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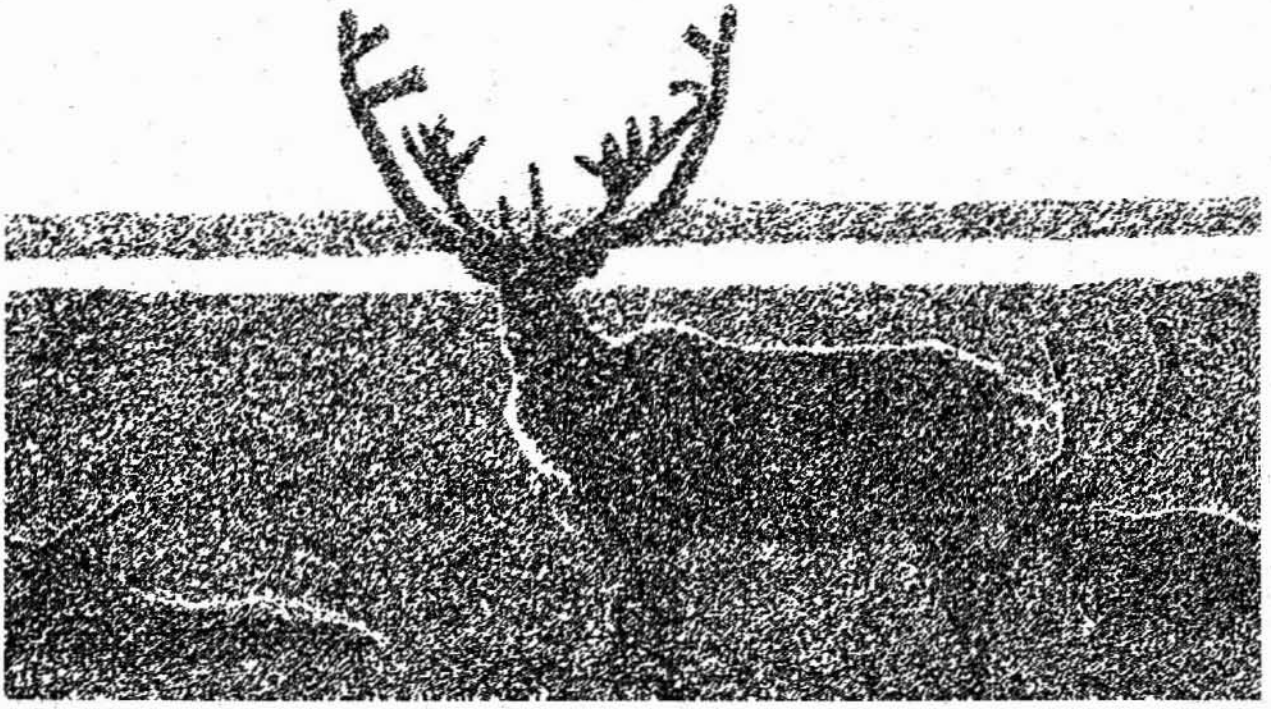
ARCTIC COASTAL PLAIN CARIBOU DISTRIBUTION, SUMMER 2001



Prepared for

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ARCTIC COASTAL PLAIN CARIBOU DISTRIBUTION, SUMMER 2001

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Jensen, P.G., and L.E. Noel. 2002. Caribou distribution in the northeast National Petroleum Reserve-Alaska, summer 2001. Chapter 3 *in* M.A. Cronin (ed.) Arctic Coastal Plain caribou distribution, summer 2001. Unpublished report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, Alaska. Pages 3- 1–101.

Noel, L.E., M.J. Nemeth and B. Streever. 2002. Caribou movement in riparian areas crossed by the Badami pipeline, Arctic Coastal Plain, Alaska, summer 2001. Chapter 4 *in* M.A. Cronin (ed.) Arctic Coastal Plain caribou distribution, summer 2001. Unpublished report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, Alaska. Pages 4- 1–54.

Cronin, M.A., and J.C. Patton. 2002. Caribou and reindeer (*Rangifer tarandus*) genetic variation and herd structure in northern Alaska. Chapter 5 *in* M.A. Cronin (ed.) Arctic Coastal Plain caribou distribution, summer 2001. Unpublished report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, Alaska. Pages 5- 1–77.

CHAPTER 1:

Caribou Distribution on the Arctic Coastal Plain of Alaska, 2001

Introduction

by

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Introduction

Summer 2001 Caribou Studies

This introduction provides background information regarding issues and potential impacts of oilfield development on barren ground caribou (*Rangifer tarandus granti*) in arctic Alaska (Figure 1). This report summarizes the results of all 2001 caribou studies on the North Slope sponsored by BP Exploration (Alaska) Inc. and the Point Thomson Unit Owners. These studies included monitoring the distribution with aerial surveys and studies designed to answer specific questions about caribou in oilfields. These included systematic aerial distribution surveys in the Milne Point Unit (MPU), Prudhoe Bay oilfield (PBOF), Badami, and Bullen Point to Staines River (Bullen-Staines) study areas (Chapter 2A; Figure 2), road-based distribution surveys in the Kuparuk, Milne Point, and Prudhoe Bay study areas (Chapter 2B), systematic aerial distribution surveys in the NPR-A study area (Chapter 3; Figure 2), remote video monitoring of caribou movements in riparian habitats crossed by the Badami pipeline (Chapter 4), and quantification of genetic differentiation of caribou herds and assessment of inter-herd exchange and range overlap for the arctic Alaska herds (Chapter 5). Each of these chapters can be read as a stand-alone report, but reading the report as a whole offers a better understanding of the issues surrounding caribou in North Slope oilfields.

Arctic Caribou Herds

Four caribou herds occur in arctic Alaska (Figure 1). From west to east, these herds are the Western Arctic Herd (WAH), the Teshekpuk Caribou Herd (TCH), the Central Arctic Herd (CAH), and the Porcupine Caribou Herd (PCH). Herd identification is based on repeated use of geographically distinct calving grounds (Skoog 1968). Cows have high fidelity to calving areas, although overlap as movement between herds on fall, winter, and calving ranges may occur (see Chapter 5 of this report). Because herds are the units of management, quantification of the independence of herds is needed for meaningful impact assessment and clear identification of management objectives.

Western Arctic Herd

The annual range of the WAH covers approximately 363,000 km^2 of northwestern Alaska (Dau 1999). The calving range is generally located within the southwest corner of the National Petroleum Reserve-Alaska (NPR-A), in the Utukok uplands in the foothills of the Brooks Range (Davis and Valkenburg 1979; Kelleyhouse 2001). The WAH was estimated to be about 75,000 caribou in 1976 (Davis and Valkenburg 1979) and increased to about 463,000 in 1996 (Cronin et al. 1998a; Dau 1999). The WAH decreased to approximately 430,000 by 1999 (P. Valkenburg, Alaska Department of Fish and Game (ADFG), pers. comm.). Currently, the WAH is the largest herd in Alaska and one of the largest in the world.

An estimated 20,000 WAH caribou are harvested each year by subsistence hunters from numerous villages across northwestern Alaska, and 3000 WAH caribou are harvested annually by sport hunters (Bente 1997). Industrial developments within the WAH annual range include the Red Dog Mine (a lead-zinc mine) with an 85-km access road to Kotzebue Sound, and portions of the Kuparuk and Alpine oilfields.

Teshekpuk Caribou Herd

The TCH was recognized as distinct from the WAH and CAH in the mid-1970s (Davis and Valkenburg 1978). The overall range of the TCH extends from northwestern Alaska, east to the Colville River and south to Galena (Kelleyhouse 2001). The annual range varies from 3772 km^2 to 219,214 km^2

(Philo et al. 1993) and is typically within the northern portion of NPR-A (Kelleyhouse 2001). The calving area is near Teshekpuk Lake, including the eastern, southern, southeastern, and northeastern shorelines (Davis and Valkenburg 1979; Carroll 1992; Philo et al. 1993; Kelleyhouse 2001).

The TCH was estimated to be approximately 3000 to 4000 caribou in 1978 (Davis and Valkenburg 1979), and increased to approximately 28,000 by 1993 (Carroll 1995; Cronin et al. 1998a). The most recent photocensus was conducted in 1999, and 28,627 caribou were counted (Carroll 2001).

Most subsistence harvest of the TCH occurs between July and October (Carroll 1999) by residents of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Hope, and Wainwright. Subsistence harvest of the TCH was estimated between 800 to 3000 caribou each year (Carroll 1995). In 1999–2000, the estimated caribou harvest was 2503 (Carroll 2001). Large numbers of TCH caribou have died during periods of extremely cold, windy weather (winters of 1989-1990 and 1992-1993; Carroll 1992, 1995). Sport hunter harvest from the TCH is generally low and from the Colville River drainage (Carroll 2001). Industrial developments within the TCH annual range include the Red Dog Mine with an 85-km access road to Kotzebue Sound, and portions of the Kuparuk and Alpine oilfields.

Central Arctic Herd

The annual range of the CAH extends roughly from the Colville River, east to the Canning River and south to the Brooks Range (Cameron and Whitten 1979). The overall range of the CAH also includes small areas west of the Colville River, east of the Canning River, and in the southern foothills of the Brooks Range. The calving areas are located between the Colville and Canning rivers within 160-km of the Beaufort Sea (Cameron and Whitten 1979; Wolfe 2000). The CAH was estimated at approximately 5000 caribou in 1978 and increased to approximately 23,000 in 1992 (Whitten and Cameron 1983; Ballard et al. 2000; Cronin et al. 2000). The CAH declined to approximately 18,000 in 1995, and increased to approximately 27,000 in 2000 (Cronin et al. 2000, 2001).

Between 200 and 600 CAH caribou are harvested each year, primarily through subsistence hunts by Nuiqsut and Kaktovik residents (Murphy and Lawhead 2000). Industrial developments within the CAH annual range include numerous developments associated with the Trans-Alaska Pipeline System and the Prudhoe Bay area oilfields.

Porcupine Caribou Herd

The annual range of the PCH extends from the Arctic National Wildlife Refuge (ANWR) in northeastern Alaska to the north-central Yukon Territory in Canada (Russell et al. 1993). The calving area is located in the ANWR and the Yukon Territory (Russell et al. 1993). The PCH was estimated to be 105,000 in 1977 (Bente and Roseneau 1978), and increased about 4.5% per year to 178,000 by 1989 (Whitten 1992). The PCH has been declining since 1989 and currently is approximately 123,000 (Cronin et al. 1998a; P. Valkenburg, ADFG, pers. comm.).

Many villages across northeastern Alaska and the Yukon Territory, Canada harvest caribou from the PCH. Estimates of annual subsistence harvest from 1984 to 1995 have ranged from 100 to 2100 and 500 to 4000 caribou in Alaska and Canada, respectively (Whitten 1997).

Caribou and North Slope Oilfields

The primary concerns regarding caribou and oilfields are: (1) displacement of calving caribou from areas of intensive development and activity, (2) decreased nutritional status and reproductive productivity of females, (3) blockage and delay of caribou movements by oilfield infrastructure between inland

foraging and coastal insect-relief habitats (Cameron et al. 1995), and (4) cumulative effects that could eventually lead to population declines.

Ballard and Cronin (1995), Cronin et al. (1998a, 2000, 2001), Ballard et al. (2000), and Murphy and Lawhead (2000) provided detailed reviews of caribou/oilfield relationships. Data presented in these papers show that while impacts to individual caribou from oilfield development have occurred, population-level impacts on the CAH have not occurred. For example, the number of CAH caribou in the western area of their range including oilfields increased from 6327 in 1995 to 14,295 in 2000 (Cronin et al. 2000, 2001). Nevertheless, Wolfe (2000) found that between 1980 and 1995, the most concentrated calving grounds of the western segment of the CAH exposed to oilfield development shifted southwest away from the oilfields (south of the Kuparuk oilfield). Additionally, Lawhead and Prichard (2002) summarized caribou survey data from 1993 and 1995–2001 and reported that the highest densities of caribou during the calving period occurred south of the Kuparuk oilfield. While it has been hypothesized that potential nutritional and reproductive consequences (and hence a numerical population response) could result from such changes in distribution (Dau and Cameron 1986; Cameron et al. 1992a; Nellemann and Cameron 1996, 1998; Wolfe 2000; Cameron et al. 2002), existing data do not support this hypothesis.

Further evidence that impacts on caribou have been limited have been documented with aerial surveys conducted during the post-calving period over multiple years within the North Slope oilfields (Pollard et al. 1996b; Cronin et al 1998b; Noel et al. 1998). These surveys have documented several characteristics of caribou use of oilfield habitats, including: (1) regular use of riparian and coastal insect-relief habitats, (2) continued use of foraging habitats within oilfields, (3) movements between these habitats and habitats outside the oilfields, (4) the occurrence of caribou close to oilfield infrastructure, and (5) use of oilfield structures (e.g., gravel roads and pads) as insect-relief habitat (Pollard et al. 1996a, Noel et al. 1998).

While some of the older portions of the Prudhoe Bay oilfield with low ground-clearance pipelines (<1.5 m) and complex infrastructure have blocked some movements of caribou across the oilfield (Cameron 1983), mitigation techniques implemented by the petroleum industry at newer developments have been successful at addressing issues of caribou movements under pipelines (Curatolo and Murphy 1986; Lawhead et al. 1993; Cronin et al. 1994).

Business Rationale

Caribou are an important part of arctic ecosystems and an important wildlife resource for native communities, sport hunters, and the general public. Maintaining caribou populations while developing oil and gas reserves are management objectives of the State of Alaska and an integral part of land-use decisions in the Arctic.

Despite more than two decades of studies, speculation remains regarding impacts to caribou resulting from development of oilfields. During early development, speculation centered around the potential to have dramatic adverse effects on caribou populations, but when these impacts failed to materialize, speculation shifted to the possibility of subtler impacts that could eventually have negative impacts on caribou (Cameron et al. 2002). A workshop organized by the Alaska Oil and Gas Association in January 2002, confirmed the persistence of concerns, including those of native communities. In keeping with broad BP policies regarding environmental stewardship and social responsibilities, continued study of caribou is warranted. In addition, aerial surveys were undertaken to provide data for environmental reports that would contribute to Environmental Assessments, Environmental Impact Statements, and other documents that may be required prior to development of the Point Thomson Unit and the National

Petroleum Reserve-Alaska (NPRA)[1]. Road surveys were undertaken to gain more detailed knowledge about avoidance of roads by caribou during the calving and post-calving periods to supplement work conducted by Cameron et al. (1992b) suggesting that caribou with calves avoid roads by 1–4 km. Work that details caribou crossings under the Badami pipeline was required by government agencies (Appendix A in Coltrane and Lanctot 2001) after pipeline vibration dampers reduced pipeline height below minimum allowable heights. Finally, genetic work was undertaken to address the degree to which individual caribou herds are unique from one another, which could be an important component in the protection of biodiversity on the North Slope.

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[1] Work was initiated in the NPR-A when BP still anticipated development of its NPR-A leases. Subsequently, BP has ceased exploration and development plans for these leases.

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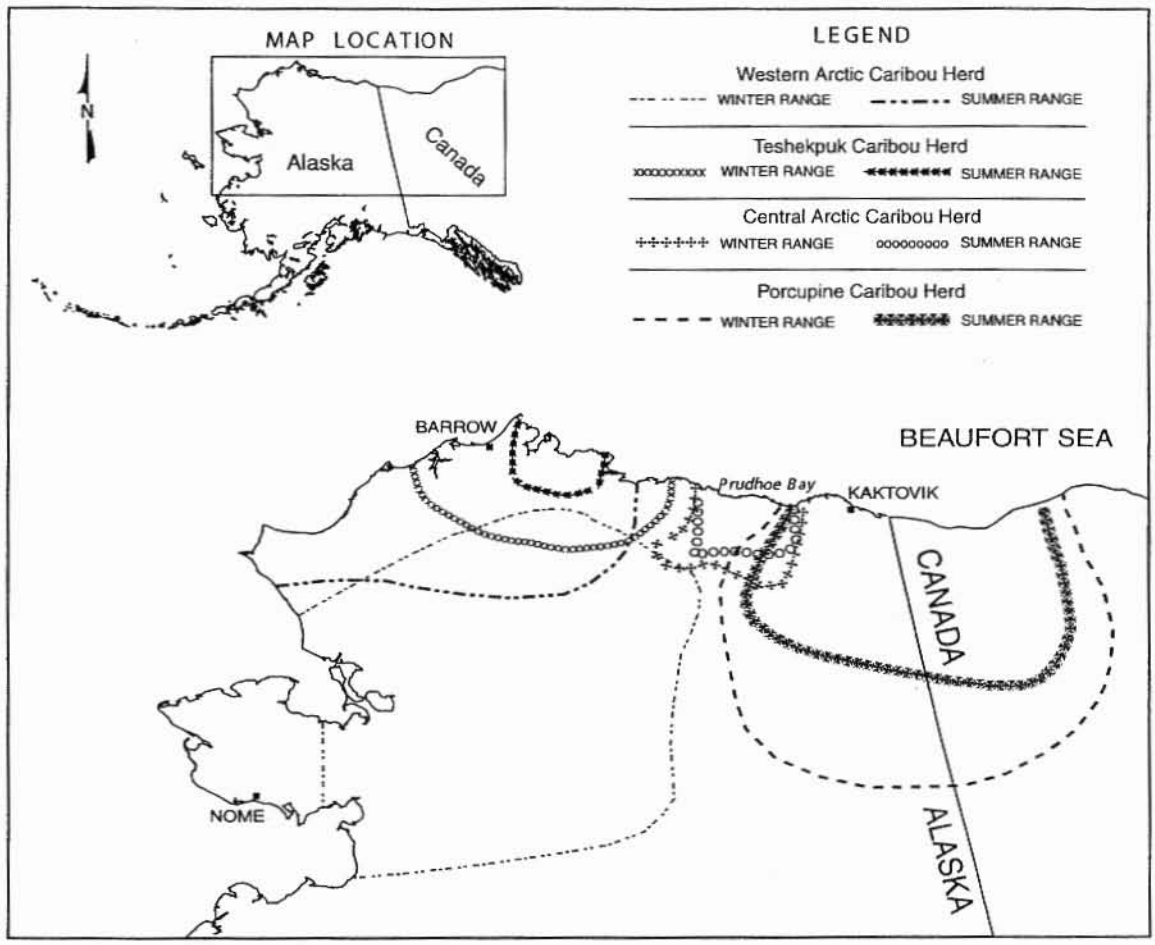

Figure 1. Summer and winter ranges of the Western Arctic (WAH), Teshekpuk (TCH), Central Arctic (CAH), and Porcupine (PCH) caribou herds, Alaska.

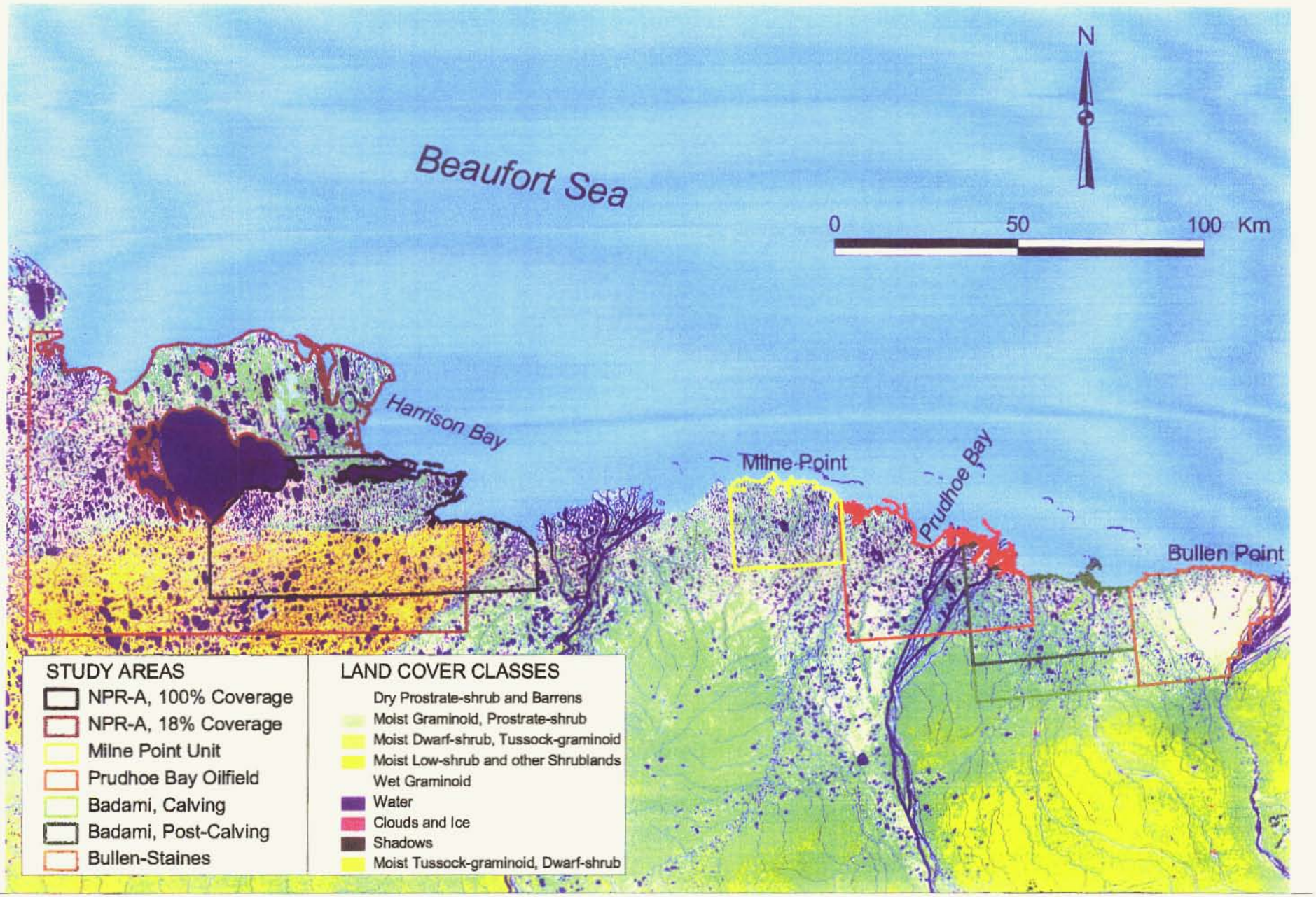

Figure 2. Study areas for aerial surveys of caribou and other large mammals, Arctic Coastal Plain, Alaska, summer 2001. Background is a land cover classification from Muller et al. (1999).

CHAPTER 2:

Caribou Distribution in the Range of the Central Arctic Herd

Part A. Aerial Surveys in the Milne Point Unit, Prudhoe Bay Oilfield, Badami, and Bullen Point to Staines River Study Areas, Summer 2001

by

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Abstract

Barren ground caribou (*Rangifer tarandus granti*) are an important wildlife resource and the most abundant large mammal on Alaska's Arctic Coastal Plain during summer. Monitoring of caribou abundance and distribution in North Slope oilfields is an important component of assessing potential effects of petroleum development on caribou. The primary objectives of this study were to determine distribution and abundance of caribou and other large mammals in the range of the Central Arctic Herd (CAH) during caribou calving (before 21 June) and post-calving (after 20 June) periods in the Milne Point Unit (MPU), Prudhoe Bay Oilfield (PBOF; post-calving only), Badami, and Bullen Point to Staines River (Bullen-Staines) study areas. Secondary objectives were to summarize calving locations from previous aerial surveys (1998–2000) and 2001 in the Badami and Bullen-Staines study areas, describe caribou distribution in relation to oilfield infrastructure during the post-calving period in the MPU and PBOF study areas, and describe caribou abundance and distribution relative to parasitic insect activity. We conducted 24 (6 calving, 18 post-calving) systematic aerial strip-transect surveys from 10 June to 2 August 2001. During the calving period we observed a total of 353 (79 calves), 3163 (893 calves), and 2129 (735 calves) caribou in the MPU, Badami, and Bullen-Staines study areas, respectively. Most caribou were more than 5–10 km from the Beaufort Sea coast during the calving period. Analysis of survey data during the calving period from the Badami and Bullen-Staines study areas (1998-2001) revealed that 34% of calves were in the Badami study area and 66% of calves were in the Bullen-Staines study area. Few calves (2%) were within the Point Thomson Unit during the calving period from 1998-2001. During the post-calving period we observed a total of 1151, 3476, 9506, and 7822 caribou in the MPU, PBOF, Badami, and Bullen-Staines study areas, respectively. For all study areas, the abundance and distribution of caribou during the post-calving period appeared to be influenced by insects during periods of harassment. In the PBOF, Badami, and Bullen-Staines study areas, caribou used riparian and coastal habitats for insect-relief. Results of an interval analysis (distance from infrastructure) for the MPU study area during the post-calving period indicated that calves were observed in greater than expected numbers in the 2-km interval, not different than expected numbers in the 1-km and 3-km intervals, and in less than expected numbers in the 4-km, 5-km, and 6- to 8-km intervals. In general, caribou in the PBOF were observed in less than expected numbers in all intervals ≤5 km from infrastructure and, with the exception of bulls, in greater than expected numbers in intervals ≥9 km from infrastructure. These results and past interval analyses show that distribution of caribou relative to oilfield infrastructure during the post-calving period is highly variable among caribou sex and age classes, study areas, and years.

Key words: arctic, grizzly bear, muskoxen, North Slope, oilfields, *Ovibos moschatus*, *Rangifer tarandus*, *Ursus arctos*

Introduction

Overview of the Central Arctic Herd (CAH)

Barren ground caribou (*Rangifer tarandus granti*) of the Central Arctic Herd (CAH) use a summer range in northern Alaska encompassing an area between the Canning and Colville rivers, and between the Brooks Range and Beaufort Sea (Smith 1996). Each year, CAH caribou migrate between winter ranges in the northern foothills of the Brooks Range and summer ranges on the Arctic Coastal Plain (Cameron and Whitten 1979; Fancy et al. 1989). Calving areas are located between the Colville and Canning rivers within 160 km of the Beaufort Sea (Cameron and Whitten 1979; Wolfe 2000). Seasonal ranges often overlap (Cameron and Whitten 1979). In general, parturient cows arrive on the coastal plain between late April and early June, calving occurs between the first and third week in June, and bulls arrive in early July (Whitten and Cameron 1980; Jakimchuk et al. 1987). After CAH caribou reach the coastal plain they separate into two groups that calve east and west of the Sagavanirktok River (Whitten and Cameron 1985; Wolfe 2000). However, interchange of caribou between these groups occurs (Cronin et al. 1997, 2000, 2001; Chapter 5 this volume). For example, Wolfe (2000) reported that ten (18%) of 55 radio-collared female caribou, for which calving was recorded in >1 year, switched between the east and west segments of the CAH.

The CAH was estimated at approximately 5000 caribou in 1979 and increased to approximately 23,000 in 1992 (Cronin et al. 1998a; Ballard et al. 2000). The herd declined to approximately 18,000 in 1995 and increased to approximately 27,000 by 2000 (Cronin et al. 2001; P. Valkenburg, pers. comm.). Between 200 and 600 CAH caribou are harvested by hunters each year (Murphy and Lawhead 2000).

During periods with little or no insect activity, caribou distribution may be related to the relative availability of easily digestible forage (White et al. 1975). However, caribou behavior and movements may be greatly influenced by harassment from mosquitoes (*Aedes* spp.) and oestrid flies (*Hypoderma tarandi, Cephenemyia trompe*; White et al. 1975; Dau 1986). When harassed by insects, caribou typically use coastal areas, river deltas and channels, wind-swept uplands and ridges, and other non-vegetated habitats such as gravel roads and pads for relief (Pollard et al. 1996a; Noel et al. 1998). During periods of insect harassment, large groups of caribou have been observed along the Beaufort Sea coastline, near Franklin Bluffs, on oilfield roads and gravel pads, and on the deltas of the Canning, Kadleroshilik, Kuparuk, Sagavanirktok, Shaviovik, and Staines rivers (Gavin 1983; Carruthers et al. 1984; Lawhead and Curatolo 1984; Pollard et al. 1996a, 1996b; Noel and Olson 1999a, 1999b; Olson and Noel 2000).

Industrial developments within the CAH annual range include numerous oilfield developments including (from west to east): the Alpine, Kuparuk, Milne Point, Prudhoe Bay, and Badami oilfields. Near the easternmost extent of the CAH range, the Point Thomson Unit may be developed within the next decade. Concerns about potential negative effects on caribou from oil and gas development have included displacement from areas of intensive development and activity (Cameron et al. 1992b, 1995), decreased reproductive productivity of females (Cameron et al. 1992a; Cameron 1994, 1995), and cumulative effects that could eventually lead to a population decline (Cameron 1983; Nellemann and Cameron 1998). Current issues involving caribou and oilfields include shifting of the west segment of the CAH's calving grounds in a southwest direction, away from the Milne Point Unit and Kuparuk oilfields (Wolfe 2000) and blockage of caribou movements between inland foraging areas and coastal insect-relief habitats along the Beaufort Sea (Cameron et al. 1995). In addition, Whitten and Cameron (1985) suggested that since the mid-1970s, movements by large post-calving aggregations through the PBOF study area have become rare or ceased entirely, but extensive data indicate otherwise (Pollard et al. 1996b; Cronin et al. 1998b; Ballard et al. 2000). Although the CAH has grown during the period of oilfield development (Cronin et al. 1998a, 2000, 2001; Ballard et al. 2000), has similar demographics

with other Alaskan Arctic caribou herds (Ballard and Cronin 1995), and the west segment has had high calf production (79 calves per 100 cows) for the past 6 years (Lawhead and Prichard 2002), concerns remain about potential nutritional and reproductive consequences that could arise from changes in distribution (Dau and Cameron 1986; Cameron et al.1992b, 2002; Nellemann and Cameron 1996, 1998; Wolfe 2000).

During the calving period, some evidence suggests that caribou avoid infrastructure (Cameron et al. 1992b). During the post-calving period, the relationship between caribou distribution and distance to oilfield infrastructure varies among caribou sex and age classes, study areas, and years. Pollard et al. (1992a, 1992b, 1996b) and Cronin et al. (1998b) demonstrated that caribou distribution is largely unrelated to distance from infrastructure. Cronin et al. (1998b) also reported that bulls were in greater than expected numbers within 1 km and 2 km from infrastructure for 4 of 6 years and 3 of 6 years, respectively. Fewer calves than expected occurred within 1 km of oilfield infrastructure during the post-calving period for 6 of 7 years in the Milne Point oilfield (Olson and Noel 2000; Noel and Demarchi 2002).

In addition to caribou, grizzly bear (*Ursus arctos*), muskoxen (*Ovibos moschatus*), moose (*Alces alces*), wolves (*Canis lupus*), and wolverine (*Gulo gulo*) are other large mammals inhabiting the Arctic Coastal Plain and are recorded during aerial surveys (Noel and Olson 2001a, 2001b). Grizzly bears use the coastal plain, especially in June and July, but occur at relatively low densities (Reynolds 1979; Young and McCabe 1998; Shideler and Hechtel 2000). After extirpation from the Arctic Coastal Plain in Alaska in the mid-1800s (Hone 1934), muskoxen were reestablished by translocation to Nunivak Island near the western Alaskan coast in 1935–1936 (Spencer and Lensink 1970) and to Barter Island and the Kavik River near the Arctic National Wildlife Refuge in 1969–1970 (Jingfors and Klein 1982). Thereafter, muskoxen numbers in northeastern Alaska have increased and their range has expanded to the Colville River on the west and beyond the Babbage River on the east (Reynolds 1998). Moose, wolves, and wolverine are relatively uncommon on the coastal plain (Stephenson 1979; U.S. Fish and Wildlife Service [USFWS] 1992; Shideler, R., Alaska Department of Fish and Game [ADFG], pers. comm.).

Business Rationale

Caribou are an important wildlife resource and the most abundant large mammal on Alaska's Arctic Coastal Plain during summer. The potential for negative effects on caribou of the CAH from petroleum exploration and development concerns industry, regulatory agencies, natives, and advocacy groups (U.S. Department of the Interior [USDOI] 1998a, 1998b). Monitoring of caribou distribution within and adjacent to North Slope oilfields allows assessment of long-term trends in habitat use, documents potential changes in distribution and movements relative to petroleum production, and provides information for predicting impacts from satellite developments. Such information is useful for designing and implementing mitigation that minimizes impacts to caribou. Additionally, information on the distribution and abundance of caribou and other large mammals will be available for use in the Environmental Impact Statement (EIS) for the Point Thomson Unit.

Objectives

The primary objectives of our summer 2001 surveys were to document the number, sex and age composition, and distribution of caribou during the calving and post-calving periods in the Milne Point Unit (MPU), Prudhoe Bay oilfield (PBOF; post-calving only), Badami, and Bullen Point to Staines River (Bullen-Staines) study areas during summer 2001. Secondary objectives were to: (1) summarize multiple years of calving distribution data in the Badami and Bullen-Staines study areas (1998–2001), (2) describe the relationship between caribou distribution and oilfield infrastructure in the MPU and PBOF study areas, and (3) describe caribou abundance and distribution relative to parasitic insect activity.

Study Areas

Milne Point Unit (MPU)

The 2001 MPU study area (694 km^2) is bounded by the Oliktok Point Road on the west, Kuparuk River on the east, the Beaufort Sea on the north, and lat 70°16.8'N on the south (Figure 1). This area, on the northern edge of Alaska's Arctic Coastal Plain, is characterized by low relief, many shallow lakes and drained lake basins, and a variety of habitats dominated by wet and moist graminoid tundra communities (Figure 1; Walker et al. 1980). Lakes and small standing water bodies comprise 21% (147 km^2) of the study area.

Fourteen production pads, a central processing facility, the Kuparuk Industrial Center, and a gravel mine site were within the 1994 MPU study area. Since systematic surveys in the Milne Point area were initiated by BP Exploration (Alaska) Inc. (BPXA) in 1991, three additional gravel production pads and access roads have been constructed (F Pad, K Pad, and NW Eileen 1). The portion of the study area south of the Spine Road between the Oliktok Point Road and the Kuparuk River includes a gravel mine site, a central processing facility, 16 production pads, and the Kuparuk airstrip. Facilities are supported by gravel pads and are connected by the Milne Point Road, the Spine Road, and secondary (access) gravel roads (totaling about 149 km in length, based on 1:63,360 scale U.S. Geological Survey (USGS) topographic maps). Gravel fill for active pads, roads, and facilities encompasses about 6 km^2 (<1% of the 2001 MPU study area, based on 1:63,360 scale USGS topographic maps).

Prudhoe Bay Oilfield (PBOF)

The PBOF study area is bounded by the Kuparuk River on the west, 147°45'W on the east, the Beaufort Sea coastline on the north, and 70°05'N on the south (Figure 1). The 1394 km^2 PBOF study area (Figure 1) was surveyed from 1990–1996. The PBOF study area includes most of the Prudhoe Bay Unit and surrounding areas and is characterized by low relief, many shallow lakes and drained lake basins, and a variety of habitats dominated by wet and moist graminoid tundra communities (Figure 1; Walker et al. 1980).

Fifty-three producing oil-well pads, 31 exploration pads, 8 gathering centers, 2 gravel landing strips, and 2 base camps are within the PBOF study area. The PBOF study area also includes the industrial camp community of Deadhorse and the associated airfield. Facilities are supported by gravel pads and are connected by a network of gravel and chip sealed roads totaling about 329 km in length. Approximately 2593 ha or 2.6% of the Prudhoe Bay oilfield has been disturbed by mine sites and gravel placement (Gilders and Cronin 2000).

Badami

The Badami study area is bounded on the west by the Sagavanirktok River, extends east to Bullen Point, north to the Beaufort Sea, and south to approximately 69°54.5'N (Figure 1). The west side of the study area overlaps with the PBOF study area (Figure 1). The study area lies within Alaska's 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 (20 to 25 ft) above the level of streams and river channels, which gives the landscape a gently rolling appearance. This topographic relief results in many well-drained areas, and 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 (Figure 1).

The 40-km Badami pipeline extends across the northernmost section of the study area. The pipeline ranges from 1 to 5 km from the coast and extends from the Endicott pipeline on the west to the Badami facility on the east. A review of the pipeline by the Alaska Department of Fish and Game found that three areas totaling about 182 m (600 linear ft; 0.5% of the total pipeline length) were elevated less than 1.52 m (5 ft; Coltrane and Lanctot 2001). Additionally, pipeline vibration dampers (PVDs) were placed between vertical support members along four sections of the pipeline totaling 8284 m (27,179 ft; 21% of the total pipeline length). The PVD's extended below the pipeline by 94 cm (37 inches) at the half-span location and 51 cm (20 inches) at the quarter-span location (Coltrane and Lanctot 2001; also see Chapter 4). The Badami facility consists of a central processing plant, dock, airstrip, and gravel mine site connected by 5 km of gravel roads.

Bullen Point to Staines River (Bullen-Staines)

The Bullen Point to Staines River study area is bounded on the west by Bullen Point, extends 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 8 km of the coast has little topographic relief. Further inland, the landscape begins a gradual assent from 8 to 107 m (25 to 350 ft) above sea level at the southern edge of the study area (about 38 km [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. Calcareous loess deposited downwind of the Canning River results in soils with high silt content, high pH (6.0–8.4), 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 (Figure 1).

There is no active oil and gas development infrastructure within the Bullen–Staines study area; however, the Point Thomson Unit is likely to be developed within the next decade. There are numerous abandoned gravel exploration pads, a few mine sites, and several gravel landing strips including the DEW line site at Bullen Point.

Methods

Aerial Surveys

Between 10 June and 2 August 2001, we conducted 24 systematic strip-transect aerial surveys (6 calving period surveys, 18 post-calving period surveys; Caughley 1977) from a Cessna 206 fixed-wing aircraft. Transect centerlines were spaced at 1.6-km intervals, oriented north-south, and centered on township and section lines from 1:63,360 scale USGS topographic maps. Transects were flown at 90 m altitude and 130–180 km/h. Two observers, each searching an 800-m wide area on their side of the transect centerline, provided 100% coverage of the study area. Aircraft wing struts were marked to enable visual control of transect strip width and estimation of distance between caribou groups and the survey aircraft (Pennycuick and Western 1972). Observers verified strut markings using an inclinometer.

Two global positioning system (GPS) receivers were used: one by the pilot for navigating the aircraft along transects and the other by observers for estimating the location of the aircraft when animals were observed. The observers' GPS receiver was linked to a notebook computer via Geolink® software (Michael Baker Jr., Inc., Jackson, Mississippi). For each large mammal sighting, species, group size, group composition, and distance perpendicular from the aircraft were recorded. During surveys, data were entered into the computer by a third person or by one of the 2 observers. Coordinates of animal

sightings were later calculated using the visual estimates of distance from the aircraft to offset the GPS aircraft positions (Appendices A through D).

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 or were near the outer margin of transect strips. When a large group was observed, the survey aircraft often left the transect centerline and circled the group to facilitate counting and classifying. The aircraft then returned to the transect at the point of departure so that no survey coverage was lost. Muskoxen were classified as bull, cow, calf, or unclassified and grizzly bears as adult or female with cubs. Arctic fox (*Alopex lagopus*) and golden eagle (*Aquila chrysaetos*) sightings were also recorded (Appendix E through H).

For each survey, we estimated levels of parasitic insect activity using predictive models of mosquito (Russell et al. 1993) and oestrid fly (Mörschel 1999; Appendix I) activity. Indices were calculated for each hour that temperature and wind data were recorded at the Deadhorse Weather Station (Alaska State Climate Center). Days (24-hr) with ≥4 hours total of either mosquito indices ≥0.5 and/or oestrid fly indices ≥0.4 were considered insect days potentially having an effect on caribou distribution (Russell et al. 1993; Cameron et al. 1995).

Data Mapping and Analysis

We used MapInfo® (MapInfo Corporation, Troy, New York) and Arcview® (Environmental Systems Research Institute, Inc., Redlands, California) Geographic Information System (GIS) software to map and analyze the aerial survey data. Base maps were 1:63,360-scale. Caribou densities were calculated by dividing the number of caribou observed in a survey by the total land area within the study area.

We summarized calf distribution during the calving period (before 21 June) for the Badami and Bullen-Staines study areas, which included surveys from 1998 (n = 2; Noel and Olson 1999a, 1999b), 1999 (n = 1; Noel and King 2000a, 2000b), 2000 (n = 1; Noel and Olson 2001a, 2001b), and the present study (n = 2). The combined multi-year distribution was converted to a grid format using inverse distance weighting interpolation (MapInfo Corporation 2001; grid cell size = 200 m; 5-km radius; 100-point maximum) in MapInfo, Vertical Mapper. The grid was then contoured based on percentile occurrence for the total number of calves, which ranged from 0 to 40.

We examined caribou distribution during the post-calving period (2001 data only) among 1-km intervals around oilfield infrastructure in the MPU and PBOF study areas. The 1-km interval width was chosen to allow comparisons of our 2001 data with prior analyses (Dau and Cameron 1986; Cameron et al. 1992b; Cronin et al. 1998b; Olson and Noel 2000; Noel and Demarchi 2002). We included active infrastructure (actively used roads, pads, pipelines, and mine sites) in and surrounding the study area into a 1:63,360-scale GIS coverage for construction of the 1-km buffers within the study area. In the MPU study area, the NW Eileen 1 access road and production pad were completed during 2001 but the access road was not open to traffic so these structures were not included in buffers for interval analysis. For each interval, we excluded area of lakes to calculate total available land area. We created 8 intervals (1–8 km) for the MPU study area and 16 intervals (1-16 km) for the PBOF study area. We combined the land area of intervals 6-8 km and 14-16 km for the MPU and PBOF study areas, respectively, because individually these intervals represented very small proportions of the study areas.

The number of observed caribou was tabulated for each distance interval for bulls, calves, and other caribou. These classes were analyzed separately because bulls and maternal cows may respond differently to habitat features (Pollard et al. 1992b, 1996b), and bulls and calves were easiest to identify. We based the interval analyses on individual caribou rather than on groups because groups were

sometimes difficult to distinguish, and often disparate in size (ranging from 1 to >1000 animals) and composition. For example, a group of 100 caribou were treated as 100 independent observations and not as 1 observation of the group. However, we acknowledge that individual caribou within groups may not be behaviorally or statistically independent from the group.

For each distance interval, we compared the proportion of caribou observed to the proportion expected (based on an even distribution) within the available land area (Manly et al. 1993). Selection or avoidance by caribou of a distance interval was inferred when the Bonferroni-corrected 95% confidence interval for the observed proportion was greater than or less than, respectively, the expected proportion (Manly et al. 1993).

Results

Overview of Aerial Surveys

We completed a total of 6 calving period and 18 post-calving period aerial surveys for caribou in the study areas between 10 June and 2 August 2001. For calving surveys we observed a total of 353 (including 79 calves), 3163 (including 893 calves), and 2129 (including 735 calves) caribou in the MPU, Badami, and Bullen-Staines study areas, respectively. During the post-calving period we observed a total of 1151, 3476, 9506, and 7822 caribou in the MPU, PBOF, Badami, and Bullen-Staines study areas, respectively. Groups observed during the calving period were dominated by cows (62%–84%). Groups observed during the post-calving period were larger and more variable in size and composition.

Caribou Distribution During the Calving Period

Milne Point Unit (MPU)

Survey 1, 10 June 2001 — A total of 31 caribou (including 2 calves) in 16 groups was observed (Table 1, Appendix A). The composition of classified caribou was 5% bulls, 84% cows, and 11% calves (Table 1). Total caribou and calf densities in the study area were 0.04 caribou/km^2 and 0.003 calves/km^2. Most groups were on the western side of the study area and between the Oliktok and Milne Point roads. All groups were inland from the coast (Figure 2). One group of 19 muskoxen was observed during the survey (Figure 2, Appendix E). Parasitic insect indices indicated that conditions were favorable for mosquito activity during 1 hour on 10 June (Table 2).

Survey 2, 20 June 2001 — A total of 322 caribou (including 77 calves) in 39 groups was observed (Table 1, Appendix A). The composition of classified caribou was 2% bulls, 68% cows, and 30% calves (Table 1). Total caribou and calf densities in the study area were 0.46 caribou/km^2 and 0.11 calves/km^2. Most groups were observed in the central portion of the study area, north of the Spine Road (Figure 2). One group of 22 muskoxen and one arctic fox were observed during the survey (Figure 2, Appendix E). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 20 June (Table 2).

Badami

Survey 1, 12 June 2001 — A total of 1150 caribou (including 376 calves) in 258 groups was observed (Table 3, Appendix B). The composition of classified caribou was <1% bulls, 63% cows, and 36% calves (Table 3). Total caribou and calf densities in the study area were 0.86 caribou/km^2 and 0.28 calves/km^2. All but 2 groups were located south of the Badami pipeline and several of the larger groups were located west of the Shaviovik River and east of the Kavik River (Figure 3). Five muskoxen, 1 arctic fox, and 3 grizzly bears were observed during the survey (Figure 3, Appendix F). Parasitic insect indices

indicated that conditions were favorable for mosquito and oestrid fly activity for 3 and 1 hours on 12 June, respectively (Table 2).

Survey 2, 17 June 2001 — A total of 2013 caribou (including 517 calves) in 250 groups was observed (Table 3, Appendix B). The composition of classified caribou was 2% bulls, 71% cows, and 27% calves (Table 3). Total caribou and calf densities in the study area were 1.51 caribou/km^2 and 0.39 calves/km^2. All but 2 groups were observed south of the Badami pipeline and were widely distributed throughout the study area (Figure 3). Three muskoxen, 6 arctic foxes, and 4 grizzly bears were observed during the survey (Figure 3, Appendix F). Parasitic insect indices indicated that conditions were favorable for mosquito activity for 1 hour on 17 June (Table 2).

Bullen Point to Staines River (Bullen-Staines)

Survey 1, 11 June 2001 — A total of 349 caribou (including 122 calves) in 100 groups was observed (Table 4, Appendix C). The composition of classified caribou was <1% bulls, 62% cows, and 38% calves (Table 4). Total caribou and calf densities in the study area were 0.39 caribou/km^2 and 0.13 calves/km^2. Most groups were observed inland and in the western half of the study area (Figure 4). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 11 June (Table 2).

Survey 2, 16 June 2001 — A total of 1780 caribou (including 613 calves) in 157 groups was observed (Table 4, Appendix C). The composition of classified caribou was <1% bulls, 64% cows, and 36% calves (Table 4). Total caribou and calf densities in the study area were 1.97 caribou/km^2 and 0.68 calves/km^2. Groups were widely distributed throughout the study area, with the exception of the southeast corner near the Staines and Canning Rivers (Figure 4). One group of 8 muskoxen and 4 grizzly bears were observed during the survey (Figure 4, Appendix G). Parasitic insect indices indicated that conditions were favorable for mosquito activity for 2 hours on 16 June (Table 2).

Caribou Distribution During the Post-calving Period

Milne Point Unit (MPU)

Survey 3, 25 June 2001 — A total of 568 caribou in 60 groups was observed (Table 1, Appendix A). The composition of classified caribou was <1% bulls, 64% cows, and 36% calves (Table 1). Groups were distributed widely throughout the study area. Most groups were seen inland from the coast, although a few were seen near Beechey Point (Figure 5). One group of 22 muskoxen and 2 arctic foxes were observed during the survey (Figure 5, Appendix E). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 25 June (Table 2).

Survey 4, 7 July 2001 — A total of 446 caribou in 29 groups was observed (Table 1, Appendix A). The composition of classified caribou was 14% bulls, 36% cows, and 50% calves (Table 1). Groups were distributed widely throughout the study area and several groups were seen between the Milne Point road and the Sakonowyak River. Most groups were observed north of the Spine Road (Figure 5). One group of 25 muskoxen, and 5 grizzly bears were observed during the survey (Figure 5, Appendix E). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 7 July (Table 2).

Survey 5, 15 July 2001 — A total of 112 caribou in 16 groups was observed (Table 1, Appendix A). The composition of classified caribou was 5% bulls, 61% cows, and 34% calves (Table 1). Most groups were seen north of the Spine Road and between the Oliktok and Milne Point roads. A few groups were seen west of Milne Point Road, as far east as the Kuparuk River (Figure 5). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 15 July (Table 2).

Survey 6, 25 July 2001 — A total of 25 caribou in 16 groups was observed (Table 1, Appendix A). The composition of classified caribou was 10% bulls, 57% cows, and 33% calves (Table 1). All groups were seen north of the Spine Road and inland from the coast. Groups were observed primarily in the eastern part of the study area (east of Milne Point Road; Figure 5). One golden eagle was observed during the survey (Figure 5, Appendix E). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 25 July (Table 2).

Prudhoe Bay Oilfield (PBOF)

Survey 1, 21 June 2001 — A total of 225 caribou in 57 groups was observed (Table 5, Appendix D). The composition of classified caribou was 8% bulls, 76% cows, and 16% calves (Table 5). Most groups were in the southeastern part of the study area, east of the Sagavanirktok River Main Channel (Figure 6). Several groups were west of the Sagavanirktok River, and west of the Trans-Alaska Pipeline. Most groups were more than 10 km from the coast, but one group was just east of the Kuparuk delta and another was near DS16 (Figure 6). Two groups of muskoxen (totals of 5 and 27 animals), 2 arctic foxes, and 3 grizzly bears were observed during the survey (Figure 6, Appendix H). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 21 June (Table 2).

Survey 2, 26 June 2001 — A total of 715 caribou in 95 groups was observed (Table 5, Appendix D). The composition of classified caribou was 11% bulls, 63% cows, and 26% calves (Table 5). Most groups were concentrated south of the Spine Road and the Badami Pipeline (Figure 6). One arctic fox and one grizzly bear were observed during the survey (Figure 6, Appendix H). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 26 June (Table 2).

Survey 3, 8 July 2001 — A total of 434 caribou in 40 groups was observed (Table 5, Appendix D). The composition of classified caribou was 46% bulls, 27% cows, and 27% calves (Table 5). Most groups were observed in the southern portion of the study area and along the Putuligayuk River, the Sagavanirktok River, and to the east of the Sagavanirktok River Main Channel (Figure 6). One group of 25 muskoxen and 1 grizzly bear were observed during the survey (Figure 6, Appendix H). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 8 July (Table 2).

Survey 4, 14 July 2001 — A total of 540 caribou in 20 groups was observed (Table 5, Appendix D). The composition of classified caribou was 18% bulls, 38% cows, and 44% calves (Table 5). Most groups were in the southeast part of the study area, east of the Sagavanirktok River main channel (Figure 6). Two groups of muskoxen (totals of 9 and 16 animals) were observed during the survey (Figure 6, Appendix H). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 14 July (Table 2).

Survey 5, 27 July 2001 — A total of 1502 caribou in 43 groups was observed (Table 5, Appendix D). The composition of classified caribou was 8% bulls, 65% cows, and 27% calves (Table 5). Two large groups were seen in the southwestern corner of the study area, near the Putuligayuk River and the Trans-Alaska Pipeline. Several groups were along the East Channel Sagavanirktok River, in the river delta, and near Point Brower. Two groups were seen near the coast along the Kuparuk River. Several groups were seen in close proximity to roads or pads. A few smaller groups were east of the East Channel Sagavanirktok River (Figure 6). One group of 26 muskoxen, 2 arctic foxes, and 1 golden eagle were observed during the survey (Figure 6, Appendix H). Parasitic insect indices indicated that conditions were favorable for mosquito activity for 5 hours on 27 July (Table 2).

Survey 6, 2 August 2001 — A total of 60 caribou in 39 groups was observed (Table 5, Appendix D). The composition of classified caribou was 42% bulls, 45% cows, and 13% calves (Table 5). Groups were

distributed mostly throughout the central and southern portions of the study area (Figure 6). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 2 August (Table 2).

Badami

Survey 3, 29 June 2001 — A total of 5017 caribou in 156 groups was observed (Table 3, Appendix B). The composition of classified caribou was 3% bulls, 44% cows, and 53% calves (Table 3). Caribou groups were concentrated in the southeastern portion of the study area (Figure 7). Three grizzly bears and 1 golden eagle were observed during the survey (Figure 7, Appendix F). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 29 June (Table 2).

Survey 4, 13 July 2001 — A total of 1440 caribou in 56 groups was observed (Table 3, Appendix B). The composition of classified caribou was 9% bulls, 53% cows, and 38% calves (Table 3). Caribou were concentrated in the southern half of the study area (Figure 7). Two groups of muskoxen (totals of 5 and 8) were observed during the survey (Figure 7, Appendix F). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 13 July (Table 2).

Survey 5, 24 July 2001 — A total of 3012 caribou in 27 groups was observed (Table 3, Appendix B). The composition of classified caribou was 19% bulls, 60% cows, and 21% calves (Table 3). Caribou were concentrated along the east and in riparian habitats (Figure 7). One arctic fox was observed during the survey (Figure 7; Appendix F). Parasitic insect indices indicated that conditions were favorable for mosquito activity for 4 hours on 24 July (Table 2).

Survey 6, 1 August 2001 — A total of 37 caribou in 29 groups was observed (Table 3, Appendix B). The composition of classified caribou was 7% bulls, 75% cows, and 18% calves (Table 3). Small, scattered caribou groups were primarily in the western half of the study area (Figure 7). One grizzly bear and 2 golden eagles were observed during the survey (Figure 7, Appendix F). Parasitic insect indices indicated that conditions were favorable for mosquito activity for 1 hour on 1 August (Table 2).

Bullen Point to Staines River (Bullen-Staines)

Survey 3, 28 June 2001 — A total of 1265 caribou in 111 groups was observed (Table 4, Appendix C). The composition of classified caribou was <1% bulls, 64% cows, and 36% calves (Table 4). Caribou were widely distributed throughout the study area. Most groups were within 15 km of the coastline area (Figure 8). Two arctic foxes were observed during the survey (Figure 8, Appendix G). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 28 June (Table 2).

Survey 4, 13 July 2001 — A total of 583 caribou in 22 groups was observed (Table 4, Appendix C). The composition of classified caribou was 16% bulls, 61% cows, and 23% calves (Table 4). Groups were widely distributed throughout the study area. The largest groups were in the southern half of the study area (Figure 8). One group of 12 muskoxen was observed during the survey (Figure 8, Appendix G). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity (Table 2) on 13 July.

Survey 5, 23 July 2001 — A total of 5957 caribou in 7 groups was observed (Table 4, Appendix C). The composition of classified caribou was 60% bulls, <1% cows, and 39% calves (Table 4). All large groups were within 10 km of the coast (Figure 8). Two large groups of caribou were at the coast, a group of 800 was near Point Gordon, and a group of 1800 was between Point Hopson and Point Gordon. One group of 1700 caribou was south of Bullen Point and a group of 1650 caribou was immediately west of

the Staines River (Figure 8). Parasitic insect indices indicated that conditions were favorable for mosquito and oestrid fly activity for 3 and 6 hours on 23 July, respectively (Table 2).

Survey 6, 31 July 2001 — A total of 17 caribou in 13 groups was observed (Table 4, Appendix C). The composition of classified caribou was 67% cows and 33% calves (Table 4). Small groups were scattered primarily throughout the eastern half of the study area (Figure 8). Many groups were more than 10 km from the coast (Figure 8). One arctic fox and 1 golden eagle were observed during the survey (Figure 8, Appendix G). Parasitic insect indices indicated that conditions were not favorable for mosquito or oestrid fly activity on 31 July (Table 2).

Calving Distribution in the Badami and Bullen-Staines Study Areas, 1998-2001

Calf distributions in 1998–2001 indicate that the largest groups with calves occurred in the Bullen-Staines study area (Figure 9). For the 6 surveys over 3 years combined, 66% of calves (49% of groups) were in the Bullen-Staines study area and 34% of calves (51% of groups) were in the Badami study area. Few calves (2% of calves, 4% of groups) were within the Point Thomson Unit during calving from 1998–2001 (Figure 9). Most calves (75%) were within 30% of the survey area (red polygons, Figure 9).

Caribou Distribution Relative to Oilfield Infrastructure

Milne Point Unit (MPU)

Interval analyses were not conducted for any classes during the calving period, or for bulls during the post-calving period, because of the small number of observations. For combined post-calving surveys in 2001, calves were observed in greater than expected numbers in the 2-km interval and not different than expected numbers in the 1-km and 3-km intervals (Table 6). Fewer calves than expected were observed in the 4-km, 5-km, and 6- to 8-km intervals (Table 6). Other caribou (excluding bulls and cow/calf pairs) were in greater than expected numbers in the 1-km and 2-km intervals and less than expected numbers for all intervals ≥3-km (Table 7).

Prudhoe Bay Oilfield (PBOF)

For combined post-calving surveys in 2001, fewer calves than expected were observed in the 1-km through 8-km intervals (Table 8). Calves were observed in greater than expected numbers in the 9-km, 10-km, and ≥12-km intervals and not different than expected numbers in the 11-km interval (Table 8). Bulls were observed in less than expected numbers in the 1-km through 5-km and 11-km intervals (Table 9). Bulls were observed in greater than expected numbers in the 12-km interval and not different than expected numbers in the 6-km through 10-km and ≥13-km intervals (Table 9). Other caribou (excluding bulls and cow/calf pairs) were observed in less than expected numbers in the 1-km through 6-km and 8-km intervals, not different than expected numbers in the 7-km interval, and in greater than expected numbers in the ≥9-km intervals (Table 10).

Discussion

Caribou monitoring on Alaska's North Slope has occurred since 1990. This extensive database allows for comparison of data on distribution and abundance of caribou and other large mammals among years and study areas.

Caribou Distribution During the Calving Period

The total number of caribou observed differed between the first and second calving period surveys and among study areas. In all three study areas where calving surveys were conducted (i.e., MPU, Badami, and Bullen-Staines), fewer caribou were observed during the first calving survey (between 10 and 12 June) than during the second calving survey (between 16 and 20 June; Tables 1, 3 and 4). This is a consistent pattern for calving period surveys in this region (Pollard et al. 1992a; Pollard and Noel 1994; Olson and Noel 1999; Noel and King 2000a) and may represent movement of cow-calf pairs into these survey areas after calving in early to mid June. Among years, several factors can influence the arrival of parturient cows on the calving grounds, including spring snow and flood patterns (Gavin 1983; Whitten and Cameron 1985).

Milne Point Unit (MPU)

The distribution of caribou in the MPU study area in 2001 was similar to results of other calving surveys conducted between 1991 and 2000 (Noel and Demarchi 2002). Most observations of caribou groups in 2001 were south of I pad on the west side of Milne Point Road and south of K Pad on the east side of Milne Point Road. It appears that few caribou calve in the northern portion of the study area and most groups were observed ≥8 km from the Beaufort Sea coast.

Overall, few caribou were observed in the MPU study area during the calving period in 2001 (Table 1). The MPU study area is used as a calving area west of the Sagavanirktok River (Haskell 2001; Noel and Demarchi 2002), while the Badami and Bullen-Staines study areas are used as calving areas to the east of the Sagavanirktok River (Wolfe 2000; Noel and Olson 2001a, 2001b). Wolfe (2000) summarized radiotelemetry data from 1980–1995 and suggested that calving to the west of the Sagavanirktok River was concentrated in the area southwest of the Kuparuk oilfield from 1987–1995. Lawhead and Prichard (2002) summarized aerial survey data from 1993 and 1995–2001 and reported that calving was concentrated south/southwest of the Kuparuk oilfield over this time period. Cameron et al. (2002) suggested that disturbance from the oilfields have caused caribou west of the Sagavanirktok River to calve in these inland areas away from oilfield infrastructure, however, research to date has not elucidated other potential factors (e.g., population density; Cronin et al. 1997) that may have an effect on calving distribution.

Badami

The distribution of caribou in the Badami study area in 2001 was similar to previous calving distributions described for 1994 and 1998–2000 by Noel and Olson (2001b). Overall, few caribou groups were observed in the northern portion of the study area and most groups were observed ≥5 km from the Beaufort Sea coast. Additionally, out of 10 surveys from 1994–2001 only 2 observations of caribou groups were made in the northwest corner of the study area.

Noel and Olson (2001b) reported that in 2000, ≤40% of caribou and few cow-calf pairs were within 4 km of the coast in June. On 12 June 2001, 48% of calves were west of the Kadleroshilik River, while 25% of calves were between the Kadleroshilik and the Shaviovik rivers and 27% were east of the Shaviovik River. By 17 June, calves were more evenly dispersed throughout the Badami area with 39% west of Kadleroshilik River, 33% between the Kadleroshilik and Shaviovik rivers, and 28% east of the Shaviovik River. Caribou distribution was more even across the Badami study area in 2001 than in the past.

Bullen Point to Staines River (Bullen-Staines)

Compared with previous calving distributions summarized by Noel and Olson (2001a) for 1993 to 2000, the most consistent pattern among years is that fewer caribou were observed in the eastern portion of the study area close to the Staines and Canning rivers, and especially in the southeast corner. Similar to the MPU and Badami study areas, most observations of groups during the calving period in the Bullen-Staines study area were greater than 5 km from the Beaufort Sea coast. For most years, the majority of caribou are inland and in the central and southwest portions of the study area.

Caribou Distribution During the Post-calving Period

Milne Point Unit (MPU)

During the post-calving period, caribou were distributed widely throughout the study area. The most caribou observed during a single survey was on 25 June (total = 758; Table 1). Thereafter, the number of caribou observed during surveys decreased to 25 on 25 July. Insect indices indicated that parasitic insects were active during the 9 days prior to the survey (Table 2); however, few caribou were present in the study area on 25 July, and no caribou were observed along the Beaufort Sea coast (Figure 5). Between 1998 and 2000, few large caribou groups have been observed along the coast (Olson and Noel 1999, 2000; Noel and Demarchi 2002), which may indicate that coastal insect-relief habitats are used in areas outside of the MPU study area. Additionally, unlike the other study areas, the MPU study area contains no large river systems (with the exception of a portion of the Kuparuk River) along which caribou travel (Smith et al. 1994) and use for insect-relief.

Prudhoe Bay Oilfield (PBOF)

In general, most caribou observed during the post-calving period were in the southern portion of the study area. For all surveys, few caribou were observed in the northwest corner of the study area between the Kuparuk River delta and Prudhoe Bay. Previous surveys in the PBOF study area between 1990 and 2000 have demonstrated that this area is used regularly by caribou for insect-relief (Pollard et al. 1996b; Pollard and Noel 1996). However, parasitic insect models suggested that weather conditions were favorable for insect activity between 16 and 24 July and on 27 July (Table 2) when 1502 caribou were observed in the study area (Figure 6).

Badami

Caribou were widely distributed throughout the study area during the post-calving period. During surveys when parasitic insect activity was predicted to be absent (Table 2), caribou were observed primarily inland in the southern and southeastern portions of the study area (Figure 7). During the 24 July survey several large groups were observed on Foggy Island Bay, just south of Point Brower (Sagavanirktok River delta) and adjacent to the Badami facility on Mikkelsen Bay (see also 27 July survey in the PBOF study area; Figure 6). This survey coincided with the end of a 9-day period of predicted parasitic insect activity (Table 2). Additionally, several large groups were located near the Shaviovik and Kavik rivers. Pollard (1994) reported that on days when mosquito harassment was severe, caribou were observed primarily in coastal and river delta insect-relief habitats within the study area. Additionally, Noel and Olson (1999b) recorded several large groups of caribou north of the Badami pipeline, near the Sagavanirktok River delta and along Foggy Island Bay. In order to access coastal and river delta insect-relief habitats in the study area, caribou crossed either the Badami pipeline or the Endicott road and pipeline. Other insect-relief habitats in the Badami study area include riparian areas along the east channel of the Sagavanirktok River, and Kadleroshilik, Shaviovik, and Kavik rivers where large groups of caribou have been observed (Noel and King 2000a; Noel and Olson 2001b).

Bullen Point to Staines River (Bullen-Staines)

Similar to the other study areas, the number of caribou in the study area declined over the post-calving period, with the exception of the 23 July survey when parasitic insects were active (Table 2). During this survey, 5957 caribou were observed, mostly in 4 large groups. Two groups were along the Beaufort Sea coast between Point Gordon and Point Hopson and the other two groups were <5 km from the coast (Figure 8). Noel and Olson (1999a) reported caribou use of the areas around Bullen Point and Point Thomson and riparian areas near the Staines and Canning rivers as insect-relief habitats. Noel and Olson (2001a) summarized the distribution of caribou along the coast for surveys conducted between 1993 and 2000 and reported that caribou during the post-calving period concentrated primarily near Bullen Point, Point Gordon, Point Sweeney, east of Point Thomson, and near North Staines River #1.

Caribou Distribution Relative to Oilfield Infrastructure

Our results from the interval analysis were similar to those reported by Noel and Demarchi (2002) for calves and other caribou (excluding bulls and cow/calf pairs) during the post-calving period in the MPU study area. Overall, the 2001 MPU study area interval analysis suggested that calves and other caribou were observed either in greater than expected or not different than expected numbers within the 1-km and 2-km intervals. The 2001 PBOF interval analysis suggested that all classes of caribou were in less than expected numbers in the 1-km through 5-km intervals and with the exception of bulls, mostly in greater than expected numbers in the ≥9-km intervals. However, Cronin et al (1998b) showed that from 1990-1996 caribou numbers were not different from expected in the 1-km through 5-km intervals. The results from the 2001 analysis for PBOF are not directly comparable to previous studies (Cronin et al. 1998b) because of the changes in the number of intervals and combination of intervals used in the analysis. However, these results and past interval analyses show that distribution of caribou relative to oilfield infrastructure during the post-calving period is highly variable among caribou sex and age classes, study areas, and years. Other analyses (e.g., by individual survey, log-linear regression; Cronin et al 1998b) may yield additional insights on the relationship between caribou distribution and habitat characteristics within the oilfields.

Differential habitat use along a continuum of insect harassment (from none to severe) and large-scale movements between insect relief and foraging habitats during the post-calving period make it difficult to detect or interpret patterns in caribou distribution relative to oilfield infrastructure. Caribou distributions during the post-calving period often change within hours in response to fluctuating weather patterns and, thus, insect activity (White et al. 1975; Pollard et al. 1996a). During any aerial survey, parasitic insects may or may not influence caribou distribution. For example, caribou often occur in large groups in non-vegetated areas along the coast or in riparian areas during severe mosquito harassment, but disperse to vegetated areas to forage when wind speed increases and/or temperature decreases. Because aerial surveys are snap-shots in time, caribou distribution is described under inconsistent weather patterns and varying levels of insect activity. Thus, it may be difficult to assess whether caribou are selecting for insect-relief or foraging habitats, or moving between these habitats. Additionally, results of the interval analyses should only be interpreted relative to the study area and should not be extrapolated to represent a population-level response by caribou to oilfield infrastructure.

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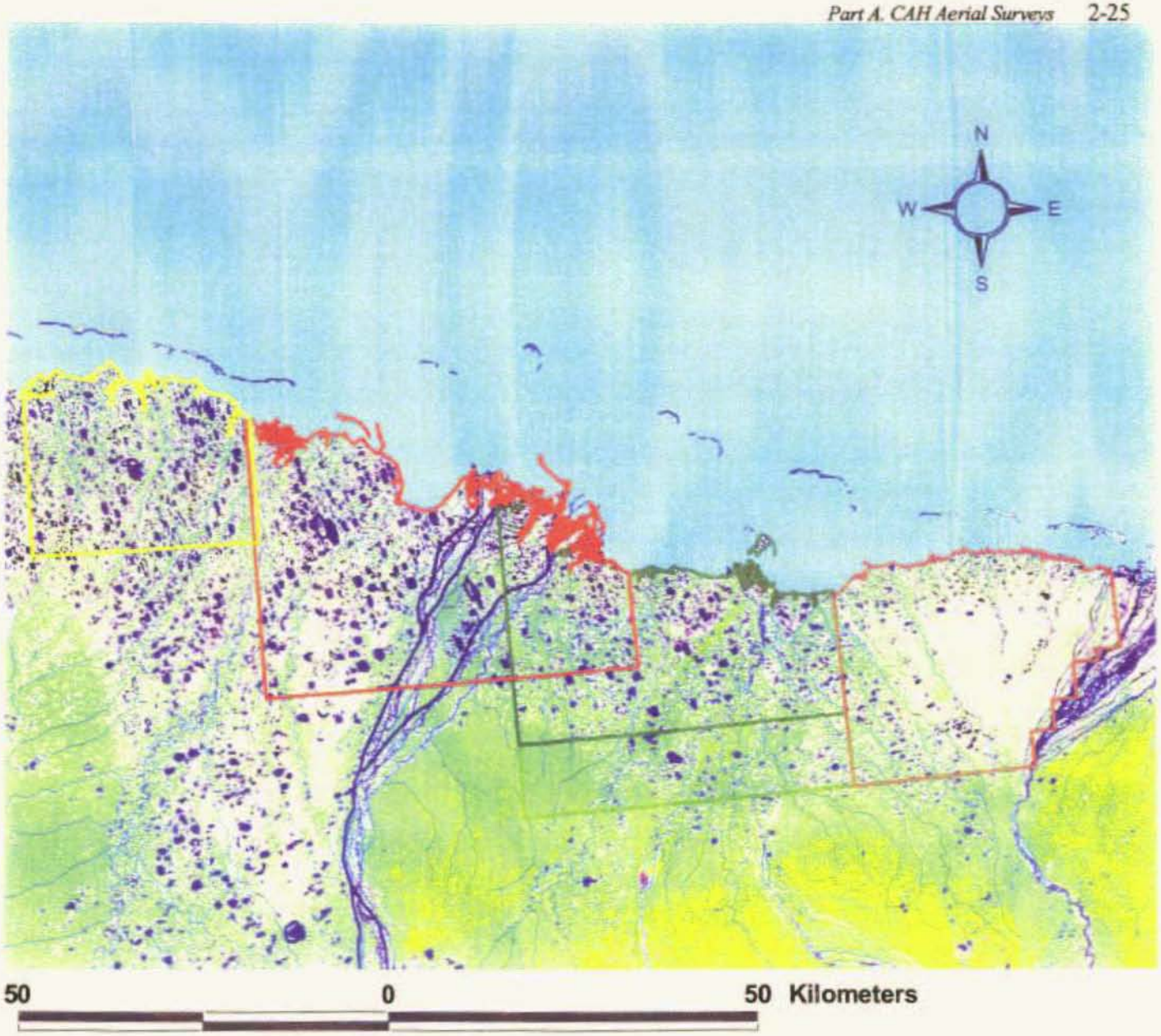


Figure 1. Milne Point Unit (MPU), Prudhoe Bay Oilfield (PBOF), Badami, and Bullen Point to Staines River (Bullen-Staines) study areas for aerial surveys of caribou and other large mammals, 10 June – 2 August 2001. Background is a land cover classification from Muller et al. (1999).

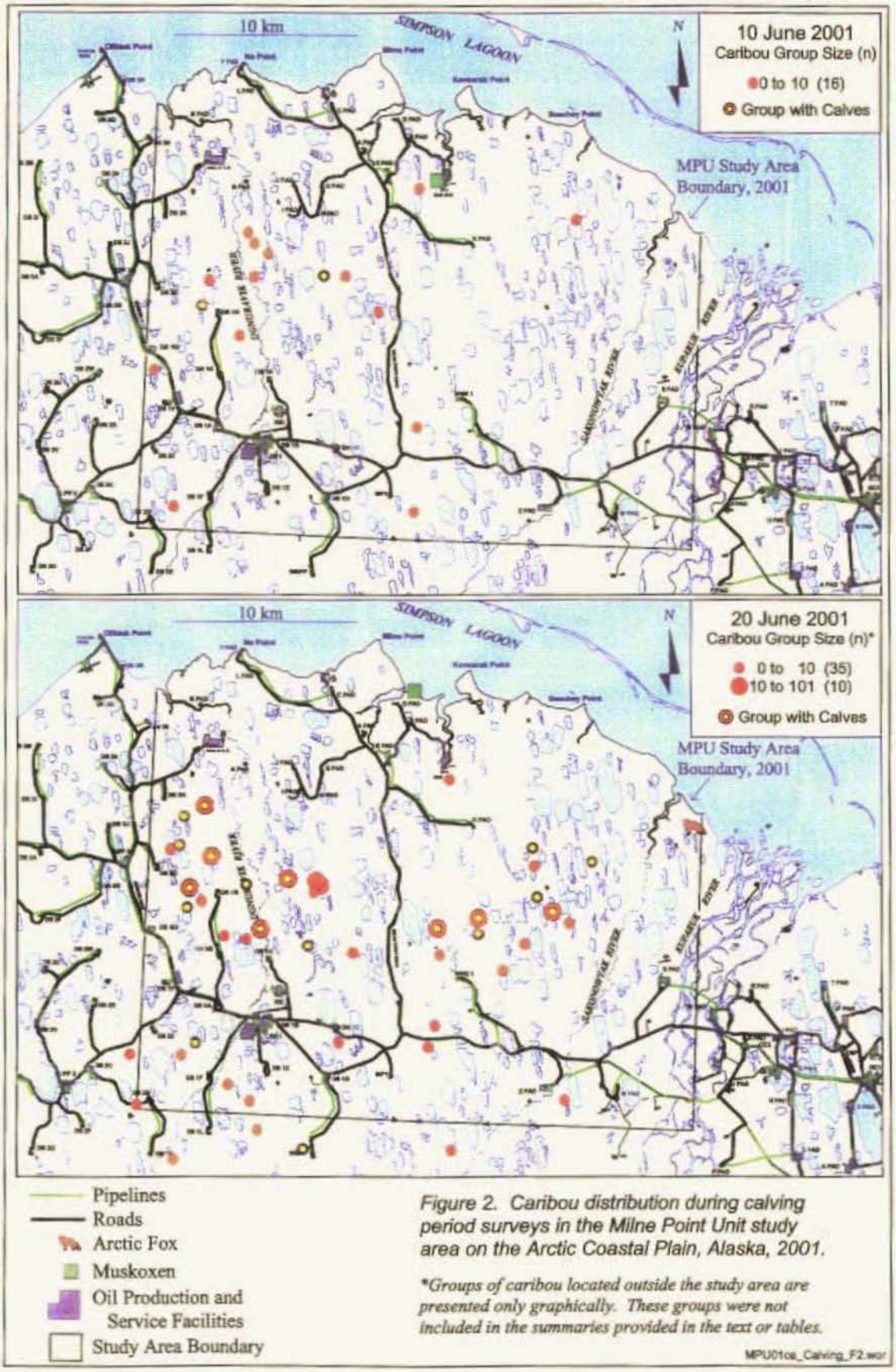


Figure 2. Caribou distribution during calving period surveys in the Milne Point Unit study area on the Arctic Coastal Plain, Alaska, 2001.

**Groups of caribou located outside the study area are presented only graphically. These groups were not included in the summaries provided in the text or tables.*

MPU01ca_Calving_F2.wor

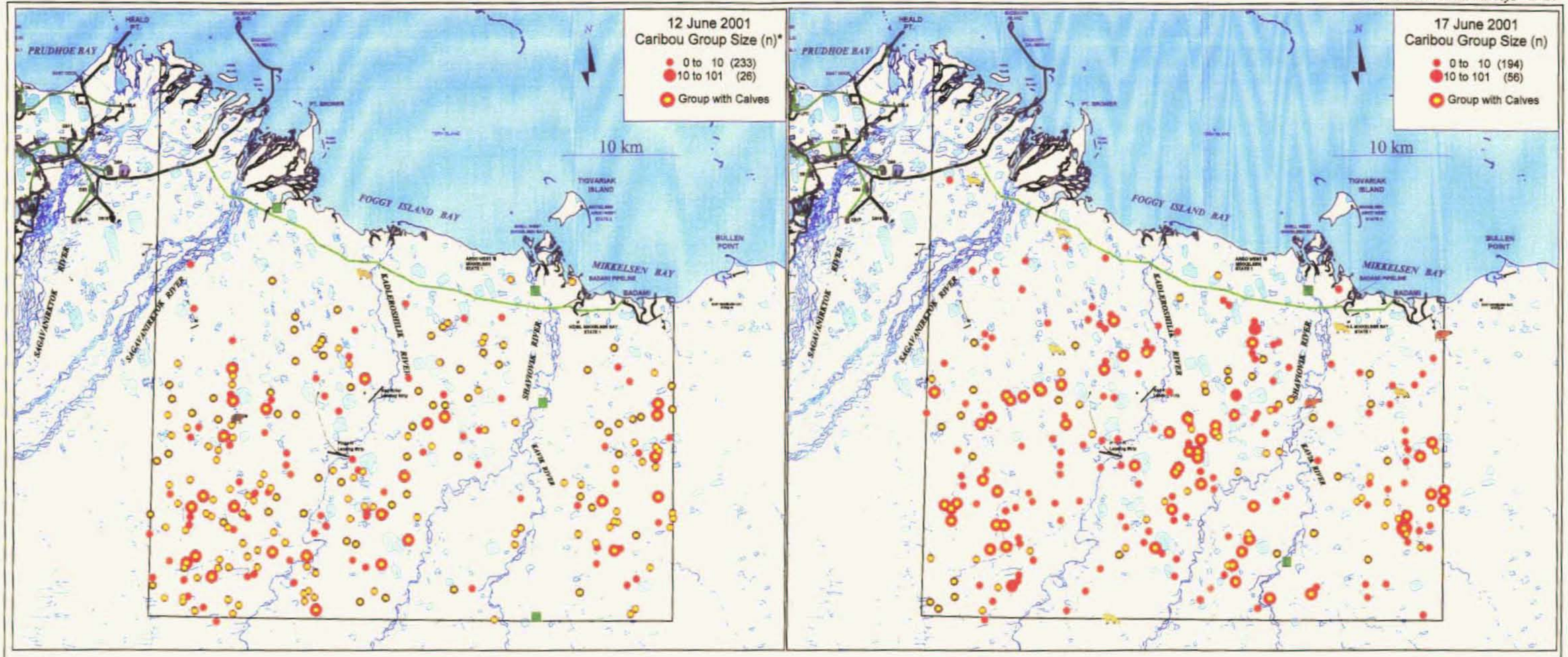


Figure 3. Caribou distribution during calving period surveys in the Badami study area on the Arctic Coastal Plain, Alaska, 2001.

**Groups of caribou located outside the study area are presented only graphically. These groups were not included in the summaries provided in the text or tables.*

Badami01ca_Calving_F3.wor

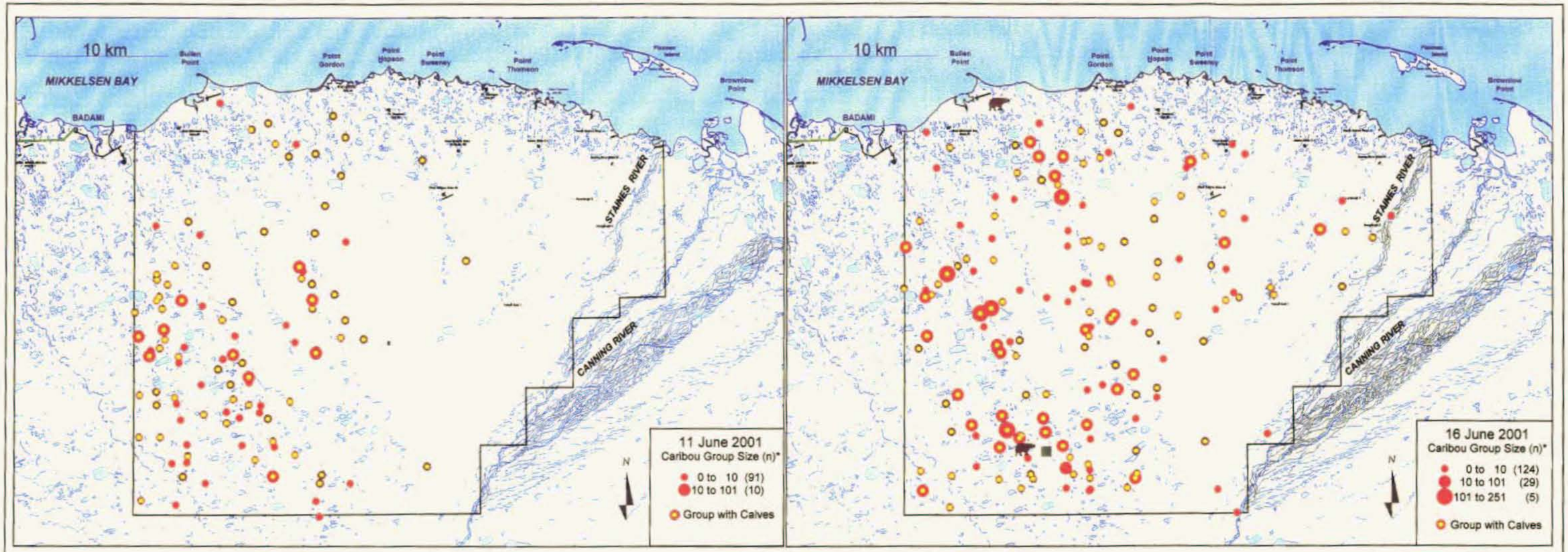


Figure 4. Caribou distribution during calving period surveys in the Bullen-Staines study area on the Arctic Coastal Plain, Alaska, 2001.

**Groups of caribou located outside the study area are presented only graphically. These groups were not included in the summaries provided in the text or tables.*

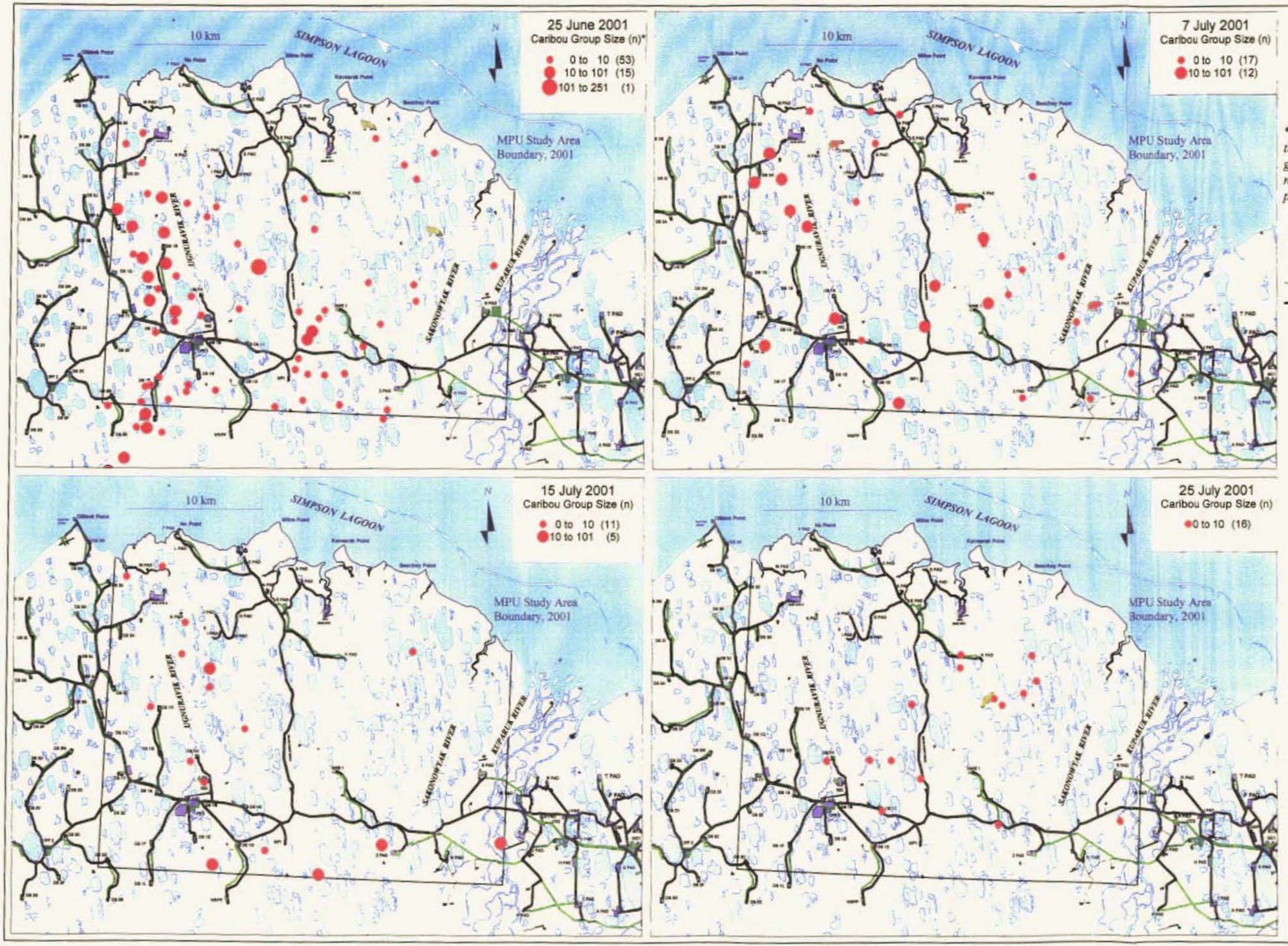


Figure 5. Caribou distribution during post-calving period surveys in the Milne Point Unit study area on the Arctic Coastal Plain, Alaska, 2001.

**Groups of caribou located outside the study area are presented only graphically. These groups were not included in the summaries provided in the text or tables.*

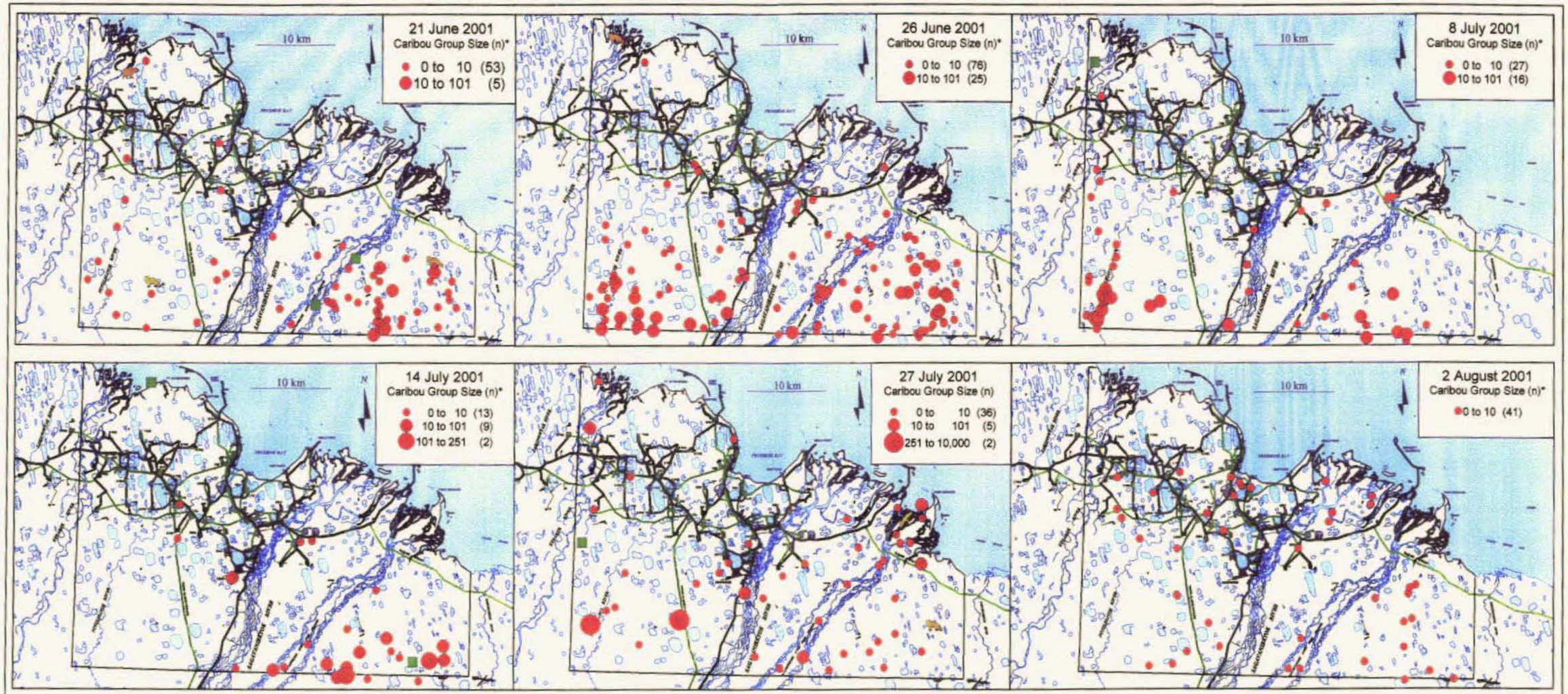


Figure 6. Caribou distribution during post-calving period surveys in the Prudhoe Bay Oilfield study area on the Arctic Coastal Plain, Alaska, 2001.

**Groups of caribou located outside the study area are presented only graphically. These groups were not included in the summaries provided in the text or tables.*

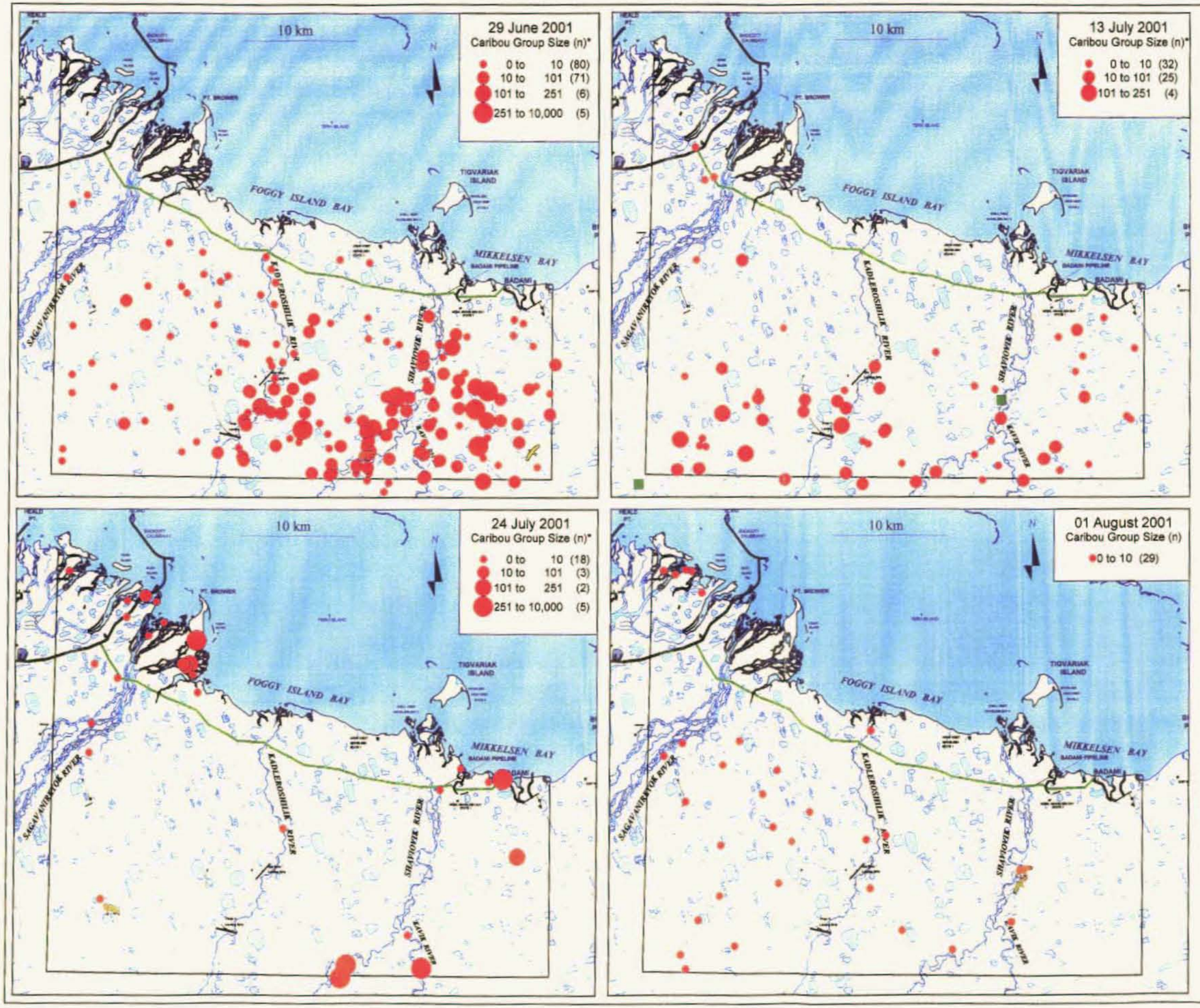


Figure 7. Caribou distribution during post-calving period surveys in the Badami study area on the Arctic Coastal Plain, Alaska, 2001.

**Groups of caribou located outside the study area are presented only graphically. These groups were not included in the summaries provided in the text or tables.*

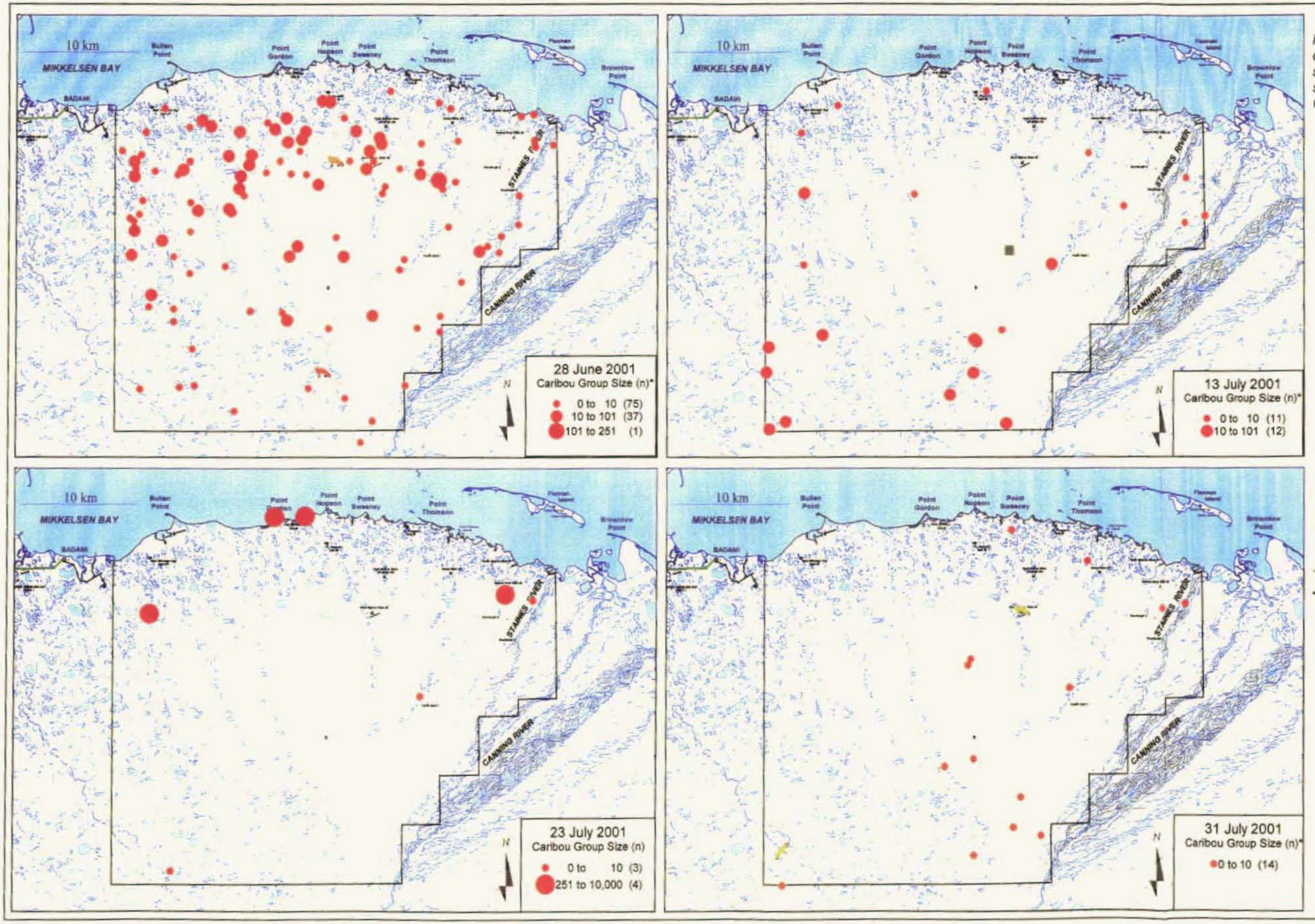
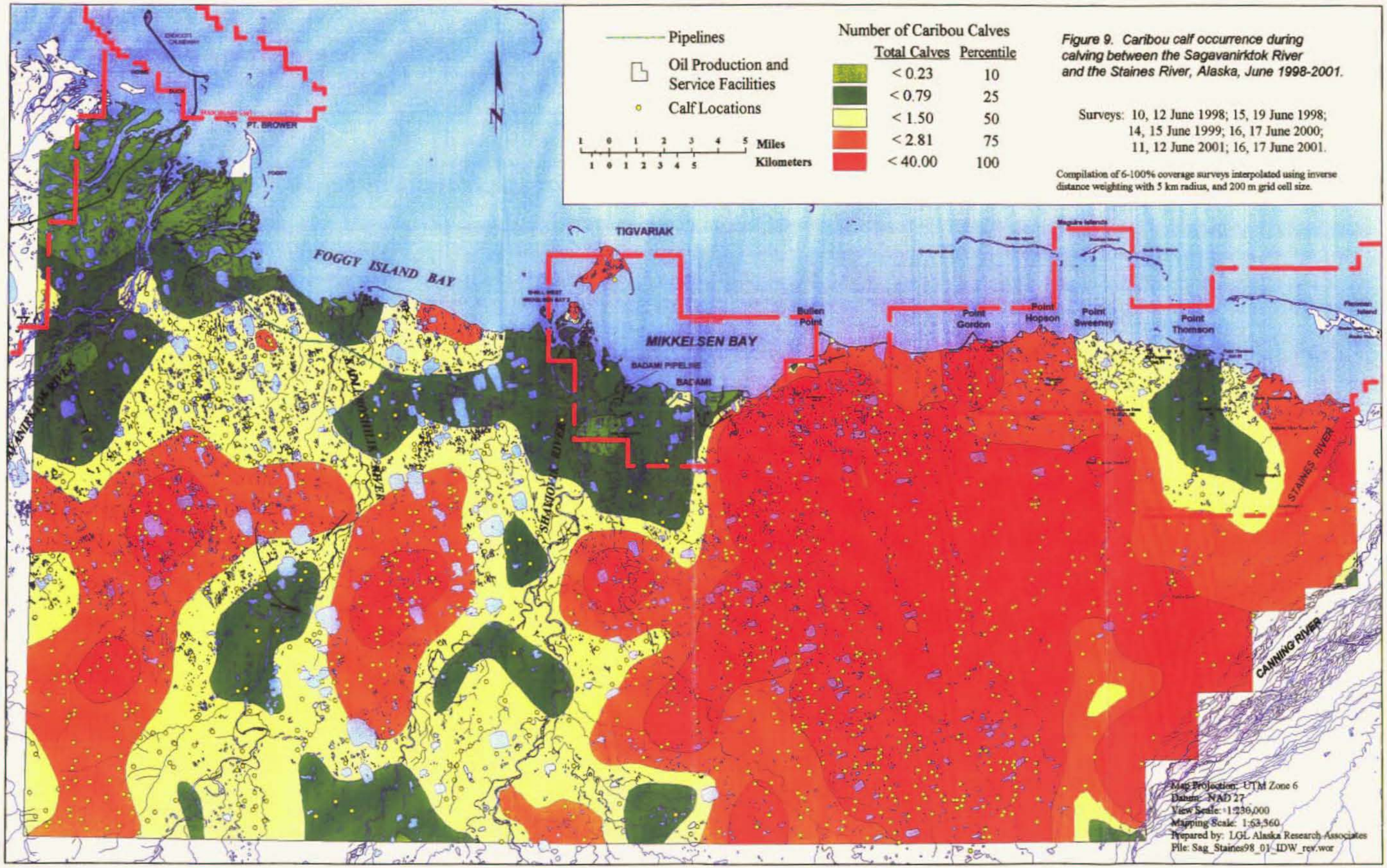


Figure 8. Caribou distribution during post-calving period surveys in the Bullen-Staines study area on the Arctic Coastal Plain, Alaska, 2001.

**Groups of caribou located outside the study area are presented only graphically. These groups were not included in the summaries provided in the text or tables.*


Pipelines
Oil Production and Service Facilities
Calf Locations
1 0 1 2 3 4 5 Miles
1 0 1 2 3 4 5 Kilometers
Number of Caribou Calves
Total Calves Percentile
< 0.23 10
< 0.79 25
< 1.50 50
< 2.81 75
< 40.00 100
Figure 9. Caribou calf occurrence during calving between the Sagavanirktok River and the Staines River, Alaska, June 1998-2001.
Surveys: 10, 12 June 1998; 15, 19 June 1998; 14, 15 June 1999; 16, 17 June 2000; 11, 12 June 2001; 16, 17 June 2001.
Compilation of 6-100% coverage surveys interpolated using inverse distance weighting with 5 km radius, and 200 m grid cell size.
N
PT. BROWER
FOGGY ISLAND BAY
TIGVARIAK
MIKKELSEN BAY
BADAMI PIPELINE
BADAMI
Bullen Point
Point Gordon
Point Hopson
Point Sweeney
Point Thomson
SHAVIOVIK RIVER
STAINES RIVER
CANNING RIVER
Map Projection: UTM Zone 6
Datum: NAD 27
View Scale: 1:230,000
Mapping Scale: 1:63,360
Prepared by: LGL Alaska Research Associates
File: Sag_Staines98_01_IDW_rev.wor