling 93,579 caribou (including repeated observations of the same animals among successive days) (Table 5). By far, most of these observations were from aerial surveys, which were more efficient for quickly locating large numbers of animals over broad areas away from the road system, totaling 89% of the groups and total number of caribou observed.

The weather during the 2002 insect season was cooler than average. The overall sum of thawing degree-days at the Kuparuk airstrip between mid-June and the end of July was below the long-term average for 1983–2001 (Figure 12, Appendix C). The occurrence of weather conducive to insect harassment (as indicated by the index of fly harassment [Mörschel 1999]) was low in the first half of July due to cool, breezy weather, and increased substantially in the second half of the month (Figure 13, Appendix D).

Mosquito harassment occurred on most days in the study period, peaking at mild levels (typically resulting in upwind movements) on 9 days (27% of the 33 days recorded) and at moderate or severe levels (typically resulting in movements to coastal relief habitat) on another 15 days (45%) (Table 5). The overall pattern of fluctuating coastal–inland movements exhibited by the western segment of the CAH in the 2002 insect season was generally similar with that seen in other years. A strong tendency for caribou to remain in the eastern portion of the study area was noted in 2002, however, particularly along the Kuparuk River drainage (Figure 14, Table 6).

When the first mosquito harassment occurred on 24–25 June, large groups of caribou (up to 3000) crossed the Spine Road as well as roads in the CPF-3 area, but use of coastal areas was limited. Mosquito-induced movements to coastal areas occurred during 29 June–1 July, 7–10 July, and 13–17 July (Table 6). Caribou returned inland when mosquito activity subsided during 26–28 June, 2–7 July, 11–13 July, and after 18 July (Table 6). The distance of inland dispersal was relatively far inland (Figure 14) during the cool weather of most the first half of July, similar to 2000 and 2001. The largest group observed inland was an aggregation of 6000–7000 caribou seen ~15 km southeast of DS-2P (Meltwater) on 6 July, shortly before caribou moved back to the coast on 7–8 July; this large group could not be relocated on 7 July.

Similar to 2001, the most intense insect harassment in the 2002 season occurred in the third week of July. Use of coastal insect-relief habitat peaked on 15–17 July, coinciding with ADFG's photocensus effort. Oestrid fly harassment was confirmed by behavioral observations of caribou on 11 days in July, although this is probably an underestimate, judging from the occurrence of weather conditions conducive to fly activity (Figure 13).

Consistent with previous years, the caribou numbers seen on our insect-season surveys decreased in late July (Tables 5 and 6, Figure 14). By mid-July in most years, oestrid flies begin to 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).

CARIBOU LATE SUMMER–FALL SURVEYS

Caribou densities were low in both the Colville Delta (mean = 0.05 caribou/km²; range 0–0.30) and Colville East survey areas (mean =0.07 caribou/km²; range 0.01–0.30) during

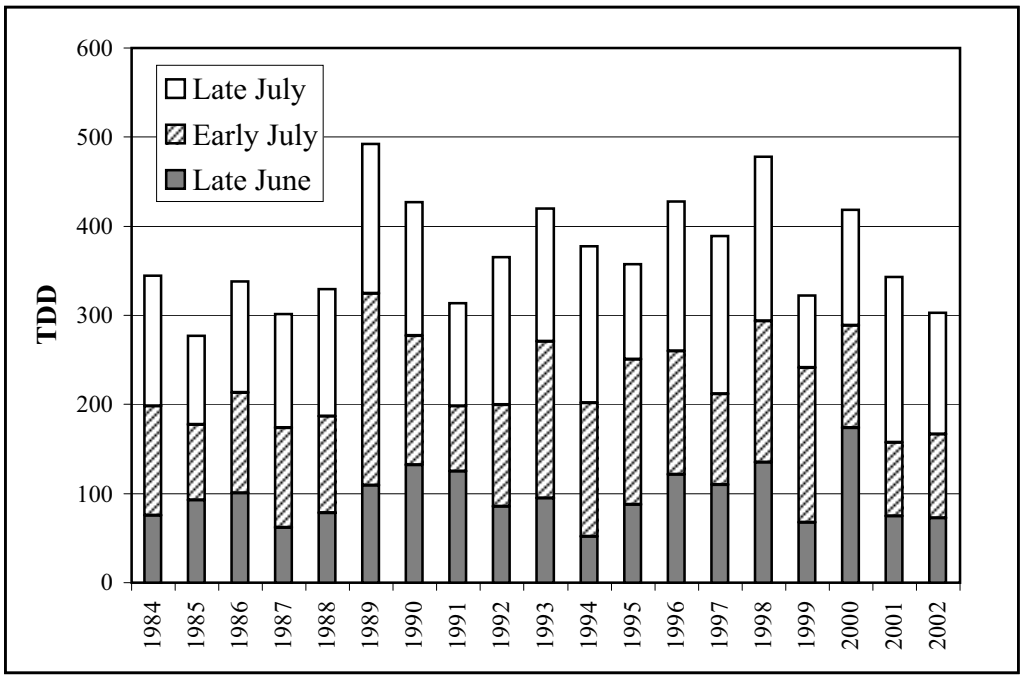

Figure 12. Index of annual insect-season severity (expressed as cumulative thawing degree-days in º C above freezing; Appendix C) from mid-June through July, 1983–2002.

all aerial surveys in summer and fall (Table 7). The low July numbers on the delta reflected the easterly distribution of the western segment of the CAH noted during the insect season, contrasting sharply with the unprecedented westward movement seen in July 2001 (Lawhead and Prichard 2002). In the Colville Delta survey area, 74 caribou were seen on 13 July, mostly on the eastern delta, but only 10 caribou total were seen on the 6 subsequent surveys (Table 7, Figure 15).

Similar to 2001 (Lawhead and Prichard 2002, Burgess et al. 2002), the number of caribou seen east of the Colville River was low in late summer and fall. Caribou were more numerous west of the Colville River in northeastern NPRA during the same period (Burgess et al. 2003). Caribou numbers in the Colville East survey area were low throughout August, reached a maximum of 255 on 9 September, and then decreased again through the end of October (Table 7). Caribou were widely scattered in small groups throughout the Colville East survey area on both sides of the Meltwater and Tarn roads (Figure 15). Caribou group size in the Colville East survey area was lowest in August (1.3–1.7 caribou/group) and increased slightly in September and October (2.7–7.0 caribou/group) (Table 7).

This year was the first in which systematic surveys of the Colville Delta were conducted during late summer and fall. Previous systematic calving surveys (Lawhead and Johnson 2000) and insect-season reconnaissance surveys of the Colville Delta (e.g., Johnson et al. 1996, 1997, 1998) demonstrated that the area is virtually unused during calving, but that large groups of caribou periodically move onto the delta during the insect season, particularly CAH caribou following prolonged periods of westerly winds coinciding with insect harassment (Lawhead and Prichard 2002). The Colville Delta was used little by caribou in summer and fall 2002, in marked contrast to 2001 (Lawhead and Prichard 2002).

MUSKOX OBSERVATIONS

Muskoxen were seen in two general locations in the Kuparuk–Colville region in summer 2002: along the eastern side of the main channel of the Colville River and near the Kuparuk River delta (Figure 16); we recorded 34 sightings between

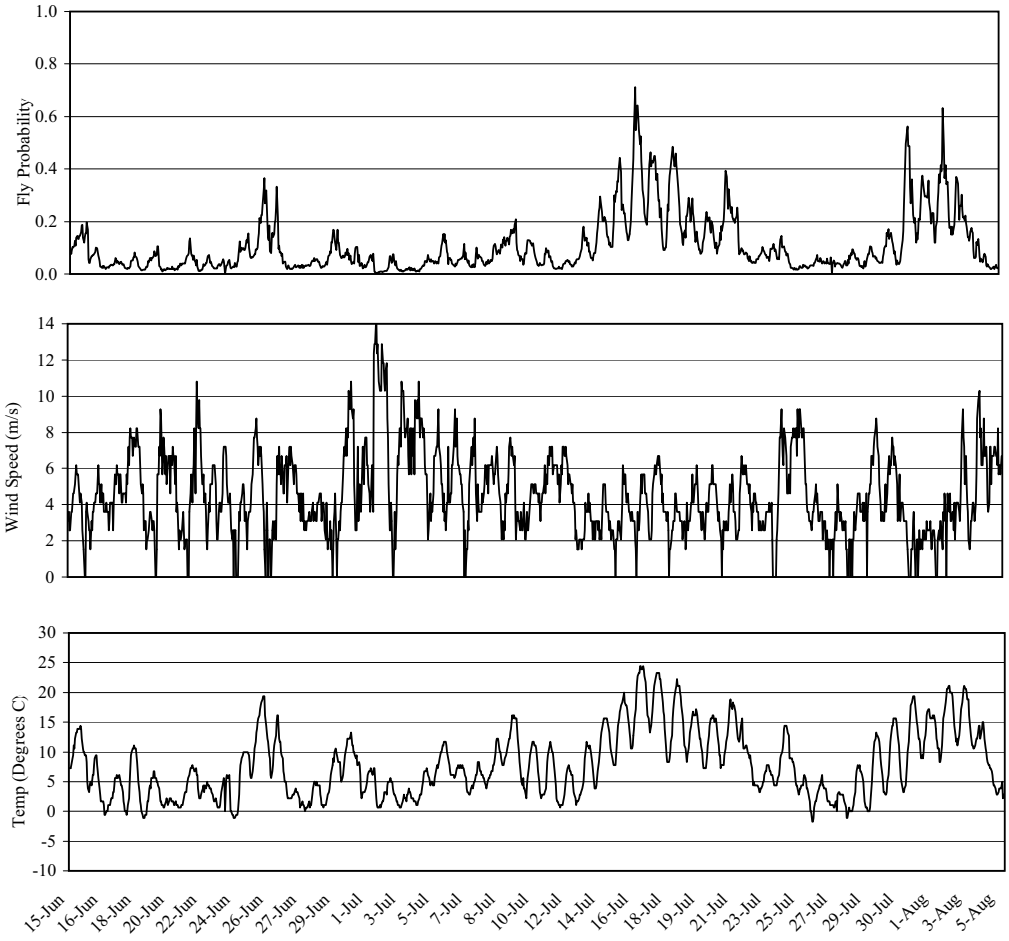

Figure 13. Probability of oestrid fly activity in summer 2002, based on wind speed and temperature recorded at Nuiqsut.

early May and late October (Table 8). The distribution of groups observed incidentally in 2002 was more constricted than in 2001 because our reconnaissance surveys were less extensive. Nevertheless, we were unable to account for as many muskoxen as we expected to see in the region based on previous years' observations. We were unable to identify individuals marked by ADFG in their ongoing telemetry study, so consequently it was difficult to identify specific groups consistently throughout the field season. In both the Colville and Kuparuk delta vicinities, groups were relatively sedentary, however, so we were fairly confident of group identity among surveys. A subgroup of the Colville River group evidently moved eastward to the western edge of the Kuparuk Oilfield in August. Our best point-in-time "snapshot" over the entire area was obtained on 7 June, when we counted 73 muskoxen in 4 locations between the Colville delta and the Kuparuk River, of which 3 were mixed-sex groups containing at least 16 calves (Figure 16). The broad distribution of reproductive groups demonstrates the success this native species has had in repopulating formerly occupied range in the region.

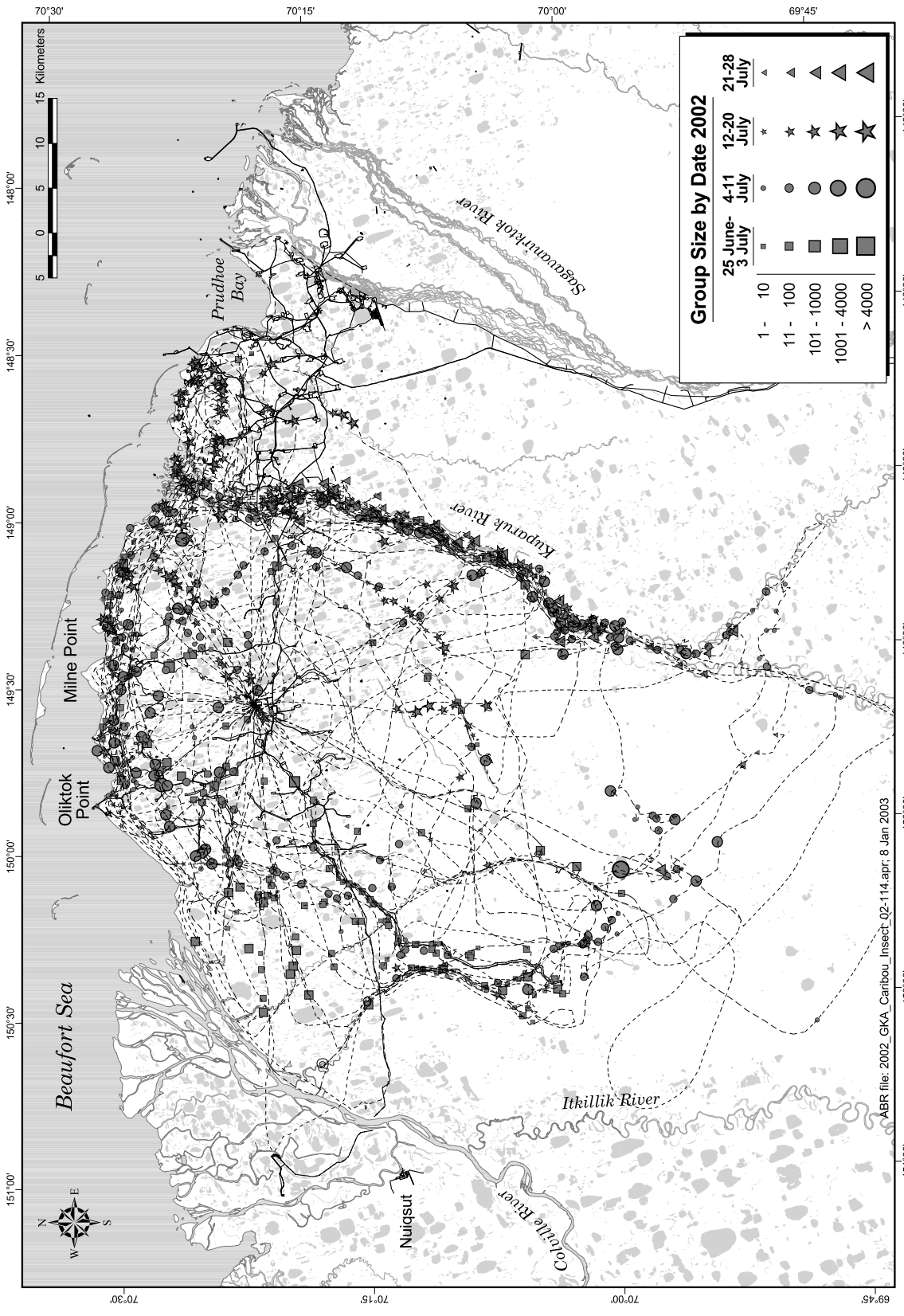

Figure 14. Distribution and group sizes of caribou observed on aerial reconnaissance surveys (routes shown as dashed lines) of the Kuparuk–Colville region during the insect season, 25 June-28 July 2002.

Table 6. Daily summary of weather conditions, insect activity, and caribou movements in the Kuparuk Oilfield region during 25 June–28 July 2002.

	Survey Type[a]		Number of Caribou by Survey Type		Temp. (° C) [at Kuparuk]		Wind Direction (degrees) & Speed (knots) [at Nuiqsut]		Mosquitoes[b]		Oestrid Flies[c]		Direction of Movement		
Date	A.M.	P.M.	Road	Air	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	Location / Notes
June 25		R	3928		12	18	240 @16	250 @13	1–2	2	0	0		NE	Large groups crossing Spine Rd., many near CPF-3; cooler near coast.
June 26		B	3439	616	8	12	var. @4	030 @11	2	1–2	0	0		0	Some caribou on coast, but most still inland.
June 27		R	34		2	3	050 @13	050 @11	1	1	0	0		0, S	Some large groups reported near Tarn and Meltwater; small groups scattered throughout field.
June 29		A		2845	3	8	060 @3	0 @0	1	2	0	9		NE	Groups inland moving north rapidly; large groups near rivers, few caribou near coast.
June 30		A		4020	11	14	200 @16	250 @19	1–2	1	0	0		0	Some caribou along coast; some large groups east of Colville Delta.
July 1	A			712	3	8	240 @10	220 @10	0	1	0	0	0		Largest aggregations northwest of Kuparuk Field.
July 2		B	184	700	1	4	250 @25	260 @23	0	0	0	0		0	Few caribou near coast; some large groups on Kuparuk and Kachemach Rivers.
July 3	A	R	164	1748	1	3	280 @16	270 @16	0	0	0	0	0	0, S	Caribou dispersed inland, with larger groups seen along Kuparuk River and in Meltwater area.
July 4	R	A	17	1310	2	6	240 @17	250 @15	0	0	0	0	0	0, S	Caribou far inland, mostly along rivers.
July 5	R	A	122	1237	8	10	240 @14	250 @12	0	1	9	9	0	0, NE	Caribou still inland, some moving north, some under buildings and pipelines.
July 6	A			9952	6	7	230 @16	280 @12	0	2	1	1	0, S		Caribou inland, 6000–7000 south of Meltwater.
July 7	A	R	408	1757	5	6	270 @12	290 @6	1	2	9	1	0, NE	NE	Caribou scattered inland in A.M., moving quickly NE in P.M.
July 8	A			1203	6	8	110 @12	090 @11	1	1	9	9	var.		Near the coast, especially near Kalubik Creek.
July 9	A	R	1606	2430	12	14	230 @11	240 @13	1–2	2	9	9	N, E	N, E	Caribou heading north or near coast between Oliktok Pt. and Kuparuk R.
July 10		B	400	6846	3	8	020 @7	050 @10	2	2	9	9		NE	Caribou near coast, most east of Oliktok Pt.
July 11		A		3703	2	5	080 @12	070 @12	0	0-1	0	0		S	Caribou dispersing inland and up Kuparuk River; few caribou west of Kuparuk Field.
July 12		A		1610	1	3	070 @14	070 @12	0	0	0	0		0	Caribou scattered in small groups in eastern Kuparuk Field and south of field; few in Meltwater area.

Table 6. (Continued).

	Survey Type[a]		Number of Caribou by Survey Type		Temp. (° C) [at Kuparuk]		Wind Direction (degrees) & Speed (knots) [at Nuiqsut]		Mosquitoes[b]		Oestrid Flies[c]		Direction of Movement		
Date	A.M.	P.M.	Road	Air	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	Location / Notes
July 13		A		4640	2	9	060 @4	040 @8	0	2	0	1		N	Large groups moving north along Kuparuk R.; some groups seen in eastern Colville Delta.
July 14	A			5785	9	13	040 @6	010 @10	2	2	1	1	NE		Large groups NE of KOC and along Kuparuk River, heading toward coast.
July 15	A			8127	13	17	var. @4	080 @6	3	3	1	1	N, E		Large groups along coast east of Oliktok Pt.; some crossed to east of Kuparuk River.
July 16	A			5260	20	24	240 @4	120 @6	3	3	1	1	0, E		Large, dense groups along coast between Oliktok Pt. and Prudhoe Bay.
July 17	A			7104	19	18	080 @10	060 @13	3	3	1	1	0, E		Large groups near coast between Kuparuk R. and Prudhoe Bay.
July 18	R	A	1	1642	14	15	010 @4	030 @9	2	2	1	1		0, S	Only 1 caribou seen west of Kuparuk River; groups east of river moving away from coast.
July 19	A			829	11	15	030 @6	020 @8	2	3	9	9	0, S		No groups seen west of Kuparuk River; groups near Prudhoe Bay moving inland in morning.
July 20	A			1568	12	14	030 @7	030 @12	1	1	0	9	0		Caribou along Kuparuk River; none seen to west.
July 21	A	R	3	1280	11	15	030 @5	030 @10	1	1	1	1	0	0	Caribou scattered along Kuparuk River; very few in oilfield.
July 22	A			1948	11	8	290 @11	290 @10	1	0	9	0	0		Most caribou along Kuparuk River south of Spine Road
July 23	R	A	2	1953	3	6	030 @5	030 @7	0	0	1	1		var.	Most caribou along Kuparuk River south of Spine Road, fly-harassed.
July 24	A			1575	7	14	230 @15	270 @16	0	0	9	9	S		Most caribou along Kuparuk River, as far south as the Toolik River.
July 25		R	2		3	5	280 @18	290 @15	0	0	9	9	0		Only 2 caribou seen from road; no caribou seen on Colville Delta.
July 26	A			585	3	5	260 @10	340 @7	0	0	1	1	0, N		Most caribou in small groups far inland along the Kuparuk River.
July 27	A			10	1	3	030 @4	010 @7	0	0	0	0	W		Few seen far inland.
July 28	A			4	1	7	000 @0	040 @7	0	1	0	9	–		Only 1 group seen.

[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. Number and density of caribou observed in spring, late summer, and fall in the Colville East and Colville Delta survey areas, 2002.

Survey Area	Date	Area Surveyed (km²)	Total Counted	Estimated Total	Density (caribou / km²)	Groups	Average Group Size
Colville East	May 3	850	26	52	0.03	15	1.73
	Aug. 3–4	850	8	16	0.01	6	1.33
	Aug. 14–15	850	5	10	0.01	3	1.67
	Aug. 27	850	19	38	0.02	7	2.71
	Sep. 9–10	850	255	510	0.30	79	3.23
	Sep. 24	614*	7	19	0.01	1	7.00
	Oct. 6–7	850	64	128	0.08	11	5.82
	Oct. 25–26	850	74	148	0.09	15	4.93
	Total		458	921	0.07	137	3.34
Colville Delta	July 13	247	74	148	0.30	8	9.25
	July 18	247	0	0	–	0	–
	July 25	247	0	0	–	0	–
	Aug. 3	247	0	0	–	0	–
	Aug. 14	247	6	12	0.02	5	1.20
	Aug. 26	247	4	8	0.02	3	1.33
	Sep. 9	247	0	0	–	0	–
	Total		84	168	0.05	16	5.25

* Part of area not flown due to fog

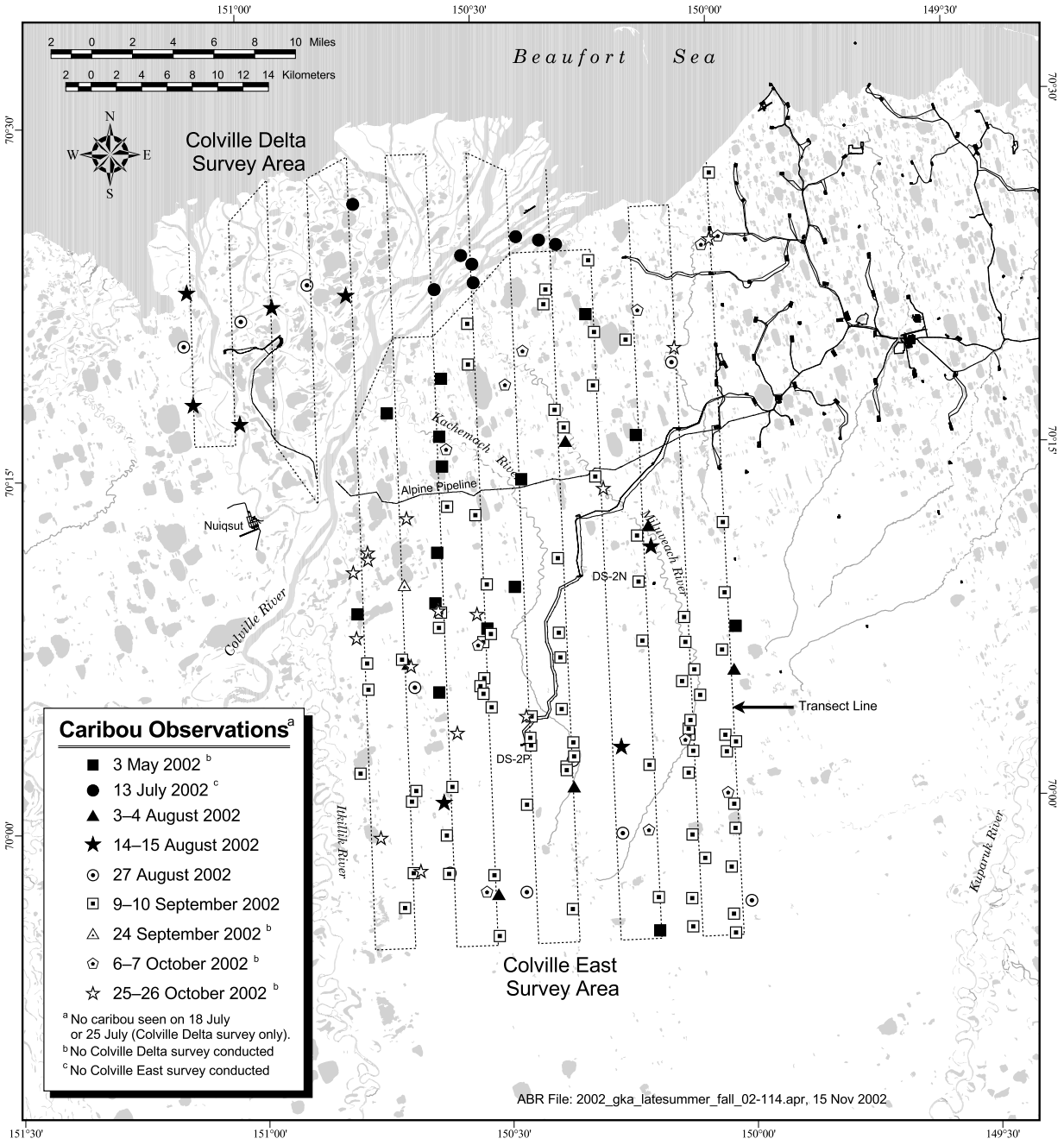

Figure 15. Distribution and number of caribou observed in late summer and fall in the Colville East and Colville Delta survey areas, 3 May and 13 July-25 October 2002.

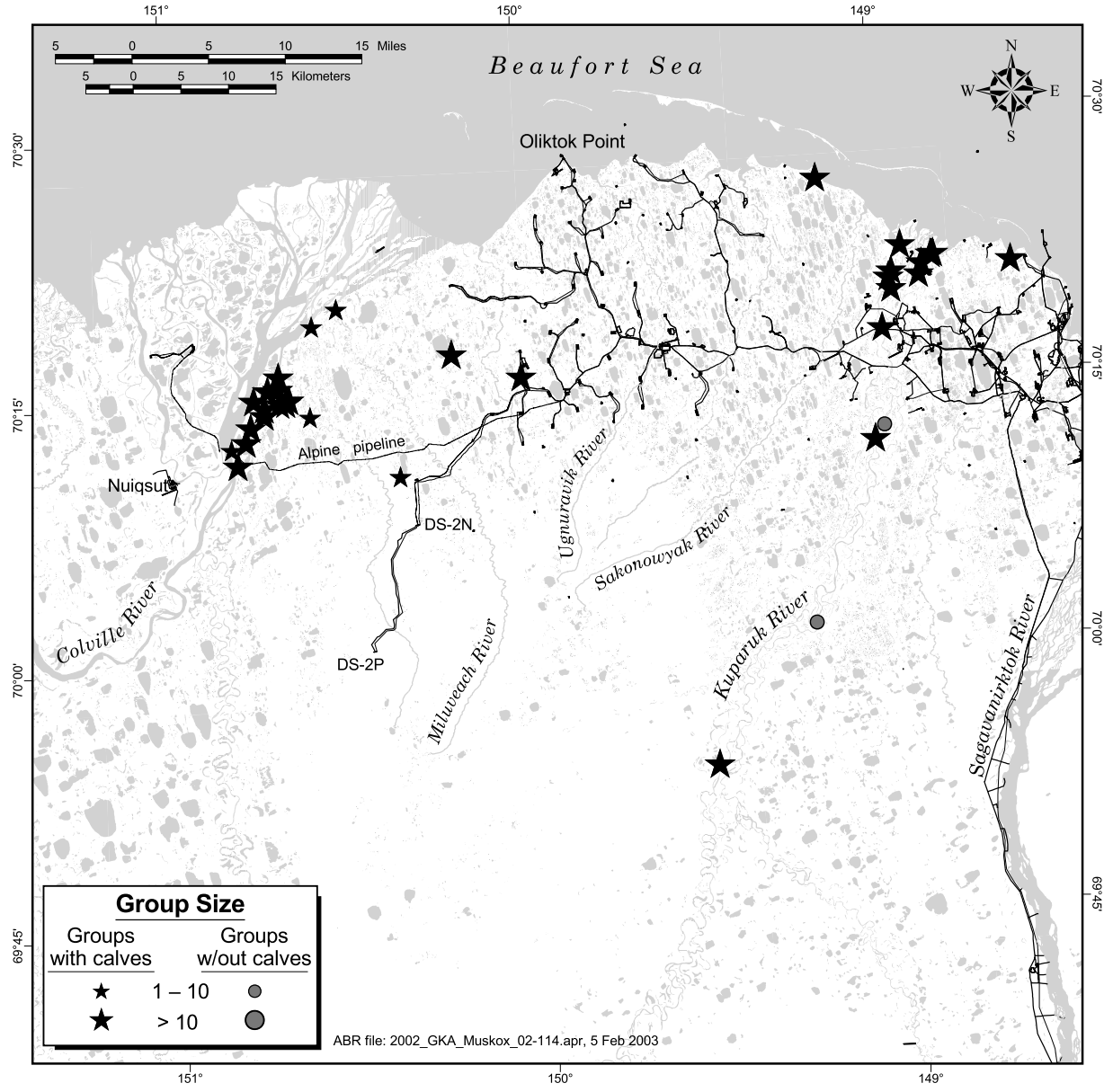

Figure 16. Distribution of muskoxen observed on aerial surveys of the Kuparuk–Colville region, May–October 2002.

Table 8. Group size, number of calves, and general location of muskoxen observed in the Kuparuk–Colville region, May–October 2002.

Group	Sighting No.	Date	Total	Large [a]	Calves [a]	General Location [b]
Colville River	1	May 3	34	33	1	Colville R., E side
	2	May 25	37	32	5	Colville R., E side
	3	June 7	8	5	3	Colville R., E side
	4	June 7	33	27	6	Colville R., E side
	5	June 10	32	nr	nr	Colville R., E side
	6	June 29	25	20	5	Colville R., E side
	7	July 13	25	nr	nr	Colville R., E side
	8	July 23	12	8	4	Colville R., E side
	9	July 25	27	23	4	Colville R., E side
	10	Aug. 4	10	7	3	Colville R., E side
	11	Aug. 4	23	19	4	Colville R., E side
	12	Aug. 14	10	7	3	Colville R., E side
	13	Aug. 15	12	10	2	Kuparuk field, W of CPF-2
	14	Aug. 22	9	6	3	Colville R., E side
	15	Aug. 22	11	9	2	Kuparuk field, S of DS-3S
	16	Aug. 26	7	7	2	Kuparuk field, W of DS-2L
	17	Sep. 24	14	9	5	Colville R., E side
	18	Oct. 7	11	nr	nr	Colville R., E side
	19	Oct. 25	15	13	2	Colville R., E side
Kuparuk Delta	1	June 7	31	24	7	Beechey Pt.
	2	June 12	32	25	7	Kuparuk R. Delta
	3	June 29	15	14	1	Kuparuk R. Delta
	4	June 30	15	14	1	Kuparuk R. Delta
	5	July 9	30	26	4	Kuparuk R. Delta
	6	July 15	29	23	6	Pt. McIntyre
	7	July 19	29	23	6	Kuparuk R. Delta
	8	July 20	13	nr	nr	Kuparuk R. Delta
	9	July 21	30	24	6	Kuparuk R. Delta
	10	July 23	30	24	6	Kuparuk R. Delta
	11	July 24	27	21	6	Kuparuk R. Delta
Kuparuk River	1	June 7	1	1	0	Kuparuk R., S of pipeline
	2	July 7	4	4	0	Kuparuk R., S of pipeline
	3	July 26	17	nr	nr	Kuparuk R., S of pipeline
	4	Aug. 27	12	nr	nr	Kuparuk R., S of pipeline

[a] nr = not recorded
[b] E = east, W = west, S = south

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Appendix A. Snow depth (inches on ground) and sum of thawing degree-days (TDD; º C above freezing) at the Kuparuk airstrip, April–June 1983–2002.

	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
2002	12	trace	0	4.4	31.1	59.4
Average	8.1	4.3	1.45	0.8	11.0	40.2

* Value for June 1

Appendix B. Estimated numbers and densities of caribou in the Kuparuk Field, Kuparuk South, Colville East, Colville Inland, and Colville Delta calving survey areas in 1993 and 1995–2002.

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 [h]	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
	6, 8 June 2002	1035	1124	1.09	304	0.29	None
	12 June 2002	1035	886	0.86	226	0.22	None
Kuparuk South [b,c,g]	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
	7 June 2002	788	4256	5.40	1002	1.27	None
	11 June 2002	788	4778	6.06	1164	1.48	None
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,i]	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

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
	3–4 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
	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
	6–7 June 2002	1432	5584	3.90	830	0.58	None
	10–11 June 2002	1432	6232	4.35	1034	0.72	None
Colville Delta	28 May 1993	637	27	0.04	0	0	High; SCF not used
	10 June 1993	637	0	0	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	0	0	High; SCF not used
	12/ 20 June 1997	636	0	0	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.
[g] Enlarged and extended east to Kuparuk River in 2002.
[h] Dropped two eastern transects in 2002.
[i] Dropped one western transect in 2002.

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 1983–2002.

	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	245.0
2001	75.0	82.2	185.6	267.8
2002	72.8	93.9	136.1	230.0
Average	96.1	125.7	142.0	267.7

* Some missing values estimated by interpolation

Appendix D. Average index values of oestrid fly and mosquito activity (adapted from Russell et al. 1993) during June–August 1983–2002, 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
2002	0.18	0.18	0.18	0.23	0.49	0.36	0.30[a]	0.24[a]	0.27[a]
1983–2002	0.08	0.28	0.18	0.44	0.47	0.46	0.41	0.16	0.28
1993–2002	0.11	0.29	0.20	0.51	0.50	0.50	0.48	0.16	0.31

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
2002	0.25	0.30	0.28	0.43	0.61	0.52	0.40 [a]	0.36 [a]	0.38 [a]
1983–2002	0.17	0.43	0.30	0.58	0.60	0.59	0.55	0.29	0.41
1993–2002	0.22	0.43	0.32	0.63	0.62	0.63	0.61	0.28	0.44

[a] Preliminary data