WILDLIFE STUDIES ON THE COLVILLE RIVER DELTA, ALASKA, 1993

Final Report

Prepared for

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EXECUTIVE SUMMARY

The primary purpose of the 1993 Colville River Delta Wildlife Study was to evaluate the distribution, abundance, and use of the delta by several species of birds and mammals. Four species of waterbirds and two species of mammals were chosen for field surveys: Yellow-billed Loon, Tundra Swan, Brant, Spectacled Eider, caribou, and arctic fox. These species were selected because of their status (i.e., rare, threatened, or resource agency concern) or because of the relative importance of the Colville Delta for that species. Additional data were gathered in the field for other species of waterbirds and mammals including Red-throated Loon, Pacific Loon, Greater White-fronted Goose, Canada Goose, King Eider, and muskox. Wildlife studies consisted of aerial and ground surveys for waterbirds and arctic fox dens and aerial surveys for caribou in different portions of the Colville Delta and adjacent areas to the east, depending on the species and the season.

The Colville Delta supports some of the highest breeding densities of Yellow-billed Loons in Alaska. Fifteen Yellow-billed Loon nests were found in 1993 on the delta (13 nests) and adjacent coastal plain (2 nests). In 1993, 11 (85%) of the Yellow-billed Loon nests and 41 (82%) of the 50 Yellow-billed Loons seen on aerial surveys of the delta during nesting were located on lakes along the Tamayayak Channel in the central delta, the area where the highest densities of Yellow-billed Loons were found during studies conducted in the early 1980s. Brood size of Yellow-billed Loons in 1993 averaged 1.0 young/successful pair.

The highest densities of breeding Tundra Swans on the Arctic Coastal Plain are found on major river deltas, including the Colville Delta. Two-hundred ninety-five Tundra Swans (including 37 adults attending 27 nests) were seen on an aerial survey of the Colville Delta and an adjacent area to the south during nesting. Brood-rearing surveys in 1993 located 19 broods and 85 groups of adults without young. Mean brood size in 1993 was 2.6 young/pair, somewhat higher than the mean brood size of 2.3 young/pair observed during 1983–89. August brood-rearing surveys yielded densities of 0.56 birds/km^2 (adults) and 15% young, somewhat lower than the average 21% young during 1983–89. The Colville Delta is a major fall-staging area for Tundra Swans; during an aerial survey in mid-September 1993, 482 swans were observed on the delta.

The Colville Delta supports the largest nesting concentration of Brant along the Arctic Coastal Plain of Alaska. In 1993, >900 Brant nests were found on, or adjacent to, the Colville Delta; most nests were located on ten islands at the mouth of the Eastern Channel. Nesting success, determined for 320 nests on six of these islands, was 55%. Brood-rearing groups of Brant from the Colville Delta dispersed at least as far east as Beechey Point and at least as far west as the mouth of the Tingmeachsiovik River. Over 800 Brant were recorded between Kalubik and Fish creeks, during a fall-staging survey in late August.

Spectacled Eiders, which were listed as a threatened species in 1993, are an uncommon breeding bird on the Colville Delta. In 1993, the density of Spectacled Eiders on the Colville Delta recorded during breeding-pair surveys was 0.09 birds/km^2. The density of Spectacled Eiders on the coastal plain east of the delta was 0.04 birds/km^2. Two confirmed and six probable Spectacled Eider nests and eleven Spectacled Eider broods were found on the northwestern portion of the delta that was searched during nesting and brood-rearing ground surveys.

Pacific Loons are the most common species of loon on the Colville Delta. Four-hundred sixty-nine Pacific Loons including pairs attending 87 nests were seen during aerial and ground surveys on the Colville Delta.

Red-throated Loons are also common breeding birds on the Colville Delta. Ninety-six Red-throated Loons and 21 nests were recorded on the Colville Delta during aerial and ground nest surveys in 1993.

The Colville Delta is a regionally important nesting area for Greater White-fronted Geese. Densities of birds and nests are the highest reported for Greater White-fronted Geese along the Arctic Coastal Plain. Intensive searches for Greater White-fronted Goose nests were not conducted on the

Colville Delta in 1993; however, 21 nests were found incidentally during ground surveys. The Colville Delta may also be important for staging Canada Geese. In 1993, no Canada Goose nests or broods were found on the Colville Delta during the nesting or brood-rearing seasons. However, over 900 Canada Geese were recorded on the delta during fall staging in late August.

King Eiders reportedly nest in low densities on the Colville Delta. In 1993, densities of King Eiders during pre-nesting surveys were 0.15 birds/km^2 and 0.27 birds/km^2 on the delta and eastern area, respectively. However, no nests were found during ground surveys on the northwestern portion of the Colville Delta. Five female King Eiders without broods were seen during brood surveys on the delta in July.

The Colville Delta is the western extent of the area used by caribou from the Central Arctic Herd (CAH) and the eastern extent of the area used by the Teshekpuk Lake Herd (TLH). Only 27 caribou were estimated to be on the Colville Delta during calving, whereas 2,181 and 1,249 caribou were estimated to be on the Colville East and Colville Inland survey areas, respectively. The densities of caribou in the Colville Inland and Colville East survey areas were 1.5–3.5 times the density observed in the adjacent Kuparuk Oilfield during the calving season. Calf production in the Colville East survey area was lower (26% of total caribou were calves) than the lowest production (28%) reported for the CAH from 1978 to 1990. At most, 107 caribou were observed on the delta during aerial surveys in the insect season, but tracks left on islands indicated that at least several hundred caribou moved through the eastern delta during insect-induced movements. Approximately 5,000 caribou from the TLH were observed on 27 July near Fish Creek (approximately 7 km west of the Colville Delta). During the rutting season, 28 caribou were dispersed throughout the area southeast of the delta.

Arctic foxes, the most common mammalian predator on the Arctic Coastal Plain, typically rely on underground dens to raise young during the summer. Twenty-four arctic fox dens (1 den/77 km^2) were identified in the study area. Five (21%) were used as natal dens in 1993 and produced a minimum of 19 pups (3.8 pups/natal den). Seven (29%) were used as secondary dens (i.e., shelter for litters that had left their natal dens). Dens were found most frequently in the banks of lakes, lake basins, and creeks (58%), and in pingos (25%).

Information on the distribution of other mammals, such as muskoxen and grizzly bears, was collected during aerial surveys conducted for waterbirds and caribou. Three observations of groups of 13–20 muskoxen including three calves were made in the southern portion of the study area. Singles and pairs of bull muskoxen were sighted throughout the study area.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

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INTRODUCTION

Located about midway between Point Barrow and Prudhoe Bay, the Colville River Delta (referred to hereafter as the Colville Delta or the delta), is the largest (600 km^2) river delta in arctic Alaska. The Colville drainage basin encompasses 60,000 km^2, or 30% of the drainages on the Arctic Slope of Alaska. The high discharge volume and heavy sediment load of the Colville River produce a dynamic deltaic system that is characterized by diverse geomorphologic and biologic processes. These processes have created a mosaic of wetlands that provide important habitats for numerous waterbirds. Regionally important breeding grounds for Yellow-billed Loons (*Gavia adamsii*), Tundra Swans (*Cygnus columbianus*), and Brant (*Branta bernicla*) occur on the delta. The delta also is an important staging area for many birds during spring migration, providing open water and snow-free areas earlier than adjacent mainland areas. The salt marshes and mud flats of the outer delta are used extensively during fall migration by several species of geese and shorebirds. Seventy-six species of birds have been recorded on the Colville Delta during the open-water season (Meehan and Jennings 1988). The delta also provides seasonally important habitats for several species of mammals, including insect-relief habitat for caribou and denning habitat for arctic and red foxes.

Recognizing these resource values in preparing for petroleum exploration on the Colville Delta, ARCO Alaska, Inc. commissioned Alaska Biological Research, Inc. (ABR), to conduct field studies of geomorphology and wildlife during the summers of 1992 and 1993. This report summarizes the 1993 results of the wildlife portion of the overall study effort; the 1992 results were presented by Smith et al. (1993).

Four species of birds and two species of mammals were selected for field surveys in 1993: Yellow-billed Loon, Tundra Swan, Brant, Spectacled Eider (*Somateria fischeri*), caribou (*Rangifer tarandus*), and arctic fox (*Alopex lagopus*). These species were accorded priority because of their status as rare or sensitive species, because of resource agency concerns, or because of the relative importance of the delta to the species. During surveys for these high-profile species, information also was gathered for other species of waterbirds and mammals: Red-throated Loon (*G. stellata*), Pacific Loon (*G. pacifica*), Greater White-fronted Goose (*Anser albifrons*), Canada Goose (*B. canadensis*), King Eider (*S. spectabilis*), muskoxen (*Ovibos moschatus*), grizzly (brown) bears (*Ursus arctos*) and wolverine (*Gulo gulo*).

The goal of the 1993 Colville River Delta Wildlife Study was to investigate the use of selected areas of the delta by these birds and mammals during May–October 1993. Three specific objectives were identified:

1. Describe the distribution and abundance of selected waterbird species during the pre-nesting, nesting, brood-rearing, and fall-staging seasons;

2. Describe the distribution and abundance of caribou during the calving and post-calving seasons; and

3. Locate and determine the status of arctic fox dens.

STUDY AREA

In 1992, ARCO Alaska, Inc. delineated several proposed drill sites on and to the east of the Colville Delta. The boundaries of the Colville Delta study area in 1992 included these proposed drill sites and extended from Kalubik Creek on the east to the Nechelik (western) Channel of the Colville River, and included the entire Colville Delta and a large area of coastal plain (Smith et al. 1993). In 1993, the locations proposed for drilling were expanded to include additional areas not included in the study area during 1992. The study area boundaries were extended in 1993 to include a 1120–km^2 block of the Kuparuk uplands (Figure 1), adjoining the southeastern portion of the 1992 study area. In the southwestern portion of the study area, a 210–km^2 area that included the mouth of the Itkillik River, also was added in 1993.

As used in this report, the Colville Delta (or the delta), refers to the area between the westernmost and easternmost distributary channels of the Colville River. The area between Kalubik Creek and the eastern channel of the Colville River is referred to herein as the eastern portion of the study area or Colville East. The 210–km^2 area between the Itkillik River on the east and the western boundary of the study area is referred to as the southwestern portion of the study area. The 1120–km^2 section of the Kuparuk uplands is referred to as the southeastern portion or Colville Inland. The entire Colville River Delta study area, encompassing all of the above areas, is referred to in this report as the CRDSA.

Uplands reaching 110 m in elevation dominate the southeastern portions of the study area. These uplands slope gradually northward into flat, low-lying terrain typical of the outer Arctic Coastal Plain. The landforms and vegetation of the Arctic Coastal Plain have been described in detail by Walker et al. (1980).

The Colville River has two main distributaries: the Nechelik (western) Channel, and the Eastern (main) Channel. These two channels together carry about 90% of the water passing through the delta during spring floods and 99% after those floods (Walker 1983). Several smaller distributaries branch from the Eastern Channel, including the Sakoonang, Tamayayak, and Elaktoveach channels. In addition to river channels, the delta is characterized by numerous lakes and ponds, sandbars, mudflats, sand dunes, and low- and high-center polygons (Walker 1973).

The Eastern Channel of the Colville River is deep and flows under ice during winter, whereas the Nechelik and other channels in the delta are shallow and freeze to the bottom in winter. Decreased river flow during winter results in an intrusion of salt water into the delta; the depth of the river at freeze-up is the main factor influencing the extent of this intrusion (Walker 1973, 1983). The Colville River flows through the zone of continuous permafrost for its entire length. The presence of continuous permafrost, combined with freezing of the upper layer of surface waters in winter, influences the volume, timing, and character of river flow and erosion within the delta (Walker 1973).

Spring is brief, lasting approximately three weeks in late May and early June, and is characterized by the flooding and breakup of the river. In late May, water from melting snow flows over and under the river ice. Flooding peaks during the first week of June (Walker 1983). Breakup of river ice usually occurs when flood waters are at maximum levels. Water levels decrease in the delta through the summer, with the lowest water levels occurring in September just before freeze-up (Walker 1983).

Lakes and ponds are dominant physical features of the Colville Delta. Most of the waterbodies are shallow (e. g., polygon ponds <2 m deep), and therefore thaw by June and freeze to the bottom in winter. Deeper ponds (>2 m deep) with steep, vertical sides are found on the delta, but are uncommon elsewhere on the Arctic Coastal Plain. Lakes larger than 5 ha are common, covering 16% of the delta's surface (Walker 1978). Some of the lakes are deep (to 10 m) and freeze only in the upper 2 m. Ice remains on these deep lakes until the first half of July (Walker 1978). Several other types of lakes occur in the delta, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, and thaw lakes (Walker 1983).

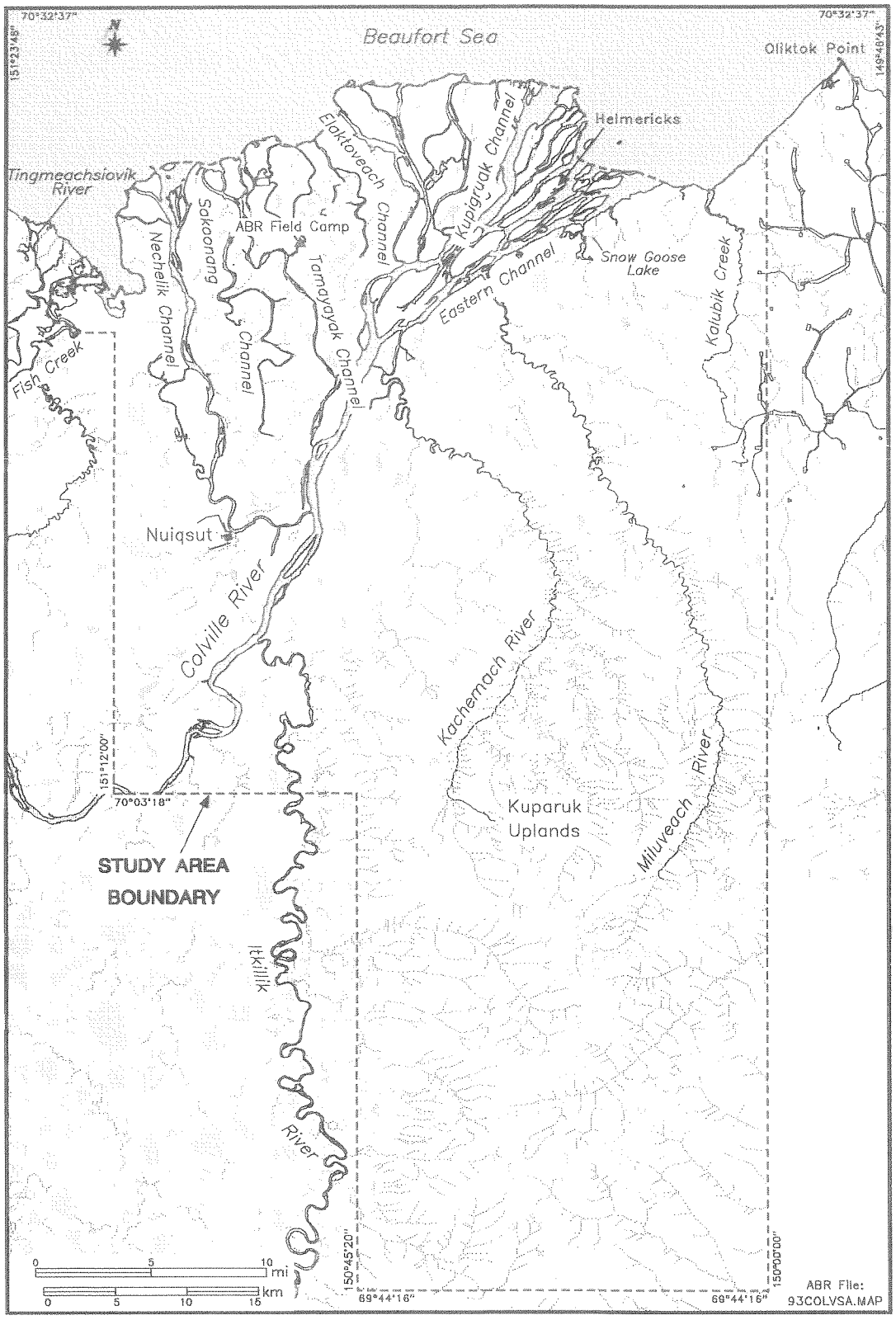

Figure 1. Study area boundaries for the Colville River Delta Wildlife Study, May-October 1993. The facilities at the eastern edge of the map are the westernmost drill sites of the Kuparuk Oilfield.

Many of the lakes in the delta are "tapped" (Walker 1978), in that they are connected to the river by narrow channels. These channels are caused by thermokarst decay of ice wedges between the river and adjacent lakes (Walker 1978). Water levels in tapped lakes usually are lower and fluctuate more dramatically than in untapped lakes (Walker 1978). River sediments raise the bottom of the lake near the channel, exposing previously submerged areas (Walker 1976, 1978). These lake "deltas" eventually support vegetation; the rate of development of the floristic communities on tapped-lake deltas depends on lake-basin morphology, the rate of sediment deposition, and distance from the coast (Rothe et al. 1983). Because tapped lakes and river channels are the first areas of the delta to become flooded in spring, they constitute important staging habitat for migrating waterfowl in that season (Rothe et al. 1983).

The study area has an arctic maritime climate. Winters last about eight months and are cold and windy. Summers are cool, with temperatures ranging from -10° C in mid-May to 15° C in July and August (Simpson et al. 1982, North 1986). Summer weather is characterized by low precipitation, overcast skies, fog, and persistent winds, which come predominantly from the northeast. Westerly winds usually bring storms, which are accompanied by high wind-driven tides and rain (Walker and Morgan 1964, North 1986).

METHODS

Wildlife studies on the Colville Delta in 1993 incorporated aerial and ground surveys for waterbirds and mammals and covered different portions of the study area depending on the species of interest and the season (Table 1). As in 1992, the bird study concentrated on the distribution and abundance of Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders during the nesting and brood-rearing seasons. Although these species were the focus of the surveys, additional information also was gathered on Pacific and Red-throated loons, Greater White-fronted and Canada geese, and King Eiders. Caribou and arctic fox were the focal species of the mammal study in 1993, as well as 1992.

Survey techniques for the bird and mammal studies differed somewhat between 1992 and 1993. In 1992, six study plots were established for some aerial and ground surveys for waterbirds. Plot sizes and locations were determined by the locations of proposed drill sites and areas of high biological interest. The 1992 plots were not surveyed specifically in 1993, however. Instead, the 1993 aerial surveys for waterbirds covered either the Colville Delta, the delta and the eastern portion of the study area, or the coastal strip between Kalubik Creek and the Nechelik Channel (Figure 2), depending on the species of interest. Ground surveys for waterbirds in 1993 were conducted in selected areas of the Colville Delta, based on sightings of breeding pairs from aerial surveys and on the locations of nest sites identified in previous studies. Incidental sightings of birds during surveys or in transit to and from base camp also were recorded (Appendix A).

Caribou calving surveys in 1993 generally were more intensive and covered a larger area than in 1992. Two aerial surveys of the delta and coastal plain to the east of the delta were flown during calving in 1992. In 1993, 11 aerial surveys were conducted during calving, covering the 1992 survey area as well as the Kuparuk uplands to the southeast. Post-calving surveys in 1993 covered the same area as in 1992. In

Table 1. Dates, areas, and types of wildlife surveys conducted in 1993 on the Colville River Delta, Alaska.

Species	Survey Type	Season	Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Area Surveyed
BIRDS								
Loons	Aerial	Nesting	27, 29, 30 June	C185	N/A	N/A	30	See Figure 2
		Brood-rearing	20 August	C185	N/A	N/A	30	See Figure 2
Tundra	Aerial	Pre-nesting	29 May	PA18	0.8	1.6	150	See Figure 2
Swans		Nesting	21 June	C185	1.6	1.6	150	See Figure 2
		Brood-rearing	17 August	C185	1.6	1.6	150	See Figure 2
		Fall staging	15 September	C206	1.6	2.4	150	See Figure 2
Brant	Aerial	Nesting	28 June	PA18	N/A	N/A	100-150[b]	See Figure 2
		Brood-rearing	10, 27, 30 July	PA18	N/A	N/A	75	See Figure 2
		Fall staging	25 August	PA18	N/A	N/A	60	See Figure 2
Eiders	Aerial	Pre-nesting	10-12 June	C206	0.4	0.8	30	See Figure 2
Waterfowl	Ground	Nesting	20 June - 2 July	N/A	N/A	N/A	N/A	Colville Delta
		Brood-rearing	18-31 July	N/A	N/A	N/A	N/A	Colville Delta
MAMMALS								
Caribou	Aerial	Calving	26, 27 May 3, 8, 11 June	PA18	0.4	1.6	90	Colville East
			23, 28 May 7, 10 June	PA18	0.4	3.2	90	Colville Inland
			28 May, 10 June	PA18	0.4	3.2	90	Colville Delta
		Insect	28 June 8, 14, 19, 30 July	PA18	3.2	3.2	150	Portions of Colville Delta and Colville East
		Rutting	20 October	H700	3.2	3.2	150	Portions of Colville Delta and Colville East
Arctic Fox	Aerial	Denning	18 May	PA18	3.2	3.2	100-150	Portions of Colville Delta and Colville East
			22 May	PA18	N/A	N/A	100-150	Portions of Colville Delta and Colville East

[a] C185 = Cessna 185, C206 = Cessna 206, PA18 = Piper "Super Cub", H700 = Helio Courier.
[b] Lower altitudes were flown to inspect colonies.
N/A = not applicable.

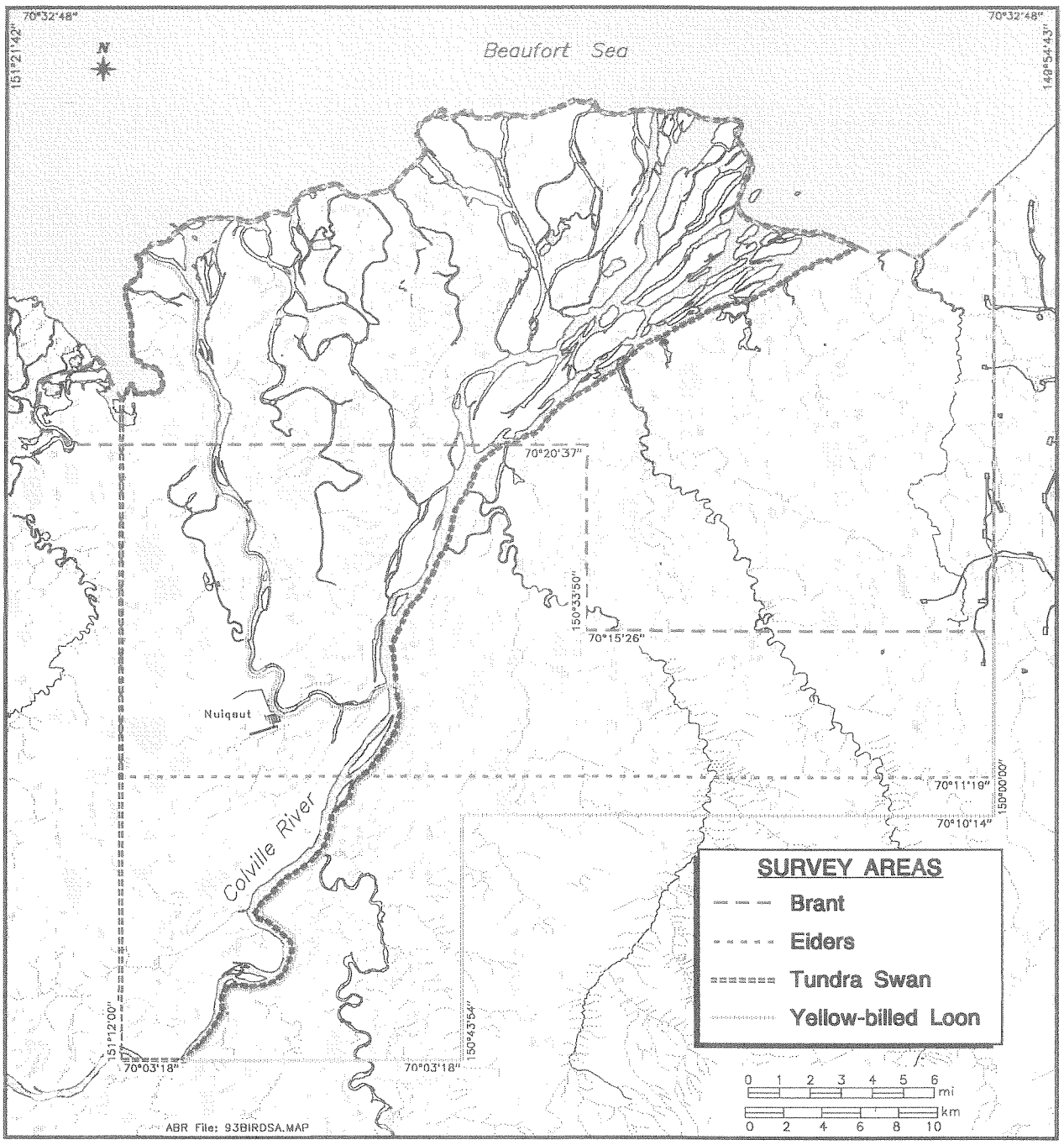

Figure 2. Boundaries of aerial survey areas for four species of waterbirds, Colville River Delta Wildlife Study, May–October 1993.

addition, one survey was conducted during the "rut" (mid-October breeding season) in 1993.

Two aerial surveys of the delta and the coastal plain east of the delta were flown to locate fox den sites as in 1992. In addition, the status of each den site located during the aerial surveys was evaluated by biologists on the ground in 1993.

Bird habitats discussed in this report follow a classification developed for the Lisburne Development Area (Prudhoe Bay Unit) and described in Jorgenson et al. (1989) and Murphy et al. (1989). Some additional habitats have been added to this classification system based on photo-interpretation of selected areas of the Colville Delta. These additions are preliminary and subject to change based on further interpretation of photos and data. A complete hierarchical listing of habitats can be found in Appendix B.

WATERBIRDS

AERIAL SURVEYS

Surveys in fixed-wing aircraft were flown periodically to locate and enumerate waterbird species during the pre-nesting, nesting, brood-rearing, and fall staging periods. Survey methods and timing depended on the species of interest (Table 1). The survey effort comprised both extensive surveys of the Colville Delta and adjacent coastal plain and more limited coastal surveys between Kalubik Creek and the Nechelik Channel (Figure 2). All location data were recorded on U. S. Geological Survey (USGS) 1:63,360-scale quadrangle maps.

Aerial surveys for Yellow-billed, Pacific, and Red-throated loons on the Colville Delta and eastern portion of the study area were conducted during nesting and brood-rearing in 1993 (Figure 2). This survey area was an expansion of the area surveyed in 1992, when aerial surveys of three study plots on the delta were the only areas surveyed for nesting and brood-rearing loons (Smith et al. 1993). In 1993, nest surveys were flown from lake to lake, with the shoreline of the lake being surveyed for nests. Lakes were selected for nest surveys by their size; lakes less than 0.1 ha generally were not surveyed. Lake-to-lake surveys also were flown during brood-rearing; however, only lakes on which nests or pairs of Yellow-billed Loons had been recorded during nest surveys were searched.

Aerial surveys for Tundra Swans were flown during pre-nesting, nesting, brood-rearing, and fall staging on the Colville Delta in 1993 (Table 1). The 1993 survey area of approximately 813 km^2 included a 449–km^2 area to the west and south of the Nechelik Channel (Figure 2) that was not surveyed in 1992. In addition, a 76–km^2 area along the eastern side of the Colville River, which was surveyed in 1992, was deleted from the pre-nesting, nesting, and brood-rearing surveys in 1993; it was included in the fall staging survey.

Survey techniques for Tundra Swans on the Colville Delta in 1993 followed U. S. Fish and Wildlife Service protocol (USFWS 1987a) and were comparable with swan surveys conducted elsewhere in Alaska. Survey transects were spaced at 1.6 km intervals. The surveys were flown at 150 m above ground level (agl). In 1992, swan surveys of the delta followed transects established by USFWS and Alaska Department of Fish and Game (ADFG) in the early 1980s. The distance between centerlines for these surveys was 2.4 km and the altitude was 150–210 m agl. The density estimates of swans in 1992 and 1993 were based on areas calculated from digitized maps of the Colville Delta using *Atlas GIS* software (Strategic Mapping, Santa Clara, CA). Density estimates for the Colville Delta reported in the literature prior to 1992 may have been based on areas that were measured less accurately (e.g., using a planimeter).

Aerial surveys were conducted for Brant during nesting, brood-rearing, and fall-staging in 1993 (Table 1). One nesting survey and two brood-rearing surveys extended beyond the western boundary of the study area (Figure 2). Methods were similar to those used from 1989–1993 for surveys of Brant between the Colville and Sagavanirktok rivers (Ritchie et al. 1990, Stickney et al. 1994). Nesting Brant were located on a survey (on 28 June) flown lake-to-lake within a predetermined path that included known colony sites and lakes with numerous islands. The numbers of adults and nests were recorded on USGS 1:63,360-scale maps. A nest was recorded where either a down-filled bowl or an adult in incubation posture was

observed. Aerial counts of Brant and their nests were conservative, because some incubating Brant were inconspicuous, because unattended nests were difficult to see, and because we purposely limited the number of passes flown over a colony to minimize disturbance.

Three aerial surveys were conducted during July to locate and enumerate brood-rearing Brant (Table 1). The survey route followed the coastline as closely as possible extending inland along the shorelines of bays and deltaic islands. Nesting areas that were located within 5 km of the coast were revisited during the survey on 27 July, to investigate use by broods of non-coastal areas. A similar route was flown to locate and count staging Brant on 25 August, and all locations used during brood-rearing were revisited.

Aerial surveys for breeding pairs of Spectacled and King eiders on the Colville Delta and the eastern portion of the study area were conducted during the pre-nesting season in 1993 (Figure 2). These surveys were an extension of the area surveyed in 1992 when six study plots and the Colville Delta were the only areas surveyed for eiders. In 1993, the centerlines of the transects were spaced 0.8 km apart, and the transect width was 200 m on either side of the plane (Table 1). Navigation along transects was accomplished by the use of a global positioning system (GPS) receiver installed in the airplane.

Data collection for the eider breeding-pair survey generally followed the protocol established by the USFWS for breeding-pair surveys (USFWS 1987b), with some modifications. All eiders (males and females) were counted on the surveys. If a male and a female occurred together, they were counted as a pair. If an odd number of males and females occurred together in a group, but several of the birds appeared to be paired, the number of pairs was recorded and the odd bird was counted as a single bird regardless of sex. A group of eiders containing five or more males, which obviously were not paired with females, was considered a flock. Flying and non-flying birds were recorded separately. Birds seen off transect were recorded for distribution records, but were removed from the data set when calculating density estimates.

Densities were calculated using the total observed number of birds, the observed number of pairs, the total indicated number of birds, and the indicated number of pairs. Following the protocol of USFWS (1987b), the total indicated number of birds was calculated by multiplying the number of males not in flocks by 2, and adding the number of males in flocks to this product. The indicated number of pairs was the same as the number of males not associated with flocks. Density estimates have not been adjusted using a visibility correction factor (VCF), a multiplier derived to account for birds present but not recorded by survey observers. The USFWS has developed a VCF of 3.58 for Spectacled Eider surveys on the Yukon–Kuskokwim Delta (Y–K Delta); however, this correction factor is currently under review and is not recommended for surveys conducted on the Arctic Coastal Plain (G. Balogh, USFWS, pers. comm.).

GROUND SURVEYS

Ground surveys to locate nesting and brood-rearing waterbirds were conducted on the Colville Delta during 20 June–2 July and 18–31 July, respectively. Field crews operated from a field camp established on the Tamayayak Channel. A river boat and rubber raft were used to transport observers to and from survey areas.

Nest searches in 1993 were designed primarily to locate nesting Spectacled Eiders, and secondarily to locate Yellow-billed Loons. Areas chosen for eider nest searches were based on sightings of breeding pairs of eiders from aerial surveys and on existing data from previous studies. Additional areas were searched for nests while observers were walking to and from these selected areas. Observers (working alone or in groups of two or three) censused selected areas by walking systematically along parallel lines while searching a strip transect approximately 2 m wide. Nest searches for Yellow-billed Loons were conducted by observers walking the perimeter of lakes. Lakes were selected for searching based on data from previous studies (North et al. 1983, 1984a, North 1986, Smith et al. 1993) and where pairs of loons were seen in 1993 during aerial surveys for nests. Nests of Pacific and Red-throated loons,

Tundra Swans, and Brant were located incidentally during ground surveys.

Each nest was numbered and the location was recorded on a 1:1,500-scale color infra-red (CIR) aerial photograph; the nest number, species, clutch size (if female inadvertently flushed from the nest), number of adults present, and comments were recorded on data sheets. Nest markers (1-m pieces of lathe or wire flags) were placed 3–5 m from the nest to facilitate relocation of the nest during subsequent searches. Down and contour feathers were collected for identification from abandoned and hatched eider nests. For those nests at which a female eider was not identified to species, tentative identification was made on the basis of color patterns on contour feathers from the nest. Categories for percentages of feathers with different patterns were developed from nests of known species (Anderson and Cooper 1994). We determined a nest belonged to a Spectacled Eider (listed as "probable" Spectacled Eider) if at least 70% of the contour feathers were striped or speckled brown, to a King Eider if no more than 50% were striped or speckled brown, and to an unidentified eider if between 51% and 69% were striped or speckled brown.

Nest-fate and brood-rearing surveys for waterfowl were conducted during 18–31 July. Nests that had been located in June were checked for signs of hatching success or failure (Downing 1980), and waterbodies adjacent to nests were searched for broods. In addition, some areas where pairs of eiders had been seen during breeding-pair surveys, but had not been searched for nests during nest searches, were searched for broods. When a brood was observed, the species and the location and number of adults and young were recorded on 1:1,500-scale CIR aerial photographs. Brood sightings were numbered and data were transcribed onto data sheets.

In 1993, USFWS biologists conducted surveys of nesting Brant at the mouth of the Eastern Channel of the Colville River during 18–20 June. Observers walked through the colony and recorded the number of nests, clutch sizes, and any sign of depredation of eggs or adults. These data were compiled and conveyed to us (P. Martin, USFWS, pers. comm.). A nest-fate search was conducted after hatch (9–11 July) by ABR personnel.

CARIBOU

CALVING SEASON

The distribution and abundance of Central Arctic Herd (CAH) caribou in the CRDSA were determined during the calving, insect, and rutting seasons by aerial surveys. The survey areas and protocols differed among the three seasons, so that areas of specific seasonal importance to caribou were surveyed and the time spent surveying was optimized.

During the calving surveys, the CRDSA was divided into three areas. Most frequently surveyed was the Colville East survey area (Figure 3), which roughly lies between the Eastern Channel of the Colville River and Kalubik Creek, and between the Beaufort Sea coast and 70 °55' N latitude. This area has been important to calving caribou in recent years (Lawhead and Cameron 1988). The Colville Inland area was added to the survey schedule in 1993 and was surveyed less frequently. The Colville Inland area ranges from 70°05' N to the Kuparuk uplands (69°44' N) and from 150°45' W to 150°00' W longitude. The Colville Delta survey area, which lies between the Eastern Channel and the Nechelik Channel, was surveyed least frequently, because it has not been an important calving area in the past (Whitten and Cameron 1985, Smith et al. 1993).

During the calving season, 11 aerial surveys were flown between 26 May and 11 June (Table 2). One observer in the rear seat of a Piper PA-18 "Super Cub" counted caribou as the pilot followed north-south oriented transect lines, while maintaining the aircraft's speed at 95–115 km/h and altitude at 90 m agl. The transect lines were 1.6 km apart in the Colville East survey area and 3.2 km apart in the Colville Delta and Colville Inland survey areas. The pilot navigated along the transects using predetermined coordinates that were tracked by a GPS. The observer counted caribou within a 400-m-wide strip on the side of each transect line that provided the best viewing (influenced most by lighting). The strip width was delimited visually by tape marks on the wing struts and windows of the

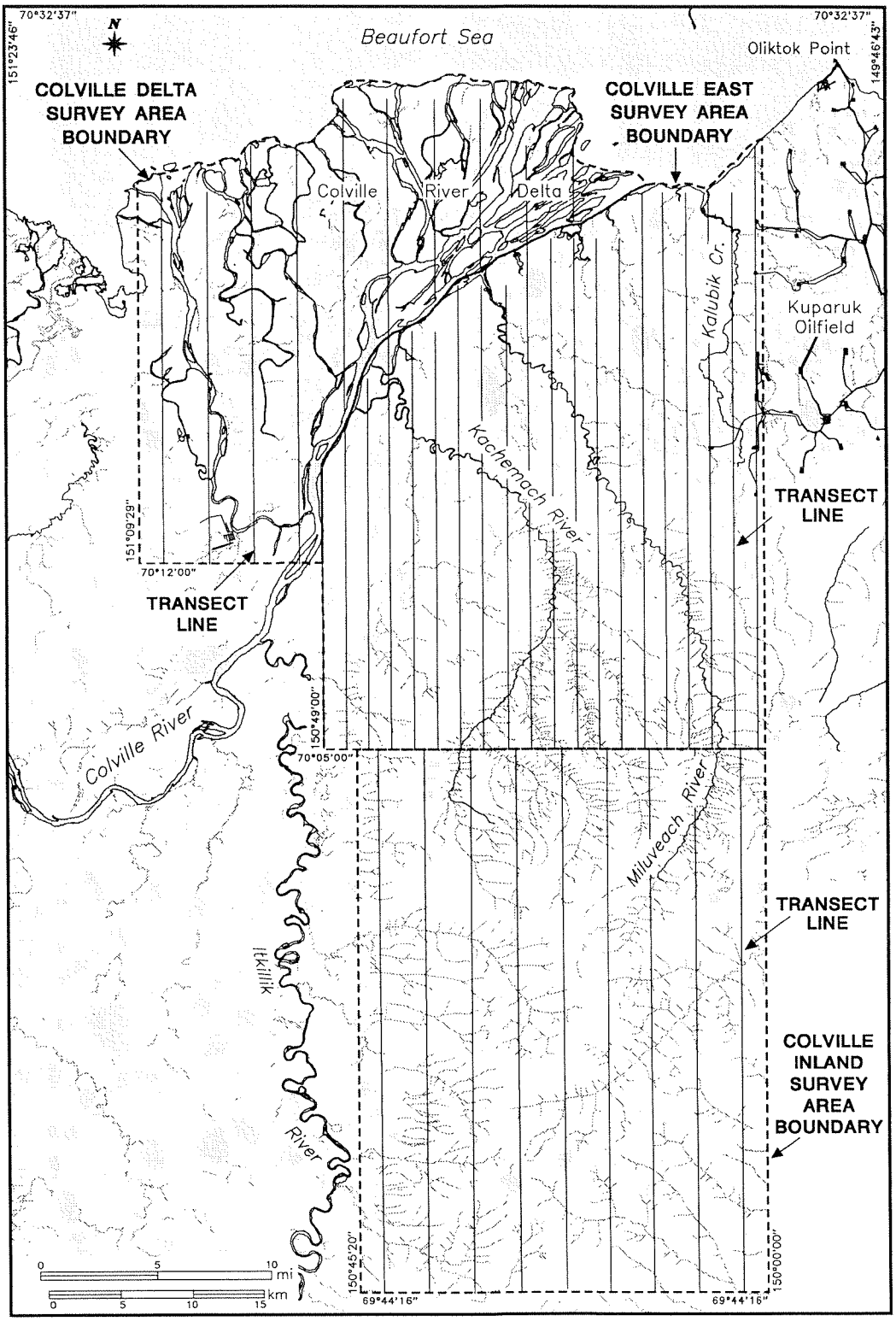

Figure 3. Survey areas and transect centerlines for aerial surveys of caribou during the 1993 calving season, Colville River Delta, Alaska.

Table 2. Summary of dates and conditions for aerial surveys of caribou during 1993 in the Colville River Delta study area, northern Alaska.

Survey Area	Season	Date	Survey Coverage	No. of Segments[a] Surveyed	% Snow Cover	Insect Condition
Colville Inland	Calving	23 May	complete	108	98	none
		28 May	complete	108	65–75	none
		7 June	complete	108	0–50	none
		10 June	complete	108	<5	none
Colville East	Calving	26 May	partial	126	~10	none
		27 May	complete	206	0–95	none
		3 June	complete	206	20–70	none
		8 June	partial	138	5–15	none
		11 June	partial	176	<5	none
Colville River Delta	Calving	28 May	complete	55	85	none
		10 June	complete	55	<5	none
Colville East and Colville Delta	Insect	28 June	partial	NA	0	mosquitoes
		8 July	partial	NA	0	mosquitoes
		14 July	partial	NA	0	mosquitoes + flies
		19 July	partial	NA	0	mosquitoes + flies
		30 July	partial	NA	0	mosquitoes + flies
Colville East and Colville Delta	Rutting	20 October	partial	NA	100	none

[a] Segments were 3.2 km long and 0.4 km wide.

aircraft (Pennycuick and Western 1972). Each transect was divided into 3.2-km-long segments and the pilot notified the observer when each segment began and ended so that the observer could record a tally of the caribou for that segment. The observer recorded the number of large (i.e., bull, cow, or yearling) and calf caribou and, when time permitted, recorded the number of antlered cows and yearlings.

Snow coverage was estimated visually on portions of each transect as an index to survey conditions. Inconsistent snow cover can reduce an observer's ability to detect caribou (Lawhead and Cameron 1988) and is probably the single most important factor diminishing the sightability (i.e., "the probability that a animal within the observer's field of search will be seen by that observer" [Caughley 1974:923]) of caribou during the spring snow melt that occurs during the calving season. One way to

adjust counts made during poor viewing conditions is to estimate sightability and calculate a sightability correction factor (SCF) (Gasaway et al. 1986).

The sightability of an observer in an airplane was estimated by flying a corresponding survey in a helicopter in the Colville East survey area on 3 June 1993, when snow coverage was estimated at 20–70%. We conducted the sightability survey from a Bell 206-B "Jet Ranger" helicopter along the same transect lines as were surveyed from the airplane and 1–2 h after the airplane surveyed each transect. The helicopter flew at 90 km/h and 30 m agl with one observer viewing one side of the transect from the front seat and the other observer viewing the other side of the transect from the rear seat. Each observer counted caribou within opposing 400-m-wide strips that were delimited visually on the near boundary by tape marks on the windows and landing skids and on the far boundary by wooden sighting guides (serving the same purpose as tape marks on the wing struts of the airplane except that the observer sighted along the straight edge of an ~0.33-m-long board) designed to fit into the windows of the helicopter. The pilot navigated with a GPS receiver using the same coordinates as were used for the fixed-wing aircraft so that the two aircraft flew nearly identical flight lines. The helicopter survey was begun 1 h after the fixed-wing survey, but the time difference increased as the survey proceeded because several refueling stops were required by the helicopter, whereas the airplane was able to fly uninterrupted.

The SCF was estimated using the formulas developed by Gasaway et al. (1986). The SCF is the number of caribou seen from the helicopter divided by the number of caribou seen from the airplane with a bias factor subtracted to correct for small sample size (Appendix C). The SCF that was calculated from the Colville East survey area was applied to counts that were conducted under similar snow conditions. Only the counts of large caribou were adjusted, because no calves were seen during the airplane portion of the sightability survey.

The population numbers for large, calf, and total caribou were estimated using their respective counts and standard errors in the derivations of formulas (Appendix C) developed by Gasaway et al. (1986) to estimate population parameters for moose. The population parameters were estimated separately for each survey area on each survey date. The density of total and calf caribou from a survey were expanded for the entire survey area to estimate the observable population (i.e., the population for the entire survey area unadjusted for sightability). In text, the estimates are followed by the 80% confidence intervals in parentheses (e.g., an observable population estimate of 70 [±30] means that the 80% confidence interval ranges from 40 to 100). The observable population estimate is multiplied by the sightability correction factor to calculate the adjusted population estimate, which is an estimate of the number of caribou in the entire survey area assuming 100% sightability.

Because caribou were thinly dispersed over the survey areas, many segments contained no caribou during the surveys, resulting in a distribution of counts strongly skewed toward zero. To avoid undue bias resulting from the departure from a normal distribution, the standard errors were calculated by using the bootstrapping technique (Mooney and Duval 1993). Bootstrapping is a nonparametric, computer-intensive technique for estimating a statistic's distribution by generating a large number of samples (with replacement) from the sample data (Mooney and Duval 1993). The technique does not require any assumptions about the sampling distribution. The bootstrapping option of the constrained nonlinear regression program in SPSS statistical analysis software (Norusis 1990) was used to generate 500 samples from which the standard error was estimated.

INSECT SEASON

Caribou abundance and distribution during the insect season, when mosquitoes (*Aedes* spp.) and oestrid flies (*Oedemagena tarandi* and *Cephenemyia trompe*) were active, were determined with aerial surveys in a portion of the area that was sampled in the calving season. The Colville East and Colville Delta survey areas were searched together, whereas the Colville Inland area was excluded from these insect-season surveys. A PA-18 "Super Cub" was flown on five surveys (Table 2) with one observer and one pilot who assisted with the count. The pilot

maintained the aircraft's speed at 125–160 km/h and its altitude at 90–150 m agl while using a GPS receiver to navigate along the transect lines. The observer searched strips 1.6 km wide on both sides of the plane as it followed east-west oriented transect lines that were separated by 3.2 km, thereby achieving 100% coverage of the survey area. Caribou were counted and individuals were classified when possible as bull, cow, calf, or yearling.

RUTTING SEASON

One survey was conducted in the Colville East and Colville Delta survey areas during the rutting season on 20 October. The survey was conducted with a Helio Courier H-700 flown at 170 km/h and 150 m agl; otherwise, the same transects and methods were used as were used for the insect-season surveys.

ARCTIC FOX

The distribution and status of arctic fox dens was determined using aerial surveys and subsequent examination on the ground. Two aerial surveys of the Colville Delta and eastern portion of the study area were flown during May to locate fox dens. Surveys were flown in a Super Cub at 100–150 m agl and 150–175 km/h. Navigation was assisted by using a GPS receiver.

The first survey was flown on 18 May along east-west oriented transects (section lines) 3.2 km apart. The plane deviated from the transects only to circle potential den sites (e.g., pingos) not readily viewed from the survey line. Coordinates of suspected den sites were recorded from the GPS receiver, so that the sites could be found and inspected from the ground.

The second aerial survey (22 May) was devoted to checking the status of den sites reported in Smith et al. (1993). Approximate locations for eight of those dens were provided by R. A. Garrott, who conducted arctic fox field investigations in the Colville Delta area in the late 1970s (Garrott 1980). Using the GPS receiver and the coordinates of each den, we flew to each den site and circled until the status of the site could be determined. Additional information about den locations and arctic fox movements was provided by observers conducting waterbird investigations.

All suspected den sites were inspected from the ground between 23 July and 7 August. During ground inspections fox dens were positively identified and recent use of the site by foxes was evaluated. The presence or absence of foxes, scat, fox tracks, fur, prey remains, and predator sign were used to determine den status. Dens were classified into three categories (from Burgess et al. 1993):

1. Active natal dens—dens that had abundant pup sign (e.g., scats from pups, fresh digging and prey remains) from the current year and were well-developed with numerous entrances and altered vegetation. Natal dens were used to whelp (give birth to) young;

2. Secondary dens—dens that contained current pup sign (but in quantities indicating shorter residency) and were poorly developed with few entrances and unaltered vegetation. Secondary dens were not used for whelping, but were used to raise litters after they were moved from natal dens;
3. Inactive dens—dens lacking current pup sign but showing evidence of use from previous years.

Absolute determination of the status of an arctic fox den requires multiple visits to the den throughout the denning season to monitor the use by and movements of fox families. Because dens were not visited prior to mid-July to determine use for whelping, and dens were not visited repeatedly to determine which natal dens were abandoned and which dens were subsequently used as secondary dens, our classification of dens was necessarily subjective. Den characteristics (e.g., landform on which the den was situated, number of entrances, plant species present.) and location coordinates (from a GPS receiver) were recorded for each den site. At each site, two photographs were taken of the location and any fox sign present.

OTHER MAMMALS

Observations of other mammals were collected opportunistically during aerial and ground surveys for waterbirds, caribou, and fox dens. Additional information on grizzly and polar bears was collected from the literature and from communications with other researchers working on the Arctic Coastal Plain.

RESULTS AND DISCUSSION

YELLOW-BILLED LOON

The highest breeding densities of Yellow-billed Loons in Alaska occur from the Colville Delta west to the Meade River (North 1986, Brackney and King 1992). Yellow-billed Loons arrive on the Colville Delta soon after the first open water appears, usually during the last week of May (Rothe et al. 1983, North 1986). Nest initiation usually occurs during the second week of June (North 1986). After hatching in mid-July, broods usually are reared on the nesting lake (North 1986).

NESTING

Fifty-six adult Yellow-billed Loons were recorded during aerial and ground surveys of the Colville Delta and aerial surveys of the eastern portion of the study area in 1993 (Figure 4). Twenty loons were seen attending 15 nests. Thirteen of the 15 nests were located on the delta and the remaining two nests were located in the eastern portion of the study area (Figure 4). Three nests had two-egg clutches at the time they were found and one nest had a single egg. Clutch size could not be determined at the remaining nests.

Ten of the 15 nests were located on deep, open lakes with polygonized shorelines (Table 3). Of the remaining five nests, two were on shallow, open lakes with polygonized shorelines; one was on a deep, open lake with a low-relief, but non-polygonized shoreline; one was in an area of flooded willows (*Salix* spp.) on the edge of a deep, open lake; and one was on an island in a drained lake. The latter two nests were located on the coastal plain, east of the delta. All nests were located within 1.0 m of the water's edge.

BROOD-REARING

Ten Yellow-billed Loon broods, consisting of one young per brood, were located on the Colville Delta during aerial and ground surveys in 1993 (Figure 5). The brood size of Yellow-billed

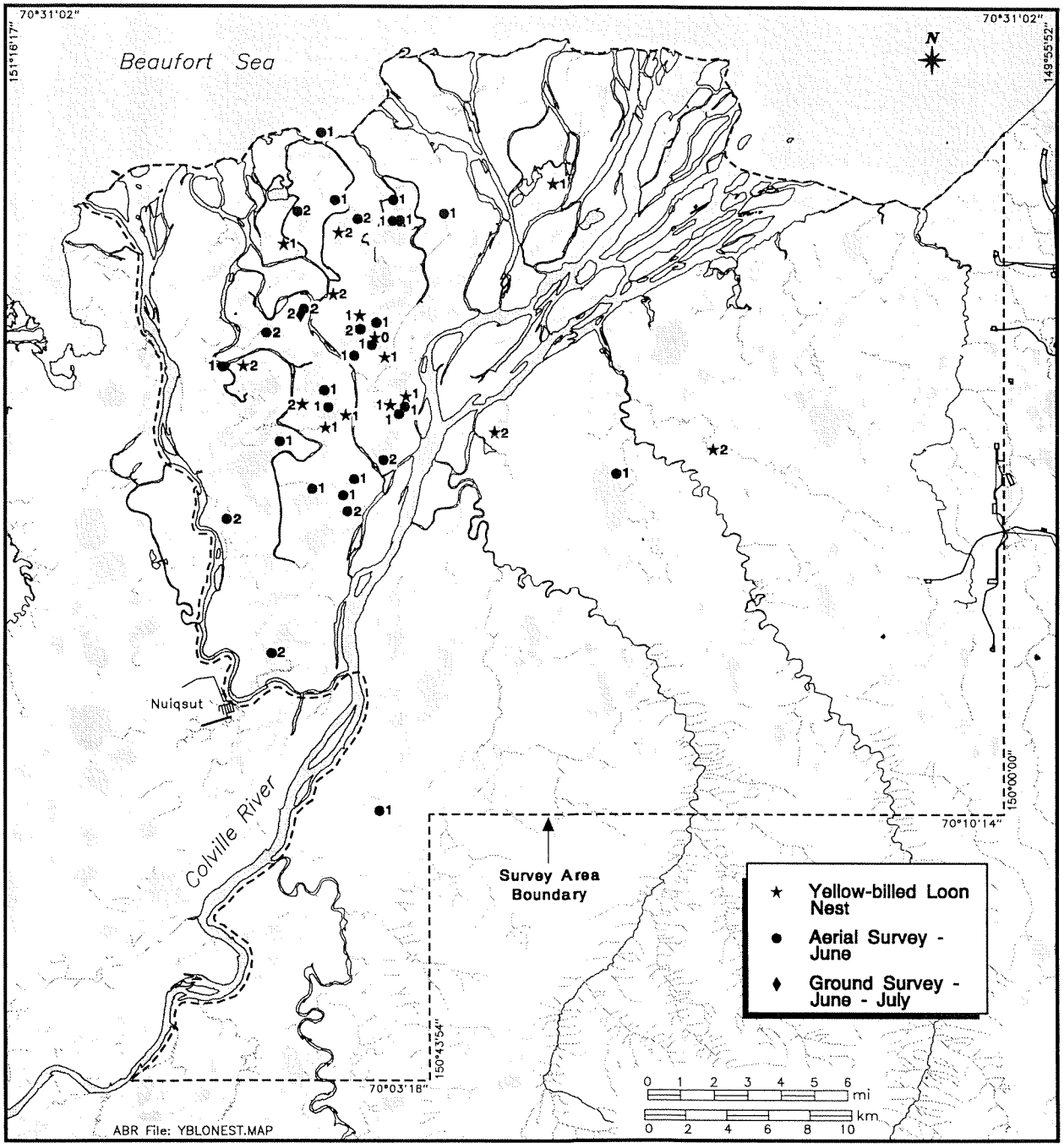

Figure 4. Distribution of Yellow-billed Loon nests and numbers of adults during aerial surveys (27–30 June 1993) and ground surveys (20 June–2 July, 1993), Colville River Delta, Alaska.

Table 3. Yellow-billed Loon nest-site characteristics and brood sizes, Colville River Delta, Alaska, 1993. Nest searches were conducted between 20 June and 2 July. Brood searches were conducted between 18 and 31 July and on 20 August.

Nest No.	Habitat[a]	Status During Brood Survey
009	Shallow open water with polygonized margins	No pair
012	Deep open water with polygonized margins	1 young
105	Deep open water with polygonized margins	Pair
010	Deep open water with polygonized margins	1 young
053	Deep open water with polygonized margins	1 young
067	Deep open water with polygonized margins	1 young
085	Deep open water	No pair
087	Deep open water with polygonized margins	1 adult
093	Deep open water with polygonized margins	1 young
100	Shallow open water with polygonized margins	No pair
110	Deep open water with polygonized margins	No pair
116	Deep open water with polygonized margins	1 young
117	Deep open water with polygonized margins	No pair
184	Deep open water (in flooded willows on shoreline)	No pair
200	Deep open water (island in actively draining lake)	No pair
None	Deep open water with polygonized margins	1 pair
None	Deep open water (with islands)	1 pair
None	Deep open water with polygonized margins	1 pair
None	Deep open water with polygonized margins	1 pair

[a] Habitats adapted from Jorgenson et al. (1989).

Loons on the Colville Delta was higher in 1992, but differences may have been influenced by later survey timing and different techniques in 1993. In 1993, information on broods was collected primarily during an aerial survey conducted on 20 August, whereas in 1992 most of the brood information was collected during ground surveys conducted in mid- to late July. A decline in productivity was reported on the Colville Delta in 1984 when the number of young/successful pair fell from 1.2 in early August to 1.0 by late August, due to chick mortality (North 1986).

Six of the 10 broods located on the delta in 1993 were associated with nests that had been found during nest surveys (Table 3). An additional four broods were seen for which nest sites had not been located. In 1993, nesting success of Yellow-billed Loons on the Colville Delta was 40% (6 of 15 nests hatched successfully). Nesting success on the Colville Delta was reported as high (94%) in 1983 and 1984 (North 1986). Several factors could account for the variation in nesting success among years. Some broods may have been missed during the aerial survey in 1993. However, during this survey, adult loons were conspicuously absent from seven of the nine nest lakes

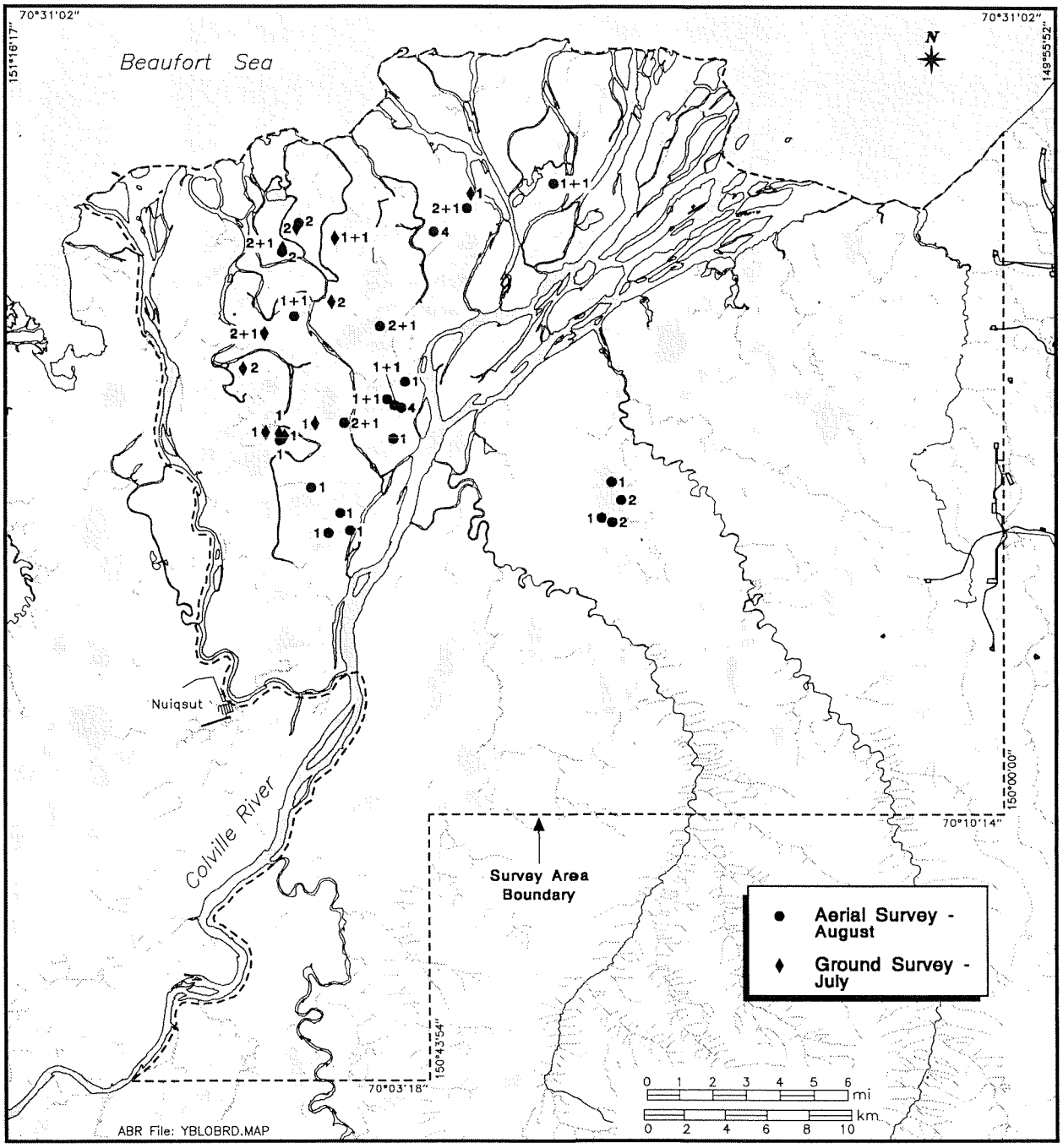

Figure 5. Distribution of Yellow-billed Loons (number of adults) and broods (number of adults + number of young) observed during ground surveys (18–31 July 1993) and an aerial survey (20 August 1993), Colville River Delta, Alaska.

at which no broods were seen later, indicating young also were absent. In addition, some pairs may have hatched young successfully, but subsequently lost their broods prior to the 20 August aerial survey. While these factors may have contributed to the low nesting success for loons observed on the delta in 1993, variation in nesting success for loons among years is not unusual. Nesting success ranged from 28–92% and 33–78% for Pacific and Red-throated loons, respectively, at Storkerson Point during a 5-year study by Bergman and Derksen (1977).

Yellow-billed Loons exhibit strong nest-site and territory fidelity (North 1986). Thirty-eight Yellow-billed Loon nests were found on the Colville Delta during waterbird studies conducted by USFWS in 1983 (17 nests) and 1984 (21 nests) (North et al. 1983, 1984a, 1984b). Ten of the 13 Yellow-billed Loon nests found on the delta in 1993 were located on the same lakes as nests found in 1983 and 1984. The highest density of Yellow-billed Loons in the Colville Delta in 1983 and 1984 occurred along the Tamayayak Channel, between the Sakoonang and Eastern channels (North 1986). This area is composed of numerous open lakes with low-relief shorelines (Walker 1983), which constitute suitable nesting habitat for Yellow-billed Loons (Rothe et al. 1983, North 1986). In 1993, 11 (85%) of the 13 Yellow-billed Loon nests and 41 (82%) of the 50 Yellow-billed Loons seen on the delta during aerial nest surveys were located on lakes in this area (Figure 4).

Twenty-four pairs of Yellow Billed Loons were recorded on the Colville Delta in 1993. Seventeen (71%) of these pairs nested, based on nest locations and brood sightings. Nesting percentages of 76% and 79% were recorded for Yellow-billed Loons on the Colville Delta in 1983 and 1984, respectively (Fields et al. 1993). In 1989, the percentage of Yellow-billed Loon pairs nesting on the delta was only 42% (Fields et al. 1993).

TUNDRA SWAN

Tundra Swans are one of the earliest spring migrants to the Colville Delta, arriving as snow begins to melt and open water develops in mid- to late May (Rothe and Hawkins 1982, Hawkins 1983). Nest initiation occurs during the last week of May and first two weeks of June (Hawkins 1983, 1986). After hatching occurs in late June or early July, broods are reared in the nesting territory. Tundra Swans molt at both coastal and inland sites on the Colville Delta. By early September, over 300 swans use the Eastern Channel and the lower reaches of the Miluveach and Kachemach rivers for staging prior to fall migration (Rothe et al. 1983). Nonbreeding swans depart the delta first in early September, followed by family groups about the third week of September.

PRE-NESTING

In 1993, an aerial survey of the delta during pre-nesting in late May located 47 swans in 18 groups (Figure 6). Group size ranged from one to nine swans, with pairs making up 78% of all sightings. Approximately 80% of the tundra on the delta was snow-covered at the time of the survey on 29 May. River channels and the margins of tapped lakes provided the only open water available. Swans were dispersed in these limited snow- and ice-free habitats.

NESTING

Two-hundred ninety-five Tundra Swans were seen during the aerial nesting survey of the Colville Delta and an adjacent area to the south conducted on 21 June 1993 (Figures 7 and 8), including 37 adults attending 27 nests (Figure 8). Because the survey area in 1993 included habitats to the south of the delta that were not surveyed in 1992, and that generally are not considered as productive for swans as habitats on river deltas (Palmer 1976, Stickney et al. 1993), direct comparisons of total numbers and densities of swans between 1992 and 1993 cannot be made. However, between-year comparisons can be made of a 364 km^2 area of the delta (located between the Nechelik and Eastern Channels) that was sampled in both 1992 and 1993. Nest densities of 0.04 nest/km^2 and 0.06 nests/km^2 were recorded during nesting surveys of this area in 1992 and 1993, respectively. The density of adults during these surveys was similar (0.71 birds/km^2 and 0.75 birds/km^2) for these same years (Table 4). An average nest density of 0.06 nests/km^2 (range = 0.05–0.10 nests/km^2) was calculated from

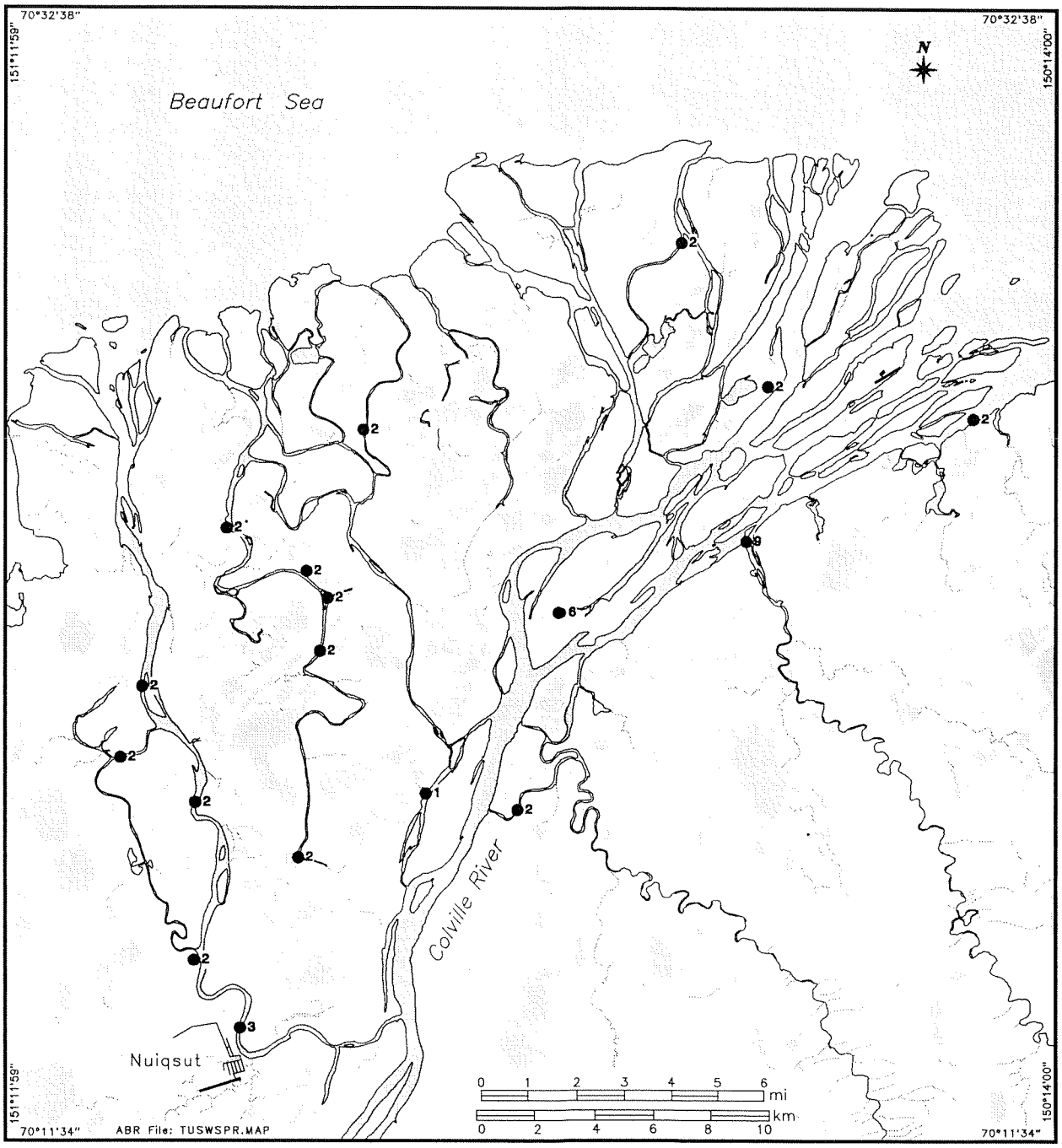

Figure 6. Distribution of Tundra Swans (number of adults) observed during an aerial survey on 29 May 1993, Colville River Delta, Alaska.

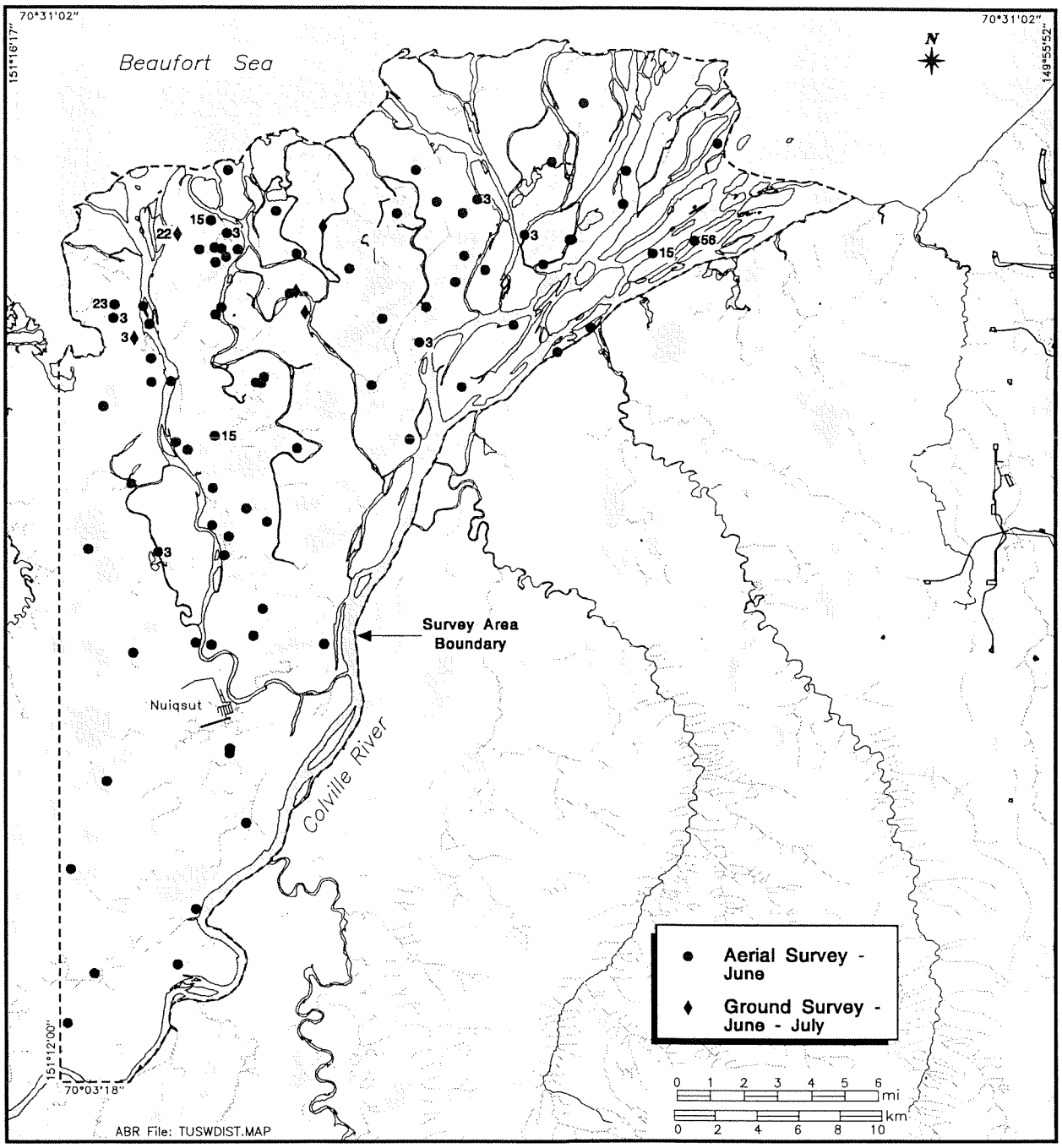

Figure 7. Distribution and numbers of Tundra Swans (number of adults) not attending nests during an aerial survey (21 June 1993) and ground surveys (20 June–2 July 1993), Colville River Delta, Alaska. Symbols without numbers indicate ≤2 birds.

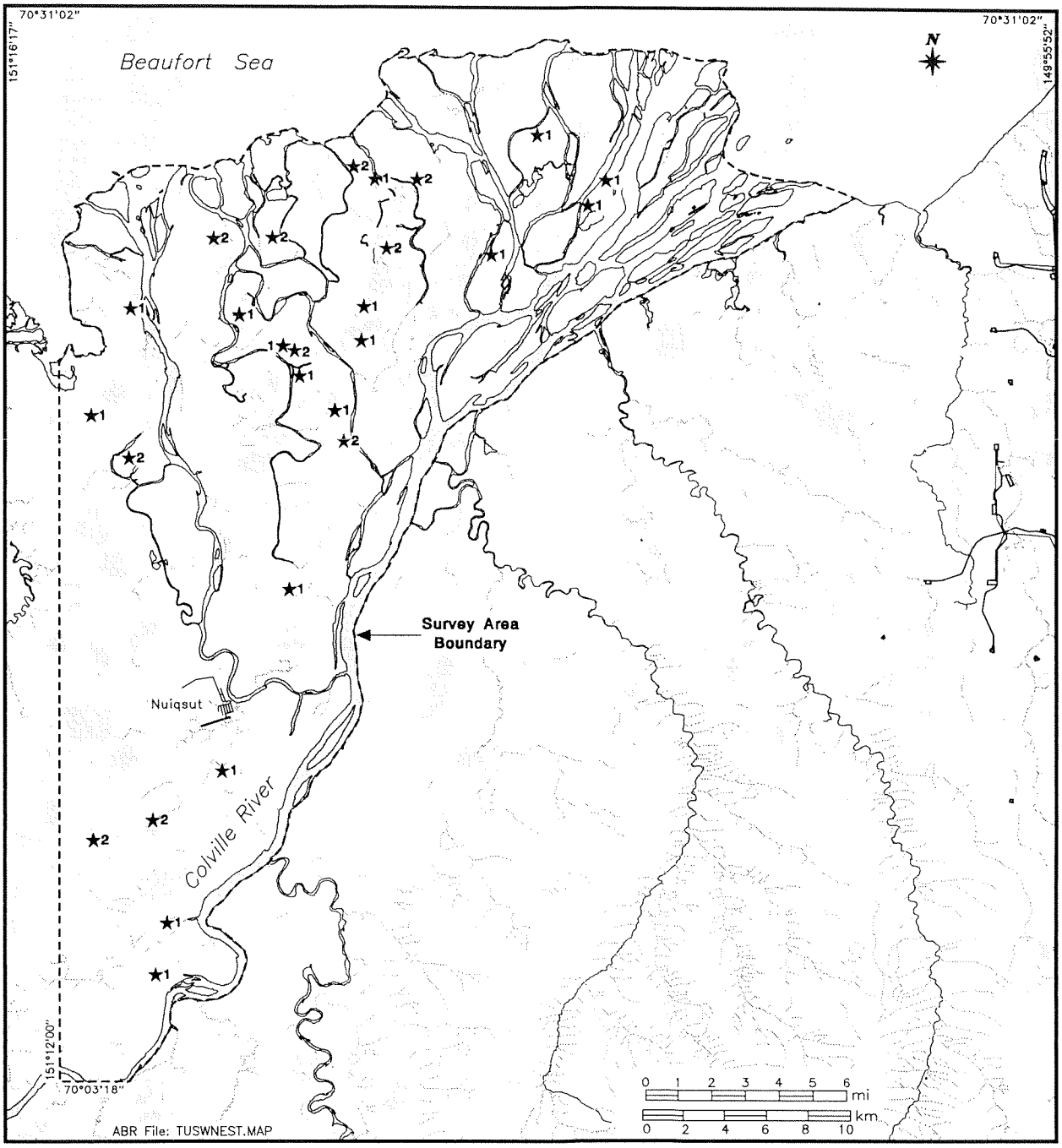

Figure 8. Distribution of Tundra Swan nests and numbers of attending adults during an aerial survey (21 June 1993) and ground surveys (20 June–2 July 1993), Colville River Delta, Alaska.

Table 4. Number and density of Tundra Swans during nesting and brood-rearing in a 364-km^2 survey area, Colville River Delta, Alaska.

		Number					Density (no./km^2)			
Season	Year	Nests	Total Swans	Adults	Young	Broods	Nests	Total Swans	Adults	Young
Nesting	1992	16	259	259	N/A	N/A	0.04	0.71	0.71	0
	1993	22	275	275	N/A	N/A	0.06	0.75	0.75	0
Brood-rearing	1992	N/A	318	270	48	19	N/A	0.87	0.74	0.13
	1993	N/A	241	204	37	14	N/A	0.66	0.56	0.10

N/A = not applicable.

aerial surveys of the Colville Delta for 1983–89 (Campbell and Rothe 1990). Intensive aerial and ground surveys of three study plots (62 km^2) conducted in 1992 yielded swan nest densities of 0.12 nests/km^2 (Smith et al. 1993). Nest densities calculated in 1982 and 1983 from intensive ground searches of a 180-km^2 portion of the western and central delta were 0.22 and 0.18 nests/km^2, respectively (Hawkins 1983).

BROOD-REARING

During brood-rearing surveys 1993, 19 Tundra Swan broods and 85 groups of adults without young were counted on the delta and adjacent area to the south (Figures 9 and 10). Fourteen broods and 72 groups of adults without young were located between the Nechelik and Eastern channels in 1993. Brood-rearing surveys conducted in 1992 yielded 19 broods and 53 groups of adults without young in this same area (Table 4).

Mean brood size in 1993 was 2.6 young/pair, compared to 2.5 young/pair in 1992 (Smith et al. 1993). The mean brood size of Tundra Swans on the Colville Delta during 1983–89 was 2.3 young/pair (range = 2.0–2.6 young/pair) (Campbell and Rothe 1990). August brood-rearing surveys of the area between the Nechelik and Eastern channels yielded densities of 0.56 birds/km^2 (adults) and 0.74 birds/km^2 in 1993 and 1992 respectively (Table 4). The percentage of young for each year was 15%, somewhat lower than the average of 21% young (range = 16–32% young) calculated from brood-rearing surveys conducted during 1983–89 (Campbell and Rothe 1990).

FALL-STAGING

The Colville Delta is a major fall-staging area for Tundra Swans, with over 300 swans using the Eastern Channel annually in September in the early 1980s (Rothe et al. 1983). In 1993, 482 swans in 48 groups (ranging in size from one to 170 birds) were observed on the delta during an aerial survey in mid-September (Figure 11). In 1992, swans were absent from the delta when staging surveys were flown on 17 September, after early freeze-up of the Colville River (Smith et al. 1993).

BRANT

The Colville Delta supports the largest concentration of nesting Brant along the Arctic Slope of Alaska (Kersen et al. 1981, Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983). Pairs of Brant arrive on the Colville Delta during late May and early June and nest initiation begins almost immediately (Kiera 1979, Rothe et al. 1983). Most Brant nests on the Colville Delta are located on ten islands at the mouth of the Eastern Channel (Simpson et al. 1982, Renken et al. 1983, Bayha et al. 1992). In addition, small isolated groups of nesting Brant are scattered across the northern half of the delta. Soon after hatching in early July, most Brant with goslings move from nesting areas and congregate in salt marshes northwest of the Eastern Channel, and on the mainland near Snow Goose Lake.

NESTING

The distribution of Brant on the Colville Delta in 1993 was not uniform. The majority of Brant nests (>900 nests) were located in the colony complex at the mouth of the Eastern Channel (Figure 12, Table 5). As in previous years (Bayha et al. 1992; P. Martin, USFWS, unpubl. data) this colony complex was surveyed by the USFWS. Most (>700 nests) of these nests were located on Char, Brant, Eskimo, and Anachlik islands. Snow Goose Lake (to the east of the delta) and the remaining islands in the colony complex supported fewer Brant nests (Table 5).

During ground and aerial surveys for nesting waterbirds on the Colville Delta in 1993, 107 Brant nests were observed outside of the colony complex in the eastern delta (Figure 12); 70 nests were found at 15 locations during the aerial survey and 37 nests were found at 5 locations during ground surveys. Most (11 locations, 73%) of the nesting locations observed during the aerial survey had <5 nests; only three locations had ≥10 nests. Five solitary nests were observed, although this count probably is low because of the difficulty of detecting solitary nests. During

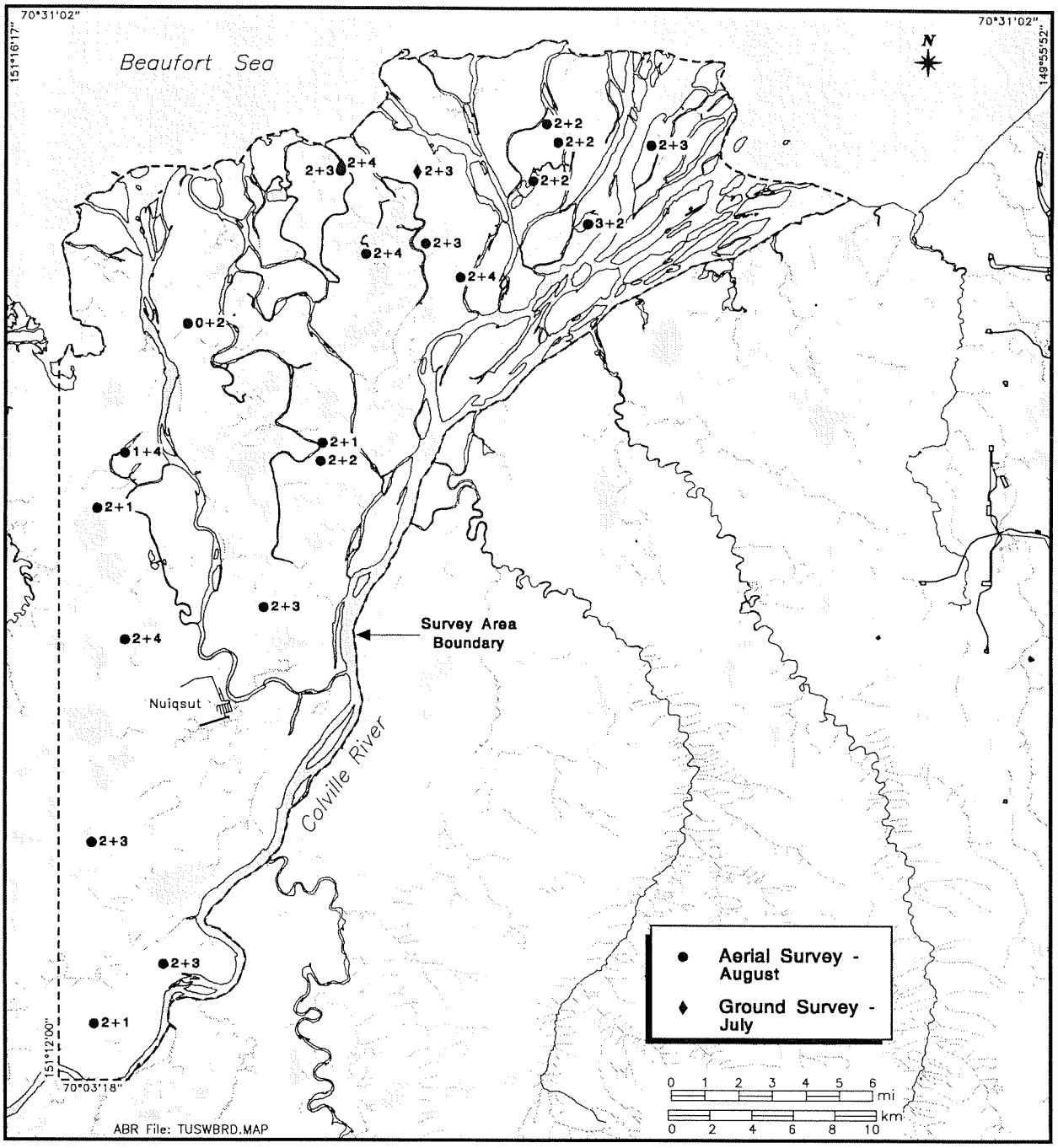

Figure 9. Distribution of Tundra Swan family groups (number of adults + number of young) observed during ground surveys (18–31 July 1993) and an aerial survey (17 August 1993), Colville River Delta, Alaska.

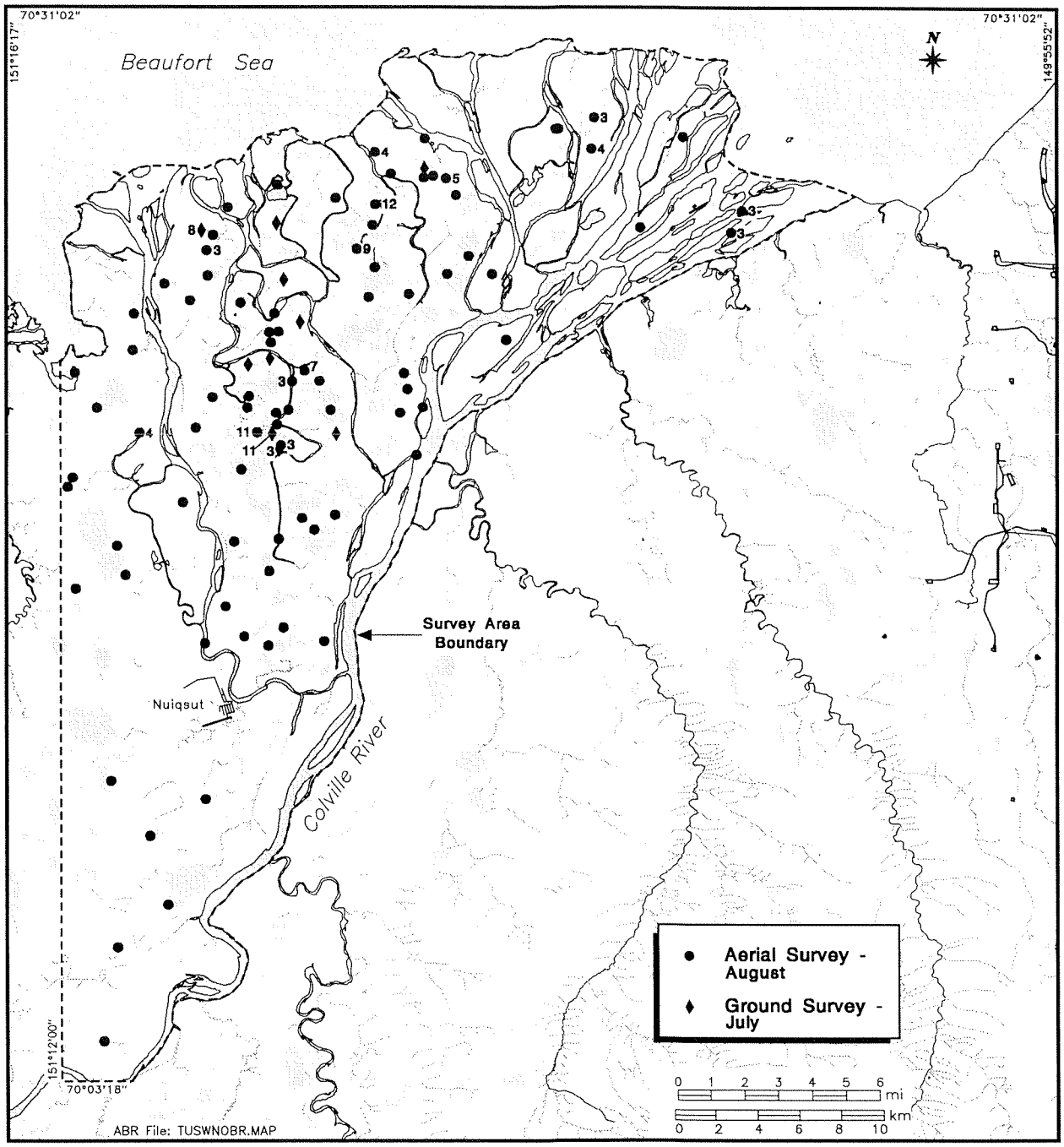

Figure 10. Distribution and numbers of Tundra Swans without broods observed during ground surveys (18–31 July 1993) and aerial survey (17 August 1993), Colville River Delta, Alaska. Symbols without numbers indicate ≤2 birds.

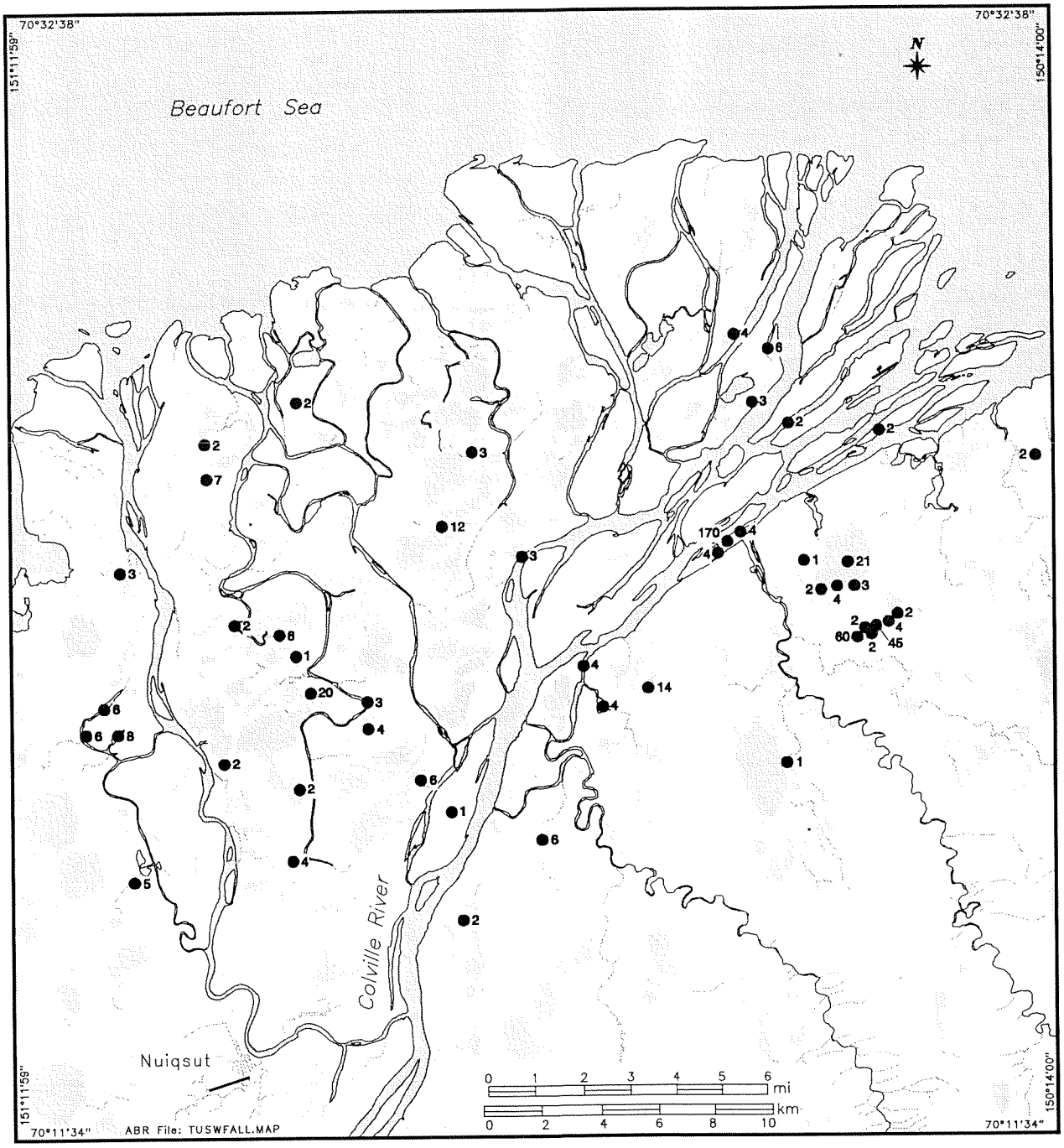

Figure 11. Distribution and numbers of Tundra Swans observed during an aerial survey on 15 September 1993, Colville River Delta, Alaska.

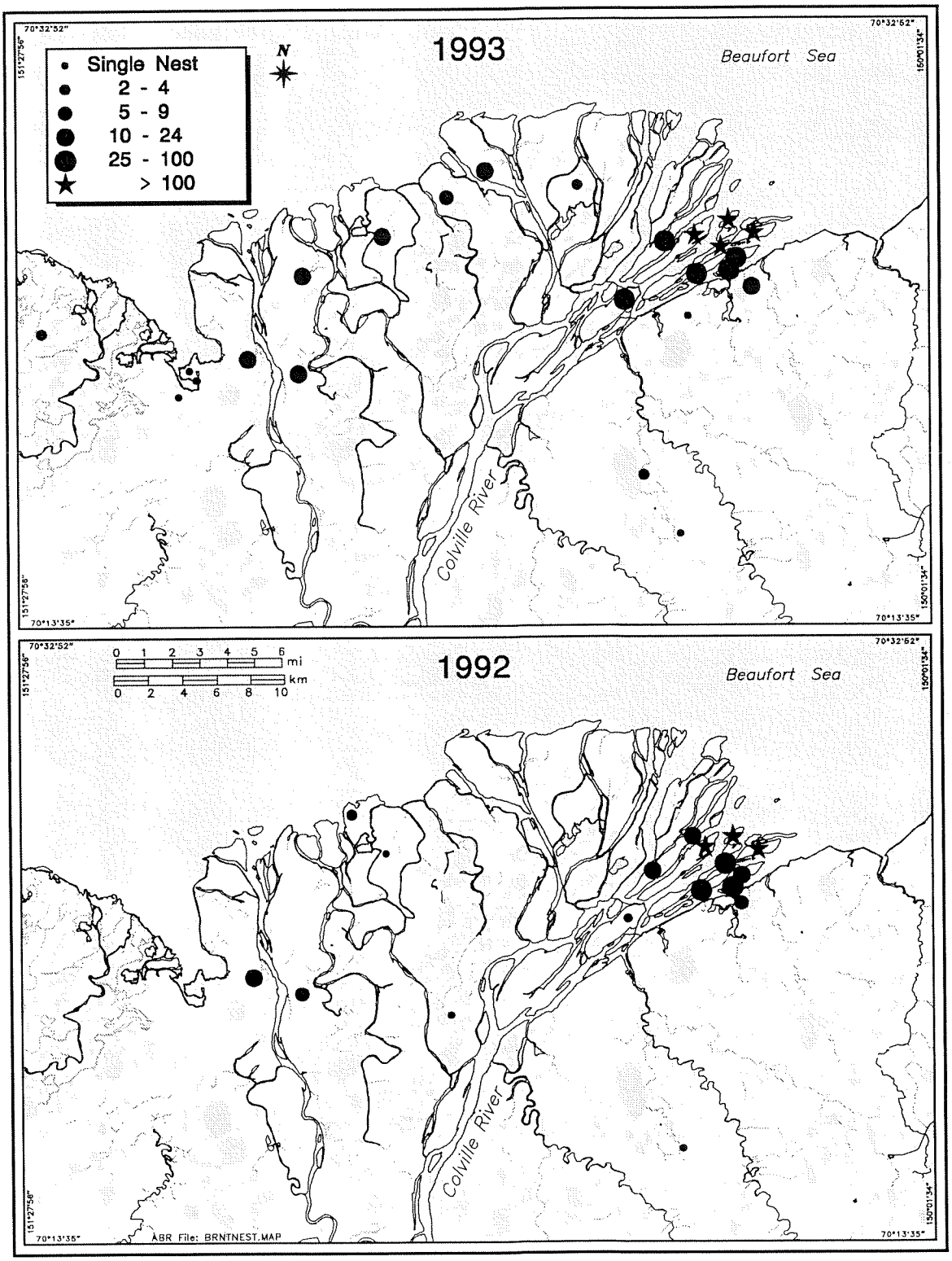

Figure 12. Distribution and numbers of Brant nests observed during aerial and ground surveys in June 1992 and 1993, Colville River Delta, Alaska. Data provided by USFWS for the eastern portion of the delta are included (P. Martin, unpubl. data, 1992, 1993).

Table 5. Number of nests and average clutch size for Brant nesting on the eastern Colville River Delta, Alaska, 1988-1993. Data from 1988-1991 are from Bayha et al. (1992), data from 1992 and 1993 are from USFWS (P. Martin, unpubl. data).

	Nesting Island												
Year	Char	Brant	Eskimo	Anachlik	White-front	North Mud Flats	Turnstone	Plover	Dune	Swan	Snow Goose Lake	Total Nests	Average Clutch Size
1988	113	157	78	67	NS	NS	NS	NS	NS	NS	NS	415	3.7
1989	59	110	67	61	NS	NS	NS	NS	NS	NS	NS	297	3.7
1990	130	107	87	109	NS	NS	NS	NS	NS	NS	NS	433	4.0
1991	N/A	N/A	N/A	N/A	NS	NS	NS	NS	NS	NS	NS	450	N/A
1992	130	180	90	190	16	14	26	24	3	40	7	720	3.7
1993	128	195	103	278[a]	29[a]	NS	37[a]	63[a]	29[a]	61	13[a]	951[a]	3.5

NS = not surveyed.
N/A = data not available or not summarized by individual island; no clutch size data collected.
[a] Preliminary data only.

Table 6. Nesting success of Brant at selected locations in the main colony complex on the eastern Colville River Delta, Alaska, 9–11 July 1993.

Island	Number of Nests				Percent Successful[a]
	Total	Successful	Failed	Unknown	
Char	117	40	71	6	36
Brant	93	58	24	11	71
Eskimo	66	52	9	5	85
Swan	14	10	2	2	83
Whitefront	23	11	8	4	58
S. Anachlik	7	5	1	1	83
Total	320	176	115	29	60

[a] Excluding nests of unknown fate.

ground surveys, observers found two solitary nests and 35 nests at three colonies, which had been identified previously from the air. More nests were located during aerial and ground surveys in 1993 than in 1992. Although different areas, which contained more preferred nesting habitat for Brant, were searched on the ground surveys in 1993, the aerial survey coverage was similar in both years.

All of the Brant nests outside of the large colony complex were located in wet meadow habitats, islands in ponds and lakes, and flooded tundra in basin wetland complexes. The majority of nests (>90%) and nesting locations (83%) were within 1.8 km of the coast (range = 0.02–12.8 km). The nests in the main colony complex on the eastern delta were located in a variety of habitat types, ranging from flooded tundra in basin wetland complexes to partially vegetated deltaic islands and tidal flats. The highest nesting density tended to be on deltaic islands. Habitat preferences of nesting Brant on the Colville Delta were similar to those observed in the neighboring oilfields (Stickney et al. 1993), where many Brant nest in small, scattered colonies, but the largest colonies are on deltaic and remnant islands. Brant are known to select basin wetland complexes for nesting elsewhere on the Arctic Slope (Derksen et al. 1982, Stickney et al. 1993).

Nesting success was determined for 320 nests on six islands within the main colony complex (Table 6). The overall nesting success was 55%, (range: 36% to 78% for individual nesting islands). Brant on Char and Whitefront islands experienced the lowest success, at 36% and 58% respectively. However, an unknown number of Brant eggs were taken from nests on Char Island by subsistence users on two different occasions (P. Martin, USFWS, pers. comm.), and an arctic fox was observed on Whitefront Island (J. Helmericks, pers. comm.). The other nesting locations in the main colony complex, which did not experience major depredation events, had relatively good nesting success (>70%). Nesting success was not determined for Brant nesting locations elsewhere on the delta. Brant nesting in the main Colville Delta colony complex experienced much better nesting success in 1993 than in 1992, when predation by a brown bear and other predators accounted for major nest losses (Smith et al. 1993). Brant in the main Colville colony complex had substantially higher nesting success in 1993 than did Brant nesting in the nearby Kuparuk and Milne Point oilfields, where the overall nesting success was only 26% (Stickney et al. 1994). Although other factors may have contributed to the poor nesting success in the oilfields, predation

appeared to play a major role, as it did in the Colville Delta colony complex in 1992.

BROOD-REARING

In 1993, brood-rearing groups of Brant from the Colville Delta dispersed at least as far east as Beechey Point (Stickney et al. 1994) and at least as far west as the mouth of the Tingmeachsiovik River. In 1993, brood-rearing groups on the Colville Delta used salt marsh habitats primarily (Figure 13). In 1992, little use of the delta was recorded because of the failure of the main colony complex. Among the sections of the Colville Delta delineated by Ritchie et al. (1990) and Bayha et al. (1992), use by Brant was not consistent among surveys (Tables 7 and 8) or between years. The area between Kalubik Creek and the Miluveach River (Section 5), just east of the main Colville colony complex, appeared to be used mostly by dispersing Brant in 1993. The largest numbers of Brant (279 birds) and groups (5) were counted in this section on 10 July; subsequent surveys observed only 1–2 groups (25–90 birds) using brood-rearing habitats in this section. In other years, however, Brant made more use of this section (Bayhà et al. 1992, Stickney et al. 1993). Likewise, use of the area between the Nechelik Channel and Fish Creek (Section 8) appeared to be limited in both 1992 and 1993, although the largest expanse of salt marsh on the delta is in this section. The largest count in section 8 was recorded on 27 June, when the survey extended west to the mouth of the Tingmeachsiovik River, where a group of 280 birds (150 adults, 130 goslings) was observed. In previous years, this section has been used by large numbers of Brant (up to 800; Bayha et al. 1992). In 1993, some Brant probably used the area west of the Tingmeachsiovik River, outside the western boundary of the our study area.

FALL-STAGING

During fall staging in 1993, more Brant were recorded using the Colville Delta than in 1992 (Figure 14 and Table 9). In 1993, over 800 Brant were observed in 22 groups between Kalubik and Fish creeks, with one large group of 700 Brant just west of the Tingmeachsiovik River. In 1992, five groups of brood-rearing Brant were observed in this area, totaling 208 birds. The largest number of groups (10) was in Section 6 (Eastern Channel to Elaktoveach Channel), but the majority of these groups had <50 birds. The largest groups (≥200 birds) were found in the Kalubik Creek area (Section 5), and west of Fish Creek (Section 8). Most groups were observed in areas that were used earlier for brood-rearing (Section 7) and included a variety habitats including salt marsh, nonpatterned wet meadow, and barren tidal flats.

SPECTACLED EIDER

Spectacled Eiders were considered locally common visitors and uncommon nesters on the Colville Delta in studies conducted in the 1980s. Spectacled Eiders first arrive on the Colville Delta during late May and early June (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983, North et al. 1984b, Nickles et al. 1987, Gerhardt et al. 1988). Dates of first nests found on the Colville Delta range from 8 to 24 June (Simpson et al. 1982, Renken et al. 1983, North et al. 1984b, Nickles et al 1987, Gerhardt et al. 1988). Male Spectacled Eiders usually remain on the breeding grounds for only two to three weeks, departing prior to hatch. Departure dates of male Spectacled Eiders on the Colville Delta range from 25 June to 11 July (Rothe et al. 1983, Nickles et al. 1987, Gerhardt et al. 1988). The fall migration of Spectacled Eiders from the Arctic Coast has not been well documented. Spectacled Eiders have been recorded on the Colville Delta as late as 21 August (Renken et al. 1983, North et al. 1984b).

PRE-NESTING

We conducted aerial surveys of approximately 1700 km of strip transects extending approximately 35 km inland to enumerate breeding pairs of eiders on the Colville Delta and eastern portion of the study area in 1993. Assuming a transect width of 400 m, 337 km^2 (approximately 50%) of the delta and 343 km^2 (50%) of the eastern portion of the study area were surveyed (Figure 2).

Thirty-one Spectacled Eiders, 13 pairs and five lone males (flying and non-flying birds) were seen

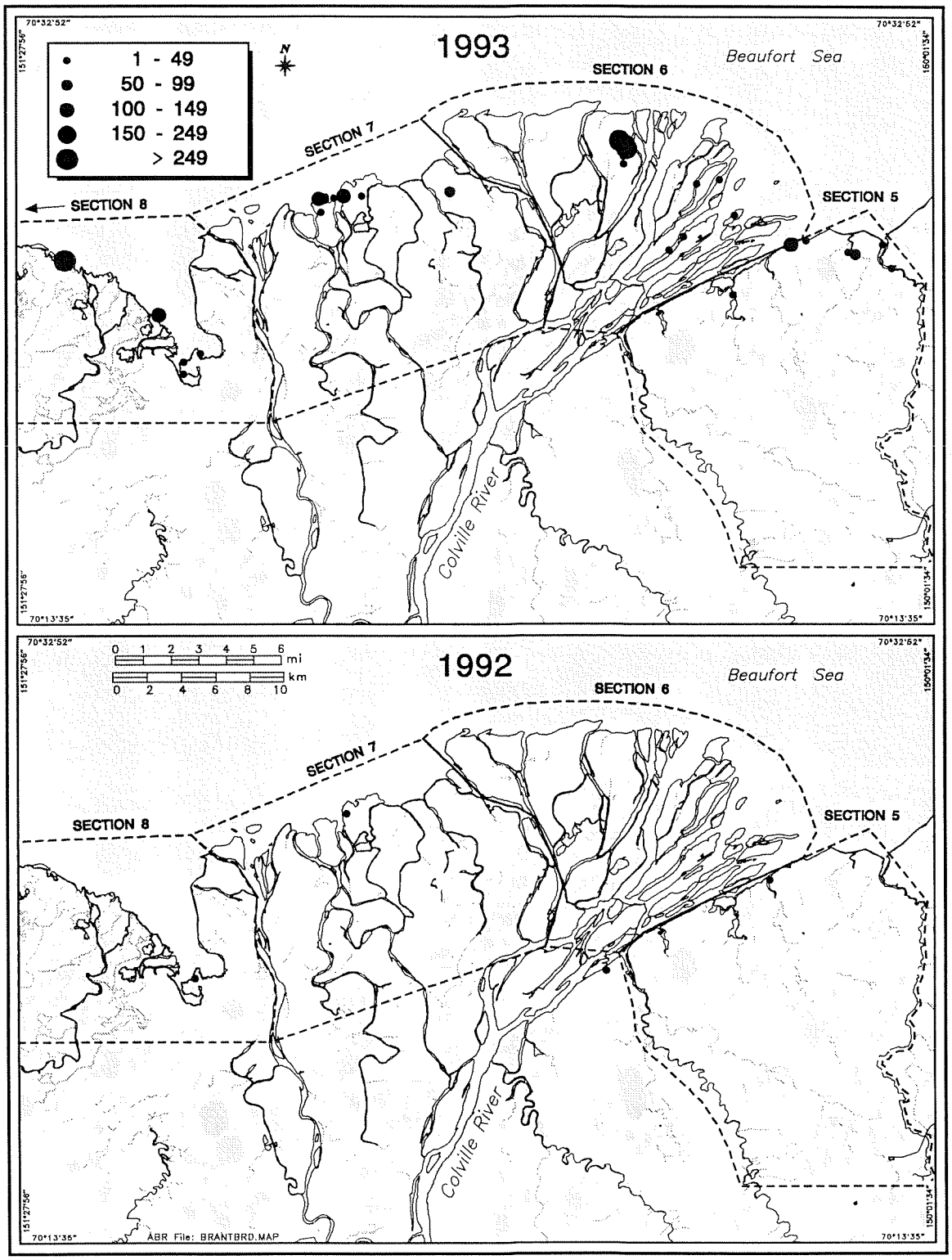

Figure 13. Distribution and size of brood-rearing groups of Brant during aerial surveys in late July 1992 and 1993, Colville River Delta, Alaska.

Table 7. Abundance and age composition of Brant in brood-rearing groups observed during aerial surveys of the Colville River Delta, Alaska, 1993. Number of groups = *n*. Coastal sections are described in Ritchie et al. (1990) and Bayha et al. (1992).

Section Number	Coastal Section	9 July 1993				27 July 1993				30 July 1993			
		Adults	Goslings	Total	*n*	Adults	Goslings	Total	*n*	Adults	Goslings	Total	*n*
5	Kalubik Cr. to Miluveach R.	182	97	279	5	15	10	25	1	41	54	95	2
6	Eastern Channel of Colville to Elaktoveach Channel	304	112	416	7	277	313	590	4	150	200	350	1
7	Elaktoveach Channel of Colville to Nechelik Channel	262	86	348	4	70	60	130	1	105	92	197	2
8	Nechelik Channel of Colville to Fish Creek[a]	12	12	24	1	238[b]	215[b]	453[b]	3	16	10	26	1
Total		760	307	1067	17	600	598	1198	9	312	356	668	6

[a] Partial survey of Section 8, which extends west of Fish Creek (see Bayha et al. 1992).
[b] Including the large brood-rearing group (150 adults and 130 goslings) at the mouth of the Tingmeachsiovik River, which is west of Fish Creek.

Table 8. Abundance of Brant in brood-rearing groups among coastal sections of the Colville River Delta, Alaska, 1988-1991. Data are from Bayha et al. (1992) and coastal sections are described in Ritchie et al. (1990) and Bayha et al. (1992).

Section Number	Coastal Section	Number of Brant							
		1988		1989		1990		1991	
		25 July	26 July	12 Aug.	13 Aug.	2 Aug.	9 Aug.	1 Aug.	7 Aug.
5	Kalubik Cr. to Miluveach River	>220[a]	>175[a]	80[b]	160	130	537	380	405
6	East Channel of Colville to Elaktoveach Channel	>70[a]	>70[a]	100[b]	137	390	475	420	400
7	Elaktoveach Channel of Colville to Nechelik Channel	>95[a]	>110[a]	90[b]	67	280	110	NC	100[b]
8	Nechelik Channel of Colville to ~12.8 km west of Fish Cr.[c]	NC	NC	610[b]	565	990[b]	NC	420	930[b]
Total		>385	>355	880	929	1890	1122	1220	1835

NC = not counted.

[a] Young were observed in groups, but not counted.

[b] Flying birds included in total.

[c] See Bayha et al. (1992).

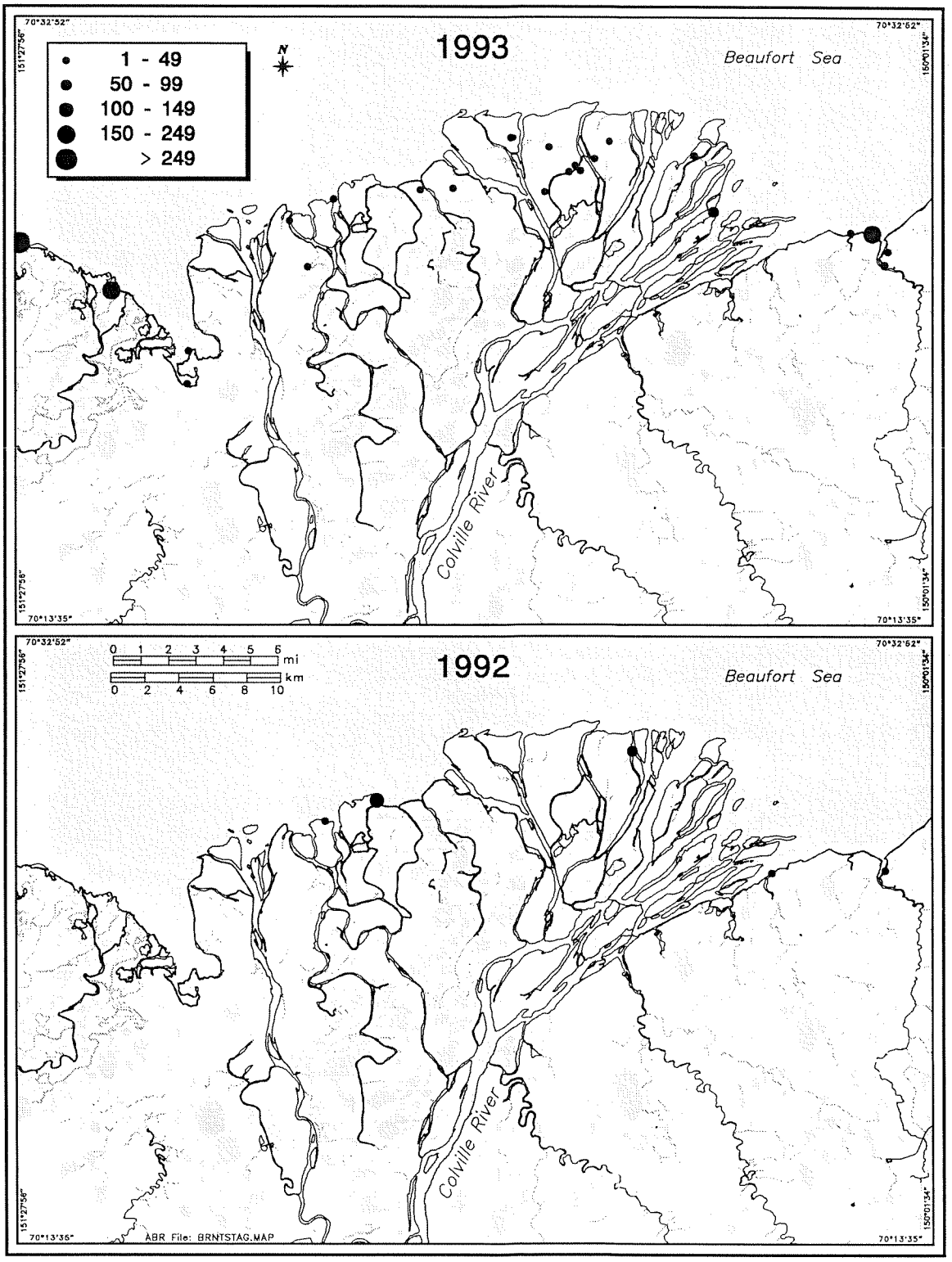

Figure 14. Distribution and size of staging groups of Brant observed during aerial surveys in late August 1992 and 1993, Colville River Delta, Alaska.

Table 9. Abundance of Brant staging in late August on coastal sections of the Colville River Delta, Alaska, 1992–1993. The coastal sections are described in Ritchie et al. (1990) and Bayha et al. (1992). The data for 1992 are from Smith et al. (1993).

		1992		1993	
Section Number	Coastal Section	No. of Birds	No. of Groups	No. of Birds	No. of Groups
5	Kalubik Cr. to Miluveach R.	18	2	250	4
6	East Channel of Colville to Elaktoveach Channel	50	1	250	10
7	Elaktoveach Channel of Colville to Nechelik Channel	140	2	131	5
8	Nechelik Channel of Colville to Fish Creek[a]	NS	NS	255	3
Total		203	5	886	22

[a] Partial survey of Section 8, which extends west of Fish Creek (see Bayha et al. 1992).
NS = not surveyed.

during aerial surveys of the Colville Delta in June 1993 (Table 10 and Figure 15). All Spectacled Eiders were observed within 16 km of the coast. Assuming each lone male represents a pair (USFWS 1987b), 18 indicated pairs of Spectacled Eiders were recorded in the area surveyed. In 1993, the density of Spectacled Eiders (total birds), on the Colville Delta was 0.09 birds/km^2 (Table 10). The density of observed and indicated pairs on the delta was 0.04 pairs/km^2 and 0.05 pairs/km^2 respectively.

Thirteen Spectacled Eiders (flying and non-flying birds) were seen during surveys of the eastern portion of the study area in June 1993 (Figure 15). Ten of these birds were paired. Assuming single males actually were paired, then seven indicated pairs of Spectacled Eiders occurred in the eastern survey area (Table 10). All Spectacled Eiders occurred within 21 km of the coast in the eastern portion of the study area. Densities of Spectacled Eiders observed in the eastern survey area were 0.04 birds/km^2 and 0.01 pairs/km^2 for total number of birds and number of pairs, respectively. Including lone males, the density of indicated pairs increased to 0.02 pairs/km^2 (Table 10).

Densities of total Spectacled Eiders and pairs were substantially lower in the eastern study area than on the Colville Delta in 1993 (Table 10). Habitat differences may explain this disparity. The Colville Delta contains a greater diversity of habitats, including large areas of high-relief (polygonized) wet meadow, polygons containing permanent water with emergent vegetation, shallow open water with polygonized shorelines, and numerous basin wetland complexes. The eastern area lacks this habitat diversity, and is

Table 10. Observed and indicated number and density (uncorrected) of eiders recorded during breeding-pair surveys, 10–12 June 1993, Colville River Delta, Alaska. The surveyed areas comprised 337 km^2 on the Colville River Delta and 343 km^2 on the Eastern Area.

	Number						Density			
Species	Males	Females	Total Observed[a]	Pairs Observed[b]	Total Indicated[c]	Pairs Indicated[d]	Observed Birds[a]/km^2	Observed Pairs[b]/km^2	Indicated Birds[c]/km^2	Indicated Pairs[d]/km^2
FLYING AND NON-FLYING BIRDS										
Colville River Delta										
Spectacled Eider	18	13	31	13	36	18	0.09	0.04	0.11	0.05
King Eider	26	25	51	21	56	26	0.15	0.06	0.17	0.08
Unidentified eider	2	1	3	1	4	2	<0.01	<0.01	0.01	<0.01
Eastern Area										
Spectacled Eider	7	6	13	5	15	7	0.04	0.01	0.04	0.02
King Eider	49	42	91	39	101	49	0.27	0.11	0.29	0.14
Unidentified eider	3	4	7	3	7	3	0.02	<0.01	0.02	<0.01
NON-FLYING BIRDS										
Colville River Delta										
Spectacled Eider	17	12	29	12	34	17	0.09	0.03	0.10	0.05
King Eider	20	22	42	18	42	20	0.12	0.05	0.12	0.06
Unidentified eider	1	0	1	0	2	1	<0.01	0	<0.01	<0.01
Eastern Area										
Spectacled Eider	5	4	9	3	11	5	0.03	<0.01	0.03	0.01
King Eider	38	32	70	29	79	38	0.20	0.08	0.23	0.11
Unidentified eider	2	3	5	2	5	2	0.01	<0.01	<0.01	<0.01

[a] Total observed = number of birds seen during survey.
[b] Pairs observed = number of pairs (one male associated with one female) seen during survey.
[c] Total indicated = (number of males not associated with a flock x 2) + number of males in flock (see USFWS 1987b).
[d] Pairs indicated = number of males not associated with a flock (see USFWS 1987b). (Flock = group of >4 males. No flocks were recorded during June surveys).

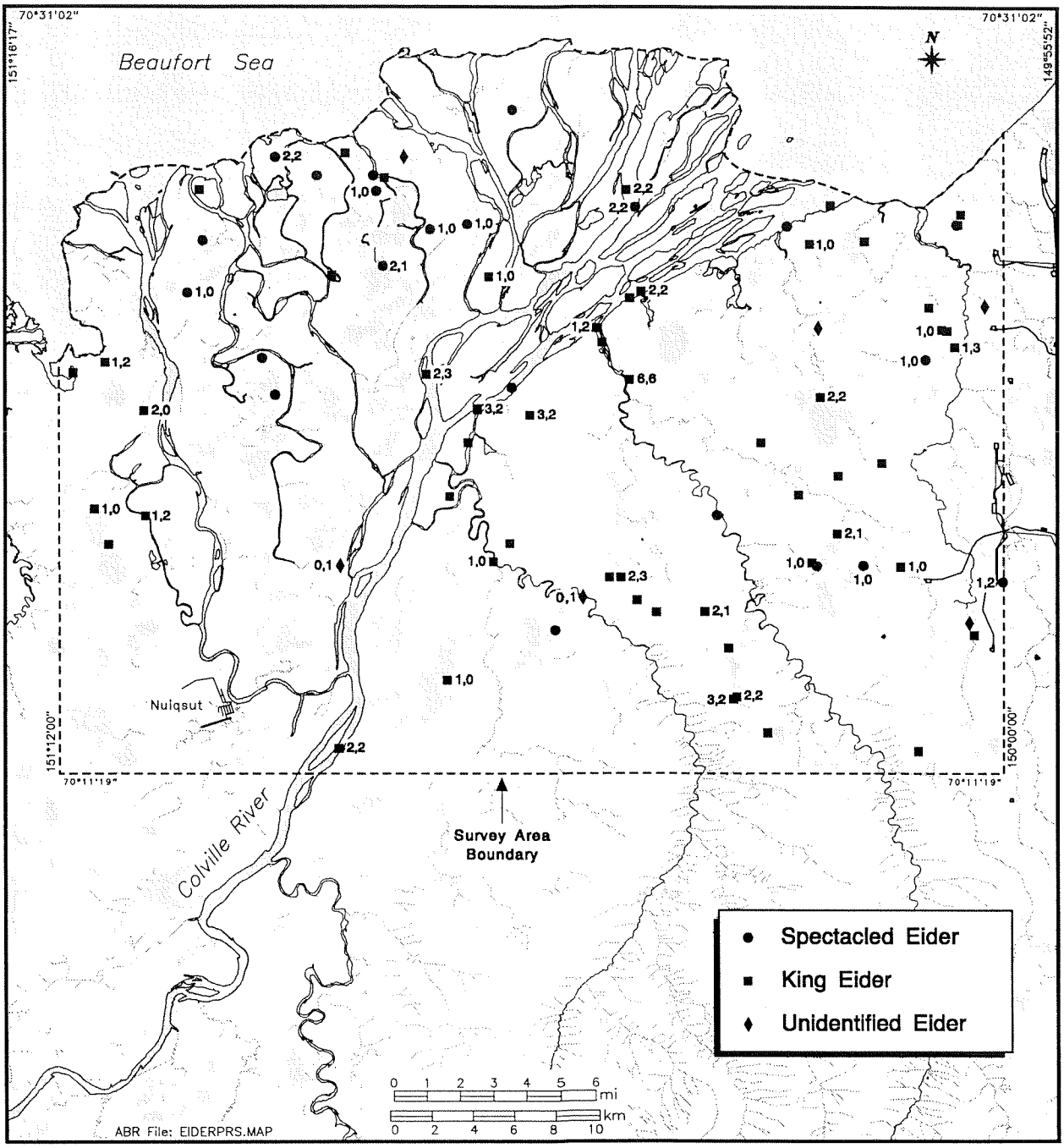

Figure 15. Distribution of Spectacled, King, and unidentified eiders (number of males, number of females) observed during aerial surveys (10–12 June 1993), Colville River Delta, Alaska. Symbols without numbers indicate a pair.

dominated by wet and moist non-patterned meadows, deep-open lakes, and some basin wetland complexes.

In 1992, aerial surveys for breeding pairs of eiders were conducted on the Colville Delta during 17–19 June. Although these aerial surveys only covered a portion (62 km^2) of the delta, the density of Spectacled Eiders was 0.04 birds/km^2 (Smith et al. 1993), half of that found on the delta-wide aerial survey conducted on 10 June in 1993. The difference between 1992 and 1993 densities (0.09 birds/km^2) on the Colville Delta may have been affected by the timing of the surveys. In a study of Spectacled Eiders conducted in the Prudhoe Bay oilfield, Warnock and Troy (1992) concluded that the optimal time to conduct breeding-pair surveys was just prior to nest initiation. Although we have no data regarding the timing of nest initiation for Spectacled Eiders on the Colville Delta, some anecdotal information on dates of arrival and departure (of males) is available. Spectacled Eiders begin to arrive on the Colville Delta during late May and early June, with arrival peaking between 1 and 10 June (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983, North et al. 1984b, Nickles et al. 1987, Gerhardt et al. 1988). Breeding pairs of Spectacled Eiders usually occupy territories on the Colville Delta by mid-June and males disperse from the territories shortly after the onset of incubation (Rothe et al. 1983). In 1992, our breeding-pair survey was flown after nest initiation was well underway and males had begun to depart from territories (Smith et al. 1993), so our estimate of the density of breeding birds may have been low.

Two aerial surveys for breeding pairs of Spectacled Eiders were flown in 525 km^2 of the Kuparuk Oilfield on 15 June and 18–20 June 1993 (Anderson and Cooper 1994). Those surveys resulted in densities for total Spectacled Eiders (flying and non-flying birds) of 0.20 birds/km^2 and 0.08 birds/km^2, respectively (Table 11). The decrease in numbers between the two surveys may be due to the timing of the surveys, with the earlier survey conducted at or near the peak of nest initiation and the later survey conducted after males had begun to depart the breeding grounds. These results are similar to those from aerial surveys conducted in the Kuvlum Corridor east of Prudhoe Bay (Byrne et al. 1994) on 16 and 17 June 1993 (Table 11). Survey timing also may account for differences between the Kuparuk and Colville surveys. The density of Spectacled Eiders on the Colville Delta was less than half the density found in the Kuparuk oilfield and Kuvlum Corridor, but the delta was surveyed five to seven days earlier in June (Table 11). The density recorded on the second Kuparuk survey (18–20 June), however, was similar to that seen on the Colville Delta survey 8–10 days earlier (Table 11). Our breeding-pair survey for Spectacled Eiders on the Colville Delta may have been conducted prior to the peak of nest initiation in 1993, as birds were still arriving on the delta.

NESTING

Approximately 580 ha of the Colville Delta was searched for nesting eiders during ground nesting surveys from 20 June–2 July 1993 (Figure 16). Six eider nests were found during these searches, including two active (females incubating) and three probable (abandoned) Spectacled Eider nests. In addition, one active eider nest was found for which the species could not be determined. Two of the three incubating females did not flush from their nests. The third female flushed when observers were approximately 3 m away; its nest contained four eggs (Table 12). Two other probable Spectacled Eider nests were located during brood-rearing surveys (Figure 16 and Table 12).

The two active Spectacled Eider nests found during nest searches were considered to have hatched successfully. The active unidentified eider nest was not checked (Table 12). One of the two probable Spectacled Eider nests found during brood-rearing surveys also was considered successful. The three abandoned nests found during nest surveys and one of the nests found during brood-rearing appeared to have been destroyed by foxes. No eggshell fragments were found, but a large amount of down was found in each of the nests. Fox scat was found near one nest.

Two of the three active nests were located on lake edges in basin wetland complexes; the third nest was on the shore of a shallow lake with a polygonized shoreline (Table 12). The remaining five nests were located on the shorelines of shallow lakes with

Table 11. Densities (uncorrected) of eiders (flying and non-flying) observed during aerial surveys in 1993, Arctic Coastal Plain, Alaska. Densities of birds and pairs were calculated from counts of birds and pairs.

	Colville River Delta 337 km^2			Colville Eastern Area 343 km^2			Kuparuk Oilfield[a] 525 km^2			Western Kuparuk[a] 126 km^2			Kuvlum Corridor Stratum 1[b]			Kuvlum Corridor Stratum 2[b]		
Species	Date	Birds/ km^2	Pairs/ km^2	Date	Birds/ km^2	Pairs/ km^2	Date	Birds/ km^2	Pairs/ km^2	Date	Birds/ km^2	Pairs/ km^2	Date	Birds/ km^2	Pairs/ km^2	Date	Birds/ km^2	Pairs/ km^2
Spectacled Eider	10 June	0.09	0.04	11-12 June	0.04	0.01	15 June	0.20	0.07	18-20 June	0.06	0.02	16-17 June	0.21	0.07	16-17 June	0.06	0.03
							18-20 June	0.08	0.02									
King Eider	10 June	0.15	0.06	11-12 June	0.27	0.11	15 June	0.13	0.04	18-20 June	1.49	0.67	16-17 June	0.35	0.11	16-17 June	0.30	0.08
							18-20 June	0.30	0.08									
Unidentified Eider	10 June	<0.01	<0.01	11-12 June	0.02	<0.01	15 June	0.01	0.01									
							18-20 June	<0.01	<0.01									

[a] From Anderson and Cooper (1994).
[b] From Byrne et al. (1994).

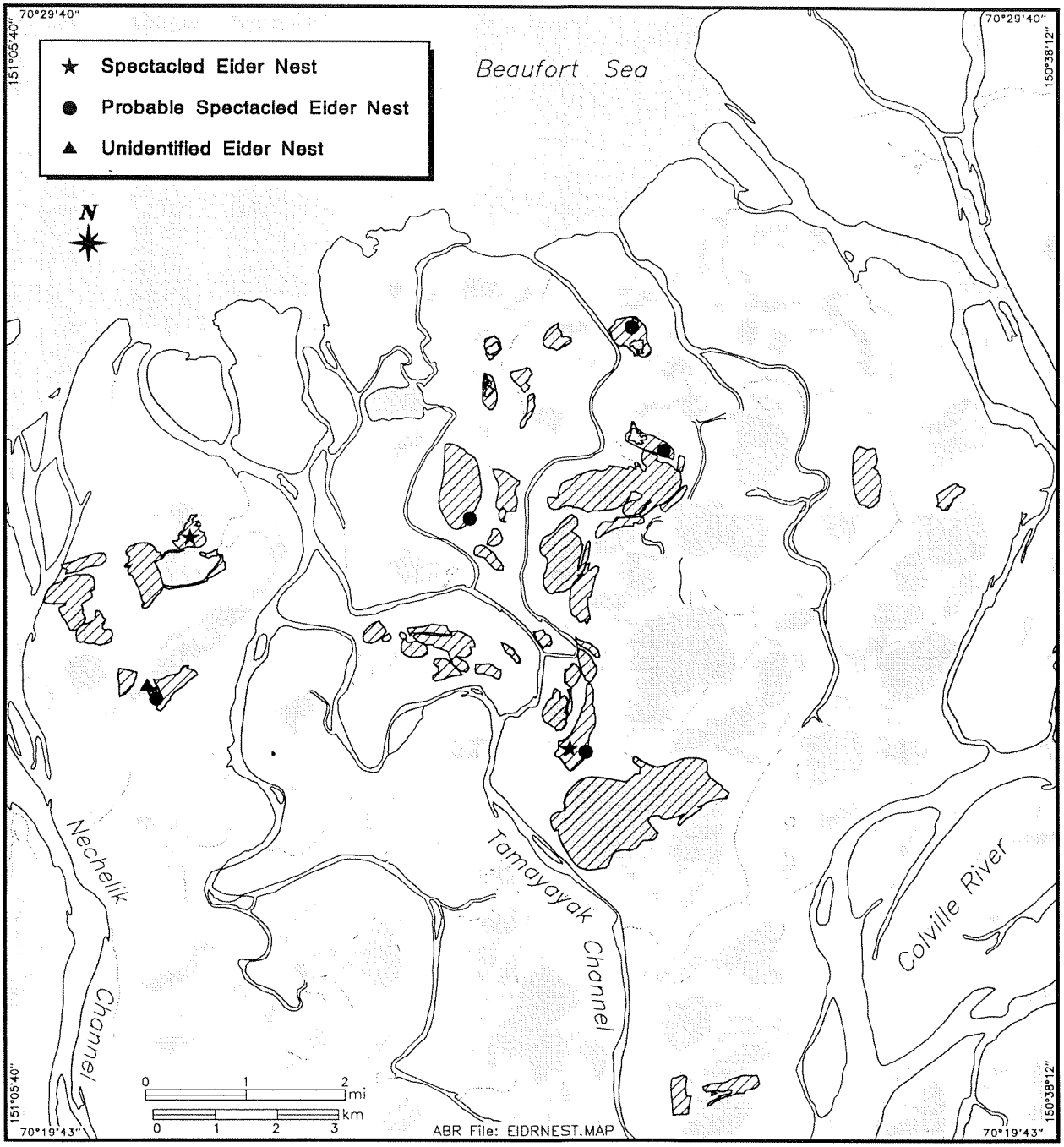

Figure 16. Distribution of Spectacled Eider, probable Spectacled Eider, and unknown eider nests located during nesting and brood-rearing surveys (20 June–20 July 1993), Colville River Delta, Alaska. Cross hatching indicates areas searched for nesting Spectacled Eiders.

Table 12. Status and habitat characteristics of confirmed and probable Spectacled Eider nests, Colville River Delta, Alaska, June–July 1993.

Species[a]	Nest No.	Date[b]	Active[c]	Success[d]	Clutch	Habitat[e]
SPEI	204	21 June	Yes	Yes	Unknown	Basin wetland complex
UNEI	220	23 June	Yes	Unknown	Unknown	Basin wetland complex
SPEI	008	25 June	Yes	Yes	4	Shallow open water w/ polygonized margins
(SPEI)	240	25 June	No	No	0	Shallow open water w/ polygonized margins
(SPEI)	241	28 June	No	No	0	Shallow open water w/ polygonized margins
(SPEI)	242	28 June	No	No	0	Shallow open water w/ polygonized margins
(SPEI)	243	24 July	No	No	Unknown	Permanent water w/ emergent sedge, polygons
(SPEI)	244	20 July	No	Yes	Unknown	Basin wetland complex

[a] SPEI = Spectacled Eider; UNEI = unidentified eider; (SPEI) = probable Spectacled Eider (based on contour feathers in nest [see Anderson and Cooper 1994]).
[b] Date nest was found.
[c] Female incubating at time nest was found.
[d] Nest hatched successfully.
[e] Habitats adapted from Jorgenson et al. (1989).

polygonized shorelines (three nests), on the edge of a polygon with permanent water and emergent sedge (one nest), and on the shoreline of a lake in a basin wetland complex (one nest) (Table 12). Each of the nests was within 0.5 m of standing water. All nests were located ≤11 km from the coast.

During previous studies on the Colville Delta, Spectacled Eider nests were found on ridges of polygons containing permanent water and emergent sedge or grass (Rothe et al. 1983, North 1990). Nests also were found on the edges of deep open lakes at Storkerson Point (Bergman et al. 1977) and in the National Petroleum Reserve-Alaska (NPR-A) (Derksen et al. 1981, North 1990), and in wet, non-patterned tundra in the Prudhoe Bay region (Troy 1990, Warnock and Troy 1992) and the Kuparuk River oilfield (Anderson and Cooper 1994).

Spectacled Eiders occurred in a variety of habitats during nesting (Table 13). A total of 21 adult Spectacled Eiders, including two females on nests, were seen during nesting. Almost 81% of these sightings occurred in basin wetland complexes and on shallow open lakes with polygonized margins. Polygons with emergents and coastal wetland complexes were used to a lesser extent (Table 13).

Table 13. Habitats used during nesting and brood-rearing by Spectacled Eiders, Colville River Delta, Alaska, 1993.

		Number Observed					Percent Observed				
Season	Habitat[a]	Males	Females	Adults	Young	Nests[b] or Broods	Males	Females	Adults	Young	Nests[b] or Broods
Nesting	Shallow open water with polygonized margins	0	7	7	0	1	0	41	33	0	50
	Basin wetland complex	3	7	10	0	1	75	41	48	0	50
	Permanent water with emergents, polygons	0	3	3	0	0	0	18	14	0	0
	Coastal wetland complex, salt affected, non-patterned	1	0	1	0	0	25	0	5	0	0
Brood-rearing	Shallow open water with polygonized margins	0	4	4	7	2	0	14	14	17	18
	Basin wetland complex	0	13	13	9	2	0	45	45	21	18
	Permanent water with emergents, polygons	0	2	2	7	2	0	7	7	17	18
	Coastal wetland complex, salt affected, non-patterned	0	0	0	0	0	0	0	0	0	0
	Coastal wetland complex, salt affected, low relief	0	5	5	2	1	0	17	17	5	9
	Coastal wetland complex, salf affected, high relief	0	4	4	17	4	0	14	14	40	36
	Inshore marine waters	0	1	1	0	0	0	3	3	0	0

[a] Habitats adapted from Jorgenson et al. (1989).
[b] Only positively identified, active nests of Spectacled Eiders.

BROOD-REARING

Eleven broods of Spectacled Eiders (including one crêche, containing two females and eight young) were located during brood-rearing surveys on the Colville Delta in 1993 (Figure 17 and Table 14). Excluding the crêche, brood size ranged from two to five young ($\bar{x}$= 3.8 young/brood). Broods were found in the same habitats as nests: shallow lakes with polygonized shorelines, polygons with permanent water and emergent sedges or grasses, and lakes in basin wetland complexes. In addition, broods were found in high-relief polygons and shallow lakes within salt-affected, coastal wetland complexes (Tables 13 and 14). All broods were located within 17 km of the coast.

Our data are consistent with previous reports that brood-rearing by Spectacled Eiders usually occurs on small ponds and lakes with emergent vegetation (Derksen et al. 1981, North 1990). In the NPR-A, Spectacled Eider broods were seen most often on shallow ponds and lakes with emergent vegetation and on deep open lakes (Derksen et al. 1981). Spectacled Eider broods were seen on ponds and lakes with emergent vegetation, in basin wetland complexes, and on deep open lakes in the Kuparuk River oilfield (Anderson and Cooper 1994).

Twenty-nine adult Spectacled Eiders (all females, including 11 with broods) were seen during brood-rearing. Although eiders used a greater variety of habitats during brood-rearing than nesting, the largest proportion (almost 45%) of the sightings of adults occurred in basin wetland complexes; fewer were seen in coastal wetland complexes (31%) and shallow open lakes with polygonized margins (14%). Eiders occurred to a lesser extent in polygons with emergents and inshore marine waters (Table 13). Coastal wetland complexes appear to be important to brood-rearing Spectacled Eiders on the Colville Delta; 45% (5 of 11 broods) of the broods we recorded used this habitat type. Shallow open lakes with polygonized margins, basin wetland complexes, and polygons with emergents each contained two (18%) of the 11 broods seen on the delta in 1993 (Table 13).

The apparent importance of coastal wetland complexes during brood-rearing, in relation to their lack of use during nesting, may be related to survey intensity. Extensive searches for nesting Spectacled Eiders could not be conducted in coastal wetland complexes in 1993 because low water and shorefast ice restricted our access. These areas were searched adequately during brood-rearing, however. In addition, broods were probably more difficult to find in basin wetland complexes, shallow open lakes with polygonized margins, and in polygons with emergents, due to the extent of vegetation growing along the margins of these waterbodies.

A limited amount of historic information is available regarding use of the Colville Delta by nesting and brood-rearing Spectacled Eiders. Two Spectacled Eider nests were found in a basin wetland complex on the west side of the delta in 1958 and four nests were found in this same area in 1959 (M. North, USFWS, pers. comm. with M. T. Myres). Three Spectacled Eider broods were found in the same complex in 1984 (M. North, USFWS, pers. comm.). In 1993, we found one nest and two broods in this same basin wetland complex and two nests in another basin wetland complex about 1.6 km to the south. In 1983, one Spectacled Eider nest and one brood were found in two different areas of the delta (M. North, pers. comm.). In 1994, we found two Spectacled Eider nests in the same area in which the brood was found in 1983. Four nests and one additional brood were found in 1984 at widely dispersed locations across the delta (M. North, USFWS, pers. comm.). Although we searched those areas for Spectacled Eider nests and broods in 1993, none were found.

OTHER WATERBIRDS

PACIFIC LOON

Pacific Loons arrive on the Colville Delta as open water appears in rivers and tapped lakes, usually during the last week of May (North 1986). Breeding territories are established in untapped wetlands as thaw progresses and nests are initiated within 7–11 days of arrival, usually during the second or third week of June (Bergman and Derksen 1977, North 1986). Hatching occurs during the first or second week of July on the Colville Delta (Bergman and Derksen and 1977, Rothe et al. 1983).

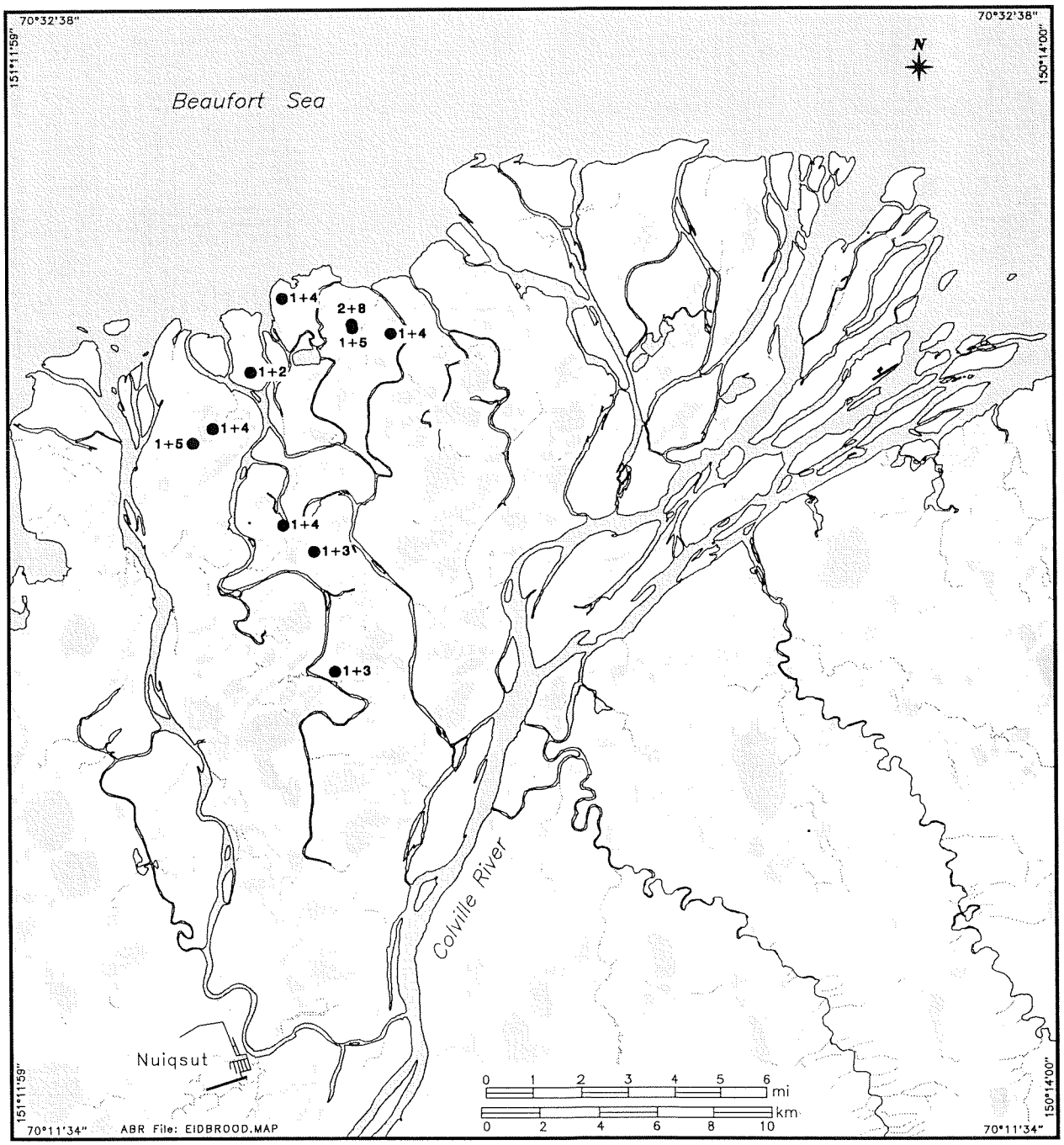

Figure 17. Distribution of Spectacled Eider broods (number of adults + number of young) located during ground surveys (20 June–2 July 1993), Colville River Delta, Alaska.

Table 14. Brood size and habitat associations of Spectacled Eiders on the Colville River Delta, Alaska, July 1993.

Brood No.	Date	Number of Adults	Number of Young	Habitat[a]
604	20 July	1	4	Basin wetland complex
703	24 July	1	4	Shallow open water w/ polygonized margins
709	24 July	1	5	Coastal wetland complex, salt affected, high-relief polygons
711	24 July	2	8	Coastal wetland complex, salt affected, high-relief polygons
713	19 July	1	4	Coastal wetland complex, salt affected, high-relief polygons
714	31 July	1	2	Coastal wetland complex, salt affected, low-relief polygons
722	20 July	1	5	Basin wetland complex
732	27 July	1	4	Permanent water w/ emergent sedge, polygons
736	27 July	1	3	Shallow open water w/ polygonized margins
741	28 July	1	3	Permanent water w/ emergent grass, polygons

[a] Habitats adapted from Jorgenson et al. (1989).

Four-hundred sixty-nine Pacific Loons were seen during aerial and ground-based nest surveys of the Colville Delta from 20 June–2 July (Figure 18). One-hundred six of these loons were associated with 87 nests. Mean clutch size for 20 of the nests was 1.6 eggs/nest; 14 nests had two eggs, three nests had one egg, and three nests had no eggs.

During brood searches, 23 of the 30 Pacific Loon nests that were found on the delta during ground-based nest surveys were revisited. Seven of the 23 nests (30%) were determined to have been successful (based on the presence of broods in the area) and 12 nests (43%) were unsuccessful (no adults or broods in the area). Status was undetermined the remaining four nest sites (17%); however, loons exhibited defensive behavior toward observers, indicating chicks may have been concealed nearby.

Twenty different broods ($\bar{x}$ = 1.2 young/brood) of Pacific Loons were counted during aerial (20 August) and ground surveys (18–31 July) for broods. Eight of these broods were associated with nests found during nest surveys. A total of 46 adult loons without broods were seen during ground-based brood surveys, and 42 adult loons without broods were seen during aerial brood surveys conducted about one month after the ground surveys.

RED-THROATED LOON

Unlike Yellow-billed and Pacific loons, Red-throated Loons do not arrive on the Colville Delta until nesting ponds begin to thaw, usually during the first half of June (Rothe et al. 1983, North et al. 1984b). Nest initiation occurs within two weeks of territory establishment (Bergman and Derksen 1977, North 1986). Hatching on the Colville Delta occurs in

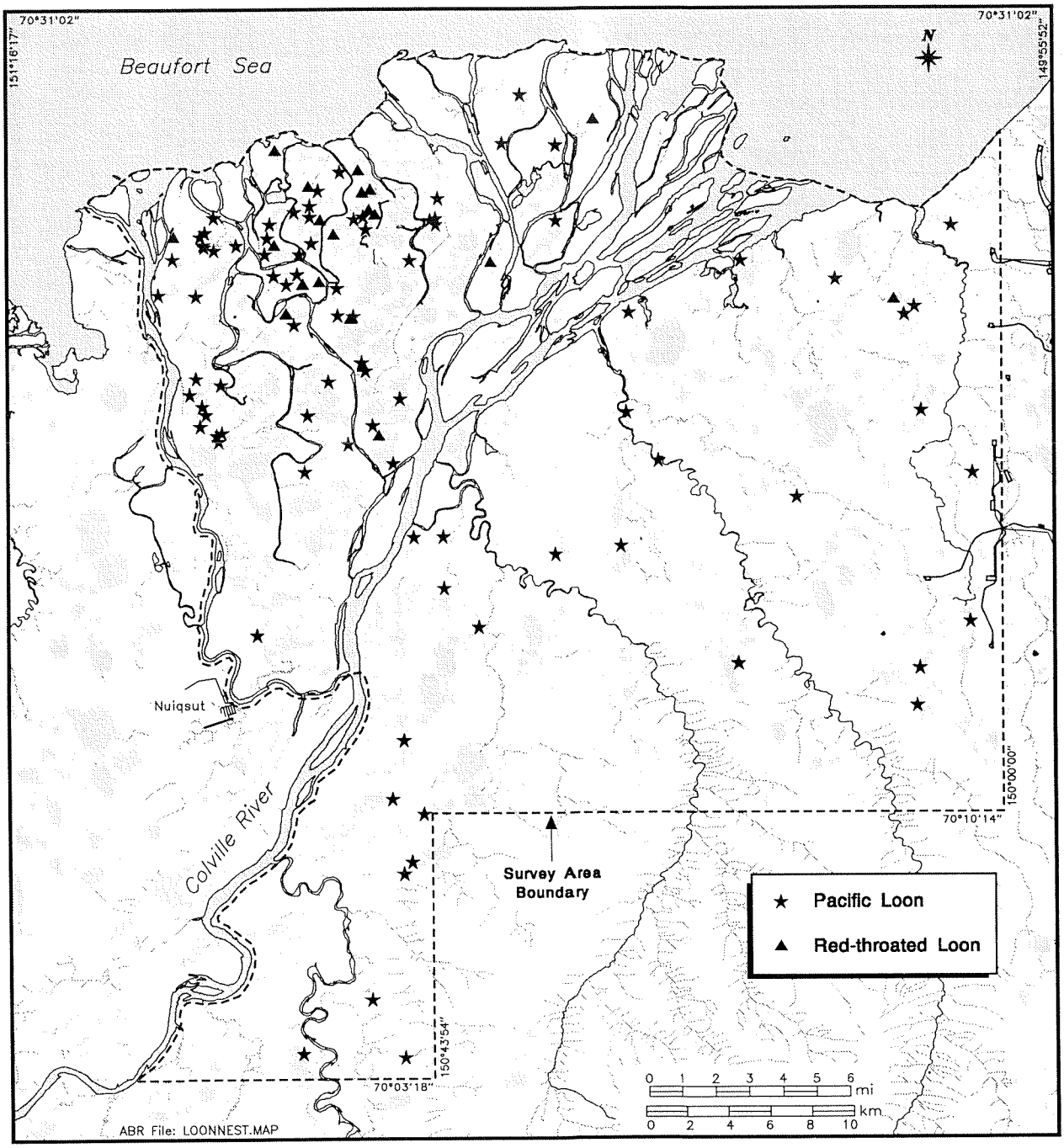

Figure 18. Distribution of Pacific and Red-throated loon nests located during aerial surveys (27–30 June 1993) and ground surveys (20 June–2 July 1993), Colville River Delta, Alaska.

mid- to late July (Bergman and Derksen 1977, Rothe et al. 1983, North et al. 1984b). Brood-rearing occurs on the natal pond (Bergman and Derksen 1977, North et al. 1984b).

Ninety-six Red-throated Loons and 21 nests were recorded on the Colville Delta during aerial and ground surveys from 20 June–2 July (Figure 18). Average clutch size for 16 nests was 1.7 eggs. Three (38%) of eight nests examined (18–31 July) were successful. Eight broods ($\bar{x}$ = 1.6 young/brood) and 17 adults were seen during ground-based brood searches.

GREATER WHITE-FRONTED GOOSE

The Colville Delta is a regionally important nesting area for Greater White-fronted Geese; the USFWS recorded mean densities of 6.28 birds/km^2 (during June) and nest densities of 1.8 nests/km^2 in the early 1980s, which are among the highest densities recorded for Greater White-fronted Geese on the Arctic Coastal Plain (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983).

Intensive searches for Greater White-fronted Goose nests were not conducted on the Colville Delta in 1993; however, 21 nests were found incidentally during nest searches for Yellow-billed Loons and Spectacled Eiders. Most (86%) of the nests were located on polygon ridges within 3 m of water, nearly the same (polygon ridges ≤2.5 m from water) as reported by Simpson and Pogson (1982). The mean clutch size in 1993 was 4.4 eggs (n = 14 nests), similar to the 4.2 eggs and 4.0 eggs recorded in 1982–83 and 1992, respectively (Simpson and Pogson 1982, Simpson 1983, Smith et al. 1993).

On the Colville Delta, Greater White-fronted Geese use sedge–willow tundra, patterned wet meadows, and aquatic sedge wetlands for nesting and feeding and aquatic grass wetlands, deep open lakes, and rivers for brood-rearing and molting (Simpson and Pogson 1982, Rothe et al. 1983). Brackish salt marshes and mudflats on the outer delta reportedly were not used by Greater White-fronted Geese during the early 1980s (Simpson and Pogson 1982, Rothe et al. 1983). In 1992 and 1993, however, molting geese were observed in salt-marsh habitat during brood-rearing searches (Smith et al. 1993, this study). In 1992, 12 groups (2324 birds) were seen during an aerial survey of the coastal portions of the delta on 20 August, while only one group (40 birds) was seen during an aerial survey of this same area on 25 August 1993 (Figure 19). These observations suggest extreme variation in the timing and/or the amount of annual White-fronted Goose use of the delta.

CANADA GOOSE

Several hundred Canada Geese nest along the banks and bluffs of the upper Colville River (Kessel and Cade 1958); however, they have never been reported nesting on the Colville Delta or in the NPR-A (Derksen 1981, Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983, North et al. 1984b). Canada Geese commonly nest on islands in coastal wetlands of the Prudhoe Bay area (Troy 1985a, 1985b, Murphy et al. 1990) and on the Arctic Coastal Plain east of the Kuparuk River (Ritchie et al. 1991).

The Colville Delta has not been identified as an important molting or brood-rearing area for Canada Geese. In 1992 and 1993 no Canada Geese were seen on the delta during aerial surveys in late July, although in 1993, two groups (36 birds) were seen on the delta during ground-based nesting and brood-rearing searches.

Although the Colville Delta was not an important area for Canada Geese during nesting, brood-rearing, or molting, it was important during fall migration. During fall, geese migrating along the Beaufort Sea coast stop to rest and feed in major river deltas, such as the Canning, the Sagavanirktok, and the Colville (Johnson and Richardson 1981, Garner and Reynolds 1986). In 1992, nearly 11,000 Canada Geese in 23 groups were seen on the delta during an aerial survey conducted on 20 August (Smith et al. 1993). In 1993, 922 birds in 21 groups were on the outer delta during an aerial survey on 25 August (Figure 19).

KING EIDER

In Alaska, the highest densities of nesting King Eiders are found in the Prudhoe Bay region, approximately 65 km east of the Colville Delta

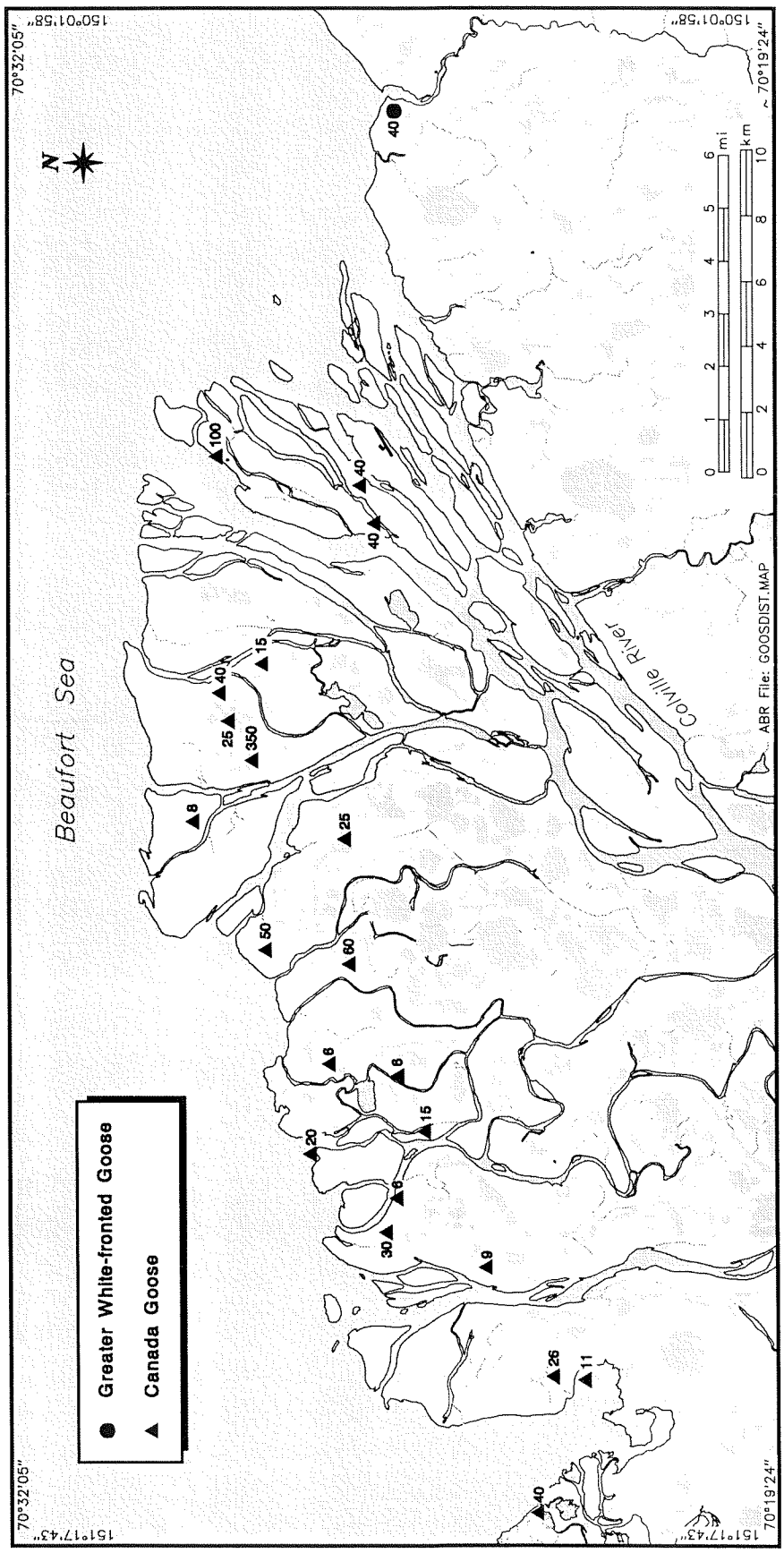

Figure 19. Distribution and numbers of Greater White-fronted and Canada geese observed during an aerial survey on 25 August 1993, Colville River Delta, Alaska.

(Derksen et al. 1981, Troy 1988). Low densities of nesting King Eiders are found in the Arctic National Wildlife Refuge (Garner and Reynolds 1986), at Barrow, and in coastal areas of the NPR-A (Derksen et al. 1981). On the Colville Delta, King Eiders were reported to be common visitors but uncommon nesters during the early 1980s (Simpson et al. 1982, Renken et al. 1983, North et al. 1984b, Nickles et al. 1987).

The same areas surveyed for Spectacled Eiders in the Colville Delta and the coastal plain east of the delta were surveyed for breeding pairs of King Eiders in 1993 (Figure 15). Fifty-one King Eiders, 21 pairs and 9 males (flying and non-flying birds) were seen during aerial surveys of the Colville Delta (Table 10). Densities of King Eiders (flying and non-flying birds combined) on the delta were 0.15 birds/km^2 and 0.06 pairs/km^2. Counting lone males as pairs (USFWS 1987b), the density of indicated pairs is 0.08 pairs/km^2 (Table 10).

Ninety-one King Eiders (39 pairs, 10 males, and 3 females) flying and non-flying birds) were seen during surveys of the eastern portion of the study area in 1993 (Table 10). Densities of total birds and pairs (flying and non-flying birds) were 0.27 birds/km^2 and 0.11 pairs/km^2, respectively. If lone males are counted as pairs, the density of indicated pairs is 0.14 pairs/km^2.

The density of King Eiders was higher in the eastern portion of the study area than on the Colville Delta, which was the opposite of the distribution of Spectacled Eiders in 1993. As with Spectacled Eiders, the difference in densities between the two areas may be related to habitat differences. King Eiders have been found nesting in a greater variety of habitats than Spectacled Eiders, including relatively drier habitats (such as strangmoor) and wet, non-patterned tundra (Warnock and Troy 1992). These habitats are more abundant on the coastal plain to the east of the Colville Delta than they are on the delta.

One pair of King Eiders, but no nests, were found during nest searches on the Colville Delta in 1993. One active eider nest (species not determined) was found on an island in a basin wetland complex (see Spectacled Eider section). Five King Eiders (all females), but no broods, were seen during brood surveys on the delta in July.

CARIBOU

The Colville Delta lies at the western edge of the summer range of the CAH and at the eastern boundary of the summer range of the Teshekpuk Lake Herd (TLH). The TLH has increased from 2,000 caribou in 1976 to 16,600 in 1989 (Carroll 1992). Caribou from the TLH have been reported to calve northeast of Teshekpuk Lake (Reynolds 1982). The CAH grew from approximately 5,000 caribou in 1978 (Whitten and Cameron 1983) to 23,000 in 1992 (Taylor 1993). Since detailed surveys began in 1978, calving by the CAH has been concentrated in two general locations, with the specific areas of concentration varying annually: between the Colville and the Kuparuk rivers west of Prudhoe Bay (the "Kuparuk concentration area") and between the Shaviovik and Canning rivers east of Prudhoe Bay (Curatolo and Reges 1984, Lawhead and Curatolo 1984, Whitten and Cameron 1985, Lawhead and Cameron 1988, Smith and Cameron 1992). Only a few caribou have been found on the limited number of aerial surveys of the Colville Delta that have been flown during calving seasons prior to 1992 (Whitten and Cameron 1985, Smith et al. 1993). Consistent with previous surveys, very few caribou were seen on the Colville Delta during the 1993 calving season, whereas relatively high numbers of caribou used the Colville East and Colville Inland survey areas.

CALVING SEASON

Snow persisted longer on the CRDSA in 1993 than it did in 1992. Snow cover in 1992 had dwindled to 20% by 4 June (Smith et al. 1993), whereas on nearly the same date in 1993, snow cover remained at 20–70% (Table 2). Snowmelt in 1993 progressed steadily from the earliest surveys (nearly 100% cover on 23 May), after which the snow on ridges and other exposed features had melted back to 65–75% cover on 28 May. Conditions were patchy and most difficult for counting caribou on 3 June, when snow cover ranged from 20% to 70%. Snow cover continued to decline from 50% or less on 7 June to less than 5% on 10 June.

Concurrent surveys by fixed-wing and helicopter were flown to develop a sightability

correction factor (SCF) on 3 June in the Colville East area, where snow conditions (i.e., patchy, intermediate snow cover) made detecting caribou difficult (Appendix C). The SCF for large caribou calculated from this survey was 1.88 (SE = 0.38). Although calves were counted by the observers in the helicopter, an SCF could not be calculated because no calves were seen in the area of overlapping survey coverage by the observer in the airplane.

The highest numbers and densities of caribou were found in the Colville East area. The peak density observed in 1993 was 2.4 caribou/km^2. The number of caribou ranged from 15 on 26 May (~60% of the area was surveyed) to 543 caribou on 11 June (~90% of the area was surveyed) (Table 15). The estimates (and 80% CI) of the observable population for the portions surveyed on those days ranged from 60 (±43) to 2,181 (±335) caribou, respectively. Caribou concentrated in the southeast portion of the survey area around the uplands and snow-free banks of the Miluveach and Kachemach rivers on 26 and 27 May, when snow cover was extensive, but became more evenly dispersed in June (Appendices D1–7). The number of large caribou counted on 3 June (the day the sightability survey was flown) was 73, but after expanding the estimate to the area sampled and adjusting with the SCF (because of the patchy snow cover), the population estimate of large caribou was 542 (±176). No calves were seen from the airplane until 8 June, when 37 were counted on a partial survey (~70% of the survey area). The calf count peaked at 139 on 11 June, when the observable number of calves was estimated to be 558 (±113).

Relatively high numbers of caribou also were observed in the Colville Inland survey area during calving (Table 15). On 28 May, 16 large caribou were counted, but the estimate was expanded (to the total survey area) and adjusted (with the SCF) to 224 (± 132), because 65–75% of the ground was covered with snow. The first calf was seen on 28 May, and the highest count was made on 10 June, when 16 calves were counted and 127 (±44) were estimated from a complete survey. Caribou were scattered evenly through the Colville Inland area on each survey, but calves were found more often in the eastern and northern portions of the area (Appendices D8–14). The highest density of caribou observed was 1.1 caribou/km^2 on 10 June, less than half the highest density observed in the Colville East. Counts ranged from one to 157 caribou, and the maximal estimate for the total survey area was 1,249 (±251) caribou on 10 June.

Only three caribou (no calves) were found in the Colville Delta survey area, on one of the two complete calving surveys (Table 15). The observable population estimate for the area on 28 May was 27 (±31) caribou. The caribou were seen in the central delta on the first survey on 28 May (Appendix D15), whereas no caribou were seen on the last survey on 10 June. In 1992, no caribou were seen on the two surveys of the delta during the calving season (Smith et al. 1993).

The distribution of caribou during the calving season on the western portion of the CAH calving grounds in 1993 was concentrated in the Colville Inland and Colville East survey areas (Figure 20), in roughly the same areas that supported high concentrations of caribou during calving in 1987 (Lawhead and Cameron 1988) and 1988 (Smith and Cameron 1989). During the latter portion of the 1993 calving season, the Colville Inland and Colville East areas supported densities of caribou that were 1.5–3.5 times higher than in the adjacent Kuparuk Oilfield survey area (0.7 caribou/km^2 [Lawhead et al. 1993]). Moreover, the density in the Colville East area (2.4 caribou/km^2) exceeded or equaled the values reported for the Kuparuk concentration area in 1980 and 1981 (0.9 caribou/km^2 [Whitten and Cameron 1985]) and 1984 (2.2 caribou/km^2 [Curatolo and Reges 1984]), in years when the western portion of the CAH primarily calved between Oliktok Point and the Kuparuk River (and when the CAH numbered approximately half of its present size). The density in 1993 also surpassed that of the previous year, when 2.0 caribou/km^2 were counted in the Colville East area (ABR, unpubl. data).

Initial calf production in 1993 was the among the lowest on record for the CAH (Valkenburg 1992). On 11 June 1993, 139 calves were counted among the 543 total caribou in Colville East, giving a ratio of 34 calves:100 adults (26% of total caribou). The adjacent

Table 15. Counts and population estimates of caribou (±80% CI) from aerial surveys during the 1993 calving season in the Colville River Delta study area, northern Alaska.

Survey Area[a]	Date	Area Surveyed[b] (km^2)	Counts		Density (no./km^2)		Total Area[d] (km^2)	Observable Population Estimate[e]				Adjusted Population Estimate[f] Large Caribou[g]	
								Total		Calves			
			Total[c]	Calves	Total	Calves		No.	±CI	No.	±CI	No.	±CI
Colville Inland	23 May	139	1	0	0	0	1107	8	9	0			
	28 May	139	16	1	0.1	0	1107	127	68	8	8	224	152
	7 June	139	149	8	1.1	0.1	1107	1186	268	64	26		
	10 June	139	157	16	1.1	0.1	1107	1249	251	127	44		
Colville East	26 May	162	15	0	0.1	0	650	60	43	0			
	27 May	265	22	0	0.1	0	1050	87	38	0			
	3 June	265	73	0	0.3	0	1050	289	58	0		542	176
	8 June	178	229	37	1.3	0.2	709	914	155	148	42		
	11 June	227	543	139	2.4	0.6	910	2181	335	558	113		
Colville Delta	28 May	71	3	0	0	0	637	27	31	0			
	10 June	71	0	0	0	0	637	0		0			

[a] Refer to Figure 2 for locations.
[b] Area of those segments that were surveyed.
[c] Total = bulls + cows + yearlings + calves.
[d] Total area within boundaries of the survey. For partial surveys, includes only those segments that were surveyed.
[e] The count of caribou expanded to the sampled area.
[f] The observable population estimate adjusted by the sightability correction factor (1.88).
[g] Large caribou = bulls + cows + yearlings.

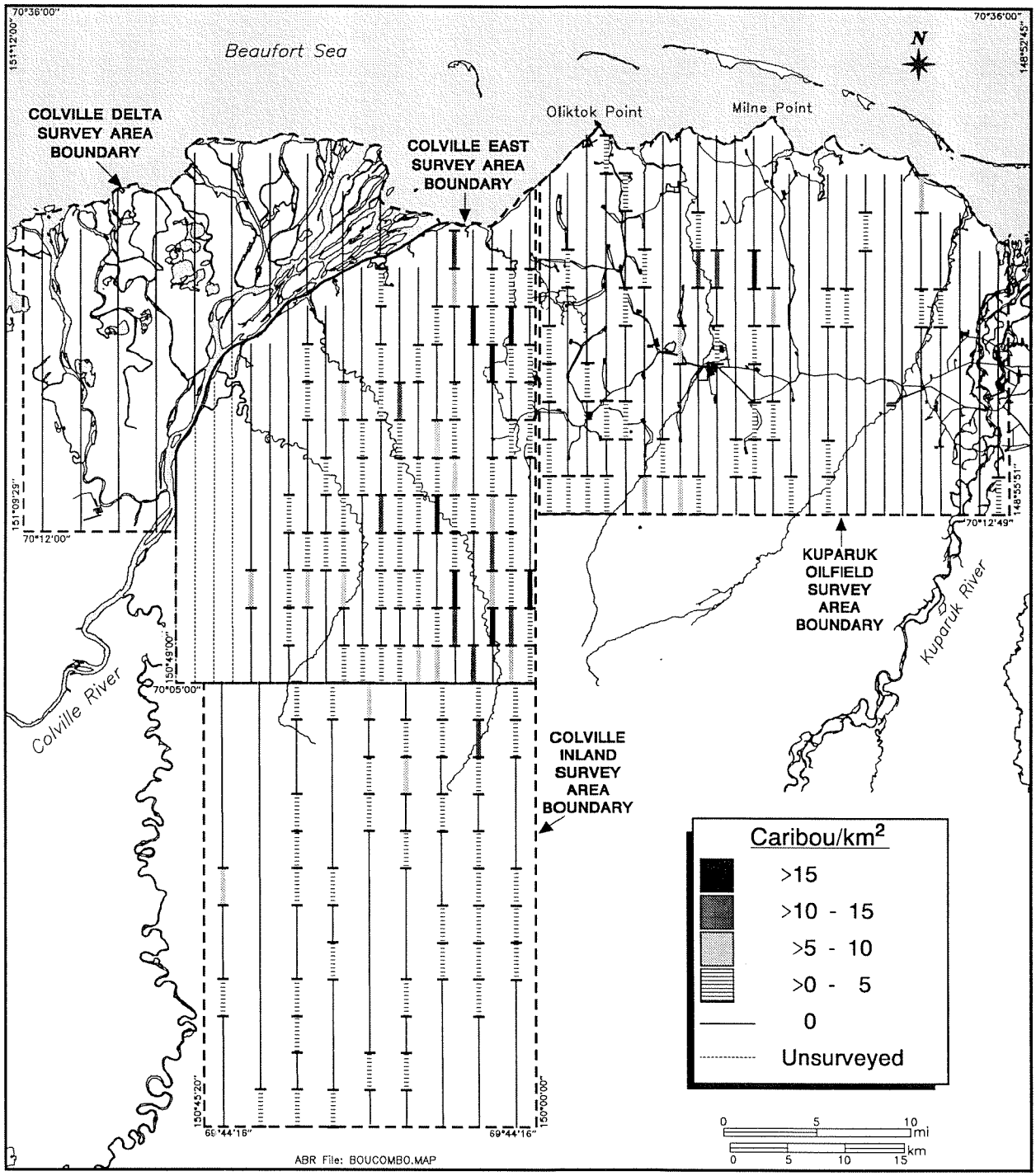

Figure 20. Distribution and density of caribou on the Colville Delta survey area (10 June), the Colville East survey area (11 June), the Colville Inland survey area (10 June, and the Kuparuk Oilfield (15 June), Alaska, 1993. The aerial surveys were conducted with the observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects. Kuparuk Oilfield data from Lawhead et al. (1994).

Kuparuk Oilfield survey area had a similar calf proportion (24% of total caribou) on 15 June 1993 (Lawhead et al. 1994). In contrast the calf proportion in the Kuparuk Oilfield and surrounding areas was never lower than 28% of total caribou from 1978 to 1990 (Valkenburg 1992). In 1993, cows, bulls, and yearlings were not differentiated in our surveys because our objective was to obtain accurate counts of total caribou and calves in the strip transect, rather than to gather detailed composition data, which would have required interrupting the survey to examine caribou more closely. However , the proportion of bulls on the calving grounds usually is small (range 2–14%), although the proportion of yearlings is higher and more variable (5–22%) (Valkenburg 1992). Using these minimal and maximal proportions of bulls and yearlings to estimate the number of cows present, the calf:cow ratio in Colville East was estimated to range from 38 to 66 calves:100 cows. A midrange estimate of 49 calves:100 cows was obtained using midrange proportions of bulls and yearlings (8% bulls and 14% yearlings). Obviously, these estimates are approximations of actual calf production, for which no variances can be calculated. Nonetheless, these estimates are consistent with the ratio (56 calves:100 cows) estimated from 18 radio-collared cows on the CAH calving grounds (R. D. Cameron, ADFG, pers. comm.). In the adjacent Kuparuk Oilfield, the calf:cow ratio also was similar (estimated to range from 35 to 60 calves:100 cows), and the most likely ratio for initial calf production in 1993 was estimated to be 45-50 calves:100 cows (Lawhead et al. 1994). Both areas in 1993 had among the lowest ratios recorded in the Kuparuk Oilfield and adjacent areas. For example, during 1978–1990, ratios ranged from 48 to 89 calves:100 cows (Valkenburg 1992). The two lowest ratings recorded previously occurred in 1989 (48:100; Valkenburg 1992) and 1991 (45:100; K. Whitten, ADFG, pers. comm.).

The low calf ratios in 1993 did not result from poor sightability, because snow cover was less than 5% on 10 and 11 June and essentially gone by 15 June in the Kuparuk Oilfield, and the viewing conditions were generally good for both surveys. The calving season may have been delayed or prolonged, which would result in lower ratios until after all calves were born. Machida (1993) reported that the Teshepuk Lake Herd, which resides on the coastal plain west of the CAH, continued to calve past 18 June 1993, nearly two weeks later than usual for that herd. Other possible explanations of the low calf ratio for the CAH in 1993 could be sampling error (Cameron et al. 1985) or an unrepresentative sample of the caribou that contained a lower percentage of calves than the overall herd; these possibilities are unlikely to have pertained to all survey areas, however.

INSECT SEASON

Mosquitoes were first observed in large numbers on 27 June, when the temperature rose to 16° C with little wind. Although only a few mosquitoes emerged (along with large numbers of midges) on the Colville Delta, mosquito harassment was severe in the Kuparuk Oilfield, where groups of caribou were observed moving north (Lawhead et al. 1994). On the first aerial survey, conducted on 28 June, 107 caribou were dispersed in small groups (≤10 caribou) across the delta and along the east bank of the Colville River (Table 16, Appendix D16); at the same time, about 4,000 caribou were counted in the Kuparuk Oilfield within 1.6 km of the coast (Lawhead et al. 1994).

Mosquito harassment remained severe during a period of high temperatures (16–20° C) with the light winds until 30 June, when northeasterly winds blew cool air off the sea ice and temperatures fell 5–10° C after midday. Cool, windy weather kept mosquito activity at low levels near the coast for several days (Lawhead et al. 1994), although on 3 July, warm, calm conditions brought mosquitoes out farther inland (e.g., Nuiqsut). On 4 July, at least 5,000 caribou moved down the Kuparuk River and stopped to rest near the Kuparuk River bridge (T. Cater, ABR, pers. comm.), suggesting that mosquito harassment was severe farther inland. Mosquitoes were mildly active on 5 July, but cool temperatures kept mosquitoes in check until the afternoon of 7 July, and no movements of caribou were observed in the neighboring Kuparuk Oilfield (no observers were stationed in the Colville study area on these days).

Table 16. Counts of caribou from aerial surveys during the 1993 insect and rutting seasons in the Colville River Delta study area, northern Alaska.

	Insect Season					Rutting Season
Date	28 June	8 July	14 July	19 July	30 July	20 October
Insect Condition	mosquitoes	mosquitoes	mosquitoes and flies	mosquitoes and flies	mosquitoes and flies	none
No. of Caribou	107	28	2763	29	76	28

The next large-scale movement of caribou caused by severe mosquito harassment was observed on 8 July, when 8,870 caribou were seen along the coast between Oliktok and Milne points (Lawhead et al. 1994). Although only 28 caribou were counted on the outer Colville Delta (Appendix D17), large numbers apparently had moved through the eastern portion of the delta the night before, according to a local resident (J. Helmericks, pers. comm.) and observations of tracks on an island. Mosquitoes continued to be a factor until 16 July, when strong winds blew from the northeast.

Oestrid flies were first observed in the study area on 10 July. Flies were presumed to be active through 20 July, because of warm temperatures and light to moderate winds. J. Helmericks (pers. comm.) reported several hundred caribou milling around Nuekshat Island the evening of 13 July. During an aerial survey on 14 July, most of the 2,763 caribou seen were found on the northeast edge of the CRDSA (Appendix D18), and another 4,363 were seen in the Kuparuk Oilfield (Lawhead et al. 1994). One group of 1,600 caribou was sighted on Drill Site 3-H and another group of 1,100 caribou was sighted on Drill Site 3-G; both groups were stationary when first observed. The following three days were characterized by warm temperatures and moderate winds, and combined severe fly and mild mosquito harassment led to movements of large groups of caribou to and from fly-relief habitat. Tracks on the banks of the Tamayayak Channel on 17 July indicated that a large number of caribou had moved through the area within the previous two days.

Mosquito activity intensified the evening of 18 July on the delta, but the only sizable groups of caribou observed were farther east, near the Spine Road (Lawhead et al. 1994). During an aerial survey on 19 July, harassment by mosquitoes and flies was severe; only 29 caribou were seen in the northern portion of the delta (Appendix D19), whereas about 5,000 caribou were observed at several locations between Kalubik Creek and the Kuparuk River (Lawhead et al. 1994). The next 10 days varied from cool to moderately warm, resulting in mild mosquito activity and, during a part of each day, oestrid fly activity. On 27 July, approximately 5,000 caribou were observed at Fish Creek. Caribou were dispersed in the Kuparuk Oilfield but were not observed on the delta on 27 July. The last aerial survey of the insect season was flown on 30 July, a cool day with no insect harassment; small groups of caribou were dispersed throughout the eastern half of the study area (Appendix D20).

RUTTING SEASON

One aerial survey was conducted on 20 October during the rutting season. Visibility was unlimited and snow completely covered the study area, resulting in good sightability conditions for the survey.

Twenty-eight caribou were found in seven groups in the southeastern portion of the study area (Appendix D21). Low numbers also were observed in the study area on 17 September 1992 (Smith et al. 1993). No caribou were sighted on the delta west of the main channel of the Colville River during fall on either survey.

ARCTIC FOX

During aerial surveys, 42 potential den sites of arctic foxes were identified, which were later visited on the ground to ascertain their status. Of the potential den sites, 24 were determined to be arctic fox dens (Figure 21), 13 were arctic ground squirrel (*Spermophilus parryii*) burrows, one was used by a short-tailed weasel (*Mustela erminea*) family, and four showed no signs of recent denning activity. A red fox (*Vulpes vulpes*) den that was reported by Markon (1982) was not located. Although no dens of red foxes were found, one red fox was seen on the landing strip in Nuiqsut during an aerial survey on 30 June.

Sixteen fox dens were found in the eastern portion of the study area and eight were found on the delta (Figure 21). The density of arctic fox dens (1 den/77 km^2) in the area surveyed was similar to the density (1 den/72 km^2) reported by Burgess and Banyas (1993) for undeveloped areas in the Prudhoe Bay area. Garrott (1980) found 40 arctic fox dens (1 den/43 km^2) during two years of investigation on the Colville Delta in a study area that extended 30 km further west and only half as far inland as our study area in 1993. The higher density of fox dens found by Garrott (1980) may have resulted from surveying more productive habitat, from surveying more intensively (aerial transects were 2 km apart, whereas ours were 3.2 km apart), from surveying more often, or from a temporal change in the distribution or abundance of foxes.

Fourteen dens (58%) were in banks of lakes, lake basins and creeks and six dens (25%) were in pingos (Appendix E). Availability of suitable sites for dens did not appear to be a limiting factor in the study area given the abundance of pingos and banks along lakes, river channels and streams.

Active natal dens were defined as dens where pups were born in 1993. At least five dens (21% of all fox dens known) were used as natal dens in 1993. Three natal dens were found on the delta and two were found on the eastern portion of the study area (Figure 21). Burgess and Banyas (1993) reported that at least 45%–58% of the dens (excluding man-made structures) evaluated in their study area produced litters in 1992.

Active natal dens produced an average of 3.2 pups (SE = 1.1), which is a minimal estimate because all pups may not be out of the den and visible at any given time and litters may be split among secondary dens. Predators were the apparent cause of at least three pup deaths in 1993 including the three dead pups in the total production, at least 19 pups were produced at dens in 1993, for an average of 3.8 pups/natal den. In addition, older remains of two pups were found at a den site. Grizzly bear (Ursus arctos) and Golden Eagle (Aquila chrysaetos) sign (e.g., digging, feathers, droppings) were present at about half of the dens.

Families occupied nine (38%) of the 24 dens in 1993, including secondary dens to which pups had been moved. Garrott (1980) reported 6% and 53% family occupancy in 1977 and 1978, respectively. The high variability in occupancy between years was probably related to the cyclic nature of the small mammal population on the Arctic Coastal Plain (primarily brown lemming [*Lemmus sibiricus*] and collared lemming [*Dicrostonyx rubricatus*]), which are important summer prey items to arctic foxes (Garrott 1980).

Seven (29%) of the dens inspected in 1993 were classified as secondary dens, that is, dens where pups were moved from their natal dens (Burgess et al. 1993). Two secondary dens, which apparently had been dug during the summer of 1993, were discovered during ground visits to dens. Because secondary dens were smaller, excavated later in the season, and generally less obvious on the tundra than were natal dens, they probably were undercounted on aerial surveys and underestimated on the survey area.

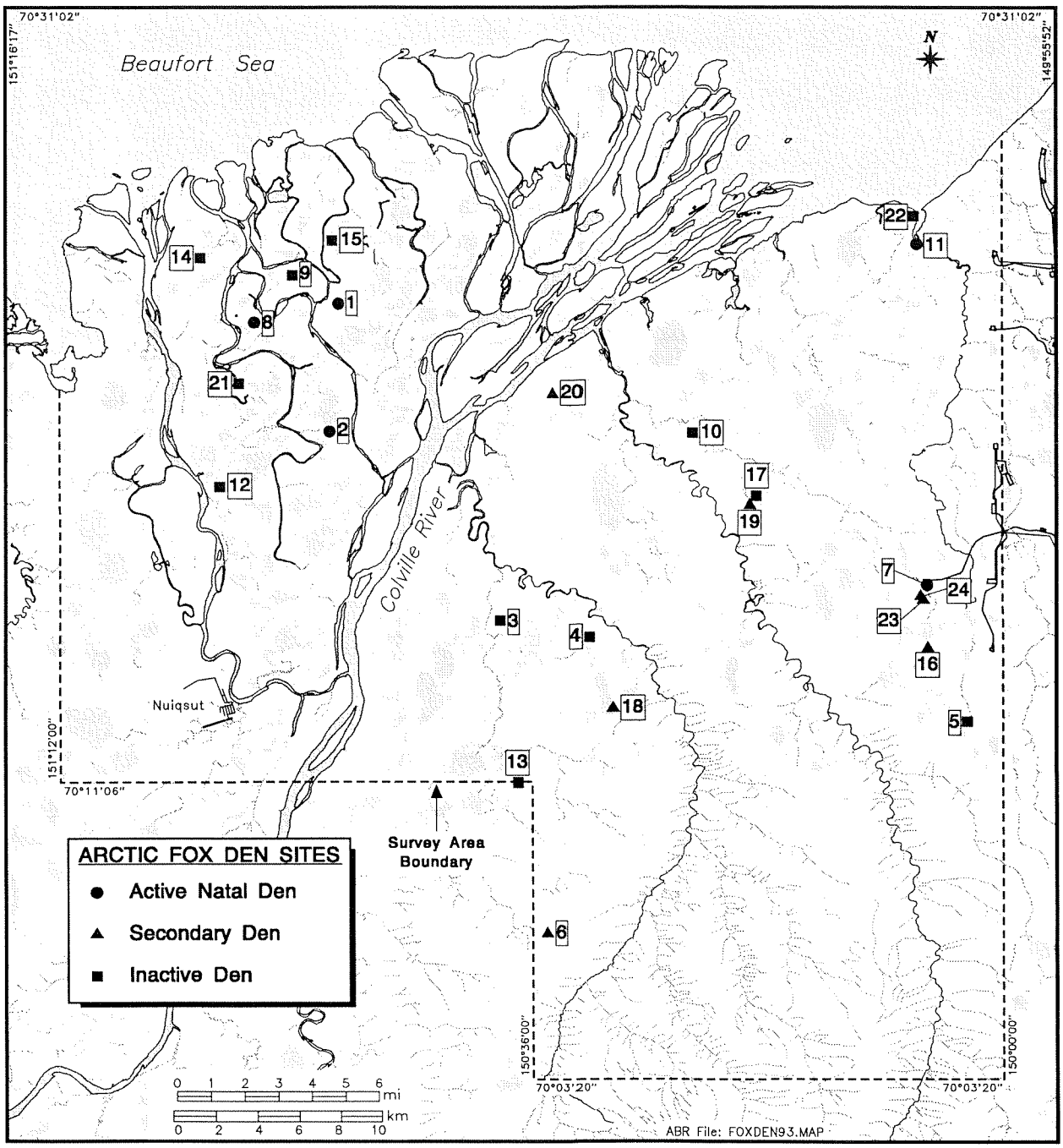

Figure 21. Location and status of arctic fox dens inspected 23 July–7 August 1993, Colville River Delta, Alaska.

OTHER MAMMALS

MUSKOX

Muskoxen were observed on 12 occasions during aerial and ground surveys of the study area (Figure 22). Because individual muskoxen were not recognizable, we do not know how many observations were resightings of the same group or individual. However, identical group sizes in similar areas suggest that several of the observations were resightings.

The uplands at the headwaters of the Miluveach and Kachemach rivers appeared to support a small herd of muskoxen in 1993. A family group of 13 animals, including three small calves, was observed on 23 May in the southeast corner of the study area. Five days later (28 May), what may have been the same group was observed 19.2 km to the southwest. On 10 June a large group (18–20 animals), which may have included the original group of 13, was observed about 4.8 km northeast of the last sighting in May. Also on 10 June, two bulls were observed in the vicinity of this large group, and a lone bull was observed 55 km to the north near the Colville River.

Lone bulls were observed on several occasions in the study area and in nearby areas in July and August. Locations ranged from the mudflats of the Colville River and the Nechelik Channel to the Drill Site 2K in the Kuparuk oilfield. In late August small family groups (three adults and one calf, two adults and one calf) were observed twice southeast of Nuiqsut, between the Colville and Itkillik Rivers (Figure 22), where 14 muskoxen were observed in 1992 (Smith et al. 1993) and where muskoxen were reported first to have overwintered in the Colville River area in 1988–89 (Golden 1990).

GRIZZLY BEAR

Grizzly bears were observed five times on the study area during 1993 (Figure 22). In addition to the five observations of grizzlies in the study area, three grizzly bears (two males and one female) that were marked by the Alaska Department of Fish and Game used the delta during the summer, and one of the males was shot in Nuiqsut (J. Hechtel, ADFG, pers. comm.). No bear dens were found on the delta, but grizzly bears have denned in cutbanks along the Kuparuk and Shaviovik rivers and in dunes on the delta of the Sagavanirktok River (J. Hechtel, ADFG, pers. comm.). Suitable denning areas for grizzlies probably exist in the extensive dunes and banks on the Colville Delta and in the many cutbanks along the Miluveach and Kachemach rivers.

POLAR BEAR

No polar bears were observed on the Colville Delta during the 1993 field season. However, at least eight polar bears (including one female with one cub) were observed in the Kuparuk and Prudhoe Bay Oilfields throughout 1993. Two polar bears were relocated outside of the oilfields by USFWS and ADFG biologists; another two bears were shot and killed at Oliktok Point. The Colville Delta and the Miluveach River are reportedly good to adequate denning habitat for polar bears (Amstrup 1989).

WOLVERINE

A wolverine was observed along a bank near the Tamayayak Channel on the Colville Delta on 27 June (Figure 22). Although wolverines are common in the foothills of the Brooks Range and the upper Colville River, they generally are scarce on the Arctic Coastal Plain; of 49 sightings recorded during 1977 and 1978 in the NPR-A, three were near the coast at Fish Creek and one was north of Teshekpuk Lake (Magoun 1979).

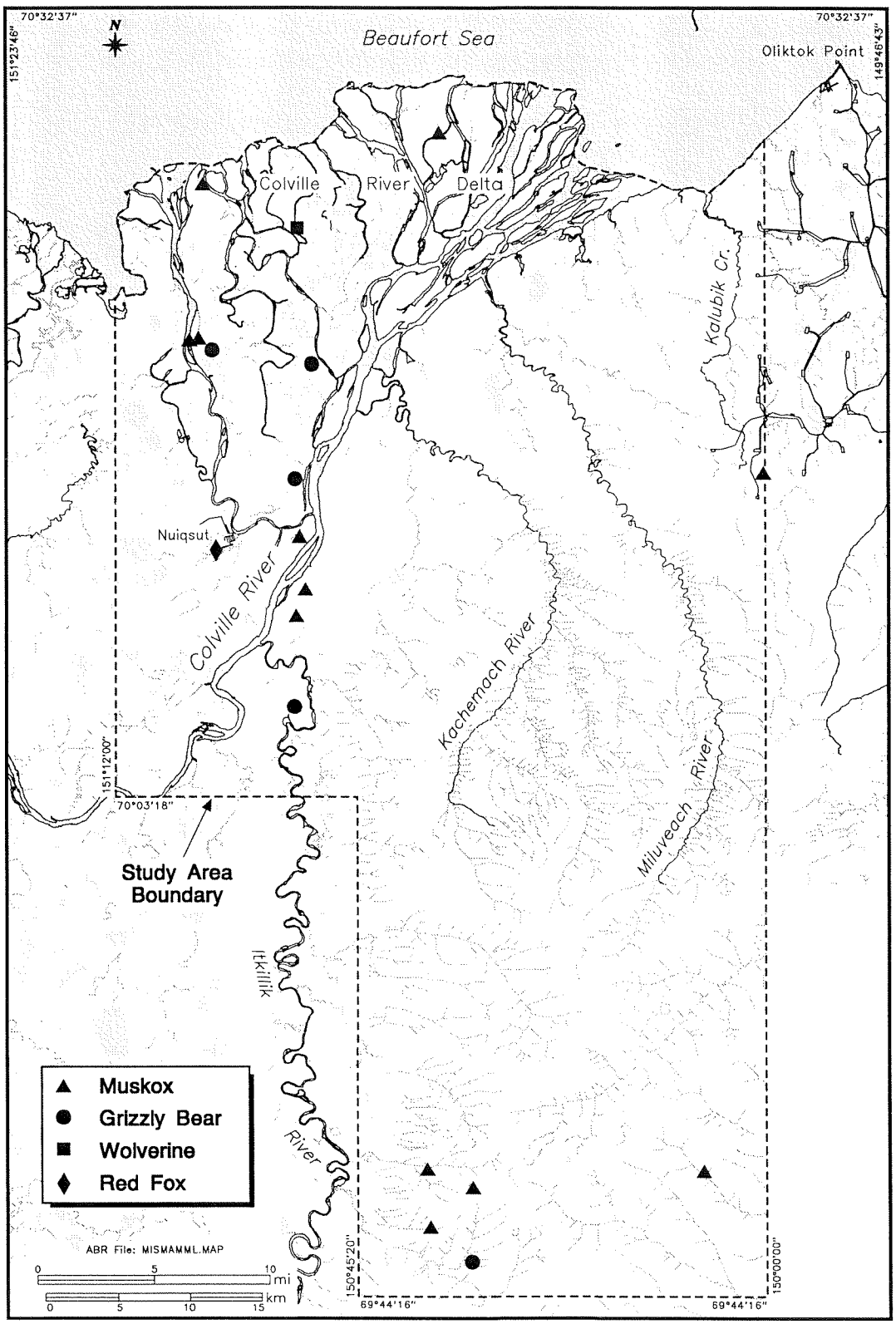

Figure 22. Location of muskox, grizzly bear, red fox, and wolverine observations, May-September, 1993, Colville River Delta, Alaska.

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APPENDIX A. Common and scientific names of birds seen during the Colville River Delta Wildlife Study, May-October 1993.

Red-throated Loon	*Gavia stellata*
Pacific Loon	*Gavia pacifica*
Yellow-billed Loon	*Gavia adamsii*
Tundra Swan	*Cygnus columbianus*
Greater White-fronted Goose	*Anser albifrons*
Snow Goose	*Chen caerulescens*
Brant	*Branta bernicla*
Canada Goose	*Branta canadensis*
Northern Pintail	*Anas acuta*
Greater Scaup	*Aythya marila*
King Eider	*Somateria spectabilis*
Spectacled Eider	*Somateria fischeri*
Oldsquaw	*Clangula hyemalis*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Red-breasted Merganser	*Mergus serrator*
Bald Eagle	*Haliaeetus leucocephalus*
Northern Harrier	*Circus cyaneus*
Rough-legged Hawk	*Buteo lagopus*
Golden Eagle	*Aquila chrysaetos*
Peregrine Falcon	*Falco peregrinus*
Willow Ptarmigan	*Lagopus lagopus*
Rock Ptarmigan	*Lagopus mutus*
Sandhill Crane	*Grus canadensis*
Black-bellied Plover	*Pluvialis squatarola*
Lesser Golden-Plover	*Pluvialis dominica*
Upland Sandpiper	*Bartramia longicauda*
Whimbrel	*Numenius phaeopus*
Bar-tailed Godwit	*Limosa lapponica*
Ruddy Turnstone	*Arenaria interpres*
Semipalmated Sandpiper	*Calidris pusilla*
White-rumped Sandpiper	*Calandris fuscicollis*
Baird's Sandpiper	*Calidris bairdii*
Pectoral Sandpiper	*Calidris melanotos*
Dunlin	*Calidris alpina*
Stilt Sandpiper	*Calidris himantopus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Common Snipe	*Gallinago gallinago*
Red-necked Phalarope	*Phalaropus lobatus*
Red Phalarope	*Phalaropus fulicaria*
Pomarine Jaeger	*Stercorarius pomarinus*
Parasitic Jaeger	*Stercorarius parasiticus*
Long-tailed Jaeger	*Stercorarius longicaudus*
Glaucous Gull	*Larus hyperboreus*
Sabine's Gull	*Xema sabini*
Arctic Tern	*Sterna paradisaea*
Snowy Owl	*Nyctea scandiaca*
Short-eared Owl	*Asio flammeus*
Common Raven	*Corvus corax*
Yellow Wagtail	*Motacilla flava*
Savannah Sparrow	*Passerculus sandwichensis*
Lapland Longspur	*Calcarius lapponicus*
Common Redpoll	*Carduelis flammea*

APPENDIX B. A provisional hierarchical classification of bird habitats for Alaska's North Slope. Classifications in bold indicate levels added in 1993 for the Colville River Delta Wildlife Study. (Adapted from Jorgenson et al. 1989, and Murphy et al. 1989).

MARINE WATERS
- Inshore waters
- offshore waters
- Sea Ice
  - Ice
  - Ice edge

COASTAL ZONE
- Nearshore waters (estuarine)
  - Open nearshore waters
  - Brackish ponds
  - **Tapped lakes**
- Coastal Wetland Complex
  - Halophytic wet meadow
    - sedge
    - grass
    - herb
  - Salt-affected meadows
    - **Nonpatterned**
    - **Low-relief**
    - **High-relief**
- Barren
  - Coastal islands
  - Coastal beaches
    - cobble-gravel
    - sand
  - Tidal flats
  - Coastal rocky shores
    - low
    - cliffs
  - Causeway

FRESH WATERS
- Open Water
  - Deep open lakes
    - **without polygonized margins**
    - with polygonized margins

Appendix B. Continued

- Shallow open water
  - without islands
  - with islands
  - **without polygonized margins**
  - **with polygonized margins**
- Rivers and Streams
  - Tidal
  - Lower perennial
  - Upper perennial
  - Intermittent
- Water with emergents (including **polygons with permanent water**)
  - Aquatic sedge
    - without islands
    - with islands
  - Aquatic grass
    - without islands
    - with islands
  - Aquatic sedge-herb
    - without islands
    - with islands
- Impoundment
  - Drainage impoundment
  - Effluent reservoir

BASIN WETLAND COMPLEXES (including **drained-lake basins**)

MEADOWS

- Wet Meadows
  - Nonpatterened
    - sedge
    - sedge-grass
  - Low relief (including **polygons without permanent water**)
    - sedge
    - sedge-grass
  - High relief (including **polygons without permanent water**)
    - sedge
- Moist Meadows
  - Low relief
    - sedge-dwarf shrub tundra
    - tussock tundra
    - herb
  - High relief
    - sedge-dwarf shrub tundra
    - tussock tundra
- Dry Meadows
  - Grass
  - Herb

Appendix B. Continued

SHRUBLANDS
- Riparian Shrub
  - Riparian low shrub
    - willow
    - birch
    - alder
  - Riparian dwarf shrub
    - Dryas
    - ericaceous
- Shrubby Bogs
  - Low shrub bog
    - mixed shrub
  - Dwarf shrub bog
    - ericaceous

PARTIALLY VEGETATED
- Floodplains
  - Barren
  - Partially vegetated
- Eolian Deposits
  - Barren
  - Partially vegetated
- Uplands
  - Barren
  - Partially vegetated
- Alpine
- Cliffs
- Burned Areas

ARTIFICIAL
- Fill
  - Gravel
    - barren
    - partially vegetated
  - Medium-grained
    - barren
    - partially vegetated
  - Sod (organic-mineral)
    - barren
- Excavations
  - Gravel
    - barren
    - partially vegetated
- Structures and Debris

APPENDIX C. Computations for caribou population estimators and the sightability correction factor and the results of the concurrent aerial surveys flown to estimate sightability.

COMPUTATIONS

The following symbols were used in formulas to estimate the populations of caribou in each survey area:

x_j = the count for the *jth* segment

n_a = the number of segments sampled by the airplane

$\bar{x}$ = the mean number of caribou per segment, here estimated by the bootstrap technique

$\hat{\sigma}_{\bar{x}}$ = standard error of the mean estimated by the bootstrap technique

c = the ratio of the total area in the survey area to the area surveyed

N = the number of segments in a survey area if 100% of the area were surveyed (= total area / area in a segment).

The number of caribou counted on the segments was expanded to estimate the population for the entire survey area, which is called the observable population estimate because it has not been corrected for sightability. The observable population estimate ($\hat{T}_{ope}$) for total caribou (large caribou plus calves) for a survey area was calculated as:

$\hat{T}_{ope} = c \sum_j x_j$, its variance was calculated as

$V(\hat{T}_{ope}) = c^2 n_a^2 \hat{\sigma}_{\bar{x}}^2 (1 - n / N)$, and the standard error was

$SE(\hat{T}_{ope}) = c n_a \hat{\sigma}_{\bar{x}} (1 - n_a / N)^{1/2}$.

These formulas are equivalent to the formulas reported by Gasaway et al. (1986) for estimating the observable population parameters for a stratum, except that we estimated the standard error with the bootstrap technique (Mooney and Duval 1993).

Appendix C. Continued.

Gasaway et al. (1986) also provided the formulas for the sightability correction factor (SCF), which we used on counts made from the helicopter and airplane during the sightability survey in the Colville East survey area. We averaged the two helicopter counts (from one observer in the left front seat and one observer in the right rear seat) for each segment to arrive at a single count for the helicopter. Only large caribou (noncalves) were used for the estimation of the SCF, because no calves were counted from the airplane during the sightability survey. The symbols required are:

$\sum_k h_k$ = sum of large caribou counted from the helicopter on k segments

$\sum_k a_k$ = sum of large caribou counted from the airplane on k segments

n_o = number of segments surveyed by both helicopter and airplane

ssb = correction for small-sample bias

$s_a^2 = [\sum_k a_k^2 / (n_o - 1)] - [(\sum_k a_k)^2 / n_o(n_o - 1)]$

$s_{ah}^2 = [(\sum_k a_k h_k) / (n_o - 1)] - [(\sum_k h_k \sum_k a_k) / n_o(n_o - 1)]$.

The sightability correction factor (SCF) was estimated by:

$$\text{SCF} = \frac{\text{number of large caribou seen from helicopter}}{\text{number of large caribou seen from airplane}} + \text{ssb, or}$$

$\text{SCF} = (\sum_k h_k / \sum_k a_k) + [n_o s_{ah}^2 / (\sum_k a_k)^2] - [n_o(\sum_k h_k) s_a^2 / (\sum_k a_k)^3]$ and the variance of the sightability correction factor is

$\text{V(SCF)} = s_{qs}^2 n_o / (\sum_k a_k)^2$ where

$s_{qs}^2 = [\sum_k h_k^2 - 2(\text{SCF})\sum_k a_k h_k - \text{SCF}^2 \sum_k a_k^2] / (n_o - 1)$.

The number of caribou that would be counted in the survey areas assuming 100% sightability was estimated by adjusting the observable population estimate with the SCF. This adjusted population estimate ($\hat{T}_{ape}$) was calculated as:

$\hat{T}_{ape} = \hat{T}_{ope} \cdot \text{SCF}$, its variance was

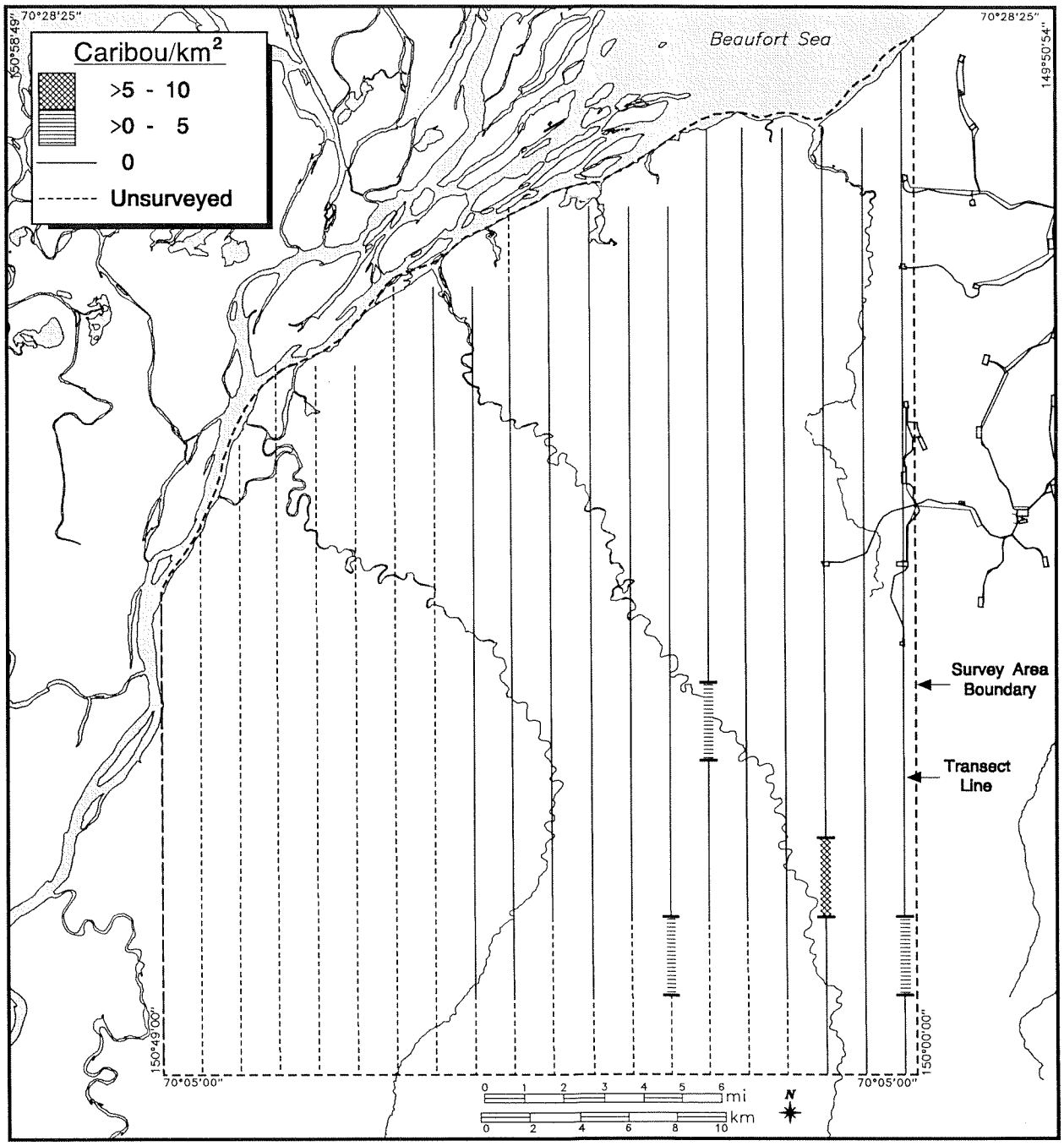
$\text{V}(\hat{T}_{ape}) = \text{SCF}^2 \text{V}(\hat{T}_{ope}) + \hat{T}_{ope}^2 \text{V(SCF)} - \text{V(SCF)V}(\hat{T}_{ope})$, and the standard error was

$\text{SE}(\hat{T}_{ape}) = \sqrt{\text{V}(\hat{T}_{ape})}$.

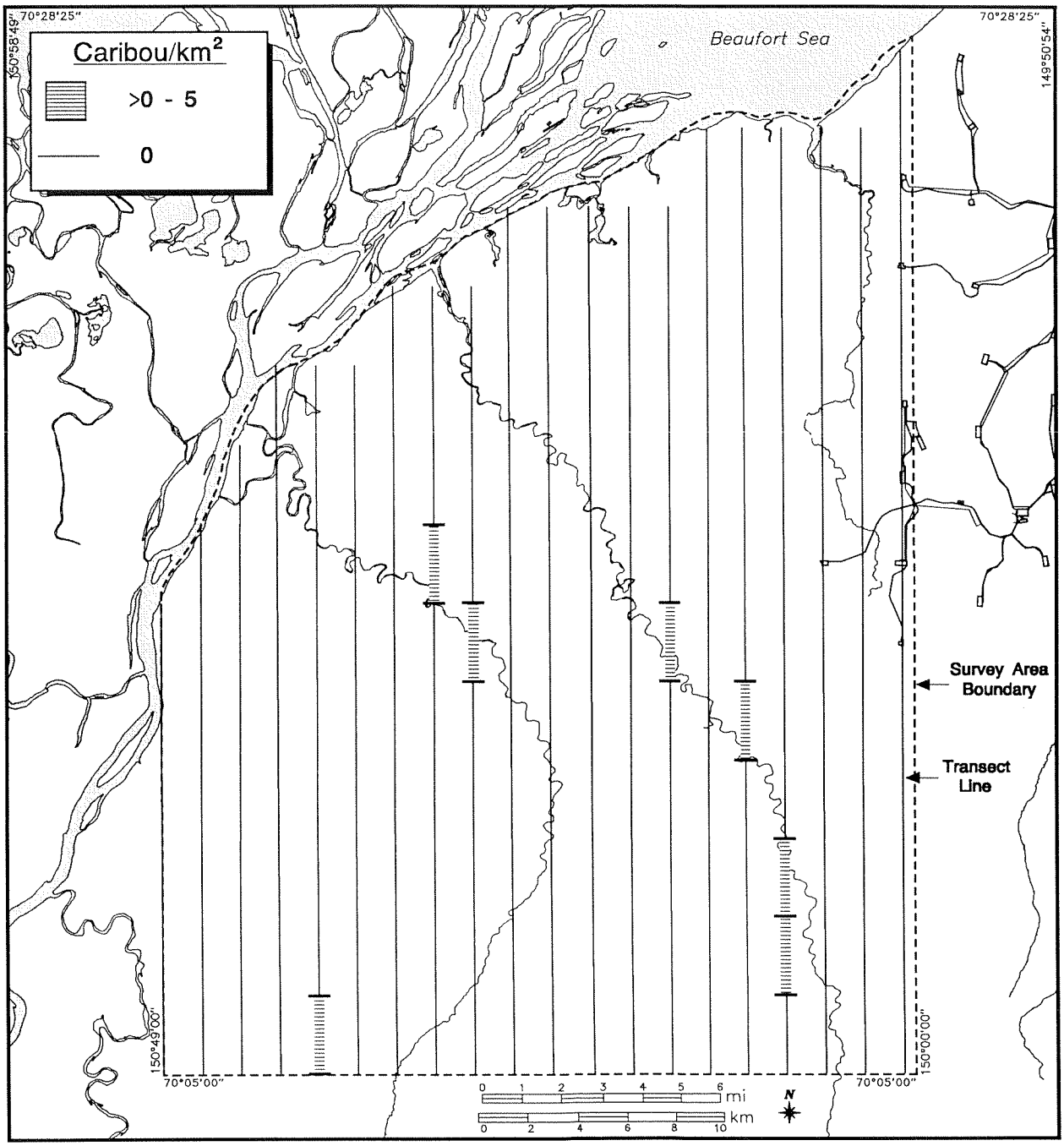
RESULTS AND DISCUSSION

Concurrent surveys by fixed-wing and helicopter were flown to develop a SCF on 3 June in the Colville East area, where snow conditions (snow cover was 20–70%) made detecting caribou difficult. Fifty-three large caribou were seen from the airplane, whereas 102 (mean count of two observers) were seen from the helicopter on the same survey segments. Although one observer counted 20 calves from the helicopter and the other observer counted 15 calves, no calves were counted by the observer in the airplane. Consequently, no SCF could be calculated for calves. The SCF for large caribou calculated from this survey was 1.88 (SE = 0.38), which implies that nearly half the caribou present on the transects were not observed from the airplane. The proportion not observed seems large, but is consistent with estimates by Lawhead and Cameron (1988) that as many as 50–60% of the caribou could be missed on aerial surveys under similar snow conditions. However, the SCF was calculated not for a constant snow cover, but rather for a range, and is best considered an average correction factor for snow cover between 20% and 70%. This range in snow cover is reflected in the high variance (and SE) of the SCF. The high variance of the SCF is one factor contributing to the width of the confidence intervals for the adjusted population estimates (Table 16); another factor is the high variance of the raw counts. Ideally, several SCFs or a linear model of sightability would be developed for the varying snow conditions encountered on calving surveys, which would allow estimation of caribou numbers to be made with greater precision (i.e., narrower confidence intervals). However, to achieve such precision would be more costly, requiring multiple sightability surveys (involving both a helicopter and an airplane) at different amounts of snow cover. Likewise, it would be costly to reduce the variation in the caribou counts, because the sampling intensity would have to be dramatically increased.

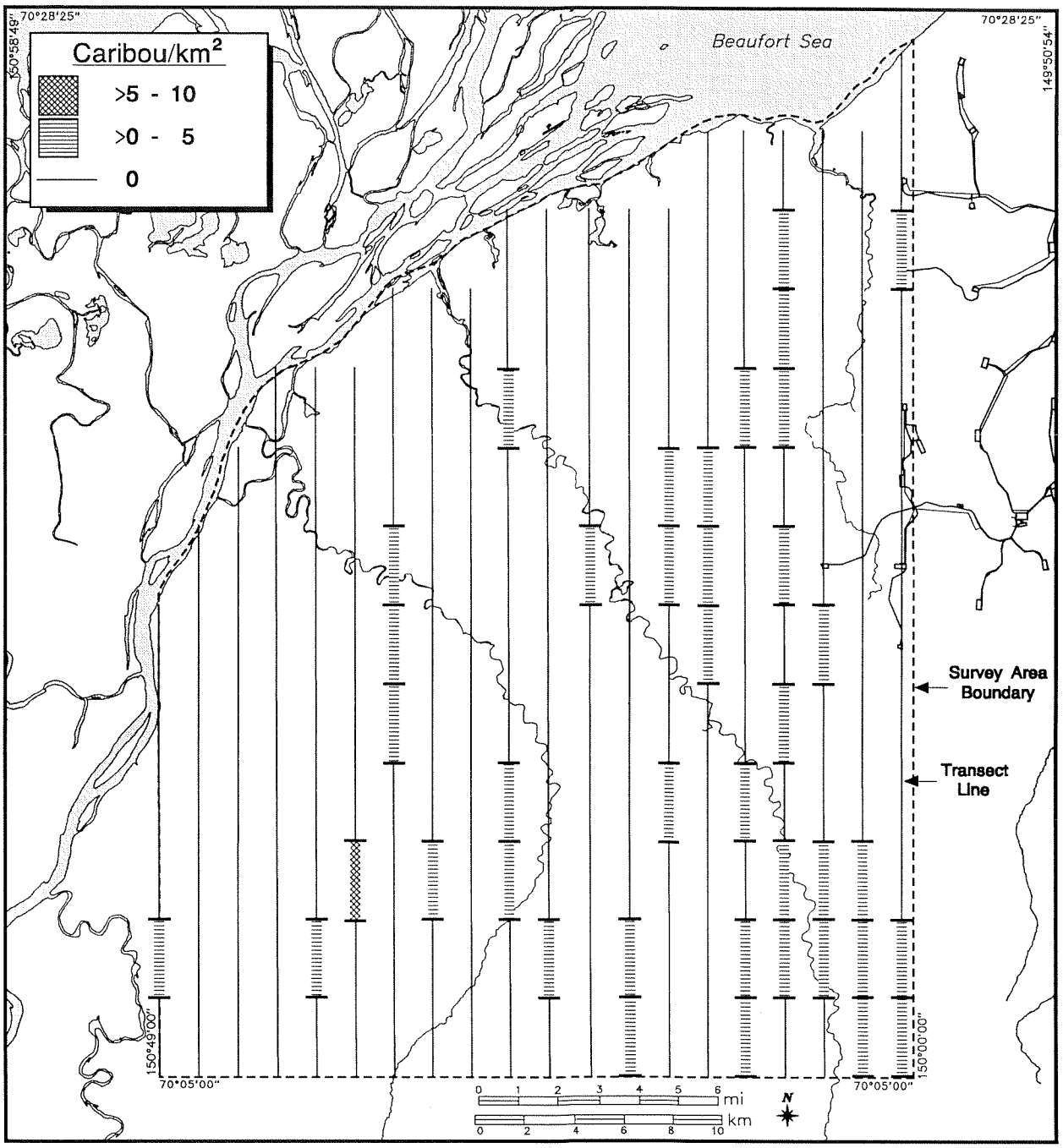
APPENDIX D. Distribution of caribou during the calving, insect, and rutting seasons, Colville River Delta study area, 1993.



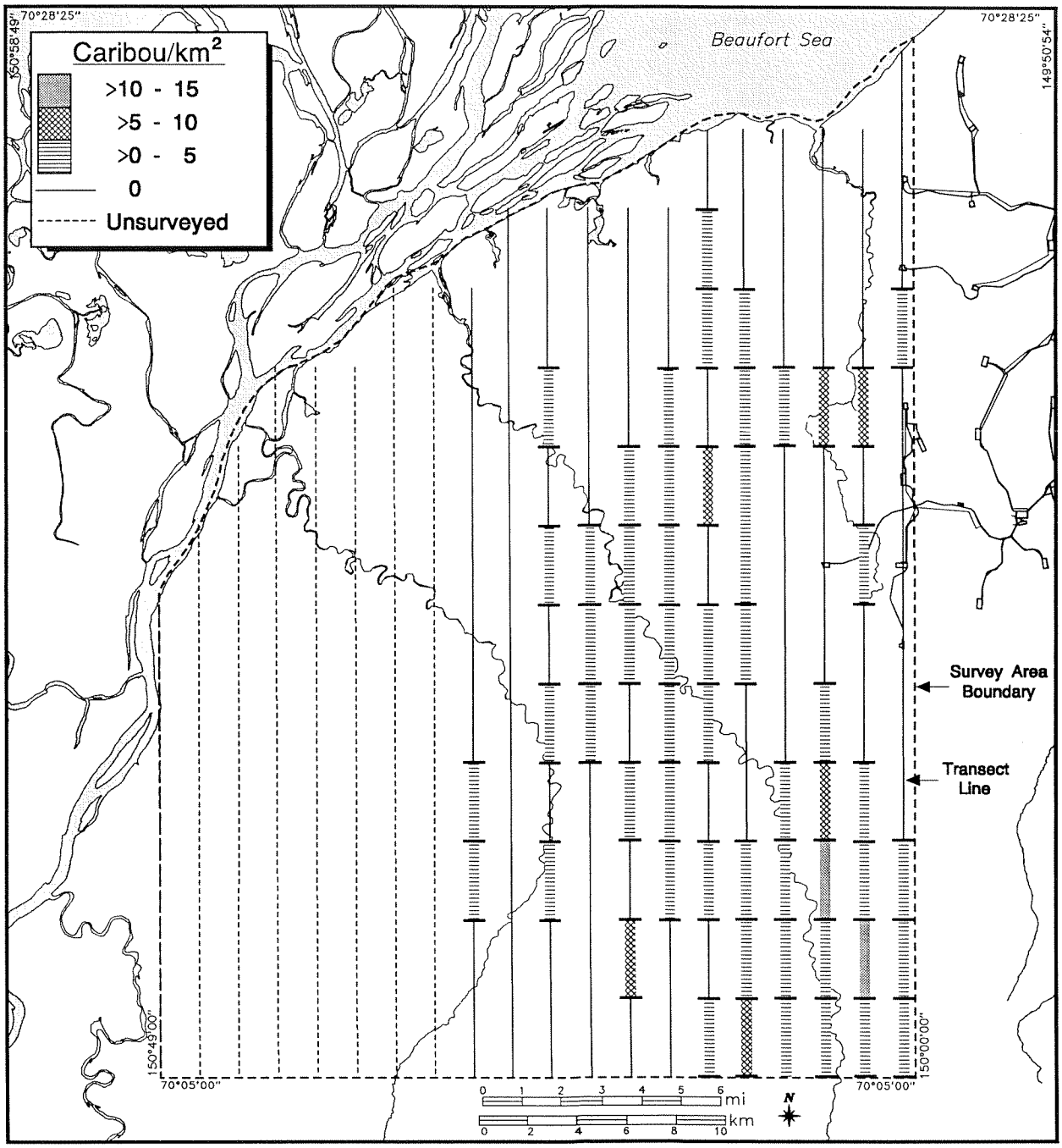
Appendix D1. Distribution and density of caribou on 26 May 1993 in the Colville East survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



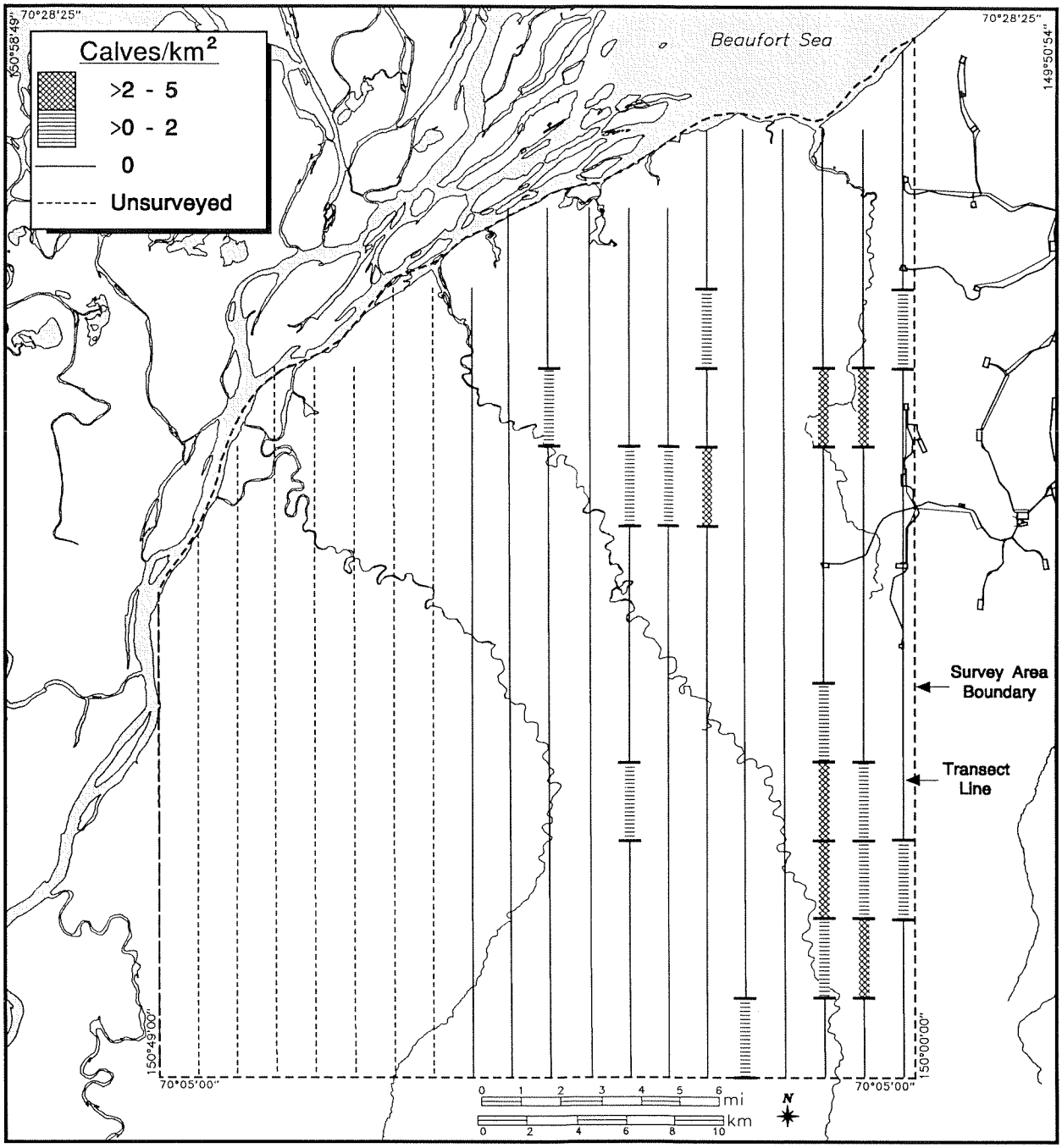
Appendix D2. Distribution and density of caribou on 27 May 1993 in the Colville East survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



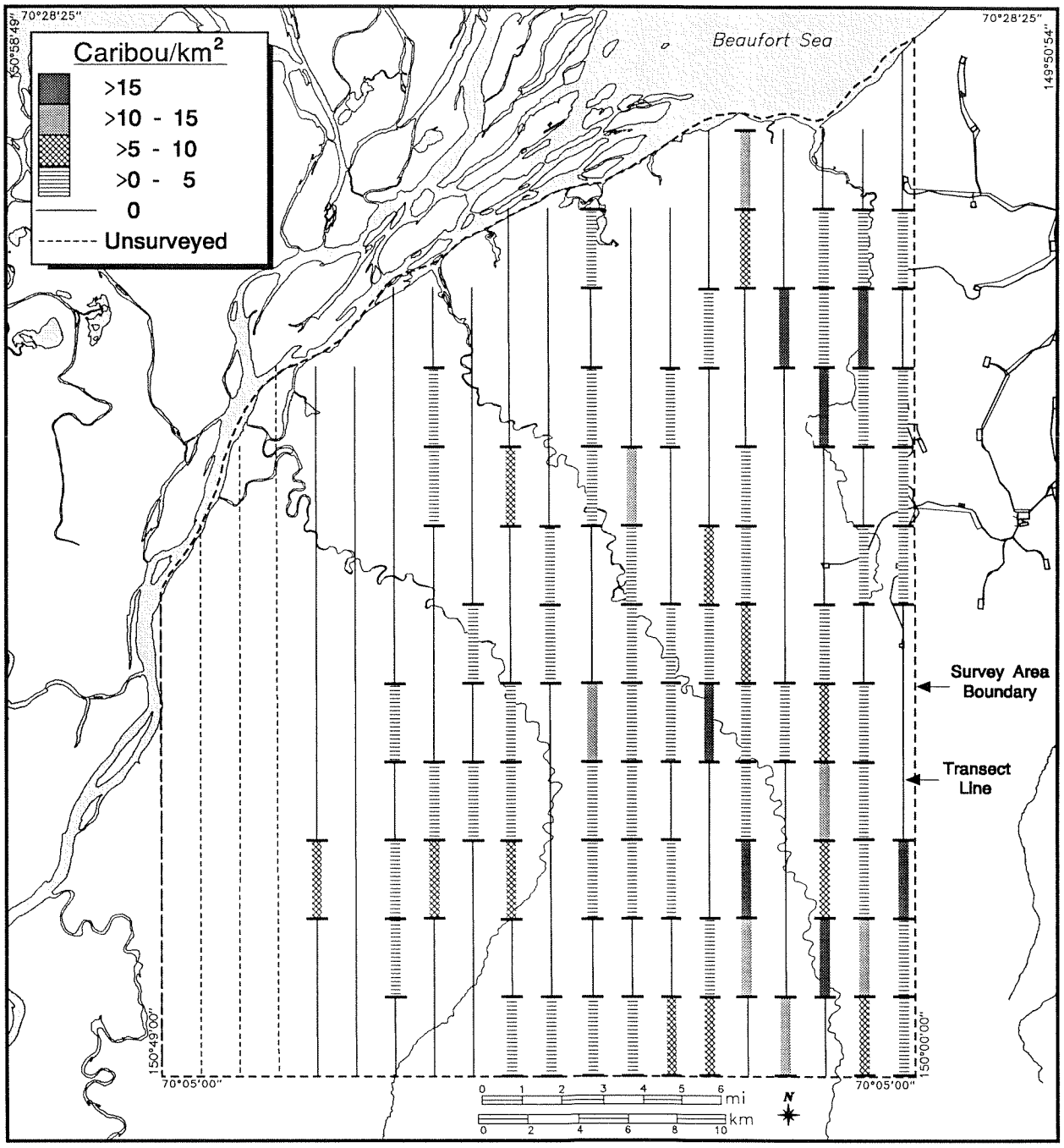
Appendix D3. Distribution and density of caribou on 3 June 1993 in the Colville East survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



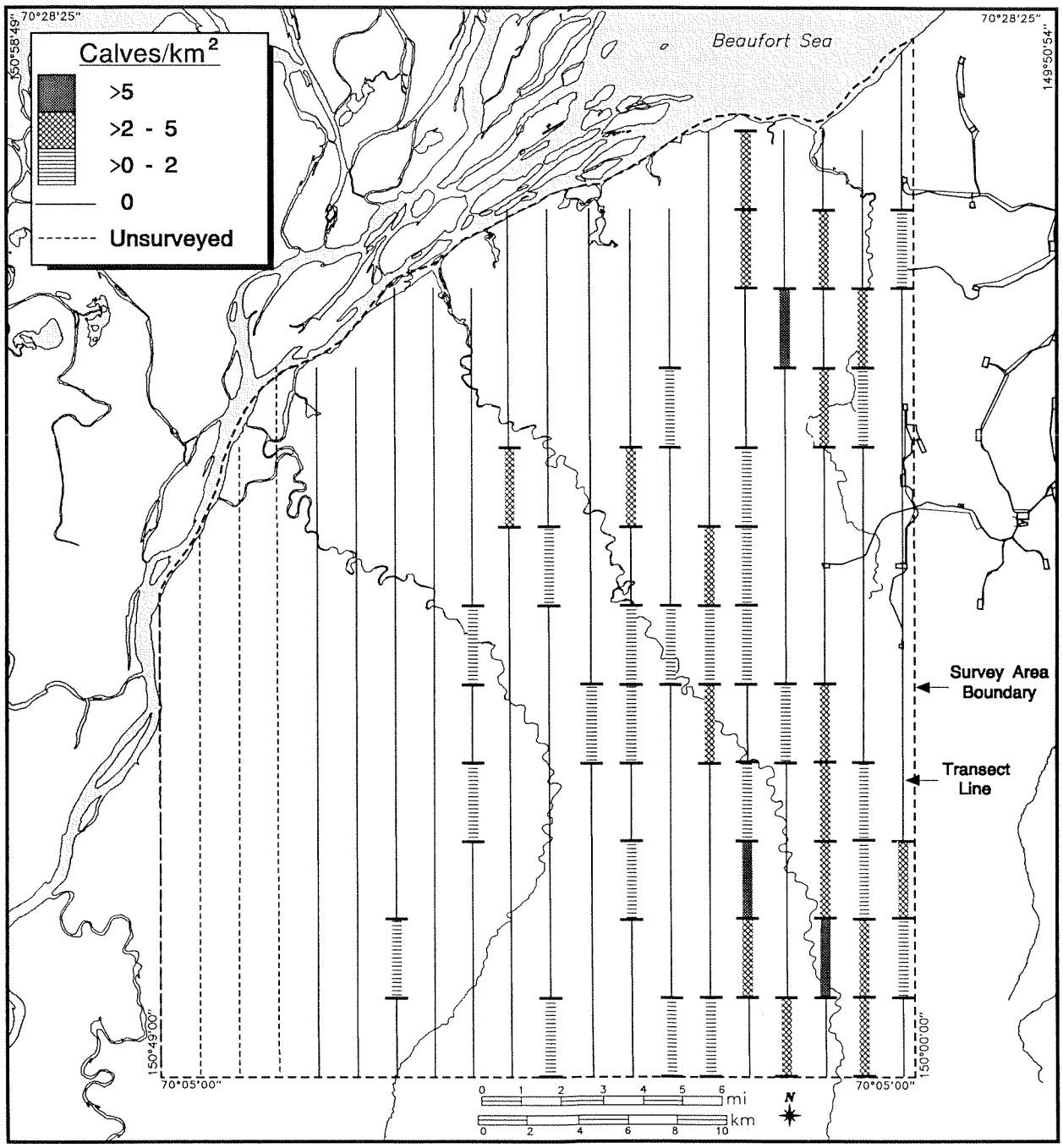
Appendix D4. Distribution and density of caribou on 8 June 1993 in the Colville East survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



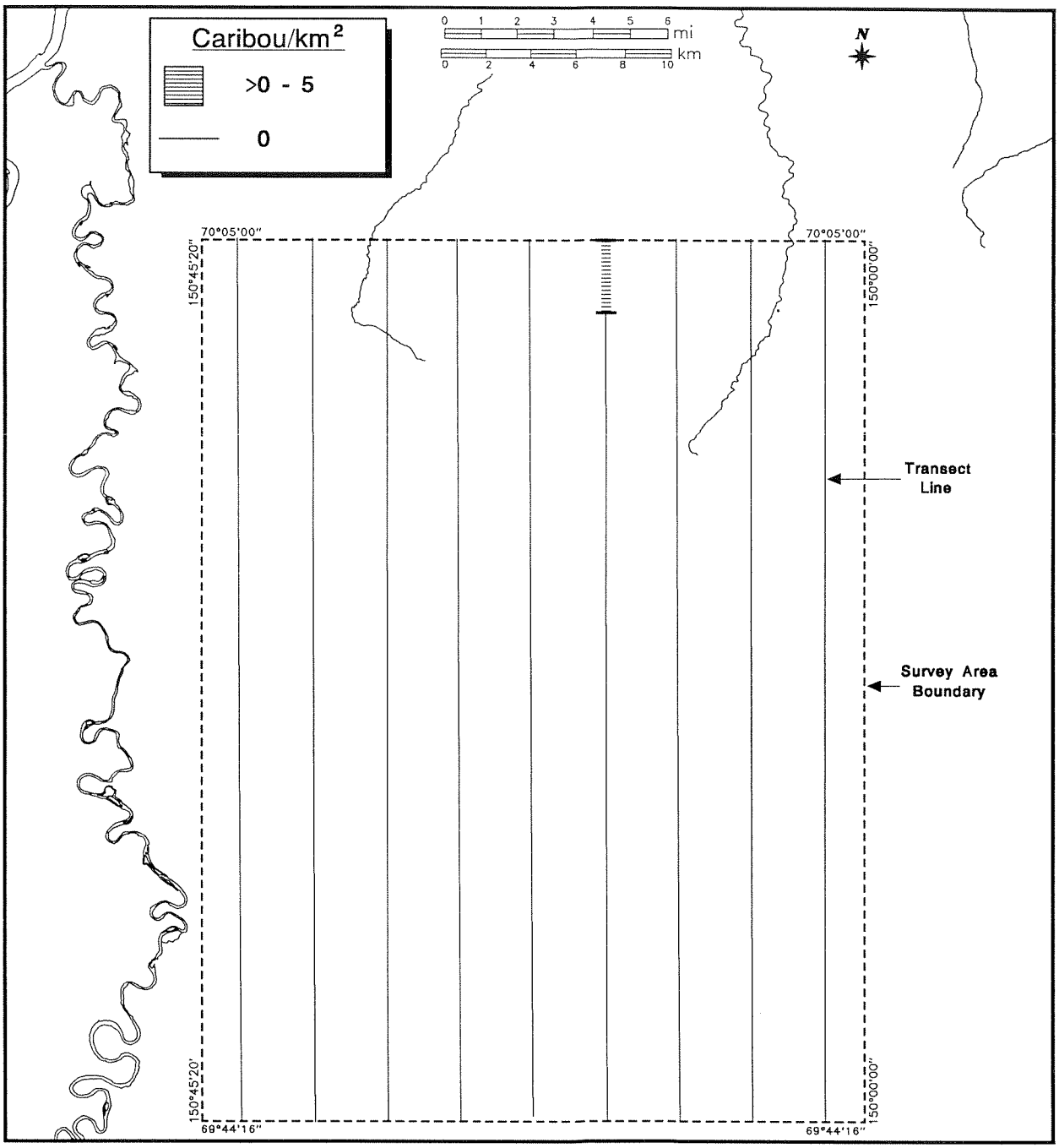
Appendix D5. Distribution and density of calf caribou on 8 June 1993 in the Colville East survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



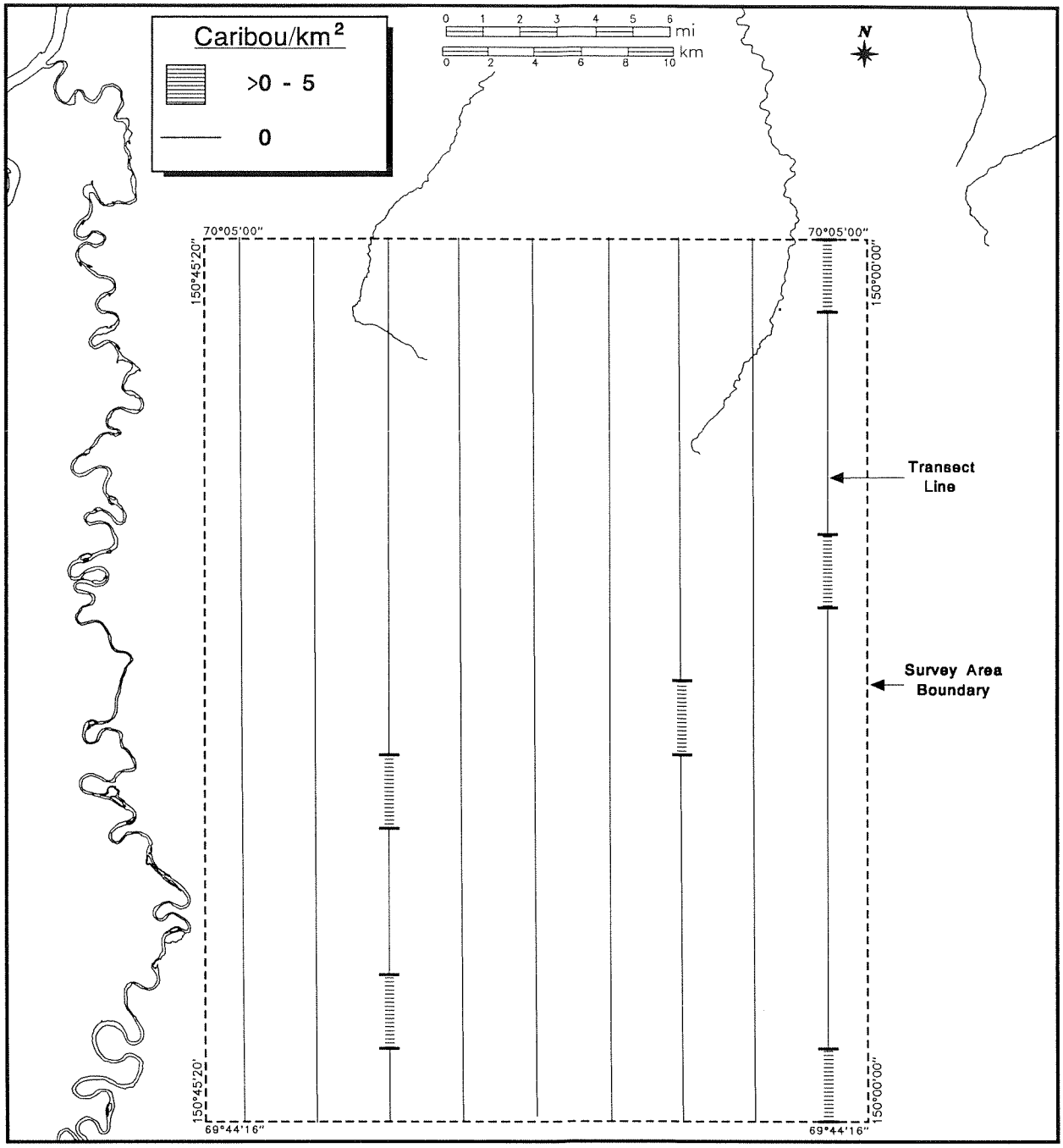
Appendix D6. Distribution and density of caribou on 11 June 1993 in the Colville East survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



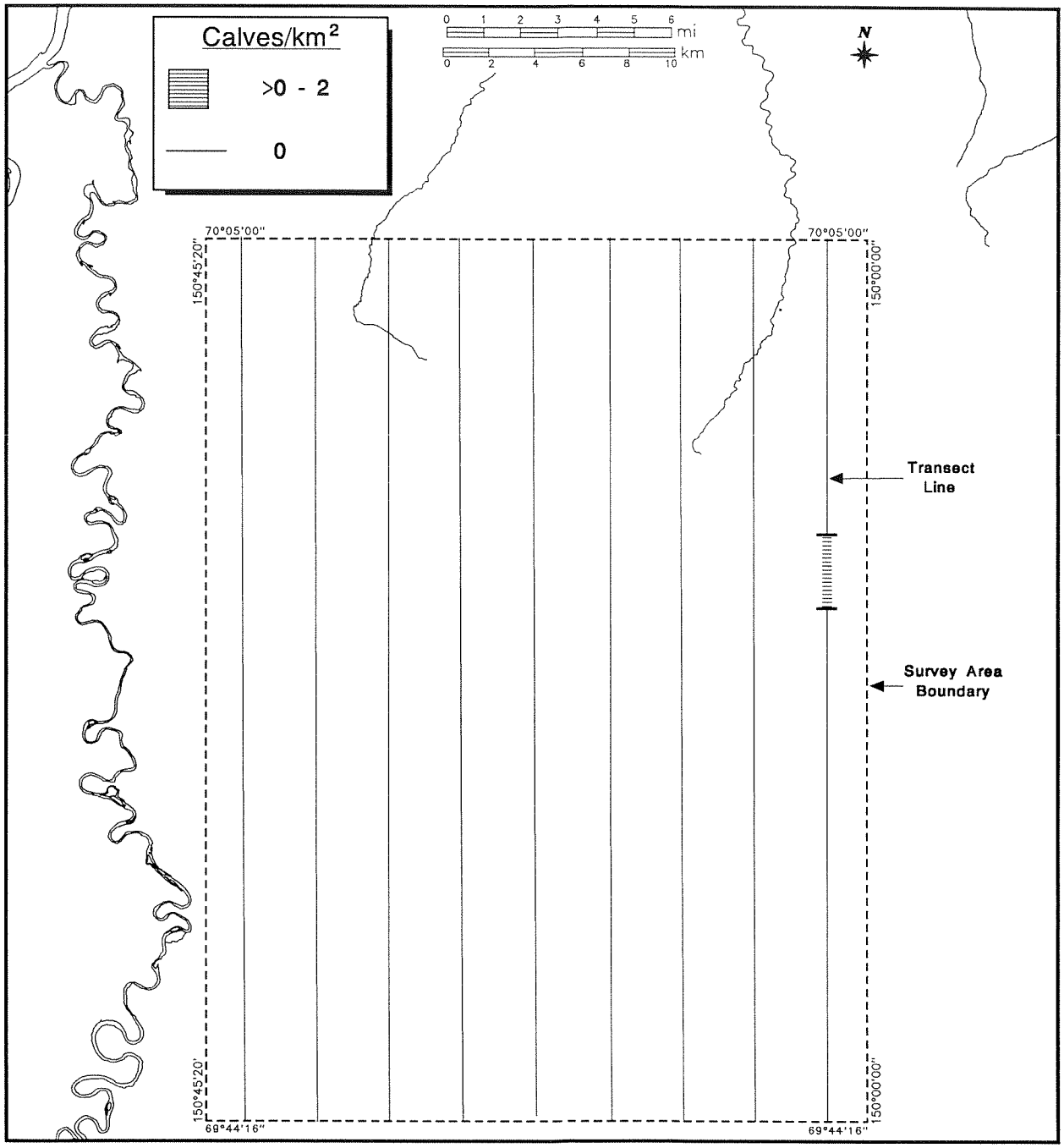
Appendix D7. Distribution and density of calf caribou on 11 June 1993 in the Colville East survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



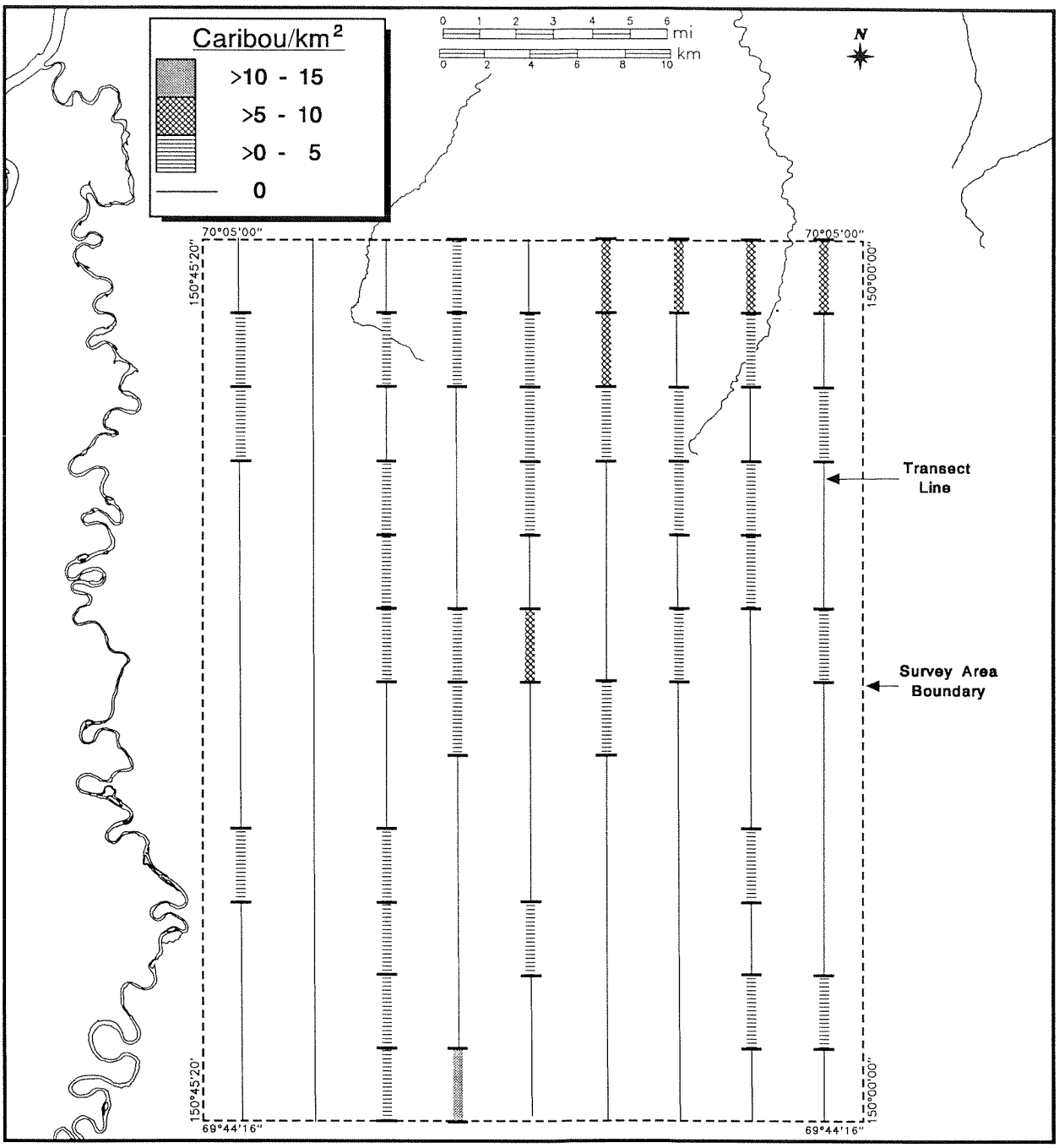
Appendix D8. Distribution and density of caribou on 23 May 1993 in the Colville Inland survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



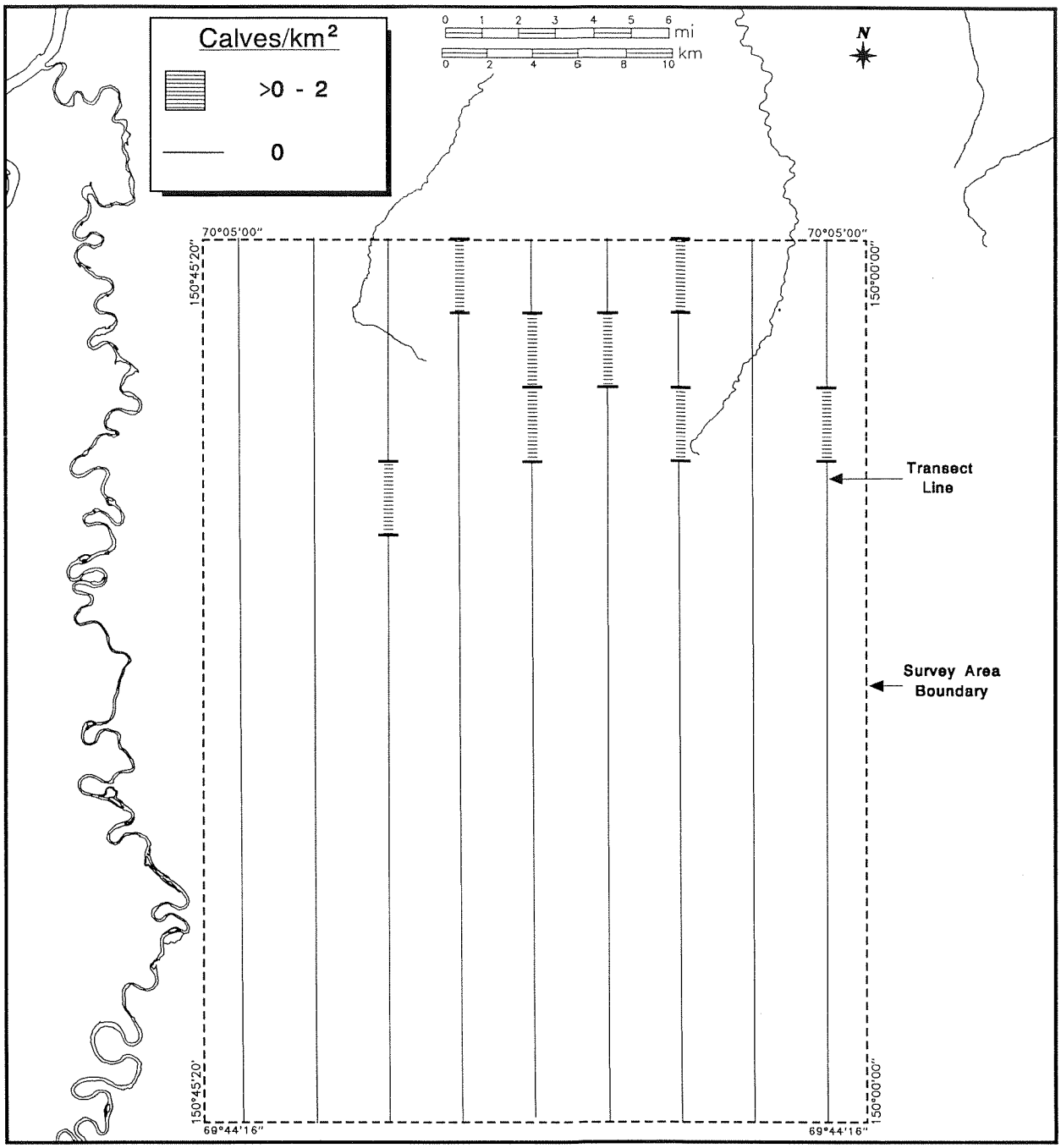
Appendix D9. Distribution and density of caribou on 28 May 1993 in the Colville Inland survey area, Alaska. the survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



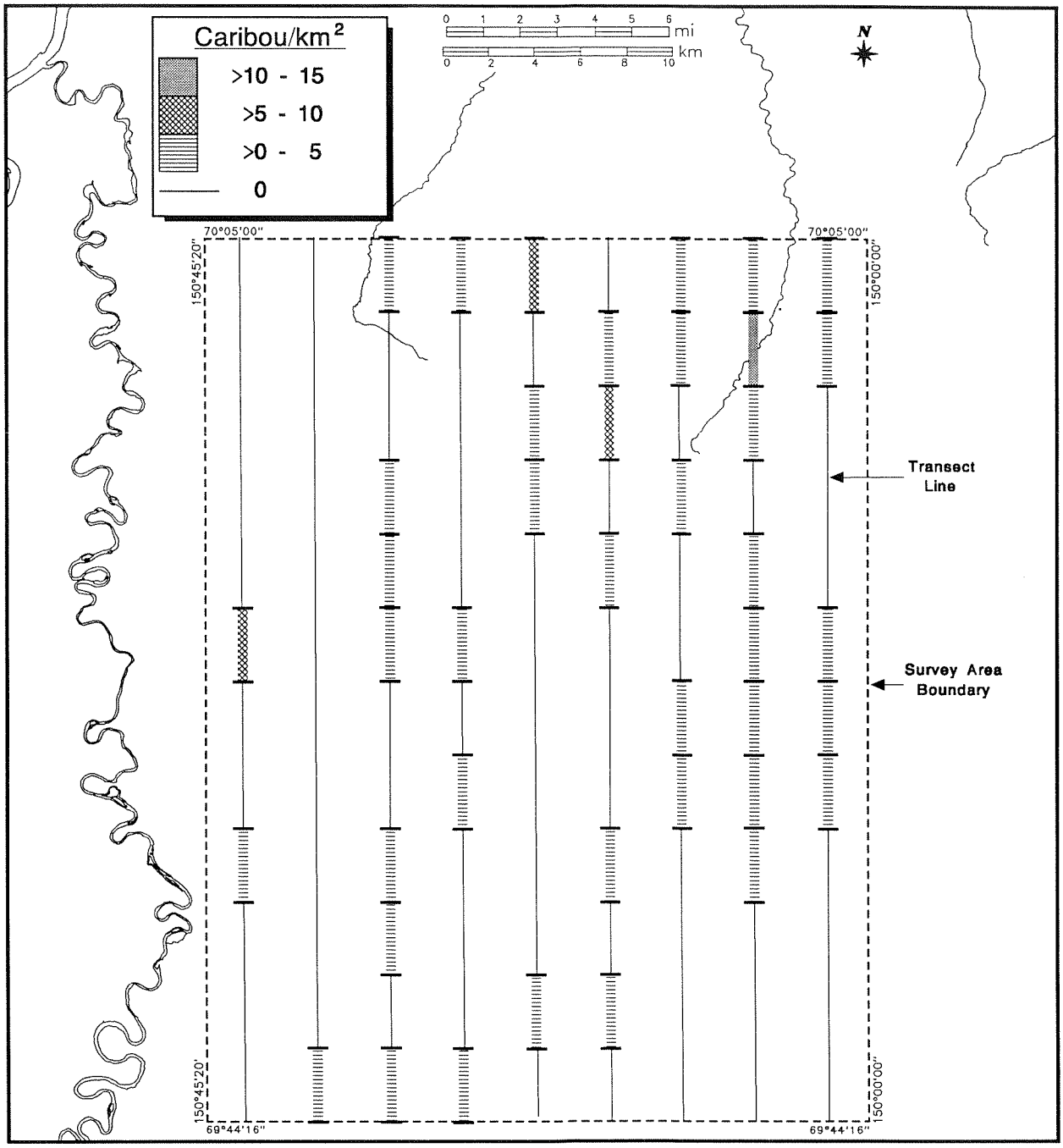
Appendix D10. Distribution and density of calf caribou on 28 May 1993 in the Colville Inland survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



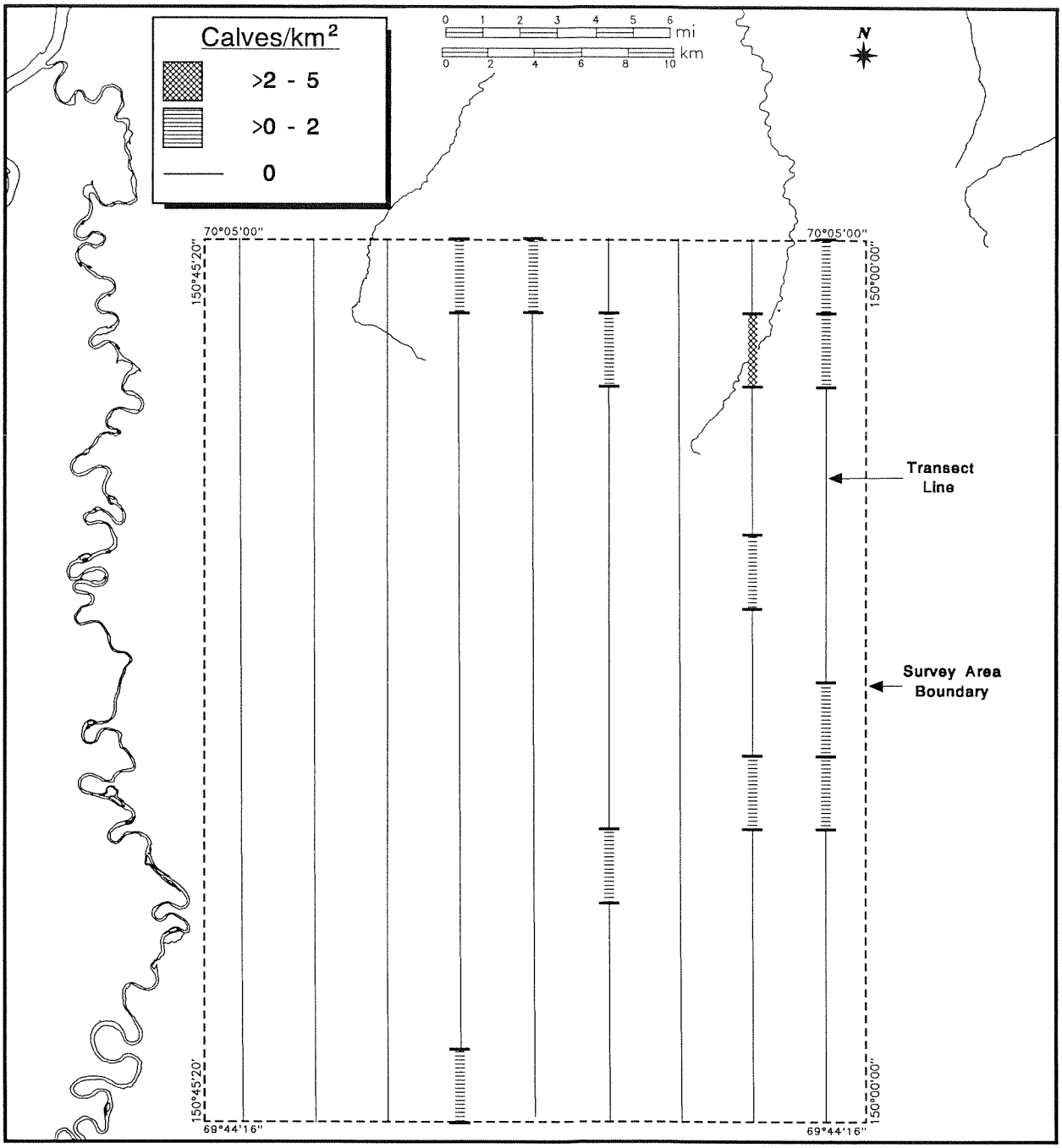
Appendix D11. Distribution and density of caribou on 7 June 1993 in the Colville Inland survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



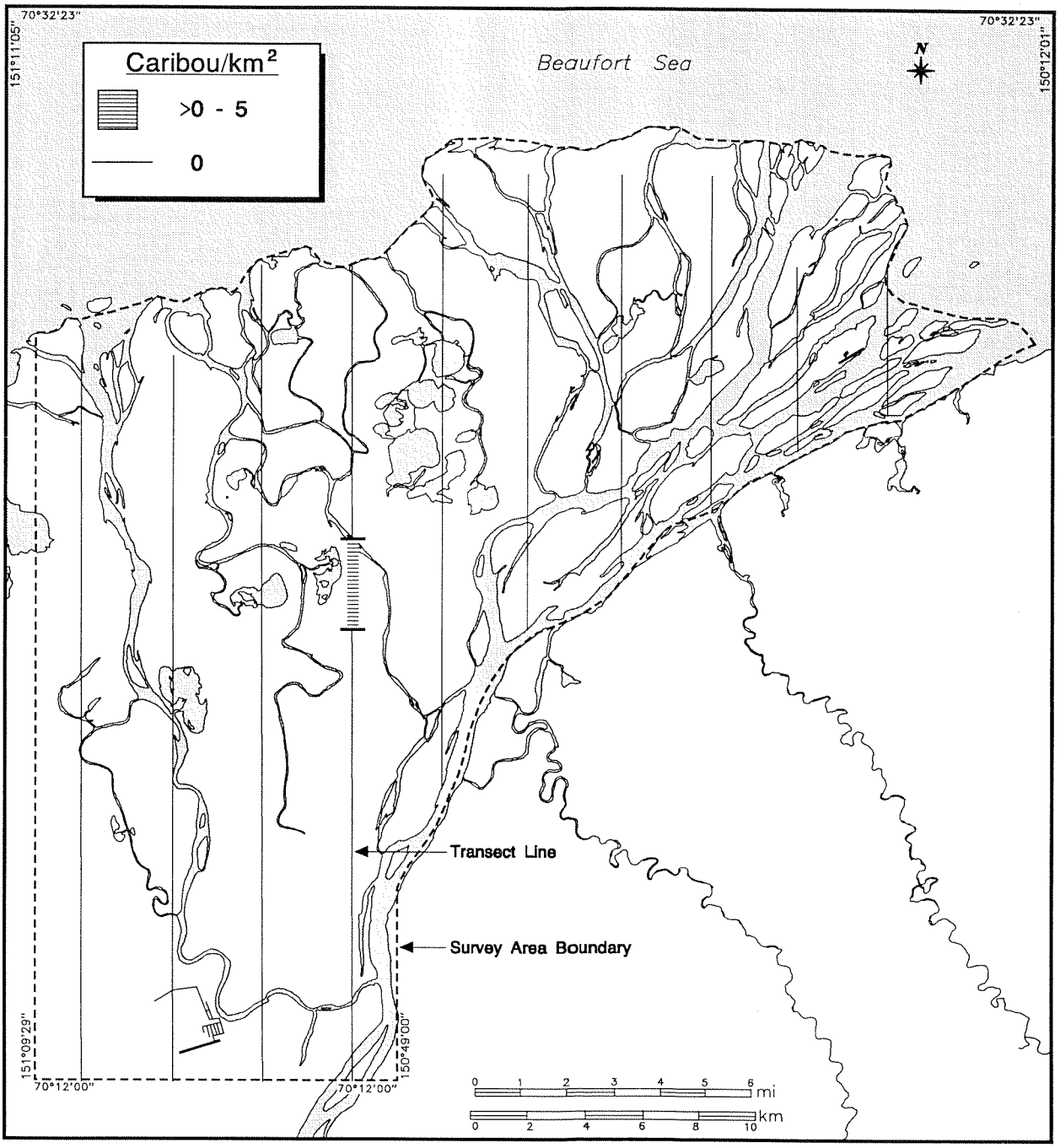
Appendix D12. Distribution and density of calf caribou on 7 June 1993 in the Colville Inland survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



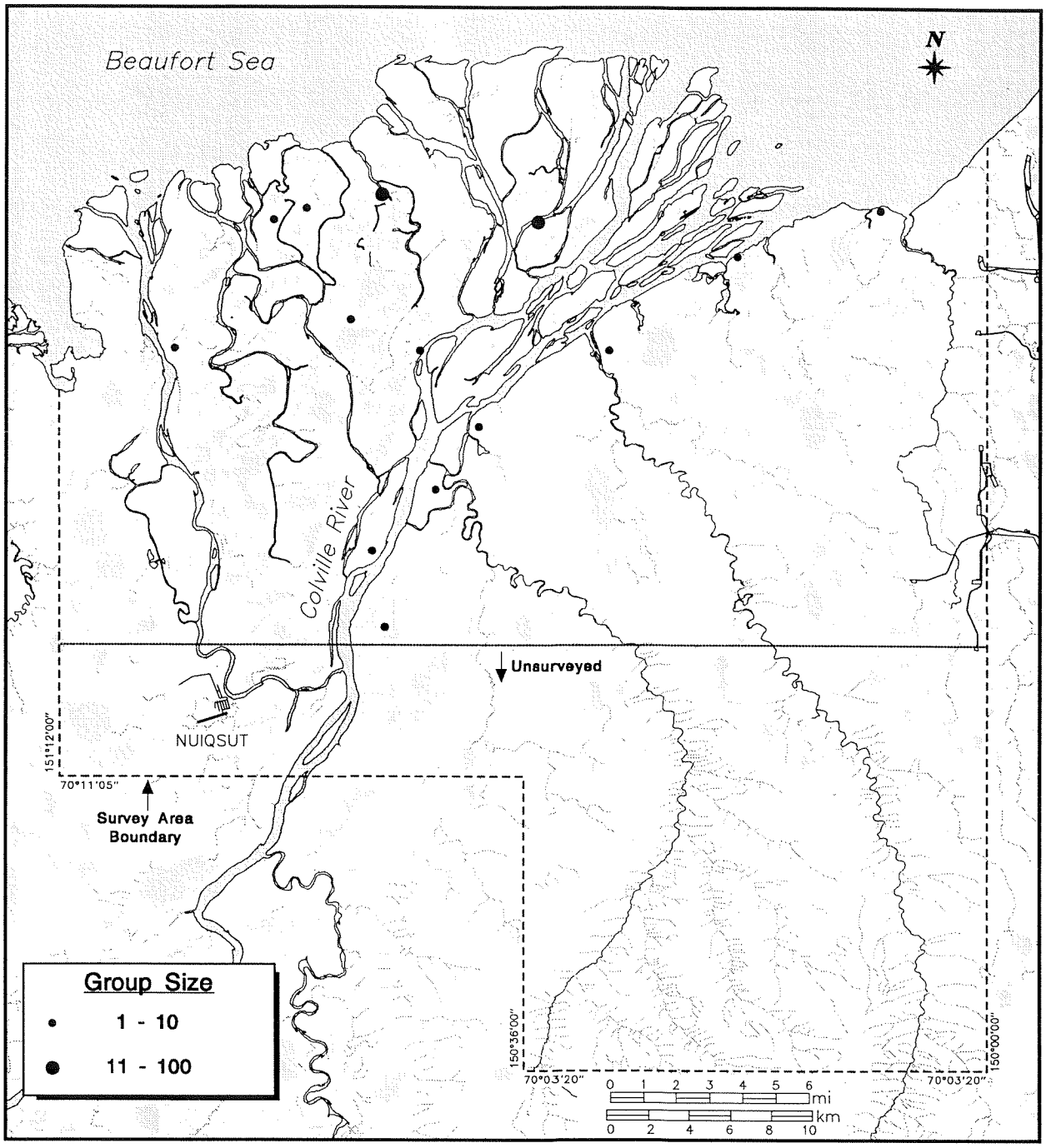
Appendix D13. Distribution and density of caribou on 10 June 1993 in the Colville Inland survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



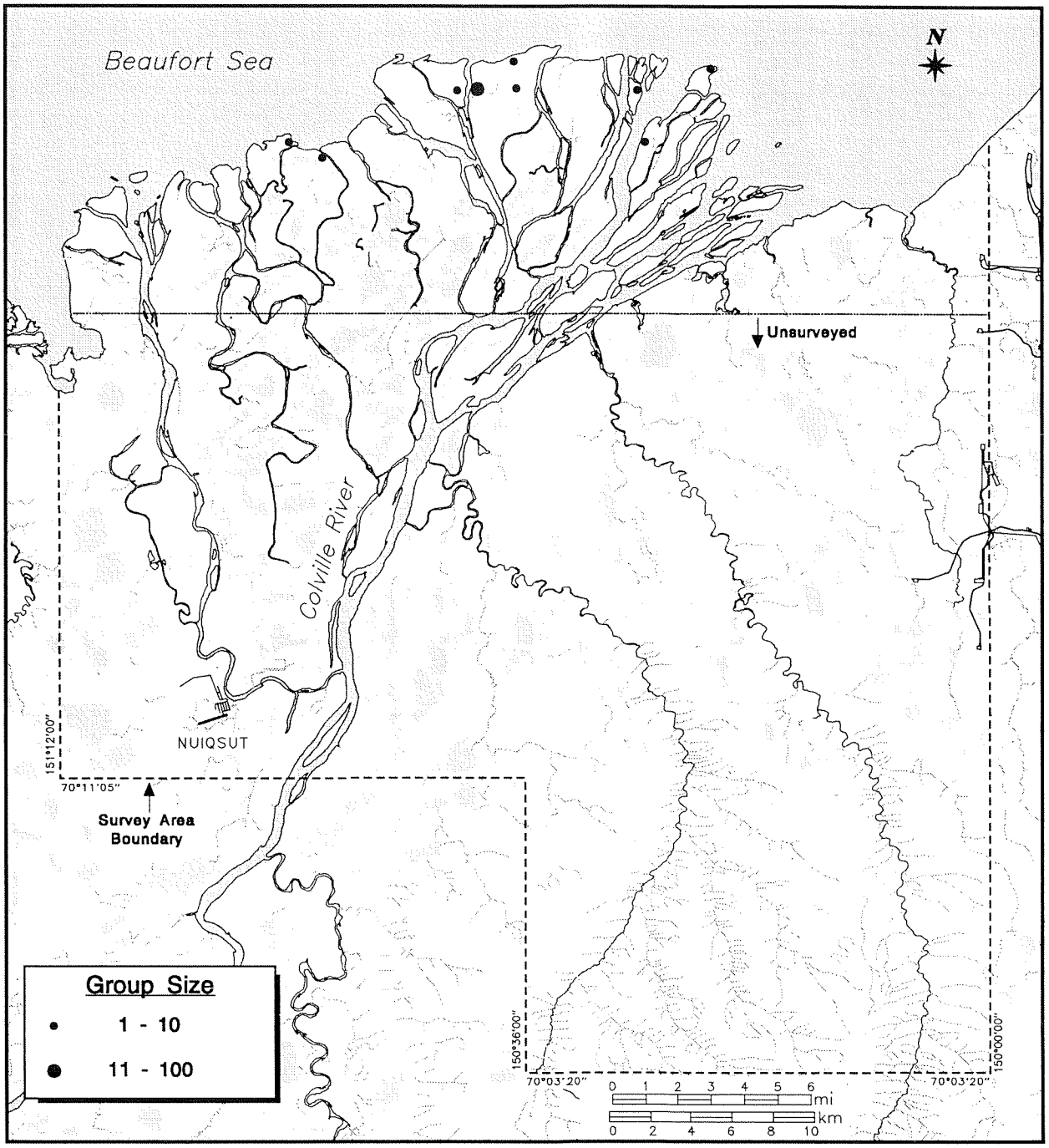
Appendix D14. Distribution and density of calf caribou on 10 June 1993 in the Colville Inland survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



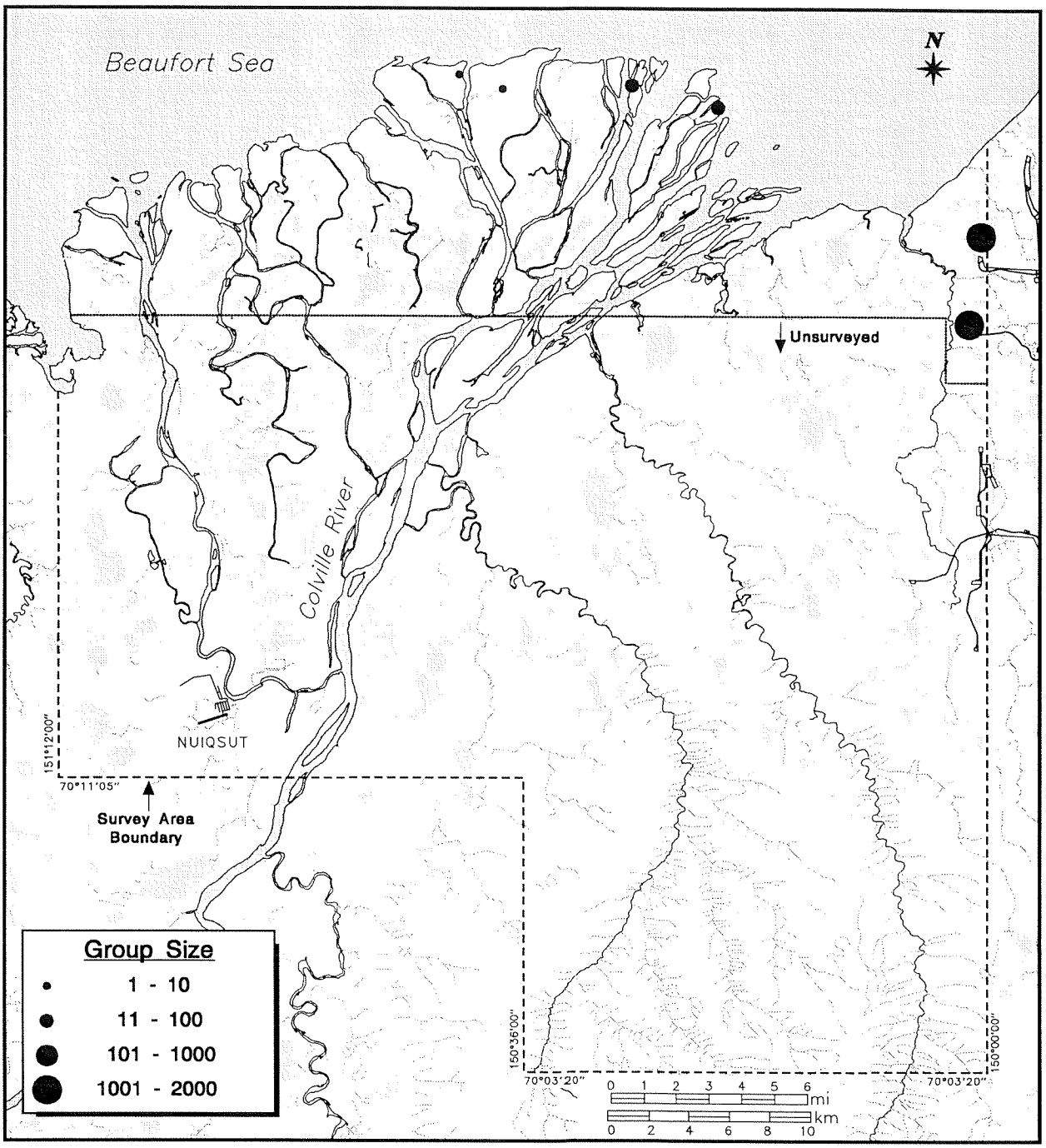
Appendix D15. Distribution and density of caribou on 28 May 1993 in the Colville Delta survey area, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2-km-long segments of 400-m-wide strip transects.



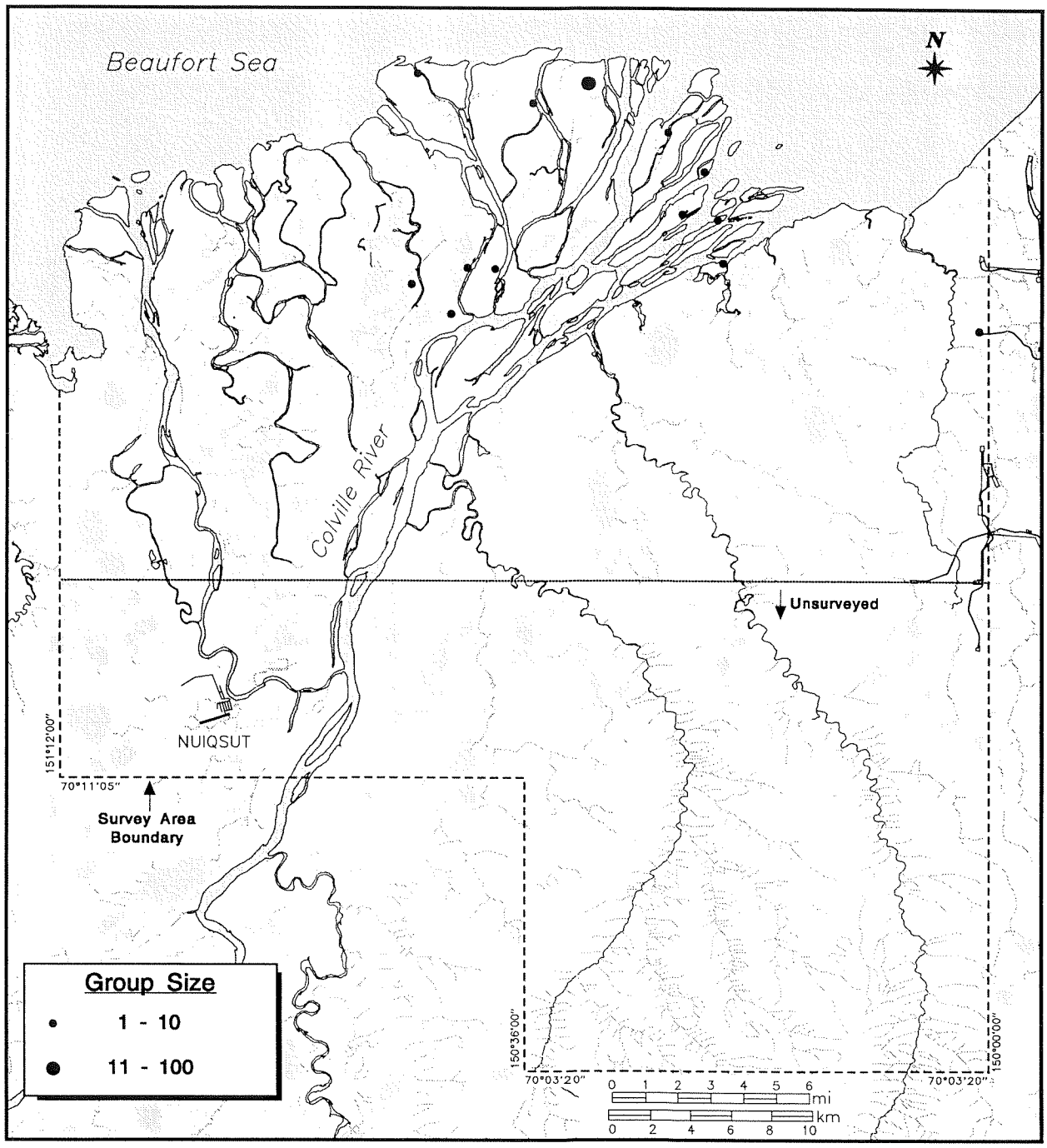
Appendix D16. Distribution and size of groups of caribou on 28 June 1993 in the Colville Delta and East survey areas, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2 km-wide strip transects.



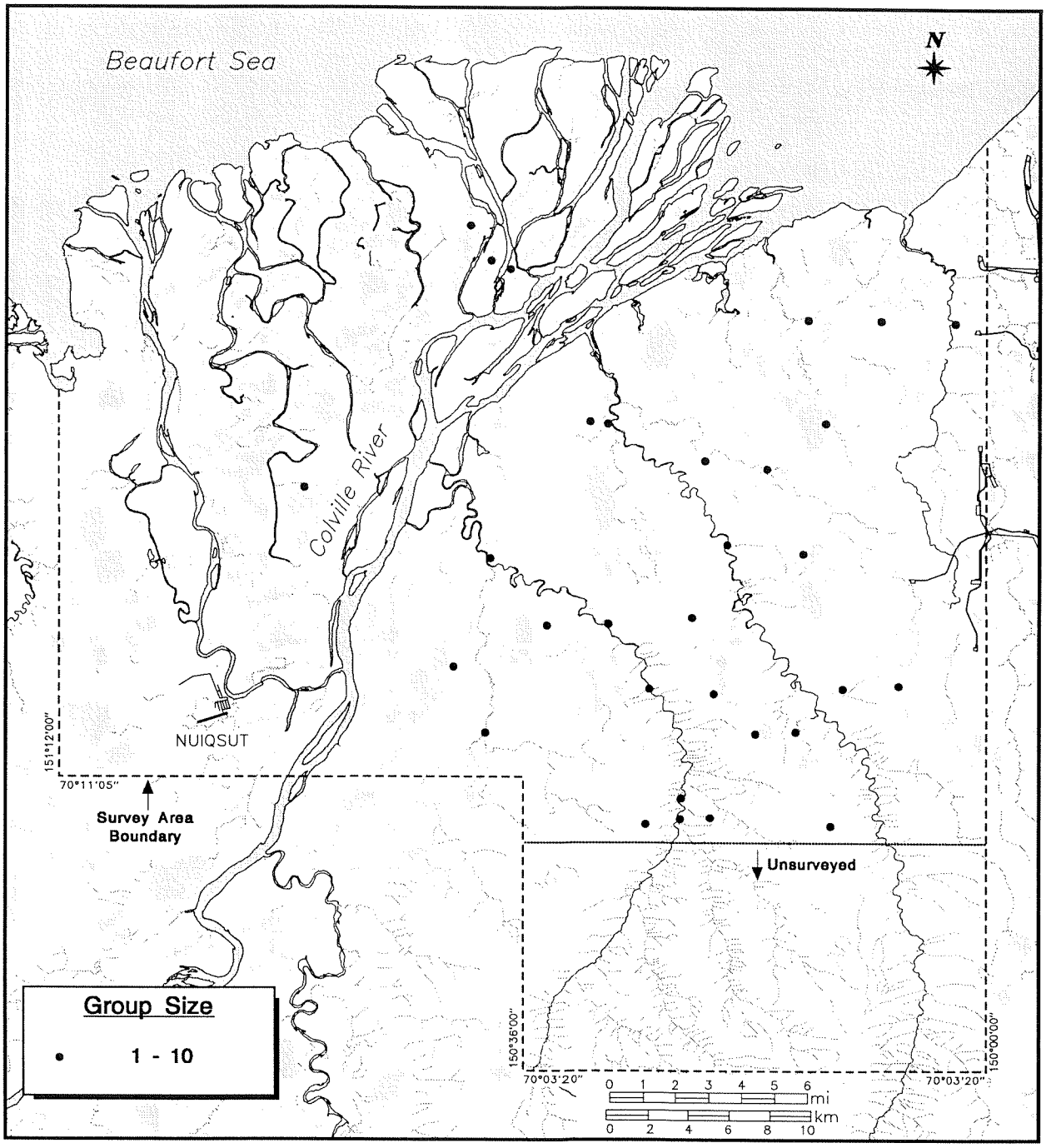
Appendix D17. Distribution and size of groups of caribou on 8 July 1993 in the Colville Delta and East survey areas, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2 km-wide strip transects.



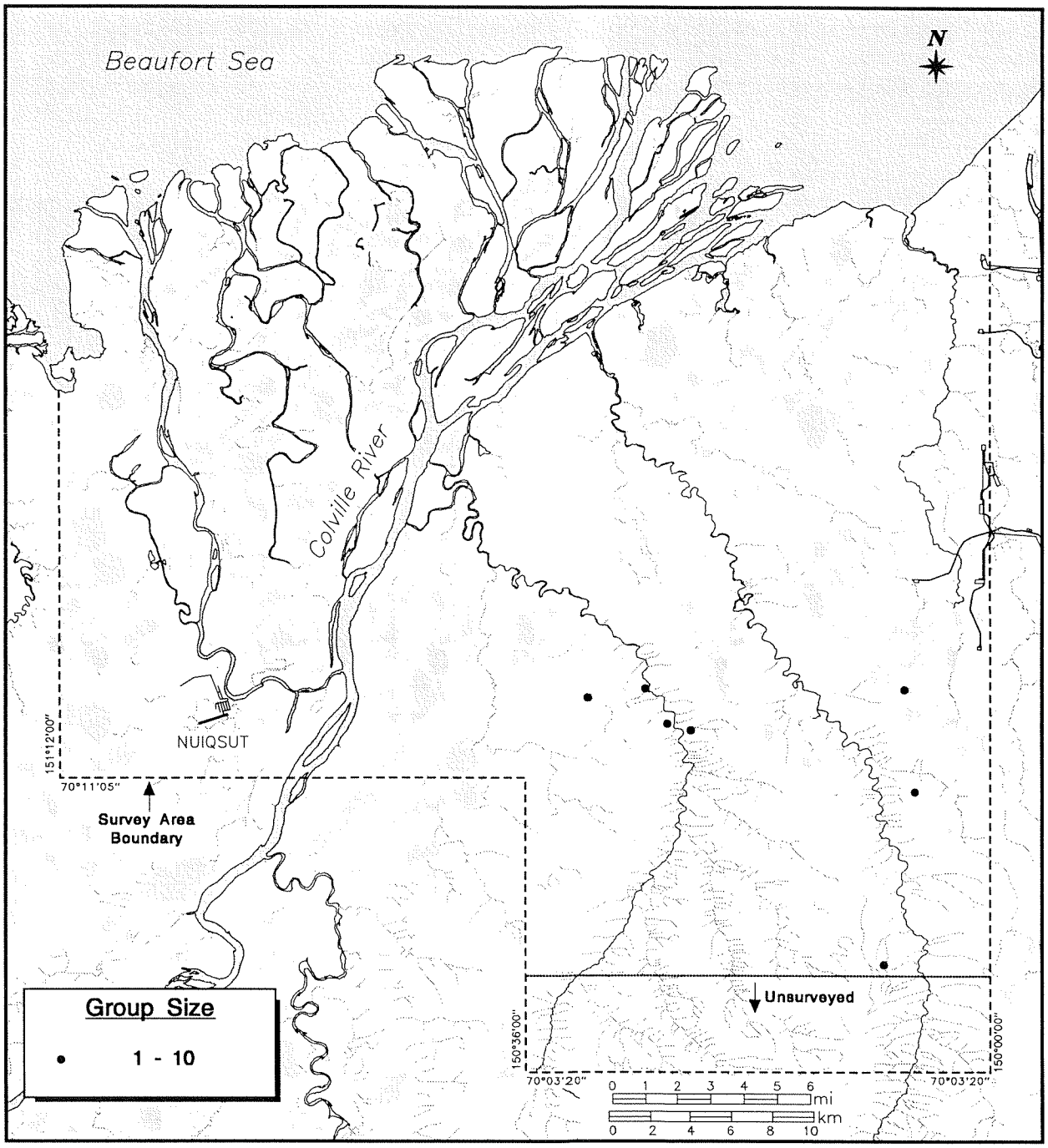
Appendix D18. Distribution and size of groups and size of caribou on 14 July 1993 in the Colville Delta and East survey areas, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2 km-wide strip transects.



Appendix D19. Distribution and size of groups of caribou on 19 July 1993 in the Colville Delta and East survey areas, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2 km-wide strip transects.



Appendix D20. Distribution and size of groups of caribou on 30 July 1993 in the Colville Delta and East survey areas, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2 km-wide strip transects.



Appendix D21. Distribution and size of groups of caribou on 20 October 1993 in the Colville Delta and East survey areas, Alaska. The survey was conducted from an airplane with one observer counting caribou on 3.2 km-wide strip transects.

Appendix E. Attributes of arctic fox dens, Colville River Delta, Alaska, 1993.

Den number	Status	Latitude (N)	Longitude (W)	Landform	Number of Entrances	Foxes Present	Comments
1	natal	70° 23.43'	150° 50.89'	dune	45	1 adult 5 pups	den not active in 1992; active natal den in late 1970s (Garrott 1980)
2	natal	70° 20.15'	150° 51.57'	dune	16	≥3 pups	also an active natal den in 1992
3	used by adults only	70° 15.27'	150° 38.40'	pingo	25	none	well-developed; probably a natal den in past; many prey remains
4	inactive	70° 14.84'	150° 31.71'	pingo	30	none	well-established; probably a natal den in past
5	used by adults only	70° 12.66'	150° 02.73'	pingo	15	none	used as a natal den in recent past; old remains of two pups at site, probably from 1992, indicative of eagle predation
6	secondary den	70° 07.14'	150° 34.85'	pingo	5	none	minimal fox sign -- a few adult and pup scats; 1 waterfowl sternum
7	natal	70° 16.19'	150° 05.78'	creek bank	>50	1 adult 3 pups	natal den in 1984, 1987, 1988, and 1989 (ABR unpubl. data)
8	natal	70° 22.95'	150° 57.35'	lake bank	25	≥2 pups	tiny scat indicates very young pups; remains of one pup; active natal den in late 1970s (Garrott 1980)
9	inactive	70° 24.17'	150° 54.43'	lake bank (dune)	27	none	well-developed; probably a natal den in past few years; active natal den in late 1970s (Garrott 1980)
10	used by adults only	70° 20.11'	150° 23.78'	pingo	41	none	active natal den in late 1970s (Garrott 1980)
11	natal	70° 24.98'	150° 06.51'	creek bank	13	2 adults 3 pups	active natal den in late 1970s (Garrott 1980)
12	inactive	70° 18.72'	150° 59.99'	bank of lake basin (dune)	≥11	none	probably a natal den in past; possibly an active natal den in late 1970s (Garrott 1980)