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LARGE MAMMAL DISTRIBUTION IN THE BADAMI STUDY AREA, SUMMER 2000

Prepared for

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ABSTRACT

We documented the distribution of large mammals within a study area from the Beaufort Sea south as far as lat 69°54.5'N between the Sagavanirktok River delta and Bullen Point on the North Slope of Alaska. Five systematic aerial strip-transect surveys, at 100% coverage, were flown from 17 June to 25 July 2000. During the 17 June caribou (*Rangifer tarandus*) calving period survey (south to lat 70°N), 915 caribou were counted, including 261 calves (48 calves:100 cows). Most calves (98%) were south of the Badami pipeline. Mean total caribou density from 1998 to 2000 calving period surveys was 0.73 ± 0.477 caribou/km^2, while mean calf density was 0.20 ± 0.161 calves/km^2. During the 4 post-calving period surveys (south to lat 69°54.5'N), the total number of caribou ranged from 1,398 to 6,167. Annual post-calving caribou densities for 1997 to 2000 ranged from 2.05 ± 4.42 caribou/km^2 in 1997 to 4.20 ± 3.83 caribou/km^2 in 2000. Across years, mean caribou density was 3.14 ± 1.19 caribou/km^2. Comparisons of the proportions of caribou within coastal (0 to 4 km) and inland (4 to 8 km) intervals, from the Beaufort Sea coast in the Badami study area with those in the adjacent Bullen Point to Staines River study area, suggest general similarities in distributions during 2000. Similarities included: (1) ≤40% of caribou were within 4 km of the coast in June; and (2) >55% of caribou were within 4 km of the coast on 2 of 3 surveys in July. To evaluate potential blockage of caribou movements between coastal insect-relief habitat and inland foraging habitats by the elevated Badami pipeline, we compared paired survey data from 1998, 1999, and 2000. We tested for differences in the proportions of caribou within coastal and inland areas. For individual Badami and Bullen Point to Staines River post-calving survey pairs from 1998 to 2000, the proportion of caribou near the coast in the Badami study area was significantly lower for 2 surveys, while there was no difference between study areas for 4 surveys. There was no consistent difference in the proportions of caribou within coastal intervals between these study areas using paired-sample analysis. We evaluated caribou distributions pre- and post-pipeline within 22 linear segments each extending 1 km north and south of the Badami pipeline and found there appears to have been a shift in concentrations from the eastern segments of the pipeline before construction to western segments of the pipeline post-construction. This apparent shift, however, was likely due to general changes in caribou distribution and abundance throughout the study area, rather than the presence of the pipeline. There does not appear to be any consistent widespread avoidance of the pipeline corridor. Other large mammals observed in 2000 included grizzly bears (*Ursus arctos*), muskoxen (*Ovibos moschatus*), and moose (*Alces alces*).

Key words: Alaska, caribou, Central Arctic Herd, elevated pipeline, grizzly bear, muskoxen, North Slope, oilfield, *Ovibos moschatus*, *Rangifer tarandus*, *Ursus arctos*

INTRODUCTION

STUDY RATIONALE

Caribou are the arctic coastal plain's most conspicuous summer resident. They are an important subsistence and cultural resource for Inupiat communities. Perceived detrimental effects of oil and gas development on caribou have affected industrial access to natural resources on the coastal plain. Controversy over potential development effects on caribou has been an issue since the beginning of oil and gas development on Alaska's North Slope. Perceptions that calving caribou and oilfield development cannot coexist, and that oilfield infrastructure blocks caribou movement to coastal insect-relief habitats, are widely held. These beliefs persist despite a lack of evidence that oilfield developments have had any herd level effect on CAH caribou (Cronin et al. 1998, 2000). A lack of pre-development caribou calving distribution data, along with a lack of post-development calving caribou use, have led to speculation that development of the Prudhoe Bay oilfield caused caribou to abandon this area for calving (Whitten 2001).

Therefore, pre-development and post-development data on caribou distribution, abundance, and reproductive status in the Badami study area are necessary to assess potential development impacts and to develop effective mitigation measures. Potential impacts to caribou from oilfield development due to construction of roads, pipelines, or other related facilities and oilfield activities in the Badami study area include: (1) displacement or blocked access of CAH caribou to calving habitats, (2) displacement or blocked access of CAH caribou to post-calving and coastal insect-relief habitats; and (3) blocked PCH and CAH movements to and from the Arctic National Wildlife Refuge.

Environmental assessments have been completed for three oil exploration and development areas between the Sagavanirktok River delta and the Staines River: (1) Sourdough, (2) Yukon Gold, and (3) Badami. In support of these environmental assessments, LGL Alaska Research Associates, Inc. (LGL) was contracted by BP Exploration (Alaska) Inc. to collect baseline large mammal distribution information during aerial surveys conducted between the Sagavanirktok and Staines rivers for most years since 1993 (Pollard and Noel 1994, 1995; Noel 1998; Noel and Olson 1998, 1999; Noel and King 2000a, 2000b). Data collection in the adjacent Bullen Point to Staines River study area allows comparison of caribou distributions between these two areas. Monitoring caribou distribution and abundance at the Badami pipeline and coastal development allows direct comparison to assess potential impacts from similar developments in the Point Thomson Unit. These data are critical to evaluate post-development effects on caribou distribution.

LARGE MAMMALS BETWEEN THE SAGAVANIRKTOK AND THE STAINES RIVERS

Caribou (*Rangifer tarandus*) from 2 herds may occur in the area between the Sagavanirktok and Staines/Canning rivers: the Central Arctic Caribou Herd (CAH) and the Porcupine Caribou Herd (PCH). Studies conducted over the past 20 years in the Arctic National Wildlife Refuge (ANWR) (Figure 1) have shown that little, if any, PCH calving occurs west of the Canning River, nor is the area used by large numbers of PCH caribou during post-calving and dispersal periods (Clough et al. 1987, Russell et al. 1993). Most caribou observed within this area probably belong to the CAH.

During spring migration, CAH caribou move from the northern foothills of the Brooks Range to the coastal plain. In general, cows arrive on the coastal plain between late April and early June, while bulls do not arrive until post-calving in early July (Whitten and Cameron 1980, Jakimchuk et al. 1987). The CAH uses two general areas for calving: (1) west of the Sagavanirktok River (near the Kuparuk and Milne Point oilfields), and (2) east of the Sagavanirktok River and west of the Canning River. Two areas with CAH calving concentrations have been documented in most years since 1969: (1) between Oliktok Point and the Kuparuk River (Kuparuk and Milne Point), and (2) between Bullen Point and the Canning River (Figure 1; Cameron and Whitten 1978, Gavin 1983, Lawhead and Curatolo 1984, Whitten and Cameron 1985, Cameron et al. 1989). Lower-density concentrations of calving caribou have been observed west of the Colville River and east of the Canning River (Carruthers and Jakimchuk 1986). Curatolo and Reges (1984) described the 1984 CAH calving distribution as low-density and relatively dispersed, especially in comparison with other herds. The number of caribou using east and west ranges fluctuate among years, probably due to movements across the Sagavanirktok River (Cronin et al. 2000).

The CAH uses a broad area along the Arctic Coastal Plain between the Colville and Canning rivers for summer range (Figure 1; Smith 1996). Coastal areas, river deltas, river channels, and wind-swept uplands and ridges are used as insect-relief habitats by mosquito- and oestrid fly-harassed caribou during the post-calving period. Large groups of caribou have often been observed near Franklin Bluffs and on the deltas of the Kadleroshilik, Sagavanirktok, Shaviovik, and Staines rivers (Gavin 1983, Carruthers et al. 1984). Lawhead and Curatolo (1984) reported that large aggregations of caribou sought relief on or near deltas of the Kuparuk, Shaviovik, and Canning rivers during intense insect harassment, as well as along the coast between Oliktok Point and the Canning River. Beginning in late July or early August, caribou begin to disperse across the coastal plain as mosquito harassment abates and oestrid fly harassment increases (Curatolo 1975, Lawhead and Curatolo 1984, Carruthers et al. 1987). Caribou gradually drift inland, group sizes decrease, and movement patterns become less directed (Carruthers et al. 1987, Jakimchuk et al. 1987, Cameron et al. 1989).

Other large mammals that occur between the Sagavanirktok and Staines rivers include muskoxen (*Ovibos moschatus*), grizzly bears (*Ursus arctos*), moose (*Alces alces*), and wolves (*Canis lupus*) (Figure 1). By the late 1800s, muskoxen were extirpated from the North Slope of Alaska and little is known about historic population levels (Clough et al. 1987). Muskoxen were reintroduced into the Arctic National Wildlife Refuge (ANWR) in 1969 and 1970 and the population has grown exponentially since 1974. Mixed-sex herds have dispersed into areas east of the Aichilik River (Clough et al. 1987), and they have also dispersed to the west as far as the Colville River (J. Helmericks, pers. comm.). Muskoxen have been regularly sighted as far west as the Sagavanirktok River near the Prudhoe Bay oilfield (Pollard and Noel 1994, 1995; Noel 1998). Muskoxen are generally considered non-migratory, but may move in response to seasonal changes in snow cover and vegetation. During summer and fall, muskoxen are found primarily in riparian habitats, which are important for travel and foraging, but they move to adjacent uplands in winter and spring (Clough et al. 1987).

Coastal areas are used seasonally by grizzly bears. Bears generally move north from denning areas in the foothills of the Brooks Range in late May and are most abundant in the study area during June and July. In late July, most bears gradually return south to the foothills (Figure 1; Clough et al. 1987). Moose are uncommon on the North Slope, but they were observed in the area during 1994 and 1995 summer surveys (Pollard and Noel 1994, 1995). Wolves are also uncommon, but were observed west of Bullen Point in the southern portion of the Badami study area during a summer 1999 survey (Noel and King 2000b).

SURVEY OBJECTIVES

Our aerial survey program in 2000 was to determine the distribution and abundance of caribou and other large mammals within the Badami study area during the calving and post-calving periods. Our primary objectives were to: (1) determine the number, sex-age composition, and distribution of large mammals during the caribou calving and post-calving seasons; (2) compare distribution and abundance of large mammals in the Badami study area with the adjacent Bullen Point to Staines River study area; and (3) evaluate the effects of the Badami pipeline on caribou movements between the Beaufort Sea coast and areas south of the pipeline.

STUDY AREA

In 1997, LGL established two study areas: (1) Badami, between the Sagavanirktok River delta and Bullen Point, and (2) Bullen Point to the Staines River. These two study areas extend from the Beaufort Sea coastline south to lat 69°54.5'N in most years. Surveys of these two study areas continued during summer 2000 and this report includes our 2000 survey results and related data analyses for the Badami study area. Results of surveys in the Bullen Point to Staines River

study area are presented in the report *Bullen Point to Staines River Large Mammal Distribution, Summer 2000* (Noel and Olson 2001)

BADAMI

The 2000 Badami study area was bounded on the west by the Sagavanirktok River, extended east to Bullen Point, north to the Beaufort Sea, and south to approximately lat 69°54.5'N (Figure 2). We used a southern boundary of lat 69°0'N during the single calving period survey. The area is part of the Arctic Coastal Plain, and is characterized by a gently rolling thaw lake plain landscape (Walker and Acevedo 1987). Tundra in the area gradually rises 6 to 8 m above the level of streams and river channels. Topographic relief results in many well-drained areas; moist and dry tundra vegetation types are common on high-centered ice wedge polygon terrain. However, drainage is poor away from fluvial gradients and low-centered ice wedge polygons; strangmoor, thaw lakes and ponds, and drained lake basins predominate in these areas. The Badami pipeline extends 40 km across the northernmost section of the study area. The pipeline ranges from 1 to 5 km inland from the coast between the Endicott pipeline to the west and the Badami facility to the east (Figure 2).

BULLEN POINT TO STAINES RIVER

The 2000 Bullen Point to Staines River study area was bounded on the west by Bullen Point, extended east to the Staines River, north to the Beaufort Sea, and south to approximately lat 69°54.5'N (Figure 1). This area is part of the Arctic Coastal Plain, which is characterized by a gently rolling thaw lake plain landscape (Walker and Acevedo 1987). Tundra within 5 mi of the coast has little topographic relief. Further inland, the landscape begins a gradual assent from 25 to 350 ft above sea level at the southern edge of the study area (about 24 mi inland from the Beaufort Sea coast). Contours within the study area form concentric bands oriented north-northwest. The area has been referred to as the Canning alluvial fan, formed by sediment deposition from the Canning River. Calcarious loess deposited downwind of the Canning River results in soils with high silt content, high pH (6.0 to 8.4), and low organic content (Tedrow 1977, Gesper et al. 1980). Vegetation in the southern portion of the study area is a mixture of dry or moist herbaceous tundra and wet herbaceous tundra. Moisture increases to the east, approaching the Canning River, and toward the coast (U.S. Geological Survey 1981, Mt. Michelson, Map I.-206).

METHODS

AERIAL SURVEYS

During summer 2000, we conducted 5 systematic strip-transect aerial surveys (Caughley 1977) from a Cessna 206 fixed-wing aircraft. A single caribou calving period (≤20 June) survey

was flown on 17 June, and post-calving period (>20 June) surveys were flown on 29 June, 7 July, 21 July, and 25 July. We completed 1 instead of the usual 2 calving period surveys in 2000, because the Alaska Department of Fish and Game (ADFG) was also flying a calving period survey within this study area. Because of a combination of problems with our additional survey aircraft and poor flying weather, we were unable to complete the 7 planned surveys. Between 1994 and 2000, 9 calving period (<21 June) surveys were conducted in 5 study years (1994 = 3, 1995 = 1, 1998 = 2, 1999 = 2, 2000 = 1). Twenty-six post-calving period surveys in 6 years were conducted between 1994 and 2000 (1994 = 7 surveys, 1995 = 2, 1997 = 3, 1998 = 5, 1999 = 5, 2000 = 4).

Transect centerlines, spaced at 1.6-km intervals, were oriented north-south and centered on township and section lines mapped on 1:63,360 scale U.S. Geological Survey (USGS) topographic maps. Twenty-seven transects (numbered 21 through 47; Figure 1) were flown during each of the 5 surveys. Surveys were flown at 90 m altitude and 115 to 125 km/hr airspeed. Two observers were used for each survey; each observer was responsible for searching an 800-m swath on one side of the transect centerline, providing for 100% transect coverage. Aircraft wing struts were marked to enable visual control of transect strip width (Pennycuick and Western 1972). Observers verified strut markings using inclinometers.

A global positioning system (GPS) receiver was used by the pilot to navigate. Locations of the aircraft at the time of animal sightings were determined using a separate Motorola Workhorse™ GPS receiver linked to a notebook computer using Geolink® software. This system associated a real-time GPS-determined position with each sighting record. Sighting data were entered by a third crewmember acting as a data recorder (17 and 29 June, 7 and 21 July) or by one of the two observers (25 July). Sighting entries included a visual estimate of distance from the aircraft, species, and number of individuals by sex-age classification. Coordinates of animal sightings were later calculated using the visual estimates of distance from the aircraft to offset the GPS aircraft positions. When possible, predominant behavior and habitat were noted along with group attributes and time of sighting on audiotapes; these data were later transcribed and added to the survey database. Behavior was defined as the activity of the majority of caribou in a group. Habitat types were categorized from the observer descriptions, which included comments on landform features and soil moisture following Walker's (1983) hierarchical classification system.

We counted and classified caribou as bulls, cows, calves, or unclassified based on body size, antler development, pelage, and calf presence. "Unclassified" caribou were adults (or yearlings) that could not be classified with confidence. Caribou near the outer margin of transect strips were most difficult to count and classify. Other factors that may have affected counting and classification of caribou include observer experience, lighting conditions, caribou behavior, and

survey weather conditions. When a large group of caribou was encountered, the survey aircraft often left the transect and circled the group to facilitate counting and classification. The GPS allowed the aircraft to return to the point of departure from the transect; therefore, no survey coverage was lost as a result of transect departures. In some cases, caribou group counts were refined using counts made from oblique 35 mm slides taken during the surveys. Muskoxen were classified as bull, cow, unclassified, or calf; grizzly bears as adult or female with cubs; and arctic foxes as adult or kit.

DATA ANALYSIS

We used MapInfo® Geographic Information System (GIS) software to map and analyze the survey data. The base maps used for analyses were at a scale of 1:63,360. To assist with describing the summer 2000 distributions, we constructed a set of concentric 1-km interval buffers around the Beaufort Sea coastline in the Badami and Bullen Point to Staines River study areas, and summarized caribou numbers by distance interval. Caribou densities (caribou/km^2) were calculated for each distance interval using the total land area of each interval. Caribou density within the Badami study area was calculated using the total land area of the 2000 Badami study area (calving = 1334.3 km^2, post-calving = 913.2 km^2) as the divisor.

Caribou observations recorded during surveys conducted in 1994, 1995, 1997, 1998, 1999, and 2000 compared caribou use of the study area among years. The southern boundary of the study area varied among years; consequently, we established a common multi-year boundary and limited most analyses to this area. Because caribou behavior, distribution, and sex-age composition differ between the calving and post-calving periods (Whitten and Cameron 1980), we prepared separate analyses for each of these two periods using ≤20 June as the end of the calving period.

We excluded 5 of these surveys (1994 and 1995 surveys and 19 June 1999 survey) from calculation of area wide calving-period statistics because of incomplete coverage of the study area. Calving and post-calving surveys were flown in 1993 within the Badami study area, but survey coverage was 50%, not 100% (LGL unpublished data). Because the post-calving surveys were primarily conducted in June and July when parasitic insects are most active (20 of 23 surveys), we limited our analyses to surveys conducted during those months. Although the 1994 and 1995 surveys were included for analyses of distributions within 8 km of the study area coastline, these surveys were excluded from calculations of area wide statistics because of limited coverage of the study area (Pollard and Noel 1994, 1995).

We calculated parasitic insect activity based on weather parameters using predictive models of mosquito activity (Russell et al. 1993) and oestrid fly activity (Mörschel 1999; Appendix B). Insects were also considered active based on a mean daily temperature of ≥13 °C and a mean

daily wind velocity of <6 meters per second (mps) following Walsh et al. (1992). Mosquito and oestrid fly activity index values were calculated for each hour that temperature and wind data were recorded at the Deadhorse Weather Station (ASCC 2001; Appendix B). All mean values are presented with 95% confidence intervals.

Caribou Distribution in Relation to the Badami Pipeline

We evaluated caribou distributions based on aerial survey data for: (1) blockage or delay of north-south movements between coastal foraging habitats and insect-relief inland habitats, and (2) changes in pre- and post-pipeline east-west crossing corridors. For north-south movements across the pipeline, we paired post-pipeline caribou surveys in the Badami study area (experimental) with caribou surveys in the Bullen Point to Staines River study area (control). For east-west crossing corridors we compared combined pre-pipeline and combined post-pipeline caribou surveys within 22 east-west segments along the pipeline corridor.

We graphically compared the proportions of caribou found within coastal and inland areas of the Badami study area to proportions observed in the adjacent Bullen Point to Staines River study area for paired surveys during summer 2000 (Noel and Olson 2001). Because the Badami pipeline is primarily within 4 km of the coastline, we summarized caribou counts by survey and study area for coastal (0 to 4 km) and inland (4 to 8 km) intervals. If caribou movements between coastal and inland habitats were blocked or significantly delayed by the pipeline, we would expect differences in the proportions of caribou in coastal vs. inland areas between these two study areas. This summary was prepared using buffers of the Beaufort Sea coastline for the Badami and Bullen Point to Staines River study areas.

We also evaluated paired aerial survey data after pipeline construction from 1998, 1999, and 2000 and tested for differences in the proportions of caribou within coastal and inland areas. We limited this analysis to paired surveys on consecutive days with ≥20 caribou within each study area. This resulted in a sample size of 6 survey pairs, 2 calving period and 4 post-calving period (29, 30 June 1998; 14, 15 June 1999; 25, 26 July 1999; 15, 16 June 2000; 28, 29 June 2000; 6, 7 July 2000). We tested the null hypothesis:

$H_0 1$: The proportions of caribou in coastal (0 to 4 km interval) and inland (4 to 8 km interval) areas are not different between the Badami study area and the Bullen Point to Staines River study area.

Test: Wilcoxon Signed Rank Test (non-parametric paired test), Comparison of Proportions (approximation for Fisher Exact Test, Zar 1974).

For changes in east-west crossing corridors, we compared pre-pipeline and post-pipeline caribou distributions along the Badami pipeline corridor. We developed a buffer that extended

1 km north and 1 km south of the pipeline and subdivided this into 22 segments that corresponded with north-south township and section lines. An assumption inherent in this presentation was that caribou either had crossed or would cross the pipeline within the segment in which they were recorded. Caribou numbers were summarized by segment for pre-pipeline (1994, 1995, and 1997; $n = 10$ surveys) and post-pipeline (1998, 1999, and 2000; $n = 13$ surveys) surveys. There is no *a priori* reason to expect caribou distributions to be consistent either day-to-day or year-to-year within these pipeline segments. Because caribou distributions are inherently variable and we have not attempted to determine or control for other factors influencing caribou distribution, no statistical analyses were completed. This summary was used to evaluate the pipeline corridor for potentially unused or avoided segments. Based on Landsat land cover mapping, habitats at pipeline segments were evaluated as the sum of area by land cover type within a 500-m buffer of the pipeline (Walker and Acevedo 1987).

RESULTS

SUMMER 2000 SURVEYS

Synopsis

Five aerial surveys of the Badami study area were completed, (Figure 3, Table 1 and Appendix A). Almost all (99%) classified caribou on the 17 June calving period survey were cows and calves. Calf density on the 17 June survey was 0.20 calves/km^2, while total caribou density was 0.69 caribou/km^2. For the 4 post-calving surveys combined, the composition of classified caribou was 36% bulls, 42% cows, and 22% calves. The density of calves during post-calving period surveys ranged from 0.20 calves/km^2 (29 June) to 0.74 calves/km^2 (7 July). Total caribou densities were highest in the Badami study area on 7 July (6.75 caribou/km^2), and 21 July 2000 (6.62 caribou/km^2).

Muskoxen were observed during 3 of the 5 surveys (Table A-2). Of the 14 muskoxen recorded, 13 were within 100 m of a stream or river (Figures A-1, A-2, and A-5). Other mammals seen included arctic foxes at dens during 2 surveys, grizzly bears during 3 surveys, and moose during 2 surveys (Figures A-2, A-4, and A-5; Table A-2).

Aerial Survey Descriptions

Survey 1, 17 June 2000.—Survey conditions were good, with clear skies, winds at 1.5 to 5.6 mps primarily from the east-northeast (50° to 90°), and temperature 12 to 14 °C from 1100 to 1700 Alaska Daylight Savings Time (ADST; ASCC 2001). The study area was primarily snow-free with some areas of flooding. Indices of parasitic insect activity indicated conditions were not favorable for mosquito or oestrid activity on 17 June (Figure 4, Table B-1). Small groups of primarily cows and calves (mean = 5.4 ± 0.93 caribou/group) were scattered throughout the study

area, primarily south of the Badami pipeline (Figure A-1, Table 2). The calf:cow ratio was 47 calves:100 cows, with calf density in the study area 0.20 calves/km^2. Many calves (55%) were west of the Kadleroshilik River, 11% were between the Kadleroshilik River and the Shaviovik River, and 34% were east of the Shaviovik River (Figure A-1). For caribou sightings with behavior and habitat noted, most (68%) were feeding or resting on moist tundra, primarily tussock tundra (Table 3). In addition to caribou, 2 muskoxen were observed on the Sagavanirktok River delta resting on moist tundra (Figure A-1, Table A-2).

Survey 2, 29 June 2000.—Survey conditions were good, with high overcast skies, winds 3.1 to 3.6 mps from the northwest (300° to 340°), and temperature 2 to 6 °C between 1000 and 1500 ADST (ASCC 2001). Indices of parasitic insect activity indicated conditions were not favorable for mosquito or oestrid activity on 29 June (Figure 4, Table B-1). Both caribou group size (mean = 12.4 ± 3.36 caribou/group) and total density (1.53 caribou/km^2) were nearly doubled from 17 June 2000. The composition of classified caribou was 21% bulls, 59% cows, and 20% calves. Ninety percent of caribou were south of the Badami pipeline and east of the Kadleroshilik River, where more than half of caribou were west of the Shaviovik River (Figure A-2). Very few caribou were north of the pipeline (Table 2). Many caribou (58%) were feeding or resting on moist or dry tundra (Table 3). Other mammals recorded during the survey included 6 muskoxen (all east of the Shaviovik River); 2 grizzly bears; and 2 arctic foxes, including one with 2 kits (Figure A-2, Table A-2).

Survey 3, 7 July 2000.—Survey conditions were good, with 5000 to 13,000 ft scattered to broken cloud cover, winds 4.1 to 6.7 mps primarily from the west (240° to 290°), and temperature 17 to 19 °C between 1000 and 1500 ADST (ASCC 2001). Indices of parasitic insect activity indicated conditions were not favorable for mosquito or oestrid activity on 7 July (Figure 2, Table B-1). Mean daily temperature and wind speed, however, may have been favorable for insect activity (Walsh et al. 1992, Figure 2, Table B-1). Mean group size increased but was highly variable (293.7 ± 249.55 caribou/group). Total caribou density was 6.75 caribou/km^2, with the composition of classified caribou 22% bulls, 46% cows, and 31% calves. Many caribou (65%), however, were not classified for sex/age. Most caribou (77%) were north of the Endicott road near the West Channel of the Sagavanirktok River (Figure A-3). Almost all caribou were within 4 km of the Beaufort Sea coast, while 13% were north of the Badami pipeline (Tables 2 and 5). For caribou groups with behavior and habitat recorded, feeding and resting were still dominant behaviors (85%), but many groups (54%) were using barren or partially barren habitats (Table 3).

Survey 4, 21 July 2000.—Survey conditions were good, with scattered clouds at 6000 and 20,000 ft, winds 2.6 to 4.1 mps from the east-northeast (50° to 70°), and temperature 11 to 14 °C between 1300 and 1800 ADST (ASCC 2001). Indices of parasitic insect activity indicated

conditions were not favorable for mosquito or oestrid activity on 21 July (Figure 4, Table B-1). Mean group size was similar to 7 July (208.4 ± 167.88 caribou/group), as was total caribou density (6.62 caribou/km^2). The proportion of bulls among classified caribou increased from previous surveys to 52% bulls, 32% cows, and 16% calves. Many caribou (77%) were along the East Channel of the Sagavanirktok River or in the river delta, while 34% were north of the Badami pipeline (Figure A-4, Table 2). About half of the caribou sightings with behavior noted, were traveling and half were resting or feeding (Table 3). For resting or feeding groups nearly half were on barren or partially barren habitats (Table 3). Other mammals recorded during the survey included a grizzly bear, a moose, and an arctic fox with 3 kits on a den (Figure A-4, Table A-2, Attribute 10). No foxes were at a 2nd den where 2 kits were observed on 29 June (Figure A-4, Table A-2, Attribute 6).

Survey 5, 25 July 2000.—Survey conditions were fair, with low clouds, occasional mist, winds 2.6 to 4.1 mps from the northwest (310° to 340°), and temperature 8 to 9 °C between 0900 and 1400 ADST (ASCC 2001). Indices of parasitic insect activity indicated conditions were not favorable for mosquito or oestrid activity on 25 July (Figure 4, Table B-1). Mean group size (61.4 ± 34.41 caribou/group) was less than half that recorded during the 21 July survey, while total caribou density declined to 2.89 caribou/km^2. The proportion of bulls among classified caribou was more similar to the 29 June and 7 July surveys with 29% bulls, 48% cows, and 23% calves. Seventy-five percent of caribou were south of the Badami pipeline between the Sagavanirktok and Kadleroshilik rivers, while 15% were near the Shaviovik River at the southern end of the study area (Figure A-5, Table 5). For caribou groups with behavior and habitat recorded 47% were feeding or resting primarily on moist or dry tundra, while 53% were moving also primarily on dry or moist tundra (Table 3). For moving caribou groups the primarily direction of travel was toward the coast (Table A-1). Other mammals observed included a grizzly bear near the Shaviovik River, a moose at a pond between the Sagavanirktok and Kadleroshilik rivers, and 6 muskoxen along the Sagavanirktok River (Figure A-5, Table A-2). The grizzly bear was within 3.5 km of the bear observed on 21 July (Figure A-4).

CARIBOU DISTRIBUTION AND ABUNDANCE IN THE BADAMI STUDY AREA: MULTI-YEAR COMPARISONS

Calving period caribou density for individual surveys from 1998 through 2000 ranged from 0.46 caribou/km^2 to 1.09 caribou/km^2. Both extremes occurred in 1998. Calf:cow ratio ranged from 38 calves:100 cows on 15 June 1999 to 51 calves:100 cows on 15 Jun 1998. Across surveys, mean total caribou density was 0.73 ± 0.48 caribou/km^2, while mean calf density was 0.20 ± 0.16 calves/km^2. Calves occurred primarily >4 km inland from the Beaufort Sea coast for all calving period surveys (Figure 5).

Post-calving period caribou density for individual surveys from 1997 through 2000 ranged from 0.01 caribou/km^2 to 7.64 caribou/km^2. Annual post-calving caribou densities ranged from 2.05 ± 4.42 caribou/km^2 in 1997 to 4.20 ± 3.83 caribou/km^2 in 2000. Across surveys, mean caribou density was 3.14 ± 1.19 caribou/km^2. To identify areas along the coast where caribou concentrated during the post-calving period, we plotted the locations of all caribou groups within 8 km of the coast by survey year (Figure 6). Coastal areas consistently used by caribou included the Sagavanirktok, Shaviovik, and Kadleroshilik rivers, deltas, and associated bays (Figure 6).

CARIBOU DISTRIBUTIONS AND THE BADAMI PIPELINE CORRIDOR

On the day prior to each Badami survey, we conducted an aerial survey of the adjacent Bullen Point to Staines River study area (Figure 2, Noel and Olson 2001). Similarities in distributions between these areas during each 2-day set of surveys flown in 2000 included: (1) ≤40% of caribou were within 4 km of the coast in June; and (2) >55% of caribou were within 4 km of the coast on 2 of 3 surveys in July (Figure 7). Caribou density was consistently higher within 8 km of the coast in the Badami study area than in the Bullen Point to Staines River study area during 2000 (Figure 7).

For individual Badami and Bullen Point to Staines River survey pairs flown on consecutive days from 1998 to 2000, the proportion of caribou near the coast in the Badami study area was significantly lower for 2 surveys, and not significantly different for 4 surveys (Figure 8). However, there was no consistent difference in the proportions of caribou within coastal intervals between these study areas using paired-sample analysis (Wilcoxon Signed Rank Test: $-T$ = -11.00 (4.00), P = 0.4185, n = 5). The 29 and 30 June 1998 survey pair was not testable because no caribou were present in the inland intervals for either study area.

We also compared the pre-pipeline and post-pipeline distributions of caribou among 22 linear segments of a 1-km buffer of the Badami pipeline (Figure 9). During the pre-pipeline surveys caribou appeared more concentrated in the eastern segments; while post-pipeline surveys indicate caribou were more concentrated in western segments (Figure 10). The peaks in proportions at Segment 21 (pre-pipeline) and Segment 10 (post-pipeline) were caused by the presence of 2 large caribou groups, 1 pre- and 1 post-pipeline (Figure 10). After pipeline construction there appears to be a trend towards more consistent presence of caribou within some western buffer segments (Figure 10). These changes may represent differences in caribou distribution attributable to the pipeline construction. They may also reflect uncontrolled variables: (1) the greater number of surveys post-construction (13 vs. 10), (2) the greater number of caribou post-construction (3,752 vs. 649), (3) the greater number of caribou groups post-construction (59 vs. 29), (4) the tighter association of caribou with riparian habitats for some surveys post-construction, or (5) a combination of these (Figure 11). Habitats at buried pipeline segments in riparian habitats (2, 6, 10, and 19) generally contained higher proportions of barren and sparse vegetation (Figure 12).

During the 3 post-pipeline years, caribou were seen in 6 segments every year (Figure 10). Two of these segments (segments 2 and 10) were associated with buried sections of the pipeline at river crossings, while 2 other segments were associated with pipeline vibration dampers (segments 1 and 6, Figures 9 and 10). During the 3 years of pre-pipeline surveys caribou were observed in 2 segments every year (segments 5 and 20, Figure 8). Annual frequency of caribou occurrence within the 22 pipeline segments was the same for 10 segments, higher for 9 segments, and lower for 3 segments after pipeline construction (Figure 10).

DISCUSSION

The area between Bullen Point and the Canning River has been used consistently by calving caribou in most years since 1969 (Pollard et al. 1992). The distribution of animals observed during calving surveys may reflect survey timing within the calving period (early or late June) and/or spring snow and flood patterns (Gavin 1983, Whitten and Cameron 1985). Calving period distributions in the Badami study area during 1994, 1998, 1999, and 2000 have consistently shown that: (1) few cow-calf pairs occur within 4 km of the Beaufort Sea coastline, and (2) most cow-calf pairs occur south of lat 70°05'N with a tendency for higher concentrations in the southeast followed by the southwest corners of the study area (Figure 3, Noel and King 2000b).

The population size of the CAH in 2000 was 27,128 animals, with 12,833 east of the west bank of the Sagavanirktok River (Lenart 2000). Caribou that calved between Bullen Point and the Canning River were considered part of the eastern segment of the CAH (Cameron and Whitten 1978, Lawhead and Curatolo 1984, Whitten and Cameron 1985, Cameron et al. 1989). But there is probably some exchange of animals between eastern and western segments of the CAH (Cronin et al. 1997, 2000; Wolfe 2000). Based on this 2000 herd size, about 7% of CAH east of the Sagavanirktok River (3% of the CAH) used the Badami study area during calving. This compares to 3% of eastern CAH (1% of the CAH) using the Bullen Point to Staines River study area (Noel and Olson 2001). The calf:cow ratio recorded for our 2000 calving period survey (47 calves:100 cows on 17 June) was lower than the 70 calves:100 cows reported for CAH calving transects flown by ADFG on 15, 16, and 17 June 2000 (Lenart 2000). ADFG's calving period transects extend further into the foothills to lat 69°45'N and composition counts are more comprehensive than our surveys; however, in previous years our reported calf:cow ratios have been comparable. It is possible that cows with calves remained further inland than our survey area due to the late snow cover; while cows that either did not calve or lost calves early continued to the coastal plain. Our post-calving ratio of 52 calves:100 cows was closer to ADFG's fall ratio of 56.5 calves:100 cows (Lenart 2000).

During the post-calving period, weather-moderated parasitic insect activity probably influences caribou distribution, movements, and behavior more than any other environmental

factor (White et al. 1975, Roby 1978, Dau 1986, Johnson and Lawhead 1989). In the Prudhoe Bay and Kuparuk oilfields, caribou were reported to move to coastal areas to ameliorate insect harassment (Roby 1978, Dau 1986, Johnson and Lawhead 1989, Pollard et al. 1996a, 1996b). Caribou were observed to drift inland and feed during periods of low temperatures and/or high wind velocities, which suppress mosquito activity (White et al. 1975, Curatolo et al. 1982, Dau 1986, Pollard et al. 1996a). During the post-calving period in 2000, the percentage of the CAH east of the west channel of the Sagavanirktok River, which used the Badami study area ranged from 11% to 48% (5% to 23% of the CAH). This compares to <1% to 20% (<1% to 10% of the CAH) using the Bullen Point to Staines River study area (Noel and Olson 2001). Across study years, post-calving distributions show that caribou primarily use riparian habitats, river deltas and estuaries across the Badami study area in response to insect activity (Figure 6).

The composition of the CAH in November 2000 was 56.5 calves:100 cows and 83.8 bulls:100 cows (Lenart 2000). The calf:cow and bull:cow ratios for combined post-calving surveys in 2000 (52 calves:100 cows, 86 bulls:100 cows) indicate that the sex-age distribution for caribou within the Badami study area was representative of the herd. This is in contrast to the Bullen Point to Staines River study area where the proportion of bulls (13 bulls:100 cows) was substantially lower in 2000 (Noel and Olson 2001).

Some resource managers are concerned that North Slope oil production infrastructure, including pipelines, roads, and facilities, will exclude caribou from required habitats. Placement of the 40-km Badami pipeline between inland foraging habitats and coastal insect-relief habitats has the potential to adversely affect free passage of caribou between these 2 required habitats. Previous studies designed to evaluate passage of caribou across pipeline corridors have concluded that a minimum pipeline elevation of 1.5 m is sufficient to allow passage of caribou (summarized in Cronin et al. 1994). During the 2000 surveys as many as 2050 caribou were recorded north of the Badami pipeline corridor (Table 2). For caribou to be north of this corridor they must cross either the Badami pipeline, the Endicott Road/pipeline, or the Badami production facility. Observations of caribou crossings at the Badami pipeline based on tower observations, indicated that 33% of caribou and 43% of caribou groups crossed successfully (Coltrane and Lanctot 2000). Coastal and inland caribou distributions from 1998 to 2000 in the Badami and the adjacent Bullen Point to Staines River study area show that for 2 of 6 paired surveys, a smaller proportion of Badami caribou were within 4 km of the coast. For 4 of 6 surveys, the coastal proportions between these 2 areas were not different. A non-parametric paired test for these surveys indicated there was no significant difference between these study areas. These evaluations suggest that caribou move freely between coastal and inland habitats in the Badami study area.

We also evaluated east-west distributions along the Badami pipeline corridor pre- and post-pipeline to look for changes in distribution that may be attributable to the pipeline. There appears to have been a shift from a concentration in the eastern segments pre-pipeline to western segments post-pipeline, the shift is primarily attributable to the presence of 2 large caribou groups (1 pre-pipeline and 1 post-pipeline). There does not appear to be any consistent widespread avoidance of the pipeline corridor. While 3 of 22 segments had lower annual frequency of use post-pipeline, 9 of 22 segments were used more frequently.

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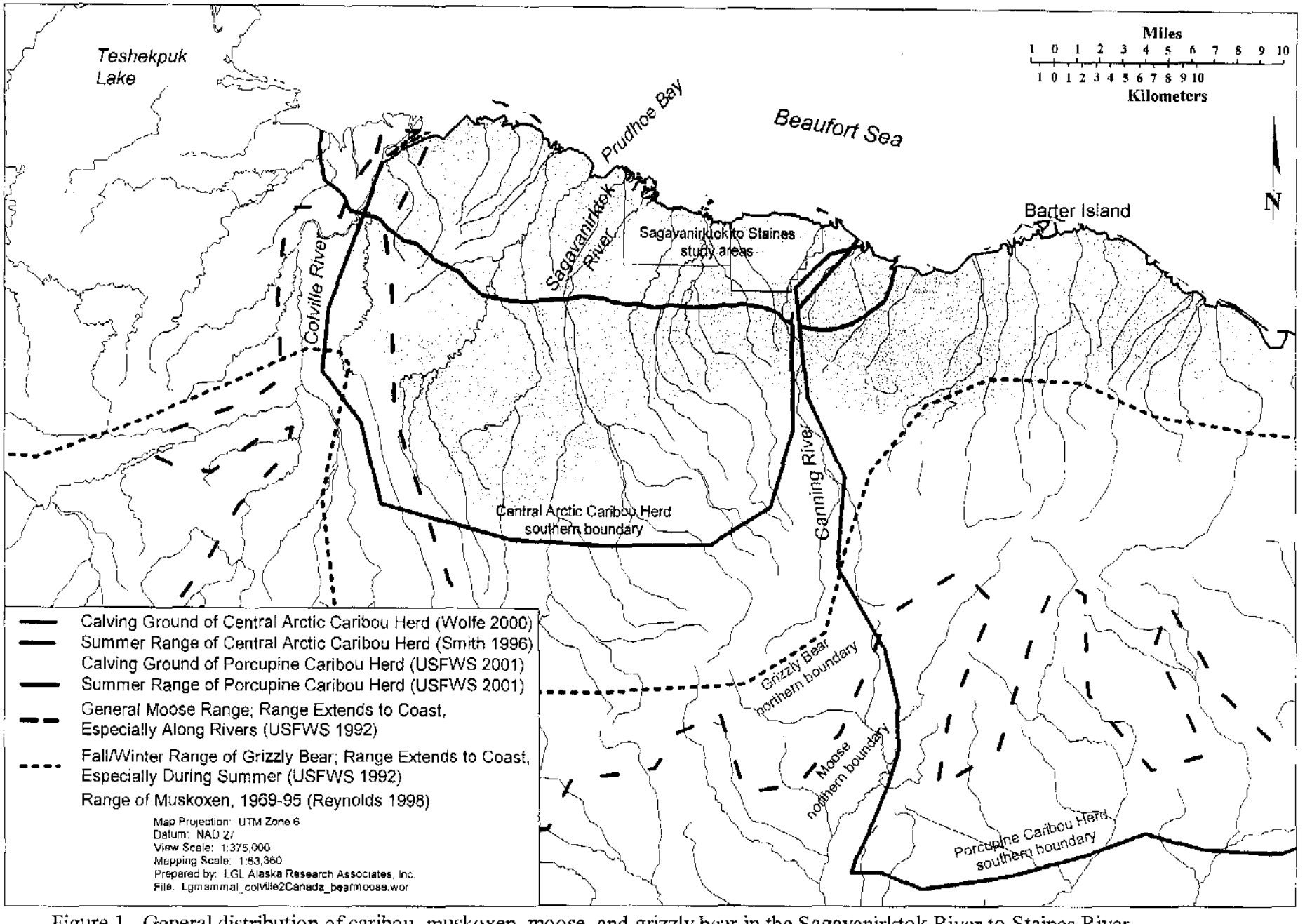


Figure 1. General distribution of caribou, muskoxen, moose, and grizzly bear in the Sagavanirktok River to Staines River study area, east of the Colville River, Alaska (Reynolds 1998, Smith 1996, USFWS 1992, USFWS 2001, and Wolfe 2000).

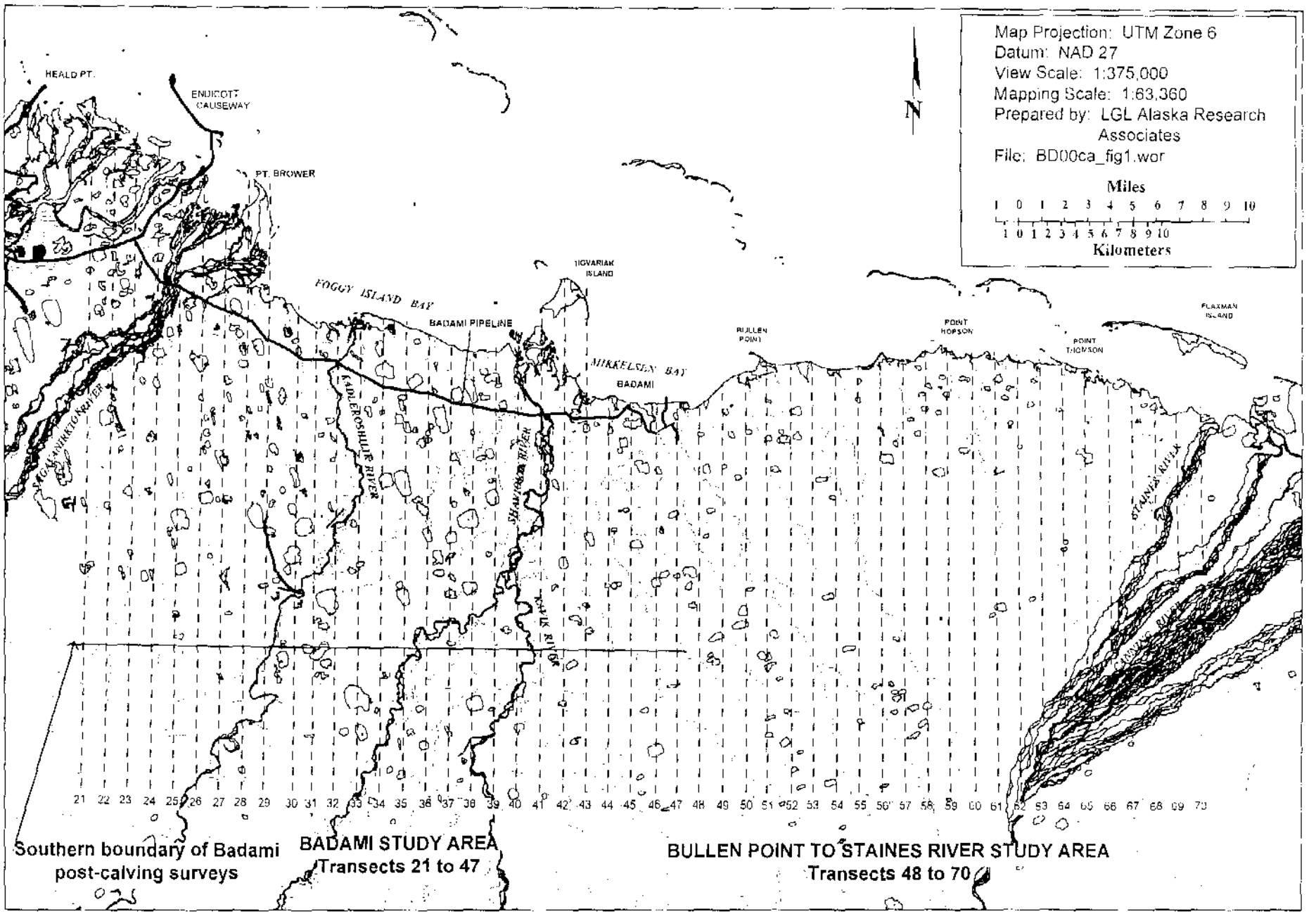


Figure 2. Survey transects in the Badami and Bullen Point to Staines River study areas, Alaska, summer 2000.

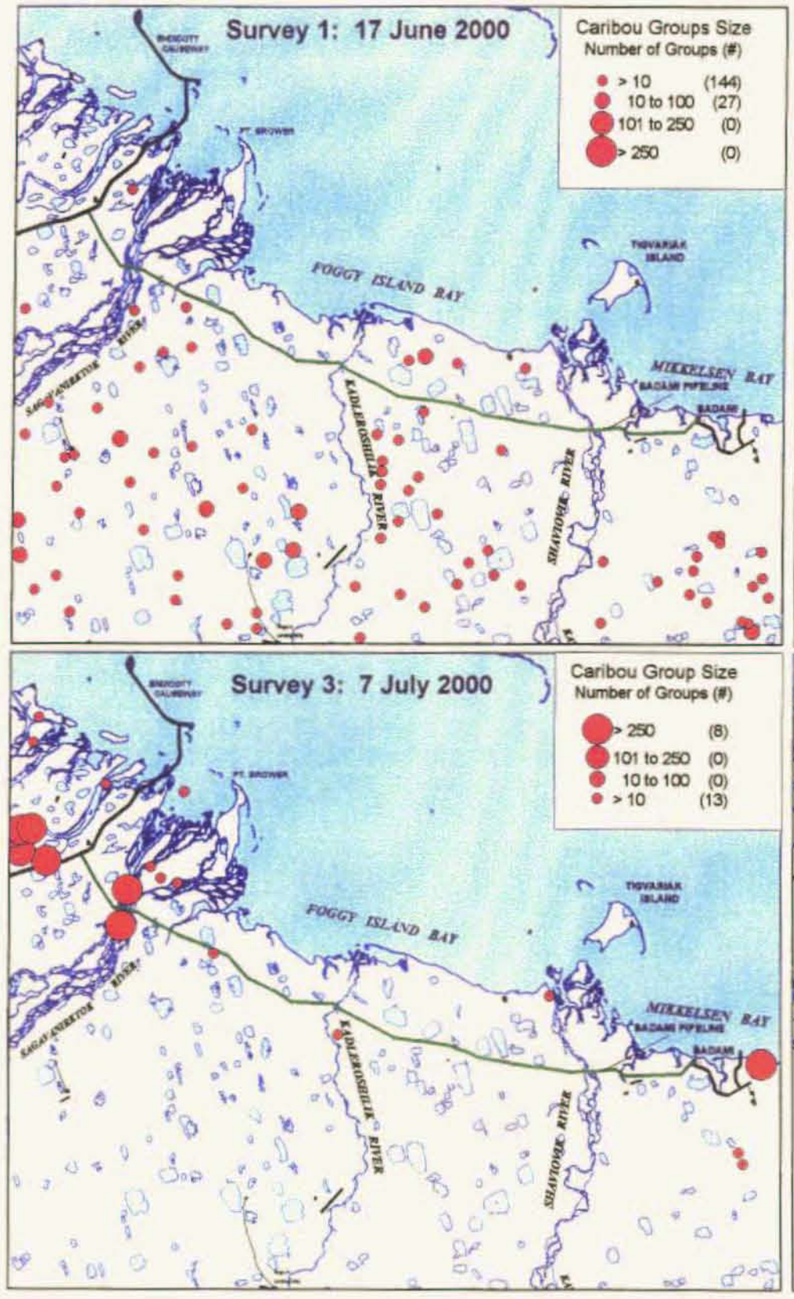


Figure 3

Distribution of caribou in the Badami study area, Alaska, during aerial surveys conducted summer 2000.

Roads

Pipelines

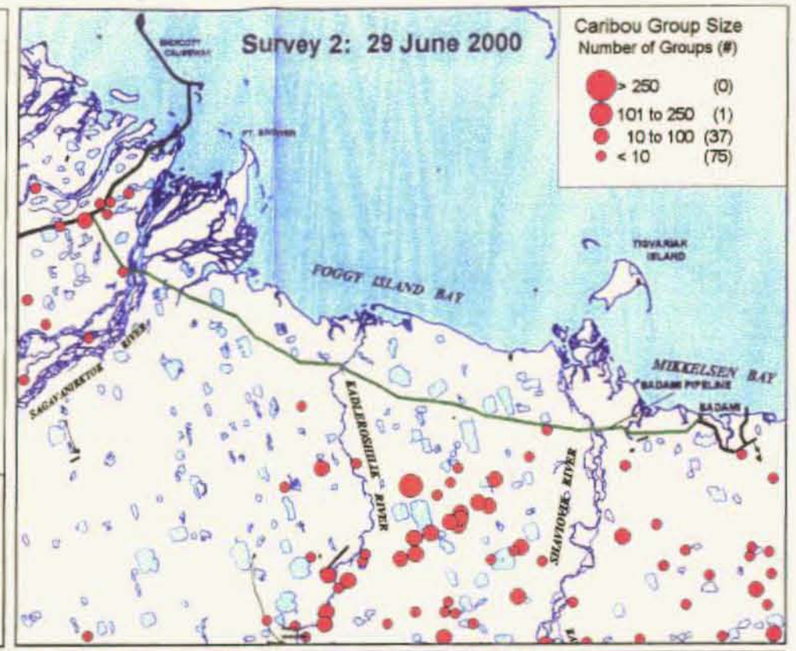
Gravel Production and Exploration Pads

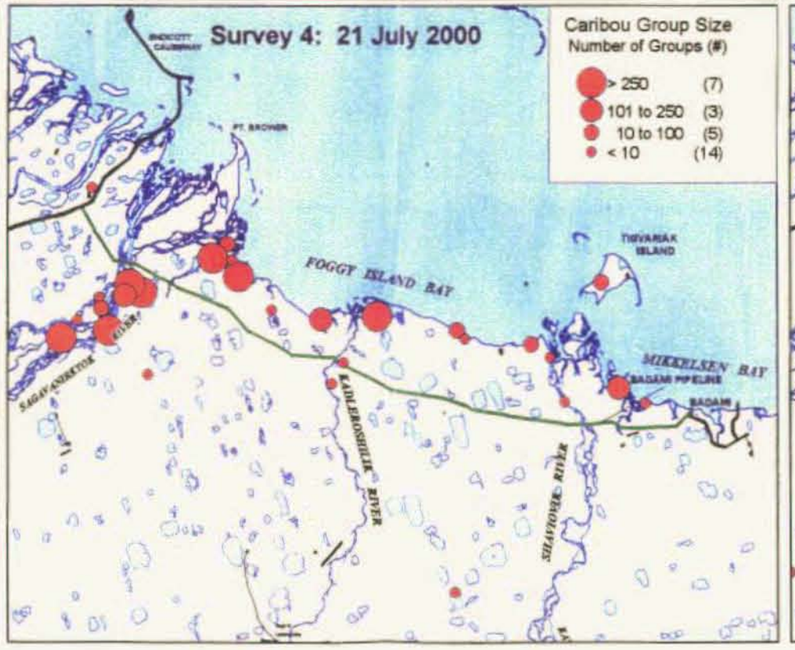
N

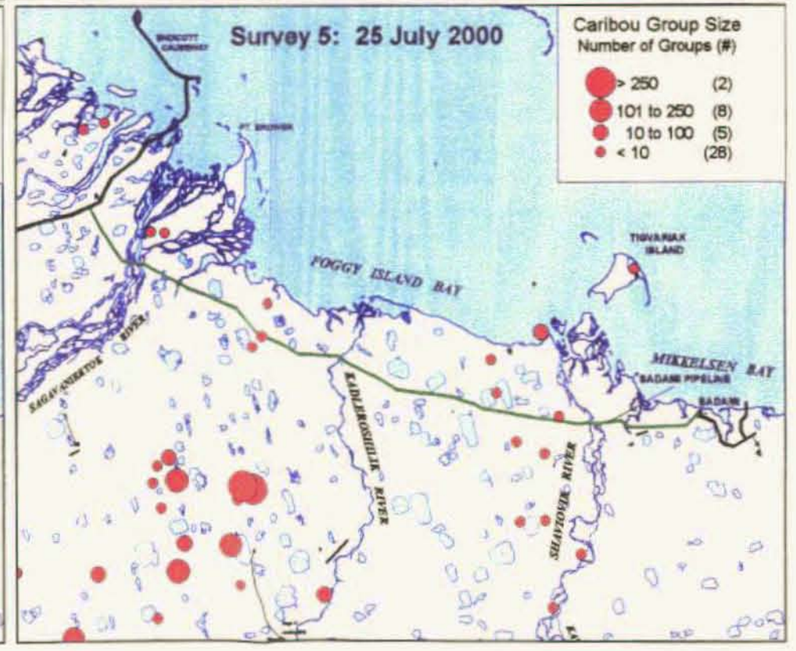
5 4 3 2 1 0 5 Miles

5 4 3 2 1 0 5 Kilometers

Projection: UTM Zone 6
Datum: NAD 27
View Scale 1:339,700
Mapping Scale: 1:63,360
File Name: BD00ca_fig3.wor







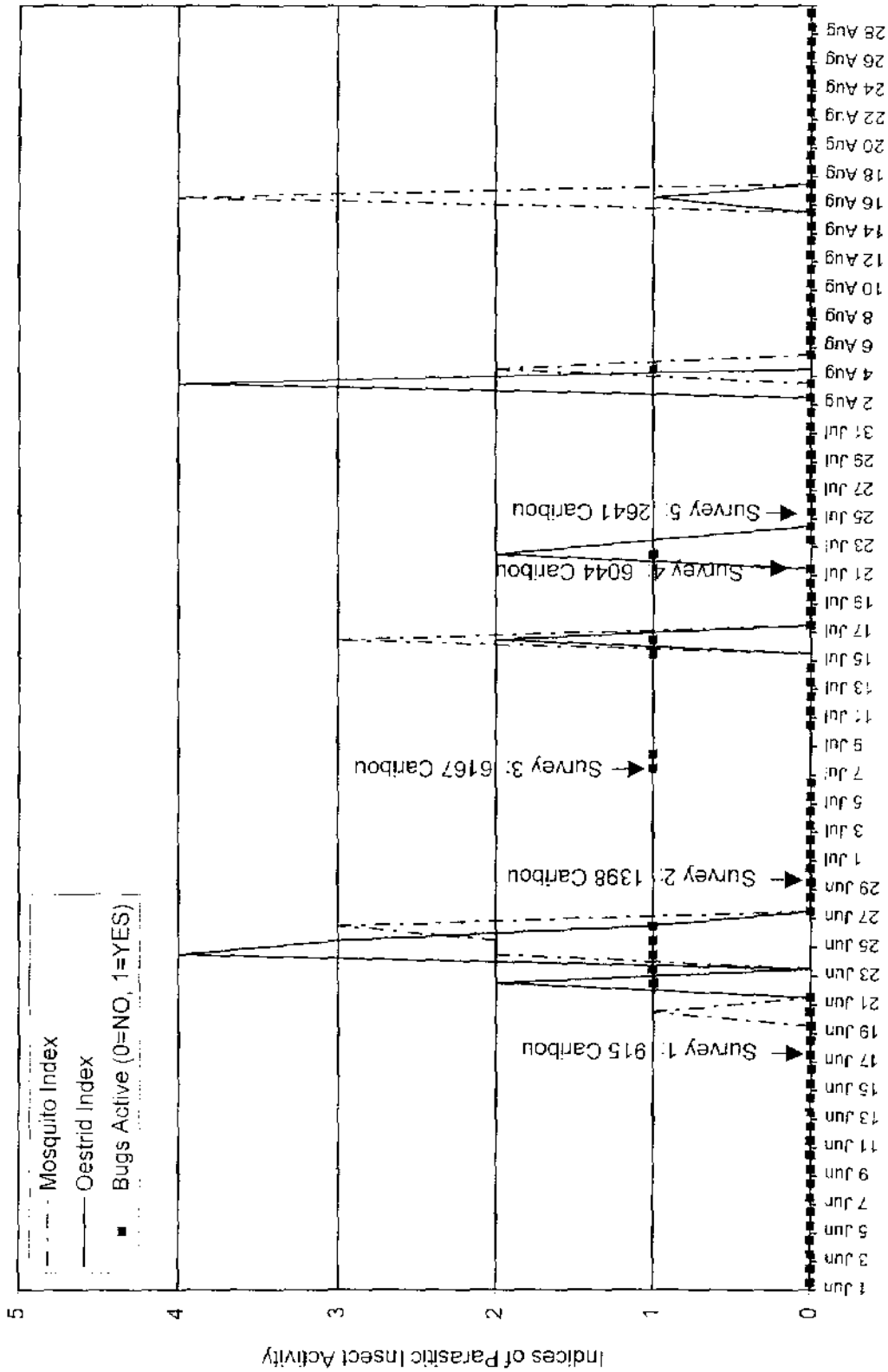
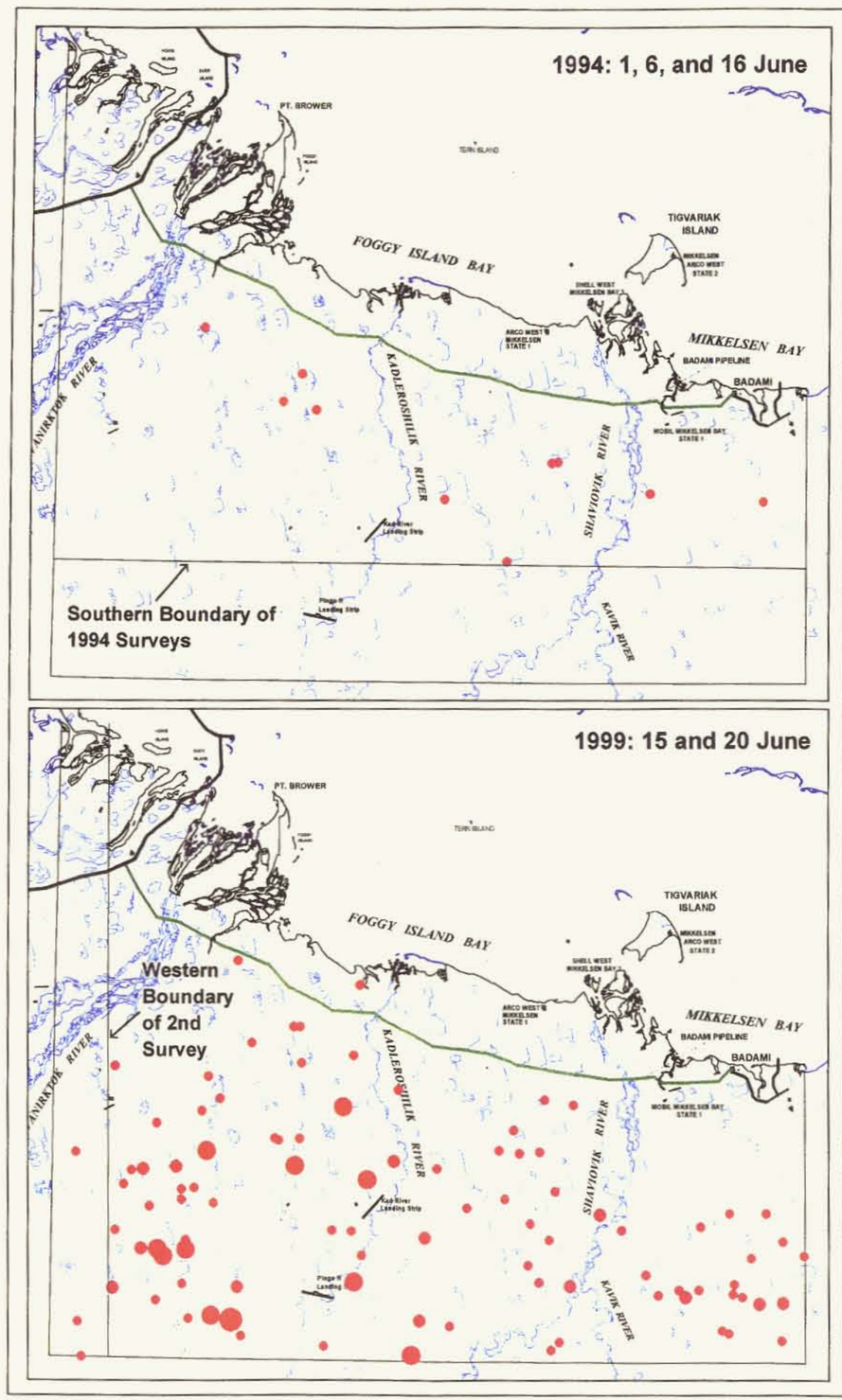


Figure 4. Daily mosquito and oestrid activity indices based on hourly weather data collected at the Deadhorse Weather Station (ASCC 2001), and aerial survey caribou counts, Badami study area, Alaska, summer 2000. Bugs active based on mean daily temperature ≥13°C and mean daily wind speed <6 mps (Walsh et al. 1992).



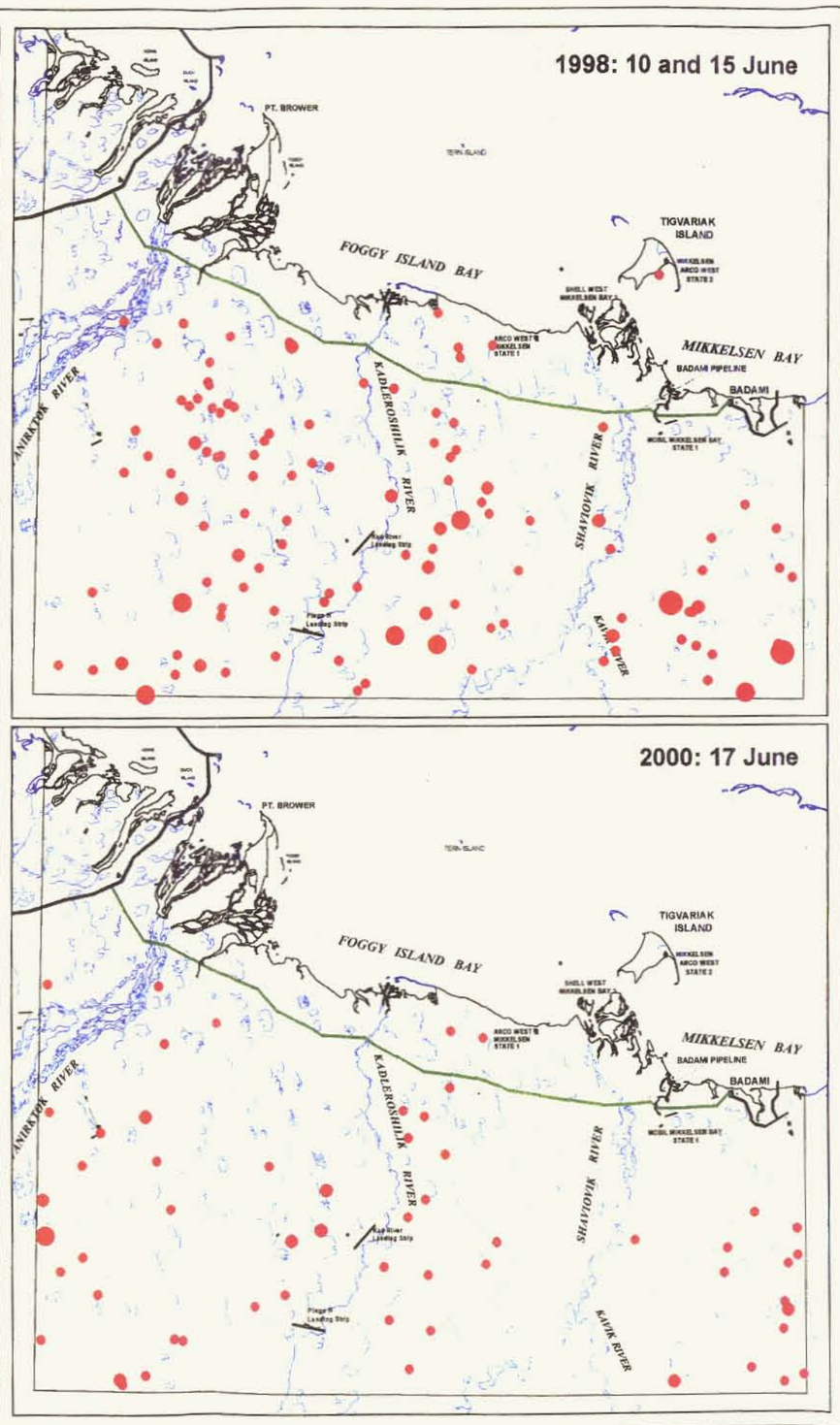


Figure 5

Distribution of caribou calves in the Badami study area, Alaska, during calving period (≤20 June) surveys conducted in 1994 and 1998 through 2000.

Number of Calves

- Less than 5
- 5 to 10
- 11 to 25
- Greater than 25

- Study Area Boundary
- Pipelines
- Roads
- Gravel Production and Exploration Pads

N

Miles

5 4 3 2 1 0 5

5 4 3 2 1 0 5

Kilometers

Map Projection: UTM Zone 6
Datum: NAD 27
View Scale: 1:322,600
Mapping Scale: 1:63,360
Prepared by: LGL Alaska Research Associates
File: BD00ca_fig5.wor

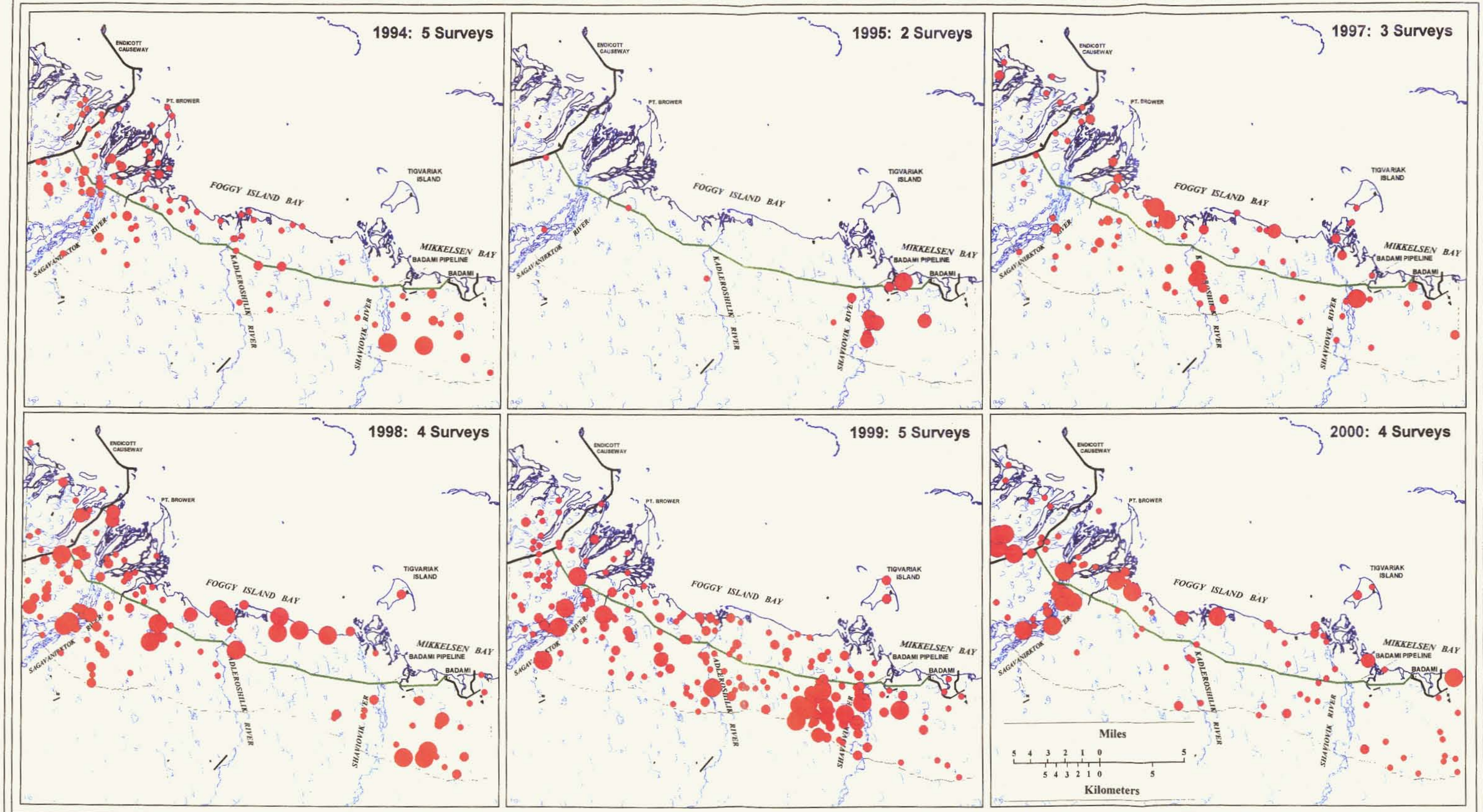


Figure 6

Distribution of caribou within 8 km of the Beaufort Sea coast in the Badami study area, Alaska, during post-calving period (21 June through 31 July) surveys conducted in 1994, 1995, and 1997 through 2000.

N

Number of Caribou

- Less than 10
- 10 to 100
- 101 to 250
- Greater than 250

Roads

Pipelines

Gravel Production and Exploration Pads

8-km Buffer of Coastline in Study Area

Projection: UTM Zone 6
Datum: NAD 27
View Scale 1:339,700
Mapping Scale: 1:63,360

BD00ca_fig4.wor

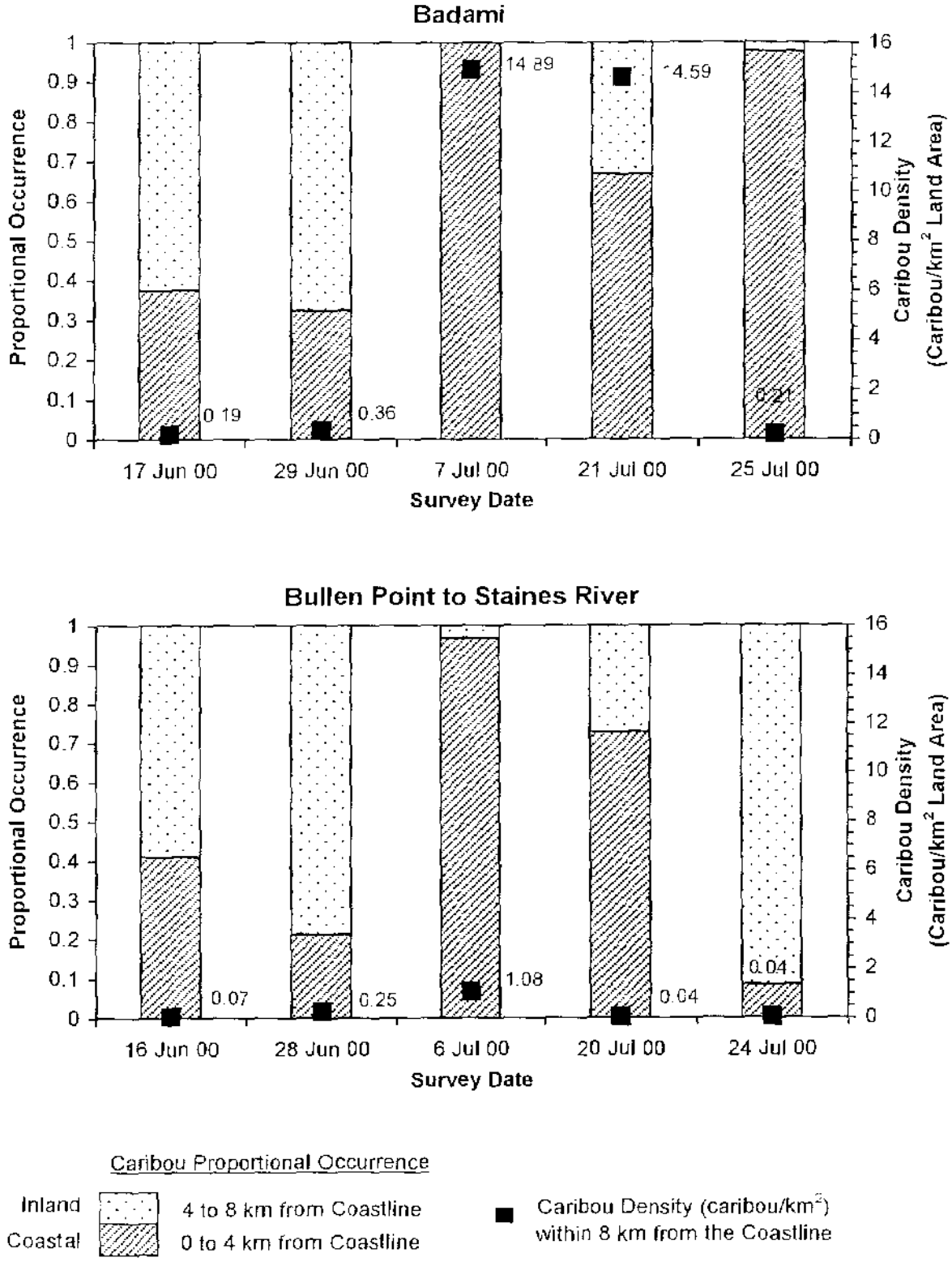


Figure 7. Proportion of caribou within coastal (0 to 4 km) and inland (4 to 8 km) intervals from the Beaufort Sea coast in the Badami and Bullen Point to Staines River study areas, Alaska, based on aerial survey data recorded during summer 2000.

Survey Pair	Survey Dates	Coastal Badami (0 to 4 km)	Inland Badami (4 to 8 km)	Proportion of Coastal Badami Caribou	Coastal Bullen (0 to 4 km)	Inland Bullen (4 to 8 km)	Proportion of Coastal Bullen Caribou	Proportion Comparison Result	Z	P
1	29, 30 June 1998	436	0	100.00	633	0	100.00	ND	0	1.0000
2	14, 15 June 1999	4	56	6.67	41	128	24.26	YES	2.93	0.0034
3	25, 26 June 1999	347	1142	23.30	156	215	42.05	YES	7.66	0.0000
4	16, 17 June 2000	30	50	37.50	9	13	40.91	ND	0.34	0.7339
5	28, 29 June 2000	48	101	32.21	16	60	21.05	ND	1.71	0.0873
6	6, 7 July 2000	6165	2	99.97	319	11	96.67	ND	0.92	0.3576

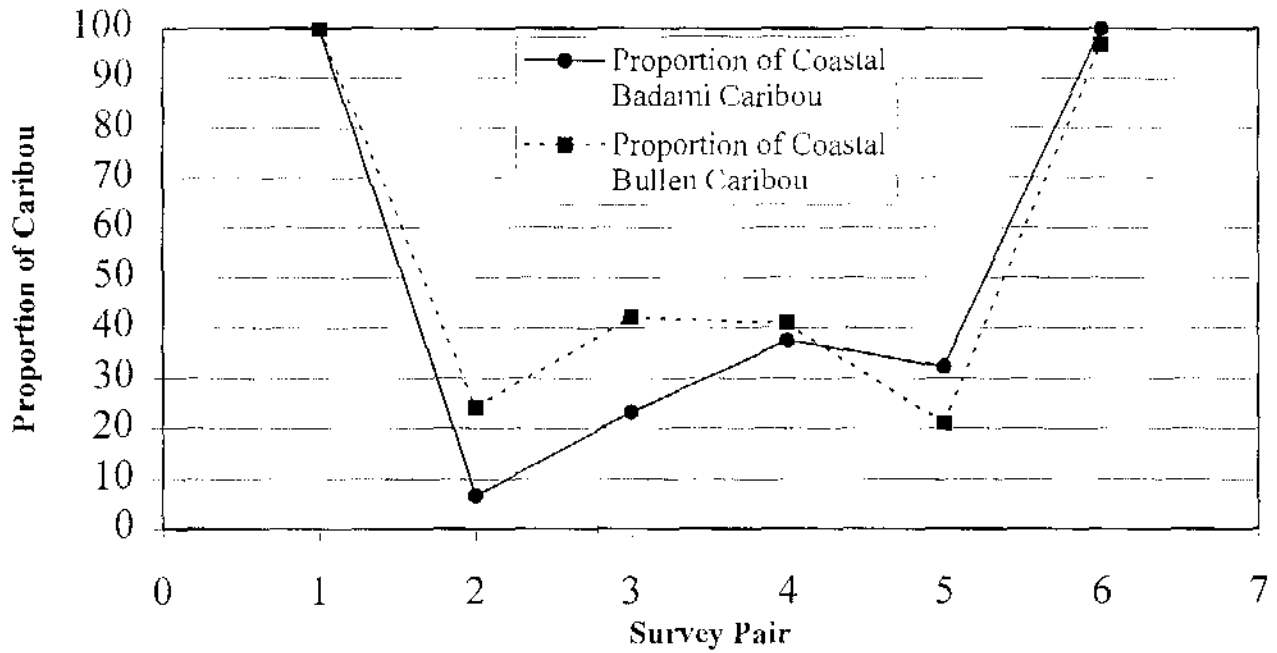


Figure 8. Comparison of the proportions of caribou in coastal (0 to 4 km) intervals from the Beaufort Sea coast during paired aerial surveys in the Badami and the Bullen Point to Staines River study areas, Alaska, summer 1998 through 2000.

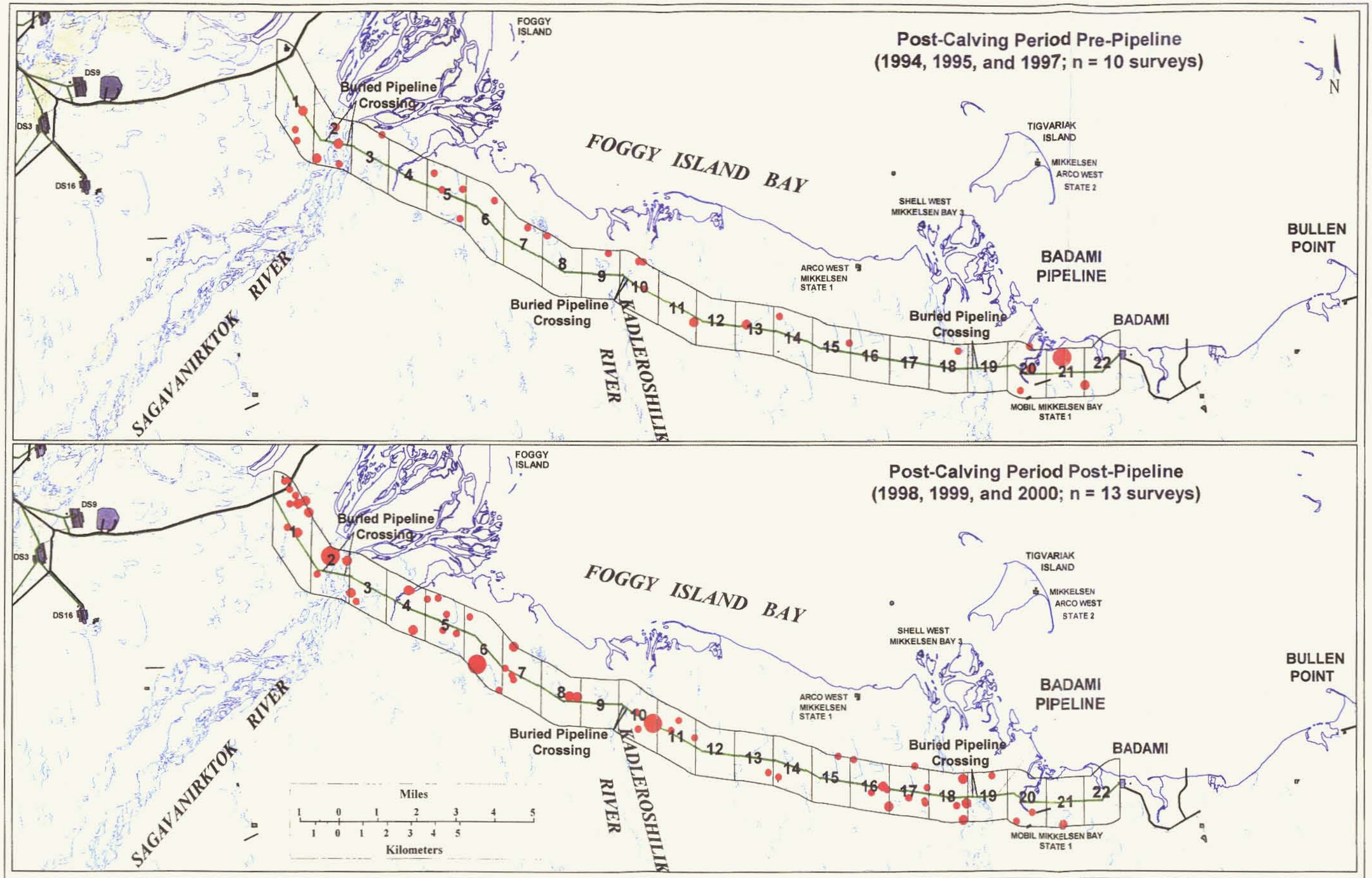


Figure 9

Distributions of caribou within buffer segments extending 1 km north and 1 km south of the Badami pipeline, 1994, 1995 and 1997-2000.

Caribou Group Size

- Less than 10
- 10 to 100
- 101 to 250
- Greater than 250

Pipelines
Roads
22 Numbered Pipeline Buffer Segment
Gravel Production and Exploration Pads

Map Projection: UTM Zone 6
Datum: NAD 27
View Scale: 1:154,600
Mapping Scale: 1:63,360

BD00_fig9.wor

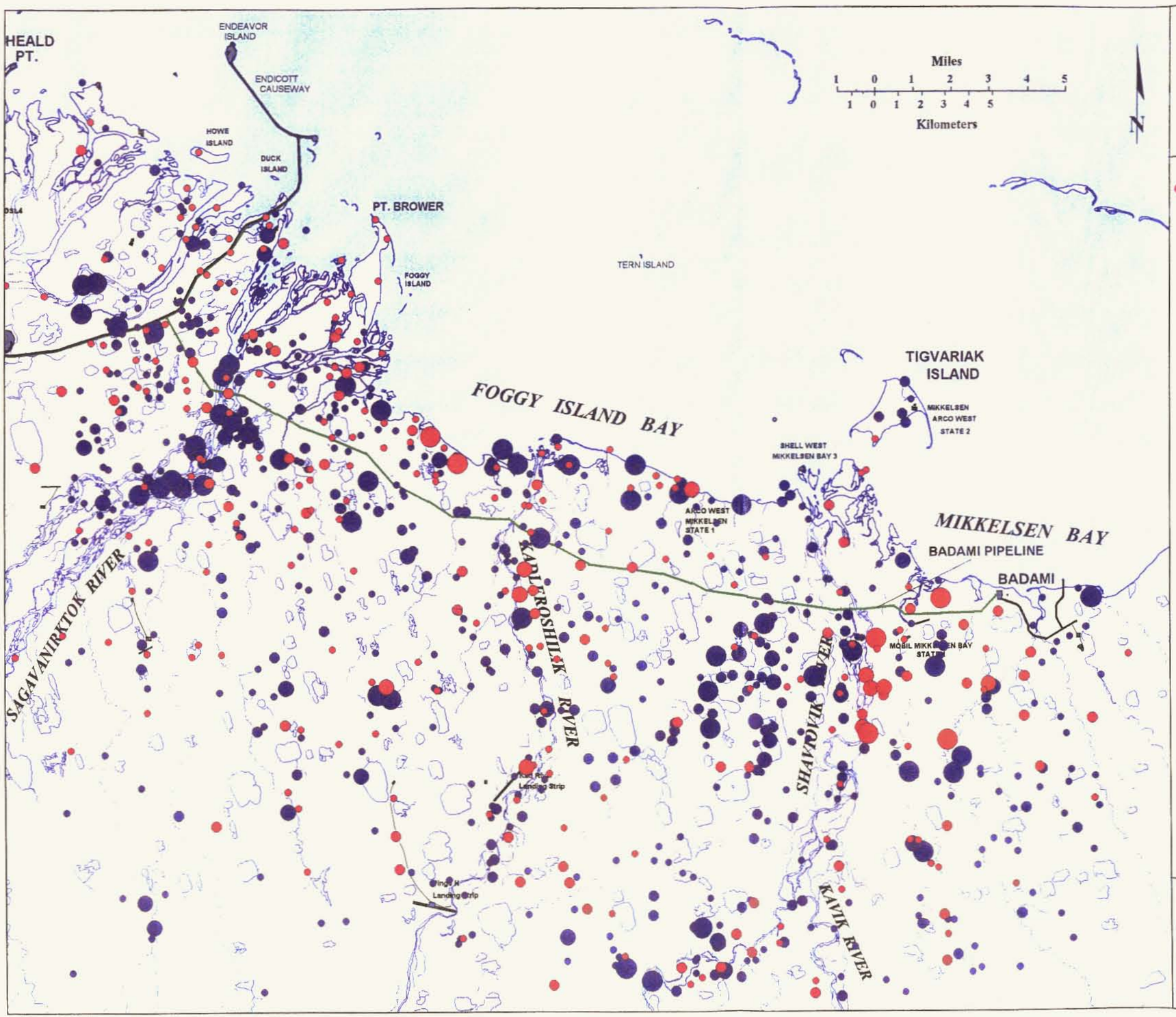


Figure 10

Post-calving period (>20 June) caribou distribution before and after the winter 1997-1998 construction of the Badami pipeline, Alaska.

Pre-construction Caribou Groups

Post-construction Caribou Groups

1994 Post-calving Surveys
- < 10 (106)
- 10 to 100 (19)
- 101 to 250 (1)
- > 250 (2)

1995 Post-calving Surveys
- < 10 (6)
- 10 to 100 (4)
- 101 to 250 (5)
- > 250 (1)

1997 Post-calving Surveys
- < 10 (88)
- 10 to 100 (43)
- 101 to 250 (4)
- > 250 (3)

1998 Post-calving Surveys
- < 10 (84)
- 10 to 100 (42)
- 101 to 250 (10)
- > 250 (16)

1999 Post-calving Surveys
- < 10 (174)
- 10 to 100 (67)
- 101 to 250 (9)
- > 250 (16)

2000 Post-calving Surveys
- < 10 (128)
- 10 to 100 (45)
- 101 to 250 (12)
- > 250 (16)

Pipelines — Roads

Gravel Production and Exploration Facilities

Map Projection: UTM Zone 6
Datum: NAD 27
View Scale: 1:170,000
Mapping Scale: 1:63,360
Prepared by: LGL Alaska Research Associates
File: BD00ca_Fig10.wor

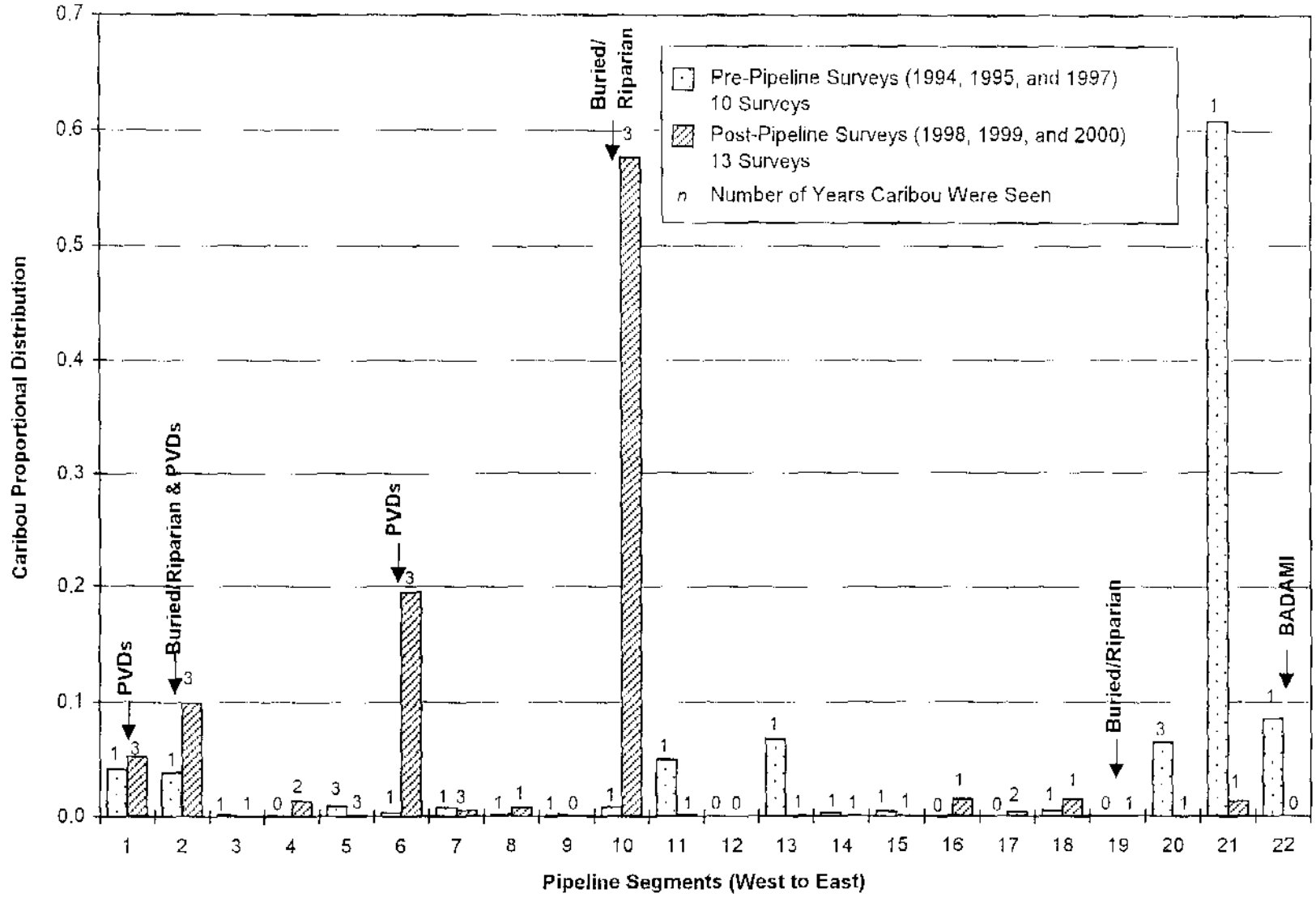


Figure 11. Pre- and post-construction caribou distribution during the post-calving period by west to east segments within a 1-km buffer north and south of the Badami pipeline, Alaska, 1994-2000. Data are summarized separately for surveys conducted prior to (1994, 1995, and 1997) and following (1998, 1999, and 2000) construction of the Badami pipeline. Annual frequency of caribou occurrence (1 to 3 years) by segment is indicated above each bar.

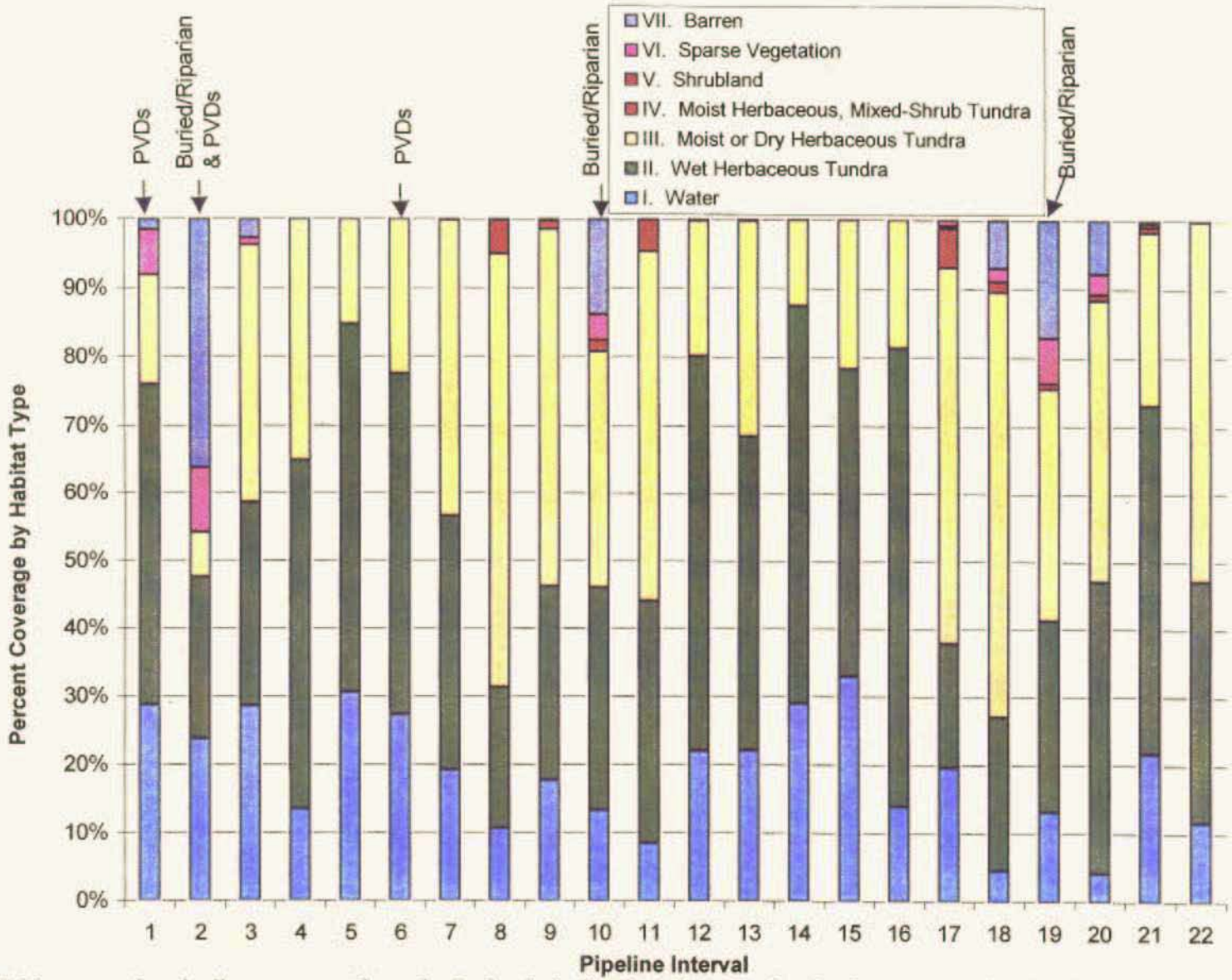


Figure 12. Habitat types by pipeline segment along the Badami pipeline based on Landsat land cover mapping (Walker and Acevedo 1987).