WILDLIFE STUDIES ON THE COLVILLE RIVER DELTA, ALASKA, 1996

Fifth Annual Report

Prepared for:

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and

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May 1997

Printed on recycled paper.

EXECUTIVE SUMMARY

The Colville River drains 53,000 km^2 or about 29% of the Arctic Coastal Plain of Alaska and forms a large (551 km^2) delta where it meets the Beaufort Sea. Oil reserves on the central portion of the Colville Delta currently are being evaluated for commercial development by ARCO Alaska, Inc. and the Kuukpik Unit Owners. In preparation for development and production, studies on the biological resources of the delta were initiated in 1992. Although the study areas and, to a lesser degree, the focal species have varied over the five years of studies, the basic goal has remained unchanged: to accumulate baseline information on the distribution and abundance of selected wildlife during pre-breeding through post-breeding seasons. In 1996, the primary species of concern were Spectacled Eiders, King Eiders, Tundra Swans, Brant, Yellow-billed Loons, caribou, and arctic foxes. Other species that were included as secondary species were Pacific and Red-throated loons, Greater White-fronted Geese, other waterbirds, muskoxen, and red foxes.

The study objectives were 1) to monitor the distribution, abundance, and habitat use of selected waterbird species, 2) to monitor the abundance and distribution of caribou, 3) to locate fox dens and evaluate their habitat associations, and 4) to describe the distribution of other large mammals in the study area.

A combination of aerial and ground surveys were used to collect field data for analysis in a geographical information system. Wildlife habitats, which were classified and mapped in 1995, were used to identify those habitats that were selected by the focal species. Habitat composition differed between the delta and Transportation Corridor, reflecting differences in salinity and riverine processes between the two areas. On the delta, the most abundant habitats were Wet Sedge-Willow Meadow (18% of the area), River or Stream (15%), Barrens (14%), and Tidal Flats (10%). Habitats unique to the delta included Brackish Waters, Tapped Lakes with Low-water Connections, Salt Marshes, Salt-killed Tundra, and Aquatic Sedge with Deep Polygons. In the Transportation Corridor, the most abundant habitats were Moist Tussock Tundra (28%) and Moist Sedge-Shrub Meadows (25%).

Spectacled Eiders—Spectacled Eiders were more numerous in the Delta survey area than in the Transportation Corridor. Although the 1996 pre-nesting survey was conducted on the same dates (10–14 June) as in past years, its timing relative to the peak of arrival of Spectacled Eiders on the delta was later than in previous years. In 1996, the density of flying and non-flying Spectacled Eiders on the Delta survey area was 0.09 birds/km^2, which was a decrease from 0.13–0.17 birds/km^2 in 1993–1995. Pre-nesting Spectacled Eiders on the delta were found no farther than 11 km from the coastline ($\bar{x}$ = 4 km; n = 25 groups) in 1996; we saw no Spectacled Eiders in the Development Area or the Facility Area. Of all the areas surveyed, the Outer Delta consistently contained the highest density of pre-nesting Spectacled Eiders. In the Transportation Corridor, we found no Spectacled Eiders during pre-nesting in 1996.

Neither the Development Area, the Facility Area, nor the Transportation Corridor appear to be important to breeding Spectacled Eiders. We did not find any Spectacled Eider nests during searches of the Facility Area in 1995 or 1996. We also found no Spectacled Eider nests during limited searches in 1995 and 1996 of the Transportation Corridor. In 1996, we saw no broods of Spectacled Eiders during helicopter or foot surveys of the Facility Area.

Spectacled Eiders strongly preferred waterbodies during all portions of the breeding season, but habitat preferences differed between the two major survey areas as a result of differences in habitat availability. On the delta, pre-nesting Spectacled Eiders preferred (i.e., use was disproportionately greater than availability) Aquatic Sedge with Deep Polygons, Brackish Water, Salt Marsh, Salt-killed Tundra, and Shallow Open Water with Islands or Polygonized Margins. In the Transportation Corridor, pre-nesting Spectacled Eiders preferred Young Basin Wetland Complex and Deep Open Water without Islands. Nesting Spectacled Eiders on the delta used many of the same habitats that were preferred during pre-nesting. Between 1992 and 1994, 7 (28%) of 25 nests on the delta were in Aquatic Sedge with Deep Polygons. Other important nesting habitats were Brackish Water, Nonpatterned Wet Meadow, and Salt-killed Tundra. The single brood seen in 1995 was in Shallow Open Water with Islands or Polygonized Margins, whereas the 10 broods seen in 1993 were in Salt-killed Tundra (36% of all locations) and Brackish Water (27%), suggesting a strong attraction to coastal habitats.

King Eiders—King Eiders were more abundant in the Transportation Corridor than on the Colville Delta. King Eiders on the delta had an affinity for the coast: maximal distance was 14 km ($\bar{x}$ = 6 km; n = 64 groups). Density of pre-nesting King Eiders in 1996 (0.11 birds/km^2) in that Delta survey area was within the range of densities from 1993 to 1995 (0.06–0.14 birds/km^2). Neither the Development Area (4 male eiders seen) nor the Facility Area (2 males) was important to breeding King Eiders. King Eiders were distributed widely and were abundant throughout the Transportation Corridor (221 eiders; 0.59 birds/km^2). A few King Eider nests have been found incidentally during searches for Spectacled Eider nests on the delta (4 nests) and in the Transportation Corridor (3 nests) in previous years. In 1996, we saw no King Eider broods in the Facility Area.

King Eiders showed strong preferences for waterbodies during all portions of the breeding season. The only preferred and the most used habitat by pre-nesting King Eiders on the delta was River or Stream; 21 groups (58%) containing 84 eiders were counted in this habitat. In the Transportation Corridor, King Eiders preferred both types of Shallow Open Water without Islands, Deep Open Water without Islands, and River or Stream. On the delta, 3 of 4 nests were in Aquatic Sedge with Deep Polygons, and the other nest was in Salt-killed Tundra. In the Transportation Corridor, one nest each was in Young Basin Wetland Complex, Nonpatterned Wet Meadow, and Moist Tussock Tundra. Only two broods of King Eiders have been recorded during brood-rearing surveys of the delta: 1 brood (1995) in Aquatic Sedge with Deep Polygons and 1 brood (1992) in Wet Sedge-Willow Meadow. During the brood-rearing survey of the Transportation Corridor in 1995, we found 16 King Eider brood groups in 6 habitats, 3 of which were preferred: Deep Open Water without Islands and both types of Shallow Open Water.

Tundra Swans—In 1996, we found 45 Tundra Swan nests on the Colville Delta, the highest number found during four years of aerial surveys. Nest densities in 1996 were higher (0.10 nests/km^2) in the Development Area than for the entire delta (0.08 nests/km^2), or for the Transportation Corridor (0.06 nests/km^2). We found only one swan nest in the Facility Area in 1996. During brood surveys on the delta in late August 1996, we counted 32 broods containing 108 young (an increase of 26% from 1995). Mean brood size in 1996 was 3.4 young/brood and the density was 0.06 broods/km^2. The Facility Area contained the highest density of broods (0.35 broods/km^2), compared to the densities in the Outer Delta (0.05 broods/km^2), Development Area (0.08 broods/km^2), and Transportation Corridor (0.05 broods/km^2). We recorded 355 swans during the fall-staging survey, which was the highest number since 1993 (295). Tundra Swans used most available habitats during nesting and brood-rearing.

Nesting swans on the delta preferred four habitats: Wet Sedge-Willow Meadow, Nonpatterned Wet Meadow, Salt-killed Tundra, and Aquatic Sedge with Deep Polygons. Most nests (42%) were in Wet Sedge-Willow Meadow. In the Transportation Corridor, swans preferred Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge Marsh, Aquatic Grass Marsh, and Young Basin Wetland Complex. Most nests (17%) occurred in Young Basin Wetland Complexes. Swan broods on the delta preferred Brackish Water, Tapped Lake with Low-water Connections, Deep Open Water with Islands or Polygonized Margins, and Aquatic Grass Marsh. However, the habitat used by the most broods (15%) was Wet Sedge-Willow Meadow. Swan broods in the Transportation Corridor preferred Aquatic Sedge Marsh, Aquatic Grass Marsh, Deep Open Water with Islands or Polygonized Margins, and Deep Open Water without Islands. Most broods (64%) were found in the two Deep Open Water habitats.

Yellow-billed Loons— We found 12 nests and 46 adult Yellow-billed Loons during aerial surveys in 1996, the same number of nests as in

1995, but an increase of 6 adults. The Facility Area had the highest density of nests in 1996 (0.12 nests/km^2), whereas the Outer Delta had slightly lower densities (0.03 nests/km^2) than did the Development Area (0.05 nests/km^2). In 1996 in the Development Area, we saw three broods (0.02 broods/km^2), and we also saw three broods (0.02 broods/km^2) in the Outer Delta. As in previous years, we saw no broods in the Facility Area in 1996. We found one nest in the Transportation Corridor in 1996, but we saw no broods during the brood-rearing survey. On the delta, Yellow-billed Loons preferred three habitats during nesting: Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Tapped Lake with High-water Connection. The habitat most frequently used for nesting (31% of all nests), Wet Sedge-Willow Meadow, was used approximately in proportion to its availability. On the delta, Yellow-billed Loon broods used only three habitats and preferred only the two types of Deep Open Water. Most broods (71%) used Deep Open Water without Islands.

Brant—More than 950 pairs of Brant nest in the Anachlik Colony-complex at the mouth of the East Channel, which is the largest concentration of nesting Brant on the Arctic Coastal Plain (this nesting location has been monitored by the USFWS and J. Helmericks; it was not included in this study). Elsewhere on the delta in 1996, we counted 41 nests at 11 locations (a 21% increase in nests from 1995). Most nesting occurred on the Outer Delta, although five nesting locations were in the Development Area in 1996. Only one of these nesting locations was in the Facility Area, but two were just outside its boundary. In the Transportation Corridor, only one of two known colonies was occupied. During brood-rearing, we counted 993 Brant (478 adults and 515 goslings), which was the second largest count (after 1995) since surveys were begun by the USFWS in 1988. All brood-rearing groups were seen in coastal areas of the Outer Delta. During fall staging, we counted 1,327 Brant at 17 locations, which was the highest count since 1992. Most Brant were at coastal locations, but two groups (20 and 16 birds) were in the Development Area. Brant preferred coastal habitats during both nesting and brood-rearing. During nesting, Brant preferred Brackish Water and Aquatic Grass Marsh habitats. During brood-rearing, Brackish Water was the preferred habitat.

Other Geese—The Colville Delta is a regionally important nesting area for Greater White-fronted Geese and supports some of the highest nesting densities recorded on the Arctic Coastal Plain of Alaska. In 1996, we located 35 nests (2.04 nests/km^2) in selected areas within the Development Area, 13 nests in the Facility Area (1.5 nests/km^2), and 3 nests (1.73 nests/km^2) near the ASRC Gravel Mine site. Prior to 1996, Canada Geese have not been reported as nesting either on the Colville Delta or in the NPR–A. In 1996, we observed 10 Canada Goose nests at a Brant nesting location just west of the delta in the NPR–A, the first record of this species nesting close to the delta. In 1996, we did not locate any Snow Goose nests on the delta, although some have been found in previous years. During brood-rearing in 1996, we conducted a systematic aerial survey for geese (25% coverage) on the delta and Transportation Corridor and counted 553 White-fronted Geese in 16 groups, no Canada Geese, and 1 brood of Snow Geese. We also saw a group (3 broods) of Snow Geese during the aerial survey for brood-rearing Brant. During fall staging (also at 25% coverage), we saw 1,356 White-fronted Geese in 28 groups on the delta, concentrated around river channels and large lakes. In the Transportation Corridor, we saw 6 groups with 399 geese. We counted 1,486 Canada Geese in 15 groups on the delta during fall staging, which was more than the numbers seen in any previous year except for 1992, when we saw 10,950 geese. We saw only three Snow Geese in one group on the Outer Delta during fall staging.

Other Birds—The distribution and abundance of other bird species was recorded opportunistically during aerial and ground-based surveys. Within the Facility Area and the surrounding search area, we found nests of Green-winged Teal, Northern Pintail, Northern Shoveler, Oldsquaw, and Willow Ptarmigan, as well as nests of shorebirds (nine species), songbirds (two species), and avian predators (three species). At the ASRC Gravel Mine Site we found fewer nests and nesting species (primarily shorebirds and ptarmigan) than in the Facility Area. During nesting and brood-rearing surveys, we recorded at least four pairs of nesting Red-necked Grebes (nests and broods seen), a new breeding record for the Colville Delta. During brood-rearing surveys in the Facility Area we saw broods of Arctic Terns, Willow Ptarmigan, Oldsquaw, other waterbirds, and songbirds. At the ASRC Gravel Mine Site, we saw broods of Greater Scaup, Red-breasted Mergansers, and Willow Ptarmigan. During fall-staging in 1996, we also saw ~200 American Wigeon and ~500 Northern Pintails feeding in three tapped lakes in the Facility Area. Although both Pacific and Red-throated loons were probably undercounted on our surveys, which were designed to count the more obvious Yellow-billed Loon, both were abundant on the delta during the nesting and brood-rearing seasons. Pacific Loons also were abundant in the Transportation Corridor, whereas Red-throated Loons were less common. In 1996 in the Facility Area, we found three Pacific Loon nests and one Red-throated Loon nest. During brood-rearing, however, we counted four broods of Pacific Loons and three of Red-throated Loons in the Facility Area.

Caribou—During the 1996 calving season, we conducted systematic aerial surveys during 2–5 and 9–13 June. Snow cover in the Colville survey areas was unusually low during the calving season in 1996. Very few (<60) caribou were found in the Colville Delta survey area at that time. In contrast, large numbers of caribou were found east of the delta in the Kuparuk South and Colville East survey areas. Caribou density was up to four times higher in Kuparuk South than in the other survey areas. Most calving occurred in the Kuparuk South area. During 9–13 June, we estimated 4,344 $\pm$ 521 (80% CI) caribou in Kuparuk South (7.3 caribou/km^2) and 2,670 $\pm$ 314 caribou in Colville East (2.0 caribou/km^2). Our estimates for all 4 survey areas totaled 9,482 caribou, of which 34% were calves. On composition surveys on 13–14 June, we classified 3,153 caribou in the Kuparuk South and Kuparuk Field survey areas, yielding an estimate of 87 calves:100 cows, the highest ratio recorded for the CAH since the mid-1980s. Yearlings constituted 7% of the composition sample, for a ratio of 14 yearlings: 100 cows, reflecting low calf production in 1995.

Insect harassment began early (mid-June) in the 1996 season. The greatest use of the Colville Delta and Transportation Corridor by caribou occurred during 8–19 July, when large numbers of caribou moved into the survey areas from the east. Numbers in the Transportation Corridor reached a peak of 6,406 caribou on 9 July. Numbers on the delta peaked on 14 July, when 3,340 caribou gathered near the Elaktoveach Channel on the Outer Delta. The largest numbers using the Development Area (1,950 caribou) were seen on 17 July 1996.

Foxes—Since 1992, we have located 44 arctic fox dens and 5 red fox dens between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield. Fourteen of the arctic fox dens and all five of the red fox dens are on the Colville Delta, 16 dens are in the Transportation Corridor, and the remaining 14 dens are located north and south of the corridor. The overall density of arctic fox dens (active and inactive) in the combined Delta and Transportation Corridor survey areas is 1 den/30 km^2. The density in the Delta area (1 den/39 km^2) is nearly half that in the Transportation Corridor (1 den/21 km^2), due to the low density of dens in the Outer Delta. Den occupancy in 1996 was approximately double that observed in 1993 and 1995, and was the highest reported for the Colville area. We attribute this high occupancy to a high population of lemmings in 1996. Pups were present at 29 (67%) of 43 arctic fox dens, including 24 natal dens (56%) and 4 secondary dens (9%). At 15 dens where we obtained complete counts, the average litter size was 6.1 pups (range = 3–15 pups). On both the delta and Transportation Corridor, Riverine or Upland Shrub was the only preferred denning habitat, although other habitats were used by denning foxes.

Polar Bear—Polar bears occur annually in the coastal zone in the vicinity of the Colville Delta and North Slope oilfields. Pregnant females enter winter dens in October or November, emerging again in late March or April. About half of the dens occupied by pregnant female polar bears in the Beaufort Sea population occur on land. Information from several sources indicates low occurrence of polar bear dens in the vicinity of the Colville Delta.

Grizzly Bears—Grizzly (brown) bears are distributed from the Brooks Range to the coast, occurring in low densities on the coastal plain. Grizzly bears den from early October to late April or May in northern Alaska. On the coastal plain, grizzlies den in pingos, banks of rivers and lakes, dunes, and steep gullies in uplands. Most bears den within 50 km of the oilfields, although some den 100–160 km inland. Several bears radio-collared by ADFG denned on the Colville Delta in the winter of 1996–1997: two young males denned together along the Sakoonang Channel near the Facility Area and a single bear denned in sand dunes on an island in the East Channel. In the Transportation Corridor, two marked bears have denned recently on the Miluveach River (one in 1995–1996 and the other in 1996–1997). Most grizzly bear dens are clustered in the uplands >15 km south of the Transportation Corridor, in the headwaters of the Miluveach and Kachemach rivers. In summer 1996, we recorded 18 sightings of grizzly bears during our surveys for other species. As in 1993 and 1995, several grizzly bears were seen on the caribou calving grounds south of the Kuparuk Oilfield in the first half of June. Most sightings in late June and July were east of the Miluveach River in the Transportation Corridor.

Muskoxen—A breeding population of muskoxen has become established in the Itkillik–Colville region since the late 1980s. The largest numbers to date (84 muskoxen, including 22 calves, in 7 groups) were recorded on 5 June 1996 in the uplands east of the Itkillik River, well south of the Transportation Corridor. Our observations suggest that most of the muskoxen population that resides in the Itkillik–Colville region winters in those uplands, then disperses seasonally in smaller groups during summer. In the first half of July 1996, a mixed-sex group of 21 muskoxen (including 7 calves) moved down the Kachemach River through the Transportation Corridor. The group remained in riverine shrub habitat along the lower reaches of the Kachemach River until 22 July, when it was seen moving southward near the mouth of the Itkillik River.

Spotted Seals—Spotted seals occur on the Colville Delta during late summer and fall. In the Chukchi and Beaufort seas, spotted seals haul out on land from mid-July through late October; favored haulout sites include small islands, spits, and shoals with adjacent deep water. As nearshore waters begin to freeze in early winter, however, spotted seals return wintering areas in the Bering Sea. In late July, approximately 24 seals were reported in the East Channel near the mouth of the Miluveach River. During an aerial survey on 23 August, we found six spotted seals hauled out on the sand spit of an island near the mouth of the East Channel of the Colville River. No seals were seen elsewhere on the delta during this survey, nor were any seen on or around the barrier islands bordering Simpson Lagoon east of the delta. Approximately 20 spotted seals were seen hauled out on the same sand spit during a waterfowl survey on 6 September.

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ACKNOWLEDGMENTS

In 1996, the wildlife studies on the Colville River Delta required a large and determined effort by many people. The biologists who spent long hours in the field and office on this project were: Betty Anderson, Brian Cooper, Jim King, Steve Murphy, Debora Nigro, and Bob Ritchie. Will Lentz, Mike Smith, and Allison Zusi-Cobb managed GIS data and crafted figures. Cecilia Brown managed the document production. Betty Anderson, Bob Day, and Steve Murphy reviewed this document. Tom DeLong, George Zusi-Cobb, and Sarah Ambrose provided logistic support. Jobe Wood, an elder of the Village of Nuiqsut, guided us expertly and safely on the delta. Sandy Hamilton of Arctic Air Alaska, and Jim Dell and Dave Deaver of Maritime Helicopters, assisted our surveys. Philip Martin, USFWS, contributed useful comments on study design and joined us in the field. Mike Joyce, ARCO Alaska, Inc., was instrumental in initiating and managing the biological studies on the Colville River Delta. To all these contributors, the authors are grateful for their help bringing this year's study and report to a successful conclusion.

INTRODUCTION

The Colville River Delta (hereafter, Colville Delta or the delta) is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fish that are found there. The Colville Delta also has attracted two permanent human habitations: the Iñupiaq village of Nuiqsut and the Helmericks family homestead, both of which rely heavily on these fish and wildlife resources. Although oil exploration on the delta has been occurring periodically for several decades, only recently have plans to commercially develop the area proceeded beyond the exploration phase. ARCO Alaska, Inc. (hereafter, ARCO) and the Kuukpik Unit Owners currently are formulating plans and seeking permits for the Alpine Development Project on the central delta. As part of this planning process and in recognition of the regional and local importance of the Colville Delta to a variety of interested parties, ARCO initiated a number of studies in 1992 to examine the biological, physical, and cultural resources of the delta. In this 1996 annual report, we present the results of our fifth year of study of the wildlife resources of the Colville Delta.

The Colville River drains a watershed of ~53,000 km^2, which encompasses ~29% of the Arctic Coastal Plain of Alaska (Walker 1976). The high-volume flow and heavy sediment load of the Colville River create a large (551 km^2), dynamic deltaic system in which geomorphological and biological processes have created a diversity of terrestrial habitats, lakes, and wetlands. The delta supports a wide array of wildlife and is known to be a regionally important nesting area for Yellow-billed Loons, Tundra Swan, Brant, and Spectacled Eiders (Rothe et al. 1983, North et al. 1984b, Meehan and Jennings 1988) (see Appendix Table A1 for scientific names). The delta also provides breeding habitat for passerines, shorebirds, gulls, and predatory birds such as jaegers and owls. In spring, the delta provides some of the earliest open water and snow-free areas on the Arctic Coastal Plain of Alaska for migrating birds. In fall, the delta's extensive salt marshes and mudflats are used by geese and shorebirds for staging. In addition to use by birds, the delta is used seasonally by caribou for insect-relief habitat, by arctic and red foxes for denning, and by spotted seals for fishing and for haul-out sites (Seaman et al. 1981). In recent years, the delta and adjacent areas have been visited increasingly by muskoxen and brown bears, and the delta occasionally is used for denning by polar bears (see reviews in Johnson et al. 1996).

Although the exact boundaries of study areas and the list of focal species that were examined varied over the five years of study (as better information on the location of the oil reservoir become available), the primary goal always has been to collect data on the distribution and abundance of selected species to be used as a baseline for conditions on the delta prior to oil development. During a meeting with the U.S. Fish and Wildlife Service (USFWS) in spring 1992, we agreed to focus our studies on particular species, based primarily on the following criteria: 1) threatened or sensitive status, 2) importance of the delta as breeding habitat, or 3) special concern of regulatory agencies. Accordingly, in 1992, Yellow-billed Loons, Tundra Swans, Brant, Spectacled Eiders, King Eiders, caribou, and arctic foxes were chosen for investigation (Smith et al. 1993). Species that were not the focus of surveys that year but were monitored opportunistically included Red-throated Loons, Pacific Loons, Greater White-fronted Geese (hereafter, White-fronted Geese), muskoxen, and red foxes. In 1993, we studied the same focal species but expanded the study area for all species to the entire delta region (Smith et al. 1994). In 1994, we surveyed the delta only for eiders (Johnson 1995). In 1995, we expanded our studies again to monitor the distribution and abundance of the same suite of species investigated in 1992 and 1993, and we added an investigation into habitat use by the focal species (Johnson et al. 1996). We continued with similar surveys in 1996 and added surveys for spotted seals and post-breeding geese.

The overall goal of the 1996 studies was to continue to collect baseline data on the use of the Colville Delta and adjacent areas by selected birds and mammals between late spring (May) and early fall (September). Our specific objectives were to:

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

2. monitor the distribution and abundance of caribou during the calving and post-calving seasons;
3. locate fox dens and describe their habitat associations;
4. locate haulouts of spotted seals; and
5. monitor the distribution of other large mammals in the study area.

STUDY AREA

In October 1996, ARCO submitted a permit application to the U.S. Army Corps of Engineers for the Alpine Development under Section 404 of the Clean Water Act. The potential development scenario currently being evaluated by ARCO includes a gravel airstrip and three gravel pads (two for drill sites and one for a processing facility), all connected by a 5-km long gravel road (Figure 1). A sales-quality pipeline to the Kuparuk Oilfield would connect this development to existing infrastructure. Although other development alternatives have been evaluated that include a road from the Kuparuk Oilfield to the delta and variations on the locations of gravel pads and facilities, in this report we consider only ARCO's preferred option that includes a pipeline to the delta and the location of all production facilities on the central delta.

The 1996 study area essentially was identical to the 1995 study area and comprised several contiguous areas in which the distribution of wildlife was monitored. As defined in this report, the Colville Delta encompasses 551-km^2 and refers to that area between the westernmost and easternmost distributary channels of the Colville River (Figure 1). The entire area within 1,000 m of the proposed airstrip and the processing facility and within 200 m of the proposed drill sites and the connecting road is called the Facility Area (8.6 km^2 total). As a result of better delineation of the oil reservoir's location and identification of environmental and economic concerns, the location of proposed surface development (Facility Area and pipeline route) has been modified from the original 1995 proposal (Johnson et al. 1996: Figure 1). The Alpine Development Area (hereafter, Development Area; 169 km^2) includes both the Facility Area and that part of the delta between the Nechelik and East (main) channels to ~2 km north of the proposed airstrip. The Outer Delta (352 km^2) is that portion of the delta north of the Development Area. Finally, the Western Delta (31 km^2) is the portion of the delta west of the Nechelik Channel that is bounded by a flood-plain terrace adjacent to the westernmost distributary. Between the Colville River and the westernmost drill site in the Kuparuk Oilfield (DS-2M) lies the proposed Transportation Corridor (343 km^2), so called because it includes the proposed pipeline route. In 1996, the Arctic Slope Regional Corporation (ASRC) applied for permits to mine gravel in the Transportation Corridor near the Colville River; the footprint for this proposed mine (2 km^2) is referred to hereafter as the ASRC Gravel Mine site.

The geographic extent of the wildlife investigations during 1992–1996 has varied due to changes in exploration plans and potential development scenarios. The boundaries of the wildlife study area in 1992 included several exploratory drill sites and extended from Kalubik Creek on the east to the Nechelik Channel of the Colville River on the west; thus, it included the entire delta and a large area of adjacent coastal plain (Smith et al. 1993). We conducted intensive surveys for a variety of bird species that year on six plots ranging from 46 to 61 km^2 in size. In 1993, the locations proposed for drilling were expanded to include additional areas not included in the 1992 study area. As a result, the study area boundaries were extended in 1993 to include a 1,120-km^2 block of the Kuparuk Uplands that adjoined the southeastern portion of the 1992 study area and a 210-km^2 area that included the mouth of the Itkillik River; we conducted surveys for the focal species throughout the expanded study area (Smith et al. 1994). In 1994, we surveyed a 478-km^2 area consisting of just the delta for eiders only (Johnson 1995). In 1995 and 1996, ARCO proposed specific sites for potential facilities and infrastructure, so the wildlife study area encompassed those proposed sites, while the entire delta was maintained as the core area for evaluating regional-scale distributions of wildlife (Figure 1; Johnson et al. 1996).

The Colville River has two main distributaries: the Nechelik Channel and the East Channel. These two channels together carry about

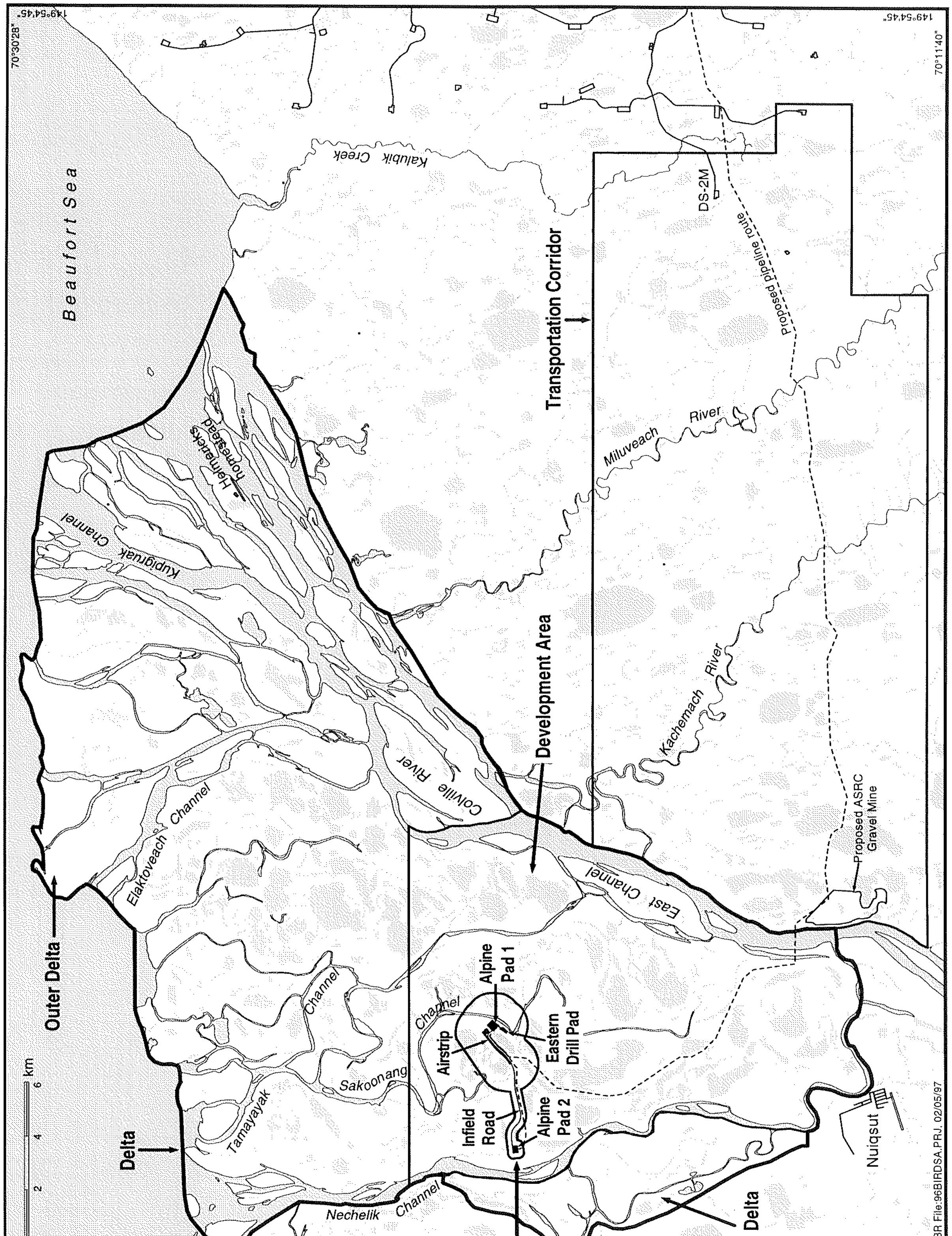

Figure 1. Survey area boundaries for the wildlife studies on the Colville River Delta and proposed Transportation Corridor, Alaska, 1996.

90% of the water passing through the delta during spring floods and 99% of the water after those floods subside (Walker 1983). Several smaller distributaries branch from the East 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-centered polygons (Walker 1983).

The East Channel is deep and flows under ice during winter, whereas the Nechelik and other channels are shallow and freeze to the bottom in winter. Decreased river flow during winter results in an intrusion of salt water into the delta, with the depth of the river at freeze-up being the main factor determining the inland extent of this intrusion (Walker 1983). The Colville River flows through continuous permafrost for its entire length. This extensive permafrost, combined with freezing of the upper layer of surface water in winter, influences the volume, timing, and character of river flow and erosion within the delta (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), so they freeze to the bottom in winter but thaw by June. Deep ponds (>2 m deep) with steep, vertical sides are common on the delta but are uncommon elsewhere on the Arctic Coastal Plain. Lakes >5 ha in size are common and cover 16% of the delta's surface (Walker 1978). Some of those large lakes are deep (to 10 m) and freeze only in the upper 2 m; ice remains on these 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).

Many of the lakes on the delta are "tapped" (Walker 1978), in that they are connected to the river by narrow channels that are caused by thermokarst decay of ice wedges between the river and adjacent lakes and by the migration of river channels (Walker 1978). Channel connections allow water levels in tapped lakes to fluctuate more dramatically than in untapped lakes, resulting in barren or partially vegetated shorelines and may allow salt water to intrude into these lakes. River sediments raise the bottom of these lakes near the channel, exposing previously submerged areas. 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).

Uplands reaching 50 m in elevation dominate the southeastern portions of the Transportation Corridor. These uplands gradually descend northward into flat, low-lying terrain typical of the Arctic Coastal Plain. The landforms and vegetation of this region have been described in detail by Walker et al. (1980).

The delta has an arctic maritime climate. Winters last about 8 months and are cold and windy. Spring is brief, lasting only ~3 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 both over and under the river ice, resulting in flooding that peaks during late May or the first week of June (Walker 1983). Breakup of the river ice usually occurs when flood waters are at maximal levels. Water levels subsequently decrease in the delta throughout the summer, with the lowest water levels occurring in late summer and fall, just before freeze-up (Walker 1983). Summers are cool, with temperatures ranging from -10° C in mid-May to $+15^{\circ}$ C in July and August (North 1986). Summer weather is characterized by low precipitation, overcast skies, fog, and persistent winds, which come predominantly from the northeast. The rarer westerly winds usually bring storms that often are accompanied by high, wind-driven tides and rain (Walker and Morgan 1964).

METHODS

In 1996, we conducted surveys for selected wildlife species to assess their distribution, abundance, and use of specific sites proposed for development. In addition, we conducted habitat studies to investigate what landforms and vegetation types were most important seasonally to wildlife on the Colville Delta and in the adjacent Transportation Corridor. Habitat studies consisted of analyses of habitat selection by a subset of wildlife species; habitat classification and mapping of the Colville Delta and Transportation Corridor were initiated in 1995 (Johnson et al. 1996) and completed in 1996 (Jorgenson et al. 1997). We included data from previous years in our assessments of distribution, abundance, and habitat use, where such data were appropriate.

HABITAT CLASSIFICATION AND MAPPING

The development of a wildlife habitat classification was a three-step process: 1) field surveys of vegetation-soil-hydrology relationships 2) development of an ecological land classification (ELC) that delineated terrain units, surface-forms, and vegetation across the study area, and 3) derivation of a reduced set of wildlife habitat classes by combining ELC types. Detailed methods for the mapping and classification were presented by Johnson et al. (1996). In 1996, the accuracy of the habitat map was assessed by Jorgenson et al. (1997).

The habitat classification was based on those landscape properties that we considered to be most important to wildlife: shelter, security (or escape), and food. These factors may be directly related to the quantity and quality of vegetation, plant species composition, surface form, soils, hydrology, and/or microclimate. We emphasize here that wildlife habitats are not equivalent to vegetation types. In some cases, we combined dissimilar vegetation types because selected wildlife species either did not distinguish between them or used them similarly. Conversely, wildlife may distinguish between habitats with similar vegetation on the basis of relief, soil characteristics, associated fauna, or other factors not reflected in plant species composition. We also emphasize that wildlife habitat classifications for the same region may differ, depending on the wildlife species or species-groups being considered. A comparison of habitat classifications previously used in this region (Johnson et al. 1996: Appendix Table A8) illustrates some of the differences among various systems. In our study, we concentrated on breeding waterbirds that use waterbody and wet- and moist-tundra types and on mammals and upland birds that use shrubland and dry tundra types.

We collapsed 195 ELC class combinations into an initial set of 49 wildlife habitat types that were based on a hierarchical classification of wildlife habitats (Table 1) used in several bird-habitat studies in the nearby Prudhoe Bay Oilfield (Murphy et al. 1989, Johnson et al. 1990, Anderson et al. 1991, Murphy and Anderson 1993). We added several new habitat types (e.g., Aquatic Sedge with Deep Polygons, Deep Open Water with Polygonized Margins, and various Tapped Lake classes) to the original system to recognize habitats unique to the Colville Delta region. We further reduced the initial 49 wildlife habitat types by eliminating types with very small areas (<0.5% of the total area) that had low levels of wildlife use and by combining similar types that had apparently similar levels of use. The combining of habitat types was subjective and incorporated information from previous wildlife investigations in the region (Bergman et al. 1977, Kessel 1979, Martin and Moitoret 1981, Seaman et al. 1981, Troy et al. 1983, Spindler et al. 1984, Meehan 1986, Nickles et al. 1987, Meehan and Jennings 1988, Murphy et al. 1989, Murphy and Anderson 1993) and our knowledge of factors important to the wildlife species under consideration.

HABITAT SELECTION

To assess the importance of various habitats to wildlife on the Colville Delta, we evaluated habitat selection with detailed analyses for selected wildlife species. We based the quantitative analyses of habitat selection by these species on the locations of bird nests, groups of birds, and fox dens observed during aerial and ground-based surveys. For each species, we calculated habitat use for applicable combinations of season (e.g., pre-nesting, nesting, and brood-rearing), year of survey (different years, depending on the species), and area surveyed (Delta or Transportation Corridor). For each combination, we calculated:

1. numbers of adults, nests, young, or dens for each habitat;
2. percent use of each habitat;
3. percent availability of each habitat;
4. selection index; and
5. the probability that use was not proportional to availability.

Percent use was calculated as the percentage of the total number of groups of birds, nests, nesting-colony locations, broods, or dens that were observed in each habitat. Use was calculated from group locations for birds that were in flocks or broods, because the assumption of independence of selection among individuals in the group was not

Table 1. Habitat classification system for the Arctic Coastal Plain of Alaska (modified from Jorgenson et al. 1989).

- **MARINE WATERS**
  - Inshore Water
  - Offshore Water
  - Sea Ice
- **COASTAL ZONE**
  - Nearshore Water
    - Open Nearshore Water (marine)
    - Brackish Water
      - Deep
        - without Islands
        - with Islands
        - with Polygonized Margins
      - Shallow
    - Tapped Lakes (deltas only)
      - Deep
        - Low-water Connection
        - High-water Connection
      - Shallow
        - Low-water Connection
        - High-water Connection
  - Coastal Wetland Complex
    - Salt Marsh
      - Halophytic Sedge
      - Halophytic Grass
      - Halophytic Herb
      - Halophytic Dwarf Willow Scrub
  - Barren
    - Coastal Islands
    - Coastal Beaches
      - Cobble-gravel
      - Sand
    - Coastal Rocky Shores
      - Low
      - Cliffs
    - Tidal Flats
    - Salt-killed Tundra
    - Causeway
- **FRESH WATERS**
  - Open Water
    - Deep Open Water
      - Isolated
        - without Islands
      - with Islands
        - with Polygonized Margins
      - Connected
    - Shallow Open Water
      - without Islands
      - with Islands
      - with Polygonized Margins
  - Rivers and Streams
    - Tidal
    - Lower Perennial
    - Upper Perennial
      - Deep pools
      - Shallow
      - Riffles
      - Falls
    - Intermittent
  - Water with Emergents (shallow, isolated, or connected)
    - Aquatic Sedge Marsh
      - without Islands
      - with Islands
      - with Deep Polygons
    - Aquatic Grass Marsh
      - without Islands
      - with Islands
    - Aquatic Herb
      - without Islands
      - with Islands
  - Impoundment
    - Drainage Impoundment
    - Effluent Reservoir
- **BASIN WETLAND COMPLEXES**
  - Young (ice-poor)
  - Old (ice-rich)
- **MEADOWS**
  - Wet Meadows
    - Nonpatterned
      - Sedge (*Carex, Eriophorum*)
      - Sedge-Grass (*Carex, Dupontia*)
    - Low-relief
    - High-relief (sedge-willow)
  - Moist Meadows
    - Low-relief
      - Sedge-Dwarf Shrub Tundra
      - Tussock Tundra
      - Herb
    - High-relief
      - Sedge-Dwarf Shrub Tundra
      - Tussock Tundra
  - Dry Meadows
    - Grass
    - Herb
- **SHRUBLANDS**
  - Riverine Shrub
    - Riverine Low Shrub
      - Willow
      - Birch
      - Alder
    - Riverine Dwarf Shrub
  - Upland Shrub
    - Upland Low Shrub
      - Mixed Shrub Tundra
      - Willow
      - Alder
    - Upland Dwarf Shrub
      - Dryas
      - Ericaceous
  - Shrubby Bogs
    - Low Shrub Bog
    - Dwarf Shrub Bog
- **PARTIALLY VEGETATED**
  - Riverine Barrens (including deltas)
    - Barren
    - Partially Vegetated
  - Eolian Barrens
    - Barren
    - Partially Vegetated
  - Upland Barrens (talus, ridges, etc.)
    - Barren
    - Partially Vegetated
  - Lacustrine Barrens (shore bottoms, margins)
    - Barren
    - Partially Vegetated
  - Alpine
  - Cliffs (rocky)
  - Bluffs (unconsolidated)
    - Barren (unstable)
    - Partially Vegetated (stable)
  - Burned Areas (barren)
- **ARTIFICIAL**
  - Fill
    - Gravel
      - Barren or Partially Vegetated
      - Vegetated
    - Medium-grained
      - Barren or Partially Vegetated
      - Vegetated
    - Sod (organic-mineral)
      - Barren or Partially Vegetated
      - Vegetated
  - Excavations
    - Gravel
      - Barren or Partially Vegetated
      - Vegetated
  - Structure and Debris

reasonable. For Brant colonies and fox dens, both of which are static in location, we used the cumulative number of locations in the analyses. For all other species, the parameters were calculated for each year surveyed. The availability of each habitat was the percentage of that habitat in the total area surveyed. Except where noted, all habitats were considered available within a survey area. However, where the survey areas differed among species, years, and seasons, the availability of habitats also differed. We used Ivlev's E ([% use – % availability] / [% use + % availability]; Ivlev 1961) for the selection index because it calculates a selection ratio bounded between –1 and 1, with values near 0 indicating that percent use equals percent availability. We calculated the multi-year selection ratios by first pooling the data for all years under consideration, then recalculating Ivlev's E with those pooled data. Separate analyses were calculated for the Delta and Transportation Corridor survey areas for each species except Yellow-billed Loons and Brant, which had only a few observations in the Transportation Corridor; therefore, no analysis was conducted on data from these two species in the Transportation Corridor. In addition to calculating habitat use and selection, we measured the distance (on the digital map) from each location to the nearest waterbody habitat to evaluate the affinity of each species for waterbody types.

We tested for significant habitat selection (use differed proportionately from availability) by conducting Monte Carlo simulations (Haefner 1996) on multi-year data for each species. Each simulation used random numbers (range = 0–100) to choose a habitat from the cumulative frequency distribution of the percent availabilities of habitat. The number of "random choices" in a simulation was equal to the number of nests, dens, or groups of birds from which percent use was calculated. We conducted 500 simulations for each species and summarized the frequency distribution by percentiles. We defined habitat preference (use is disproportionately greater than availability) to occur when the observed use by a species was greater than the 97.5 percentile of simulated random use. Conversely, we defined habitat avoidance (use is disproportionately less than availability) to occur when the observed use was less than the 2.5 percentile of simulated random use. The percentiles were chosen to achieve an alpha level (Type I error) of 5% for a two-tailed test. Habitats with nonsignificant selection (i.e., ≥2.5 and ≤97.5 percentiles) were deemed to have been used approximately in proportion to their availability. The simulations and calculations of percentiles were conducted in a Microsoft® Excel spreadsheet on a personal computer. The number of simulations was determined by limitations on the number of rows that a single spreadsheet had available (~65,000). We conducted one analysis with 1,000 simulations (using more than one spreadsheet) and could detect no significant change in the probabilities of the observed values.

WILDLIFE SURVEYS

For the 1996 wildlife studies, we used both fixed-wing aircraft and helicopters to fly aerial surveys over the Colville Delta and the Transportation Corridor for selected avian and mammalian species (Table 2). We also conducted several ground-based surveys near the proposed Facility Area and ASRC Gravel Mine site. As in previous years, the 1996 avian studies focused on the distribution and abundance of Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, and Brant during different seasons (detailed in the methods for each species). During surveys, we collected additional information opportunistically on other waterbirds, such as White-fronted Geese, Canada Geese, Snow Geese, and Pacific and Red-throated loons. Surveys for mammals concentrated on caribou, arctic foxes, and spotted seals, but we also collected information opportunistically on other species, such as brown bears and muskoxen.

EIDERS

In 1996, we flew aerial surveys during the pre-nesting period and conducted ground-based surveys to search for eider nests and broods (Table 2). For the pre-nesting survey, we used the same methods as in 1994 (Johnson 1995) and 1995 (Johnson et al. 1996), although the survey areas differed in extent. In 1996, we flew surveys over the entire delta and Transportation Corridor. We flew the pre-nesting survey with two observers (one on each side of the plane) and a pilot. The pilot navigated with a Global Positioning System (GPS) and flew east–west transect lines spaced 400 m apart. Each observer visually searched a

Table 2. Descriptions of wildlife surveys conducted on the Colville River Delta and adjacent areas, Alaska, 1996.

Species	Survey Type	Season	Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Area Surveyed
BIRDS								
Eiders	Aerial	Pre-nesting	10, 11, 13 June	C185	0.4	0.4	30–35	Delta
			10, 13, 14 June	C185	0.4	0.4	30–35	Transportation Corridor
	Ground	Nesting	18–25 June	-	-	-	-	Facility Area and ASRC Gravel Mine site
	Ground	Brood-rearing	20–22 July	-	-	-	-	Facility Area and ASRC Gravel Mine site
Tundra Swan	Aerial	Nesting	20–22 June	C185	1.6	1.6	150	Delta and Transportation Corridor
		Brood-rearing	19–21 Aug.	C185	1.6	1.6	150	Delta and Transportation Corridor
		Fall staging	6 Sep.	C185	n/a	n/a	150	Delta and Transportation Corridor
Loons	Aerial	Nesting	27–28 June	C185	n/a	n/a	30–40	Delta and Transportation Corridor
		Brood-rearing	25–26 Aug.	206L	n/a	n/a	30–70	Delta and Transportation Corridor
	Ground	Nesting	18–25 June	-	-	-	-	Facility Area and ASRC Gravel Mine site
		Brood-rearing	20–22 July, 27–28 Aug.	-	-	-	-	Facility Area and ASRC Gravel Mine site
Brant	Aerial	Nesting	19 June	PA18	n/a	n/a	50–80[b]	Portions of the Delta and Transportation Corridor
		Brood-rearing	25 July	PA18	n/a	n/a	75	Portion of Outer Delta
		Fall staging	22 Aug.	C185	n/a	n/a	90	Delta and Transportation Corridor
Other geese	Aerial	Brood-rearing	25–26 July	PA18	0.4	1.6	90	Delta and Transportation Corridor
	Aerial	Fall staging	22 Aug.	C185	0.4	1.6	90	Delta and Transportation Corridor
Other breeding birds	Ground	Nesting	22 June	-	-	-	-	Facility Area
			24–25 June	-	-	-	-	ASRC Gravel Mine site
MAMMALS								
Caribou	Aerial	Calving	2 June	C185	0.8	3.2	90	Colville Delta survey area
			3–4 June	C185	0.8	1.6	90	Colville East survey area
			4 June	C185	0.8	1.6	90	Kuparuk South survey area
			9–10 June	206L	0.8	1.6	90	Kuparuk South survey area
			12–13 June	206L	0.8	1.6	90	Colville East survey area
			13 June[c]	C185	0.4	0.4	90	Colville Delta survey area
		Insect	18 June–25 July	PA18, 206L	1.6	1.6, 3.2	150	Development Area and Transportation Corridor (transect surveys & general reconnaissance)
Foxes	Aerial & ground	Denning	27–30 June, 2 July	206L	1.6	1.6	90	Delta and Transportation Corridor (helicopter survey with stops at dens to assess activity)
	Ground	Denning	10–15 July	-	-	-	-	Delta and Transportation Corridor (evaluation of pup production)
Spotted Seals	Aerial	Late summer	23 Aug.	C185	n/a	n/a	450	Colville R. East Channel and distributaries, south to Itkillik R.

[a] C185 = Cessna 185 fixed-wing airplane; PA18 = Piper "Super Cub" fixed-wing airplane; 206L = Bell "Long Ranger" helicopter.
[b] Colonies were inspected from lower altitudes.
[c] Survey on the delta was conducted concurrently with the eider survey on that date.
n/a = not applicable.

200-m-wide transect, thereby covering 100% of the survey areas. The strip width for this and other transect surveys was delimited visually by tape marks on the windows and wing struts or skids of the aircraft (Pennycuick and Western 1972). We recorded the locations of eiders on 1:63,360-scale USGS maps and used audio tapes to record numbers, species, and sex of eiders and their perpendicular distance from the flight line. The locations of eiders were entered manually into a GIS database for mapping and analysis.

From the data collected during the pre-nesting survey, we calculated the observed number of birds, the observed number of pairs, the indicated number of birds, the indicated number of pairs, and densities (number/km^2) for each study area. Following the USFWS (1987b) protocol, the total indicated number of birds was calculated by first doubling the number of males not in flocks (a flock is defined here as a group of >4 males), then adding this product to the number of males in flocks. The indicated number of pairs was the number of males not in flocks. Density estimates were not adjusted with a visibility correction factor.

We conducted ground-based nest searches using the same techniques as in 1994 and 1995; however, the 1996 survey area was restricted to the vicinity of the proposed facilities and the ASRC Gravel Mine site (Figure 1). Six researchers lived in a temporary camp and used boats from Nuiqsut and a helicopter to access remote areas. We searched on foot all waterbodies and polygonal areas in the Facility Area, the ASRC Gravel Mine site, and selected adjacent areas. Although we primarily searched for Spectacled Eider nests, we also recorded locations of King Eider, Tundra Swan, goose, loon, or other waterbird nests when they were encountered. For each nest, we recorded the species, distance to nearest waterbody, waterbody class, habitat type, and, if the bird flushed, the number of eggs in the nest. During brood-rearing, two to three observers conducted the ground-based survey for eider broods and inspected all waterbodies in the Facility Area and the ASRC Gravel Mine site. We mapped all nest locations on copies of 1:18,000-scale color aerial photographs and added the nest locations found in 1996 to the existing GIS database containing nest locations identified in 1992–1995.

Habitat selection by Spectacled Eiders was analyzed for group locations during pre-nesting and brood-rearing in the Delta and Transportation Corridor survey areas. For analysis of selection during the pre-nesting season, we used locations from aerial surveys in 1993–1996. The pre-nesting survey in 1993 and portions of the brood-rearing survey in 1995 were flown at 50% coverage; all other surveys were flown at 100% coverage. Habitat selection by broods could be calculated only for 1995, the only year we flew aerial surveys during brood-rearing. For all other surveys conducted with coverage that was not representative of the delta or Transportation Corridor (e.g., nesting, when ground-based searches were done only in selected areas), we summarized the percent use of each habitat but did not calculate selection indices.

TUNDRA SWANS

In 1996, we flew one survey for Tundra Swans during each season (nesting, brood-rearing, and fall staging; Table 2). We conducted aerial surveys during nesting and brood-rearing over the entire delta and Transportation Corridor in accordance with USFWS protocols (USFWS 1987a, 1991). We flew east–west transects spaced at 1.6-km intervals in a fixed-wing airplane that was navigated with the aid of a GPS. The two observers (one on each side of the plane) each visually searched 800-m-wide strips while the pilot navigated and scanned for swans ahead of the aircraft. Locations and counts of swans were marked on 1:63,360-scale USGS maps. We recorded nest locations with a GPS and photographed the nests with a 35-mm camera for site verification. The same methods were used for nesting and brood-rearing surveys on the delta in 1993 and 1995 and in the Transportation Corridor in 1988–1993 and 1995 (Smith et al. 1994, Johnson et al. 1996). From 1988 to 1993, surveys in the Transportation Corridor were conducted as part of swan studies in the Kuparuk River Unit (see Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993, 1994). During nesting in 1992, the survey on the delta differed from those of other years, in that it was flown along east-west survey lines spaced 2.4 km apart (Smith et al. 1993). During brood-rearing in 1992, parallel lines oriented northeast-southwest were flown at approximately 2.4-km intervals.

The fall-staging surveys departed from the standard USFWS protocol, because we flew fewer flight lines (spaced 5.4 km apart) and flew at a higher altitude (215 m agl). We diverged from those lines frequently to count swans observed in the distance; we also revisited locations where we had seen swans during previous staging surveys.

We calculated total numbers of swans, nests, and broods and calculated densities for each survey area and season. We estimated nesting success from the ratio of broods to nests counted during aerial surveys of the Colville Delta. The accuracy of these estimates of nesting success can be affected by a number of factors. First, swan broods are less likely to be missed by observers during aerial surveys than are swan nests (see Stickney et al. 1992), thus inflating the estimated nesting success. Second, some broods probably are lost to predation between hatching and the aerial survey, thus deflating estimated nesting success. Finally, swan broods are mobile and can move into or out of a survey area prior to the survey, thus biasing the estimated nesting success in either direction. However, immigration and emigration of broods are less of a problem for estimating nesting success in large, well-defined areas, such as the Delta survey area. Accordingly, we calculated estimates of nesting success only for the delta, and these should be considered only relative indices of annual nesting success.

Habitat selection was calculated for Tundra Swan nests and broods for each year surveyed. Each survey was flown at 100% coverage, so we used the entire Delta and Transportation Corridor survey areas for calculating available habitats. We calculated the selection indices from the locations of each nest or brood and assumed that these locations were independent among years. Although some of the nest sites probably were used in multiple years, we were not able to distinguish these sites objectively from others where nests were close, but not in exactly the same location, in consecutive years. In addition, none of the nest sites was used in all the years that surveys were conducted. Therefore, we conclude that the potential for lack of independence among nest sites has a minimal affect on the selection analysis.

LOONS

In 1996, we conducted a survey from a fixed-wing aircraft for nesting loons and a survey from a helicopter for brood-rearing loons (Table 2). The same methods were used in 1995 (Johnson et al. 1996), whereas in 1992 and 1993 both the nesting and brood-rearing surveys were flown in a fixed-wing aircraft (Smith et al. 1993, 1994). On the Colville Delta, all surveys were flown lake-to-lake, concentrating on lakes ~10 ha or larger in size, including adjacent smaller lakes, but excluding tapped lakes with low-water connections to river channels and brackish water lakes. We used the 10-ha-size criterion in 1995 and in 1996 to concentrate our efforts on Yellow-billed Loons, which typically nest and rear their broods on lakes >10 ha. Sjolander and Agren (1976) found 14 nests near Alaktak, all on lakes 20–150 ha in size, and North and Ryan (1989: derived from Figure 1) found 72% of 25 nests on the Colville Delta occurred on lakes ≥10 ha. Aerial surveys conducted in the Transportation Corridor in previous years indicated that this area was used minimally by Yellow-billed Loons during the breeding season (Johnson et al. 1996). Consequently, in 1996, we surveyed only large lakes with suitable nesting habitat and areas where Yellow-billed Loons had been seen previously. During the nesting season in 1996, we revisited with a helicopter those lakes in the Delta and Transportation Corridor survey areas where Yellow-billed Loons had been sighted on the initial aerial survey but where nests had not been found. We recorded locations of nesting and brood-rearing Pacific and Red-throated loons during all surveys. However, surveys for these two species were not thorough, because we did not systematically search small lakes (<10 ha), which often are used by these species for nesting and brood-rearing.

In the Facility Area in 1996, we conducted intensive searches by helicopter and on foot of all waterbodies for nesting and brood-rearing loons (Table 2) and recorded locations of nests and broods of all three loon species. The ground-based searches in 1996 were conducted similarly to those in 1995. In 1996 only, we conducted ground-based searches during the nesting and brood-rearing seasons at the ASRC Gravel Mine site.

We calculated the total number of adults, nests, broods, and young by season for all three species of loons. We calculated density (number/km^2) only for Yellow-billed Loons because our survey coverage for Pacific and Red-throated loons was inadequate for estimating density. We present data for survey areas within the Colville Delta and the Transportation Corridor, that is, the Development Area, Facility Area, Outer Delta, and ASRC Gravel Mine site. For the Outer Delta, we analyze and report data from only that portion of the total area that was surveyed in both the nesting and brood-rearing seasons for 1993, 1995, and 1996. Habitat selection by nesting and brood-rearing Yellow-billed Loons was analyzed only for the Delta survey area because the sample size was too small for analysis in the Transportation Corridor. We calculated selection indices for nests found in 1993, 1995, and 1996 and for broods found in 1995 and 1996.

BRANT AND OTHER GEESE

In 1996, we flew aerial surveys for Brant during nesting, brood-rearing, and fall staging (Table 2). Methods were similar to those used since 1989 for surveys of Brant between the Colville and Sagavanirktok rivers (Ritchie et al. 1990, Anderson et al. 1997). The survey area extended up to 15 km inland from the coast on the delta and up to 20 km inland in the Transportation Corridor. Nesting surveys were flown lake-to-lake along a predetermined path that included known colony sites and lakes with numerous islands (i.e., potential colony sites). We did not survey the Anachlik Colony complex (nesting colonies at the mouth of the East Channel), specifically to avoid disturbing the large number of nesting birds there (>950 nests; Martin and Nelson 1996). We recorded a nest wherever we saw either a down-filled bowl or an adult in incubation posture. Our aerial counts of Brant and their nests should be considered minimal numbers because incubating Brant are inconspicuous, unattended nests are difficult to see, and the number of passes flown over a colony purposely was limited to minimize disturbance.

During brood-rearing, the aerial survey route followed as closely as possible the shorelines of bays, deltaic islands, and river channels and extended ~10 km inland. We also revisited colonies that were identified as being active during the nesting survey, to investigate their possible use by broods. To survey fall-staging Brant, as well as other geese, we flew a systematic survey at 100 m agl on east–west flight lines that were 1.6 km apart (Table 2). One observer searched a strip 400 m wide, thereby achieving 25% coverage of the survey area.

We tallied the number of Brant observed during nesting and brood-rearing surveys and compared those totals to numbers observed in previous years. The annual nest counts do not include the Anachlik Colony complex. During brood-rearing, large groups of birds were photographed, and counts were made later from the photos.

Habitat selection values were calculated only for that portion of the Outer Delta that was surveyed annually. Because Brant use the same nesting sites each year, we based habitat selection on the cumulative number of nesting colony (≥1 nest) locations observed for all years surveyed (1992, 1993, 1995, and 1996). We analyzed selection from the number of nesting colonies in each habitat, without regard to the number of nests in each colony (although we report the number of nests for each habitat), because individual nest locations in colonies are not likely to be independent of each other.

In 1996, we flew a systematic brood-rearing survey in late July specifically to count White-fronted Geese; the methods and coverage were similar to those described for the fall-staging survey for Brant. During a similar systematic survey in August (fall staging), we counted White-fronted and Canada geese, and Brant. In addition to these surveys, we opportunistically collected information on geese during surveys for eiders, swans, and loons.

OTHER BIRDS

During the 1996 aerial and ground-based surveys, we opportunistically collected data on birds other than the focal species. Special emphasis was placed on gathering information from the Facility Area and the ASRC Gravel Mine site. During various surveys for focal species, we recorded the location of nesting, brood-rearing, and staging ducks, jaegers, gulls, terns, and ptarmigan, and noted the occurrence of nesting shorebirds and passerines.

We also conducted an intensive breeding-bird survey of all species at the proposed locations of the airstrip, processing facility, drill pads, and infield road (22 June 1996), and at the proposed excavation pit and overburden pile of the ASRC Gravel Mine (24–25 June 1996). This intensive survey required 3–7 researchers to search the footprint area by walking in a zig-zag path ~10 m apart. We recorded all species encountered on the ground or in flight but did not concentrate on finding nests, because most nests either had hatched or were in the later stages of incubation at the time of our survey. We used digitized versions of the proposed footprints overlaid on a satellite image of the area to define the boundaries of our search areas.

CARIBOU

Calving Season

During the 1996 calving season (late May–mid-June), we conducted aerial surveys in survey areas that encompassed the Colville Delta, the Transportation Corridor, other areas north and south of the Transportation Corridor, and the area south of the Kuparuk Oilfield. The objectives of these surveys were to monitor the distribution and abundance of caribou near the peak and end of the calving season.

We flew calving surveys during 2–5 and 9–13 June (Table 2). The first survey, scheduled to coincide with the expected peak of calving activity, covered three areas surveyed in 1993 (Smith et al. 1994) and 1995 (Johnson et al. 1996): Colville Delta, Colville East (as expanded in 1995), and Kuparuk South (called Kuparuk Inland by Johnson et al. [1996]); these survey areas are depicted on Figure 24. The second survey was scheduled near the end of calving, to coincide with the timing of comparable surveys by the Alaska Department of Fish and Game (ADFG) in previous years, and was coordinated with a calving survey in the adjacent Kuparuk Field survey area (Lawhead et al. 1997). The Colville Delta survey area was omitted from the second survey because caribou were recorded during the pre-nesting survey for eiders, which was conducted at a lower altitude and closer transect spacing (therefore constituting a census) than the usual calving surveys. The Kuparuk South survey area was shifted 1.6 km (1 mi) south for the second survey to eliminate overlap with the Kuparuk Field survey area.

As in previous years, we surveyed systematically spaced strip transects during the calving season. A pilot and two observers in a fixed-wing aircraft (first survey) or helicopter (second survey) followed north–south-oriented transect lines. A GPS receiver was the principal means of navigation, supplemented by periodic checks of location and ground elevation on USGS topographic maps. Transects were spaced at intervals of 1.6 km (1 mi) in the Colville East and Kuparuk South survey areas and at 3.2 km in the Colville Delta survey area. Each observer viewed a 400-m-wide strip on opposite sides of the aircraft, resulting in 50% coverage of the survey area at 1.6-km spacing and 25% coverage at 3.2-km spacing. We tallied the number of caribou observed in 3.2-km-long segments of transect lines that followed section lines on topographic maps. Caribou were classified either as "large" animals (adults and yearlings) or as calves.

We estimated population numbers for total ("large" + calves) caribou and for calves within the survey areas using formulas modified from Gasaway et al. (1986). The counts of total caribou and calves from each survey were extrapolated (using the ratio of the entire survey area to the actual area surveyed on transects) to estimate the "observable" population (i.e., the population for the entire survey area, unadjusted for sightability). In text, estimates are followed by the 80% confidence interval (CI); for example, an observable population estimate of 70 ± 30 means that the 80% CI ranges from 40 to 100 caribou.

During the calving season, we also sampled the sex and age composition (cows, calves, yearlings, bulls, and unclassified "large" caribou) of caribou groups in the Kuparuk South survey area on 14 June to estimate initial production of calves. Helicopter speed ranged from 40 to 125 km/h (slowing frequently to observe groups closely), and altitude ranged from 30 to 50 m agl, with two observers viewing from opposite sides of the helicopter. Transect lines from the calving surveys generally were followed on this survey, but alternating lines were surveyed to avoid duplicate counts of caribou among successive transects. Deviations from transects were made only when it was necessary to examine groups closely.

Insect Season

We conducted surveys during the insect season (the time of year when mosquitoes and oestrid flies harass caribou) to document the movements and abundance of caribou in the Delta (primarily the Development Area and Western Delta) and Transportation Corridor survey areas. Distribution and movements were monitored by an observer stationed at ARCO's Kuparuk facility from 26 June to 25 July; additional observations were provided by biologists working on other projects. Daily observations recorded weather conditions, levels of insect harassment, and the movements by caribou, which were tracked primarily by aerial surveys. Supplemental observations from a truck were used to monitor the general movements of caribou in the vicinity of the oilfield road system.

Insect-season surveys employed a combination of systematic strip-transect surveys specifically for caribou and nonsystematic observations during other wildlife surveys (e.g., for fox dens and waterbird broods). For the systematic transect surveys, we usually used a helicopter, that carried one observer and the pilot, although some surveys in the second half of July were conducted with a fixed-wing airplane (Table 2). We surveyed 1.6-km-wide, east–west-oriented strip transects and viewed out to 0.8 km on each side of the aircraft to achieve complete coverage of the transect strip. This broad strip width was sufficient for detecting most groups of caribou, but single animals and very small groups (<5 animals) probably were undersampled. Survey intensity varied among surveys, depending on the prior distribution and movements of caribou in the study area; daily observations allowed us to keep close track of caribou movements. We recorded the location and number of caribou groups on USGS 1:63,360-scale maps, and recorded group type (cow/calf-dominated, bull-dominated, mixed sex/age); when possible, we determined age and sex composition of groups (bull, cow, yearling, calf, and unknown).

FOXES

We evaluated the distribution and status of arctic and red fox dens on the Colville Delta and Transportation Corridor in 1996 with both aerial and ground-based surveys (Table 2). We examined known dens in and near the Facility Area while conducting nest searches during 18–23 June. We conducted an aerial survey by helicopter in the Transportation Corridor (the first complete survey of this area) on 27 June and in the Development Area and Western Delta on 28 June. This survey followed east–west-oriented transect lines spaced 1.6 km apart (the same transects as the caribou insect-season survey). Transect strip width was 0.8 km on each side of the aircraft, resulting in complete coverage of the survey area. The pilot navigated using a topographic map and GPS receiver, deviating from the transect lines to check potential den sites. Additional observations on 29 June–3 July employed a helicopter to check the status of known dens and to search for other dens along drainages, banks of drained lake basins, and on mounds and pingos. We landed at each den site to determine its status.

During ground-based inspections, we evaluated evidence of use by foxes and confirmed the species using the den. Fox sign evaluated to determine den status included the presence or absence of adult and pup foxes; presence and appearance of droppings, diggings, and tracks; trampled vegetation; shed fur; prey remains; and predator sign (e.g., pup remains; following Garrott 1980). We classified dens into three categories (following Burgess et al. 1993):

1. natal dens—sites at which young were whelped, characterized by abundant adult and pup sign early in the current season;
2. secondary dens—sites not used for whelping, but used by litters moved from natal dens later in the season (determination made from sequential visits or from amount and age of pup sign); and
3. inactive dens—sites with either no indication of use in the current season or those showing evidence of limited use for resting or loafing by adults, but not inhabited by pups.

Because foxes commonly move pups from natal dens to secondary dens, repeated observations during the denning season are needed to classify den status with confidence. We expended more effort in 1996 than in previous years to determine den status. Based on our initial assessment of den activity, ground visits during 10–15 July were devoted to counting pups at as many active dens as possible. Observers were dropped off by helicopter at suitable vantage points several hundred meters from den sites, from which they conducted observations with binoculars and spotting scopes over periods of 3–5 hours;

observations usually were conducted early and late in the day, to correspond with active periods of foxes.

Habitat selection indices for foxes were calculated by using the total number of dens located for both arctic and red foxes (during 1992, 1993, 1995, and 1996). Our measure of habitat availability was the total area of all terrestrial habitats; waterbodies were omitted because they cannot be used for fox dens. In the selection analysis, no distinction was made between active (natal or secondary) and inactive dens, because den status can change annually.

OTHER MAMMALS

Incidental observations of grizzly bears and muskoxen were recorded during aerial and ground-based surveys for waterbirds, caribou, and fox dens. On 5 June 1996, we flew a reconnaissance (nonsystematic) survey specifically for muskoxen in the uplands east of the Itkillik River with a fixed-wing airplane. Information on grizzly and polar bear dens was assembled from the literature and from communications with agency biologists (S. Amstrup, USGS Biological Resources Division, Anchorage; R. Shideler, ADFG, Fairbanks).

We flew one survey specifically for spotted seals on the Colville Delta on 23 August 1996, in a fixed-wing airplane at ~450 m agl. We surveyed the eastern channels of the delta, including the Elaktoveach, Kupigruak, and East channels, from the confluence of the Itkillik River downstream to the ocean, as well as several offshore islands. The pilot and single observer scanned for seals in the water or hauled out on river bars and islands. The flight path followed the channels and stayed on one side to optimize visibility. We flew multiple passes over wider portions of channels to ensure complete coverage of the area surveyed. The observer used binoculars to scan distant objects on spits, sandbars, or in the water.

RESULTS AND DISCUSSION

HABITAT CLASSIFICATION AND MAPPING

We reduced 195 classes (terrain unit, surface-form, and vegetation combinations; see Johnson et al. 1996) identified by the ecological land classification to a set of 24 wildlife habitat types for the Delta and Transportation Corridor survey areas (Figure 2, Table 3). This aggregation resulted in 12 waterbody, 10 terrestrial, and 2 wetland-complex types. The habitats are described in Appendix Table B1, and a list of plant taxa found within them are reported in Johnson et al. (1996).

The large differences in availability of habitats between the Delta and the Transportation Corridor survey areas reflected differences in marine and riverine processes between the two areas (Figure 2, Table 3). On the delta, the most abundant habitats were Wet Sedge-Willow Meadow (18% of the total area), River or Stream (15%), Barrens (14%), and Tidal Flat (10%). Other habitats that were less abundant but were unique to the delta included Brackish Water (1%), Tapped Lake with Low-water Connections (4%), Salt Marsh (3%), Salt-killed Tundra (5%), and Aquatic Sedge with Deep Polygons (2%). The most abundant habitats in the Transportation Corridor were Moist Tussock Tundra (28% of the total area), Moist Sedge-Shrub Meadow (25%), and Deep Open Water without Islands (9%).

Basin Wetland Complexes were particularly important features of the Transportation Corridor, where they included a variety of moist, wet, and aquatic habitats. In our usage, Basin Wetland Complexes are portions of thaw-lake basins that delineate areas containing a complex mosaic of habitat patches, components of which were below the scale of mappable units (<0.25 ha for waterbody habitats and <0.5 ha for terrestrial habitats). Most habitats within thaw-lake basins, however, were large enough to map as distinct, rather homogenous types (e.g., emergent grass, shallow lakes). Therefore, Basin Wetland Complexes are not strictly equivalent to thaw-lake basins, so the areas calculated for Basin Wetland Complexes represent only a small portion of the total area covered by thaw-lake basins. Although the total area of thaw-lake basins could be calculated from the ELC terrain unit classifications (old and young thaw basins plus the surface area of waterbodies within the basins), the larger thaw-basin concept was not used because it involves classifying ecosystems at a different scale, and there are a wide variety of stages in thaw-basin evolution that could confound analyses of habitat use.

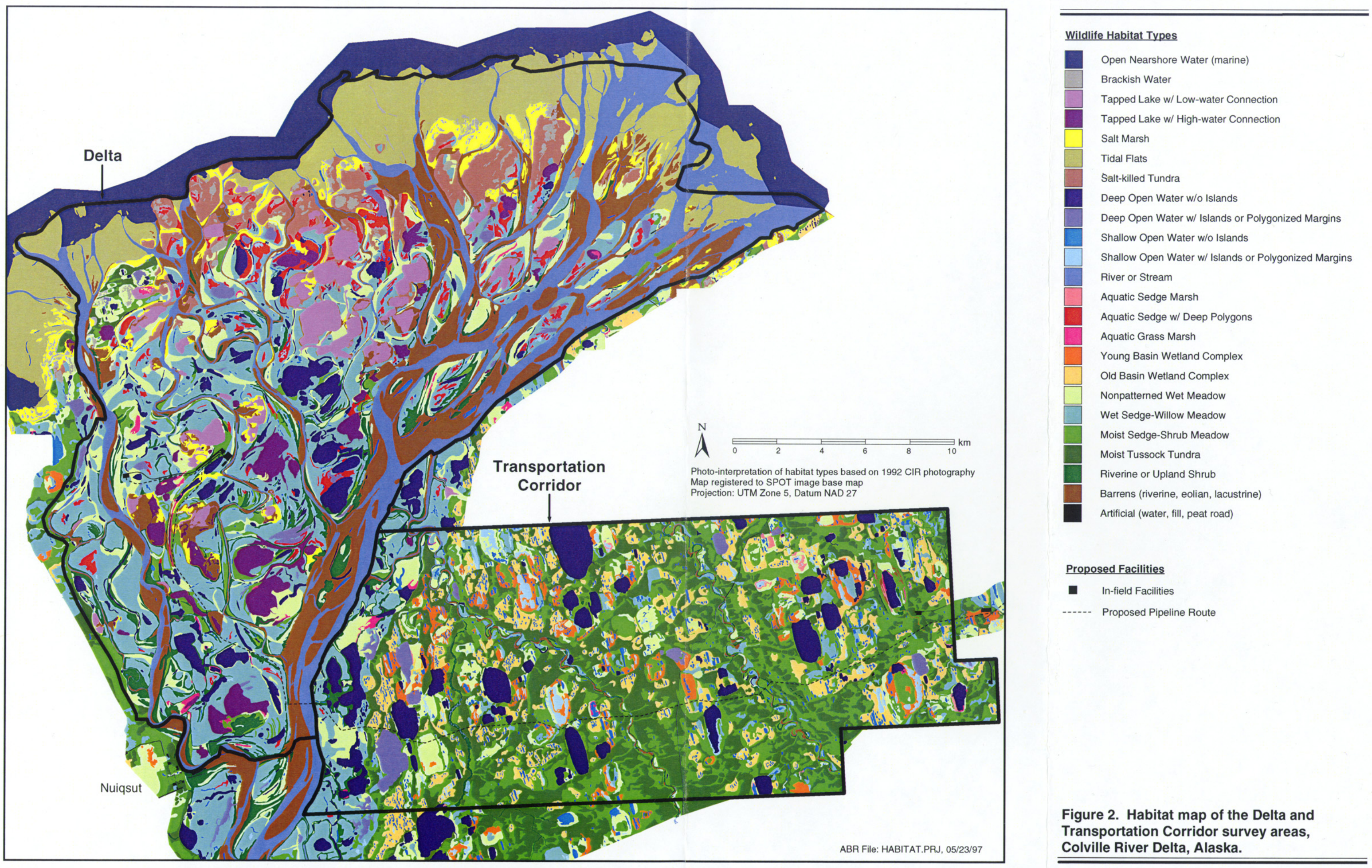

Figure 2. Habitat map of the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska.

Table 3. Availability of wildlife habitat types in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1996.

Habitat	Delta		Transportation Corridor	
	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)
Open Nearshore Water (marine)	10.46	1.9	0	0
Brackish Water	6.50	1.2	0	0
Tapped Lake w/ Low-water Connection	21.42	3.9	0	0
Tapped Lake w/ High-water Connection	20.36	3.7	0.10	<0.1
Salt Marsh	16.73	3.0	0	0
Tidal Flat	55.90	10.1	0	0
Salt-killed Tundra	25.63	4.6	0	0
Deep Open Water w/o Islands	23.31	4.2	30.76	9.0
Deep Open Water w/ Islands or Polygonized Margins	5.13	0.9	6.52	1.9
Shallow Open Water w/o Islands	2.32	0.4	10.84	3.2
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0.1	7.36	2.1
River or Stream	81.76	14.8	2.30	0.7
Aquatic Sedge Marsh	0	0	0.97	0.3
Aquatic Sedge w/ Deep Polygons	13.58	2.5	0.03	<0.1
Aquatic Grass Marsh	1.37	0.2	0.65	0.2
Young Basin Wetland Complex	<0.01	<0.1	14.23	4.1
Old Basin Wetland Complex	0.01	<0.1	35.59	10.4
Nonpatterned Wet Meadow	41.98	7.6	24.47	7.1
Wet Sedge-Willow Meadow	102.23	18.5	19.87	5.8
Moist Sedge-Shrub Meadow	13.10	2.4	84.66	24.7
Moist Tussock Tundra	2.49	0.5	94.60	27.6
Riverine or Upland Shrub	27.40	5.0	7.74	2.3
Barrens (riverine, eolian, lacustrine)	79.01	14.3	1.93	0.6
Artificial (water, fill, peat road)	0.02	<0.1	0.47	0.1
Total	551.25	100	343.11	100

Because of our interest in reducing the number of habitats to facilitate analysis and presentation, some habitats may include some rather dissimilar ecological land classes. For example, the Riverine and Upland Shrub class combined tall willows on the floodplains with *Dryas* tundra on upland ridges, because the *Dryas* tundra covered a very small total area. Similarly, several ELC classes with different surface-forms were combined into one habitat type (e.g., Wet Sedge-Willow Meadow combined areas of high and low density polygons). A cross-reference between our habitat classes and other wildlife habitat classifications that have been used on the Arctic Coastal Plain was presented by Johnson et al. (1996).

EIDERS

BACKGROUND

Spectacled Eiders are uncommon nesters (i.e., they occur regularly but are not found in all suitable habitats) on Alaska's Arctic Coastal Plain that tend to concentrate around large river deltas (Johnson and Herter 1989). Derksen et al. (1981) described them as common breeders in the National Petroleum Reserve–Alaska (NPR–A), but uncommon east of there at Storkersen Point. Spectacled Eiders arrive on the Colville Delta in early June, and the first nest dates in different years and areas have ranged from 8 to 24 June (Simpson et al. 1982, North et al. 1984b, Nickles et al. 1987, Gerhardt et al. 1988). Male Spectacled Eiders leave their mates and nesting areas after incubation begins

(Gabrielson and Lincoln 1959, Kistchinski and Flint 1974, TERA 1995). The latest record of Spectacled Eiders on the Colville Delta is 28 August (Gerhardt et al. 1988).

King Eiders nest in high densities in the Prudhoe Bay area (Troy 1988) and Storkersen Point (Bergman et al. 1977), but densities appear to decline west of the Colville River (Derksen et al. 1981). On the Colville Delta, they are common visitors but uncommon or rare nesters (Simpson et al. 1982, North et al. 1984b). King Eiders occur frequently in flocks on open channels and waterbodies in early June, after Spectacled Eiders have dispersed to nesting habitats (Johnson 1995); thus, King Eiders possibly arrive on the delta slightly later and/or they use the delta as a staging area before moving to nesting areas farther east.

Common Eiders are rare on the Colville Delta (Simpson et al. 1982, Renken et al. 1983, North et al. 1984b), and recent records of Steller's Eiders east of Point Barrow are scant (Johnson and Herter 1989). Five Steller's Eiders were seen on the delta on 10 June 1995, but they were not relocated on subsequent visits (J. Bart, Boise State University, pers. comm.).

DISTRIBUTION AND ABUNDANCE

Pre-nesting

The distribution of both Spectacled and King eiders in 1996 was similar to that recorded on surveys flown in 1993–1995 (Figures 3 and 4), and to the sightings made on smaller study plots in 1992 (Smith et al. 1993). Spectacled Eiders were more numerous in the Delta survey area than in the Transportation Corridor, whereas King Eiders were more numerous in the Transportation Corridor. In five years of aerial surveys, we observed only one pair of Common Eiders, a pair seen on the coastline of the delta in 1992.

Although our pre-nesting survey in 1996 was conducted on the same dates as in the past (10–14 June), its timing relative to the peak of arrival of Spectacled Eiders on the delta was later than in previous years. In 1996, we saw no flocks of more than two birds, and we saw fewer Spectacled Eiders than in previous years, suggesting that pairs had dispersed to breeding habitat, and that some males had already left their mates. During pre-nesting, the proportion of groups of Spectacled Eiders that was either singles or pairs was 100% in 1996, 73% in 1995, 85% in 1994, and 82% in 1993. In 1996, as in previous years, we found a higher percentage of single birds and pairs among groups of Spectacled Eiders than among groups of King Eiders. The proportion of King Eider groups that were single birds or pairs was 71% in 1996, 54% in 1995, 78% in 1994, and 67% in 1993.

Other researchers on the Arctic Coastal Plain in 1996 also found the breeding season advanced in the adjacent Kuparuk Oilfield (Anderson et al. 1997) and in Prudhoe Bay (D. Troy, TERA, pers. comm.). Snowmelt occurred earlier than it had in the previous four years, with snow cover essentially gone (0–5%) by the first week of June. We suspect that the lower number of Spectacled Eiders counted in 1996 was largely a result of the advanced seasonal chronology.

Delta—Spectacled and King eiders on the Colville Delta were strongly associated with coastal areas in all years (Figures 3 and 4). During pre-nesting in 1996, groups (singles, pairs, or flocks) of Spectacled Eiders were found no farther than 11 km from the coastline, and the average distance was 4 km (n = 25 groups). From 1993 to 1995, the farthest inland Spectacled Eiders were seen during pre-nesting was 14 km, and the average distance was 4 km (n = 98 groups). Derksen et al. (1981) reported that Spectacled Eiders in the NPR–A were attracted to coastal areas and Kistchinski and Flint (1974) found the highest numbers of Spectacled Eiders in the maritime area on the Indigirka delta, although they estimated that area extended 40–50 km from the sea. King Eiders on the Colville Delta had a similar affinity for the coast: the maximal distance a group was found from the coast between 1993 and 1996 was 14 km, and the mean was 6 km (n = 64 groups).

In 1996, King Eiders were the numerically dominant eider species during pre-nesting surveys on the delta; we counted 59 King Eiders (57%), 41 Spectacled Eiders (39%), and 4 (4%) unidentified eiders (Table 4). The relative species composition on the delta in 1996 was unlike that in 1994 and 1995, when Spectacled Eiders comprised the majority of the eiders seen (Johnson 1995, Johnson et al. 1996). In 1993, however, Spectacled Eiders were the minority species, representing only 44% of all eiders seen (Smith et al. 1994).

Densities of Spectacled Eiders in 1996 declined somewhat from densities measured over

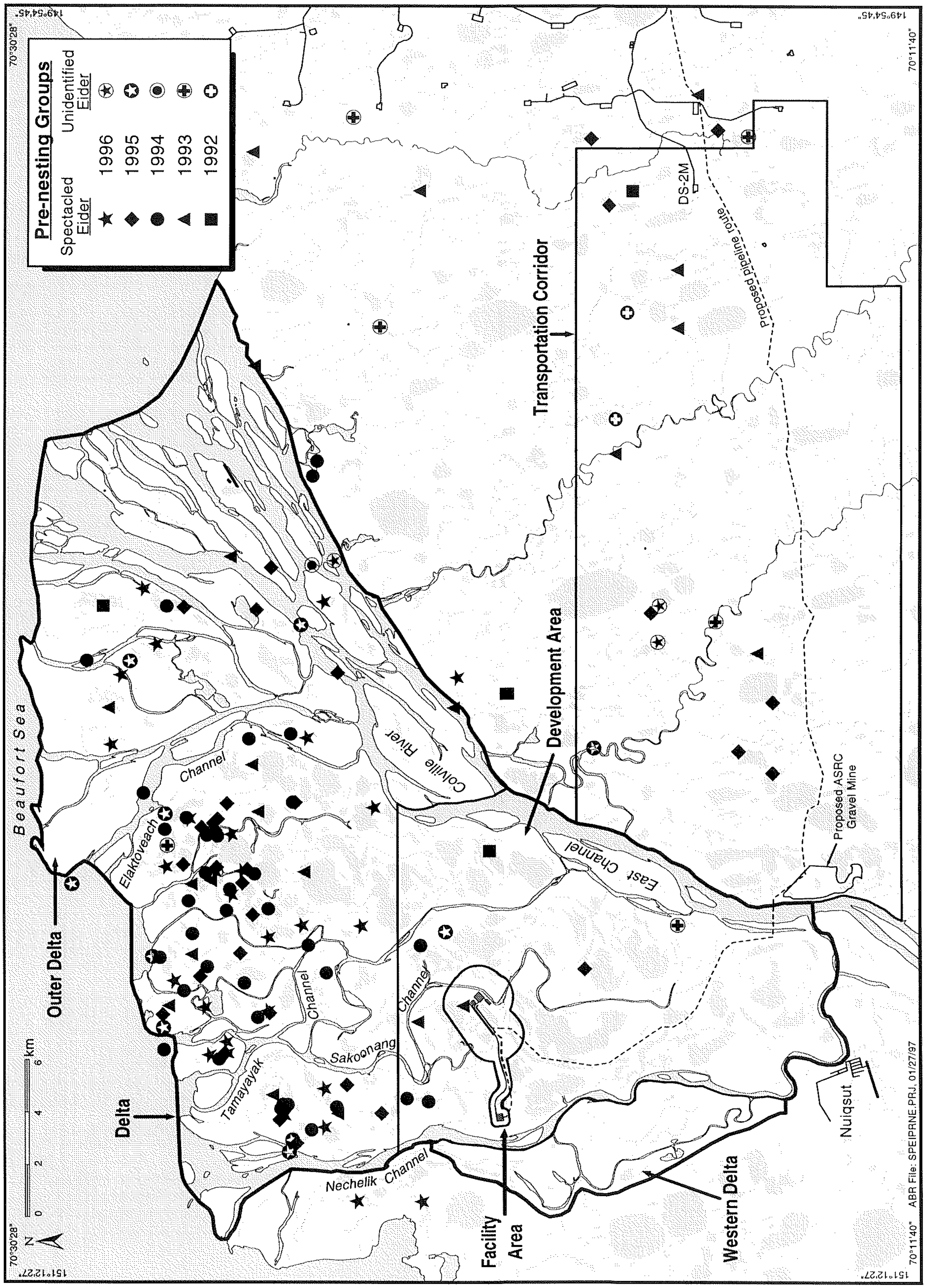

Figure 3. Distribution of Spectacled and unidentified eider groups observed during pre-nesting aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

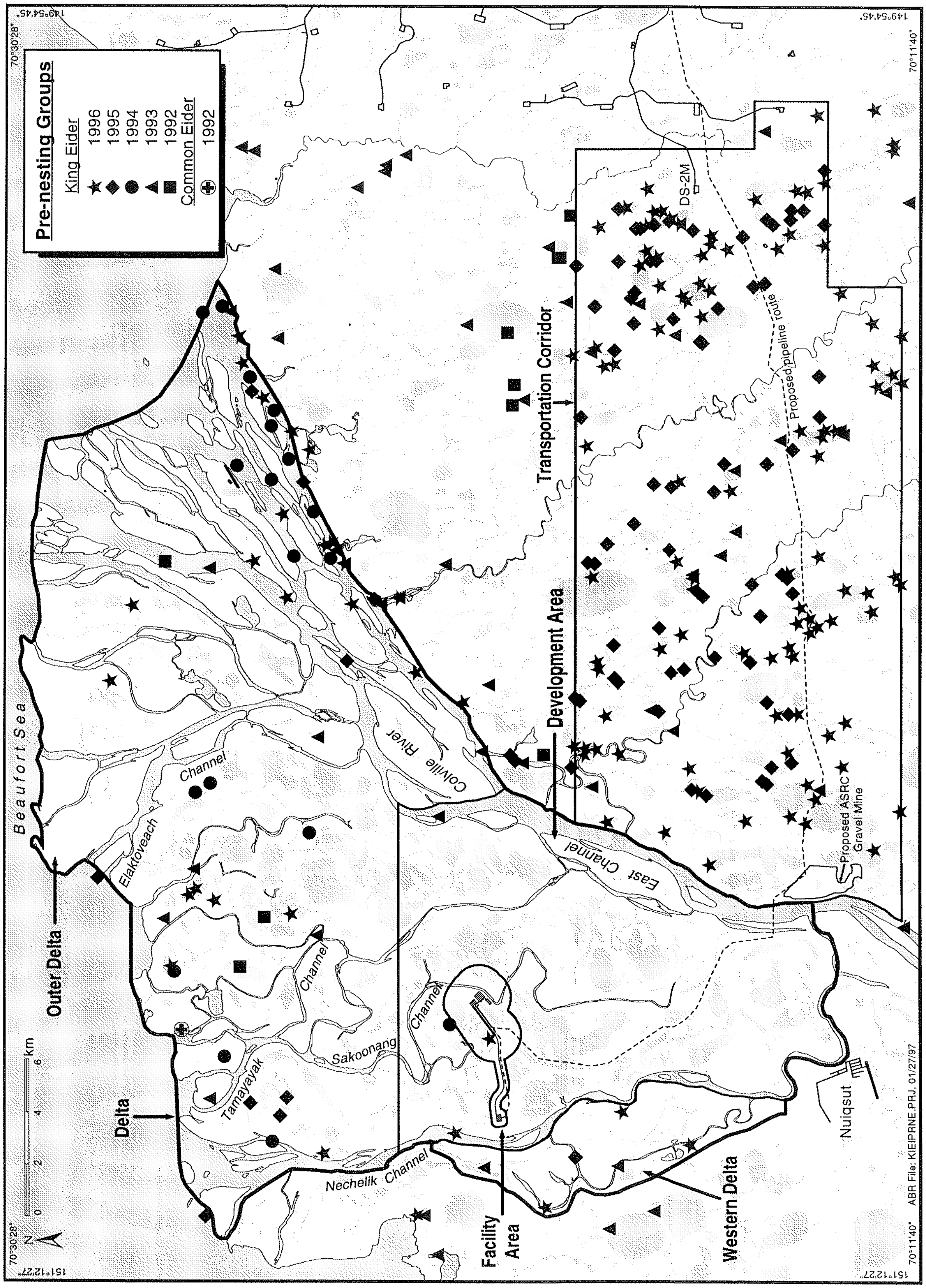

Figure 4. Distribution of King and Common eider groups observed during pre-nesting aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

Table 4. Numbers and densities (uncorrected) of eiders seen during aerial surveys (100% coverage) of the Delta survey area (523 km^2), Colville River Delta, Alaska, 10–13 June 1996.

	Numbers						Density (birds or pairs/km^2)			
			Observed		Indicated		Observed		Indicated	
Species	Males	Females	Total	Pairs	Total[a]	Pairs[b]	Total	Pairs	Total[a]	Pairs[b]
NON-FLYING BIRDS										
Spectacled Eider	20	13	33	13	40	20	0.06	0.02	0.08	0.04
King Eider	22	12	34	12	44	22	0.07	0.02	0.08	0.04
FLYING BIRDS										
Spectacled Eider	5	3	8	3	10	5	0.02	0.01	0.02	0.01
King Eider	18	7	25	7	36	18	0.05	0.01	0.07	0.03
Unidentified eider	2	2	4	2	4	2	0.01	<0.01	0.01	<0.01
NON-FLYING AND FLYING BIRDS										
Spectacled Eider	25	16	41	16	50	25	0.08	0.03	0.10	0.05
King Eider	40	19	59	19	80	40	0.11	0.04	0.15	0.08
Unidentified eider	2	2	4	2	4	2	0.01	<0.01	0.01	<0.01

[a] Total indicated = (number of males not associated with a flock × 2) + number of males in flocks (see USFWS 1987b).
[b] Pairs indicated = number of males not associated with a flock (see USFWS 1987b). Flock = group of >4 males.

the previous three years in which surveys were conducted over the majority of the delta. In 1996, the uncorrected density (i.e., raw counts of birds that were uncorrected for sightability) of flying and non-flying Spectacled Eiders on the Delta survey area was 0.08 birds/km^2 (Table 4). Because of changes in study area boundaries over the years, that density is not strictly comparable to the densities reported for 1993–1995 (Smith et al. 1994, Johnson 1995, and Johnson et al. 1996). Recalculating these densities for an area surveyed in 1994 (478 km^2) that was common to all 4 years of study resulted in estimated densities of 0.09 birds/km^2 in 1996, which was a decrease from 0.13–0.17 birds/km^2 in 1993–1995 (Table 5). In contrast, the density of King Eiders in 1996 (0.11 birds/km^2) in that common survey area was within the range of densities from 1993 to 1995 (0.06–0.14 birds/km^2).

Table 5. Numbers and densities of eiders during pre-nesting in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska. Counts were made from fixed-wing aircraft in early June 1993–1996 (Johnson et al. 1996, this study). Survey areas varied in size among years but are adjusted here to the area common to all four years; therefore, numbers and densities may differ from those reported for the original survey areas. See Figure 1 for survey areas.

		1996			1995			1994			1993[a]		
Area	Species	No.	Birds/ km^2	Area (km^2)	No.	Birds/ km^2	Area (km^2)	No.	Birds/ km^2	Area (km^2)	No.	Birds/ km^2	Area (km^2)
Delta[b]				478			478			478			239
	Spectacled Eider	41	0.09		61	0.13		79	0.17		31	0.13	
	King Eider	53	0.11		30	0.06		58	0.12		34	0.14	
	Unid. eider	4	0.01		15	0.03		4	0.01		3	0.01	
Development Area				126			126			126			63
	Spectacled Eider	0	0		2	0.02		4	0.03		4	0.06	
	King Eider	4	0.03		0	0		1	0.01		5	0.08	
	Unid. eider	0	0		2	0.02		0	0		1	0.02	
Facility Area				9			9			9			4
	Spectacled Eider	0	0		0	0		0	0		2	0.47	
	King Eider	2	0.23		0	0		0	0		0	0	
Outer Delta				352			352			352			176
	Spectacled Eider	41	0.12		59	0.17		75	0.21		27	0.15	
	King Eider	49	0.14		30	0.09		57	0.16		29	0.16	
	Unid. eider	4	0.01		13	0.04		4	0.01		2	0.01	
Western Delta				31			31			0			31
	Spectacled Eider	0	0		0	0		-	-		0	0	
	King Eider	6	0.20		4	0.13		-	-		5	0.16	
Transportation Corridor[c]				274			274			0			137
	Spectacled Eider	0	0		9	0.03		-	-		7	0.05	
	King Eider	162	0.59		240	0.88		-	-		31	0.23	
	Unid. eider	1	<0.01		0	0					1	0.01	
ASRC Gravel Mine site				2			1			0			1
	Spectacled Eider	0	0		0	0		-	-		0	0	
	King Eider	0	0		0	0		-	-		0	0	

[a] Coverage of survey areas in 1993 was 50% of that in 1994–1996.
[b] Although the delta encompassed 551 km^2, only 478 km^2 (not including the Western Delta) were common to four years of surveys.
[c] Although the Transportation Corridor encompassed 343 km^2 in 1996, only 274 km^2 were common to three years of surveys.

Neither the Development Area nor the Facility Area appears to be important to breeding eiders (Figures 3 and 4). During pre-nesting surveys in 1996, we saw no Spectacled Eiders and four King Eiders in the Development Area and only two male King Eiders in the Facility Area. On aerial surveys in previous years, no more than four Spectacled Eiders and five King Eiders were seen in the Development Area (Table 5). Of those eiders, only one pair of Spectacled Eiders was found in the Facility Area.

Of all the areas surveyed, the Outer Delta consistently contained the highest density of Spectacled and King eiders (Table 5). In 1996, the density of Spectacled Eiders in this area (0.12 birds/km^2) was lower than that in 1993–1995 (0.15–0.21 birds/km^2). The density of King Eiders in 1996 (0.14 birds/km^2) was higher than in 1995 (0.09 birds/km^2), but similar to that in 1993 and 1994 (both 0.16 birds/km^2).

Overall, the annual distribution of eiders on the delta was consistent, but abundance and relative species composition varied among years, with survey timing contributing to this variation. Except for declines in densities of Spectacled Eiders in 1996 and King Eiders in 1995, changes in densities among years were minor.

Transportation Corridor—Spectacled Eiders were widely distributed in the Transportation Corridor, but occurred in low densities and farther inland than in the Delta survey area (Figure 3). In 1996, we found no Spectacled Eiders and only one unidentified eider (Table 6). Spectacled Eiders occurred in low numbers in 1993 and 1995 (7 and 9 birds, respectively) and composed a small percentage of the total eiders in the Transportation Corridor (Table 5). The density of Spectacled Eiders declined slightly from 0.05 birds/km^2 in 1993 to 0.03 birds/km^2 in 1995. Spectacled Eiders were found 10 km farther from the coast than they were on the delta; during the two years of pre-nesting surveys that Spectacled Eiders were seen in the Transportation Corridor, all occurred within 24 km of the coast.

King Eiders also were distributed widely throughout the Transportation Corridor, but unlike Spectacled Eiders, they were abundant (Figure 4, Table 6). In 1996, we counted 221 King Eiders in the Transportation Corridor. Densities increased almost four-fold from 1993 to 1995 (0.23 to 0.88 birds/km^2), but declined in 1996 (0.59 birds/km^2; Table 5). We saw especially large numbers of groups in the eastern portion of the Transportation Corridor. King Eiders were found 14 km farther from the coast in the Transportation Corridor than on the delta. The maximal distance pre-nesting King Eiders were seen was 28 km.

Nesting

Delta—The northern portion of the delta, where eiders tended to concentrate during pre-nesting (Figures 3 and 4), also is where eiders appear to nest most commonly (Figure 5). We have not found any documented nest locations that were farther than 13 km from the coast, although we emphasize that nest-search coverage has never been complete on the delta. In 1995 and 1996, when nest searching was restricted to the Facility and Development areas and small portions of the Transportation Corridor (Johnson et al. 1996), no Spectacled Eider nests were found, and only one probable King Eider nest (identification based on color patterns of contour feathers in the nest; Anderson and Cooper 1994) was found in the Development Area in 1996. During 1994, however, Johnson (1995) concentrated searches closer to the coast in areas of historic locations of nests and where pairs were sighted during a pre-nesting aerial survey; those searches found 17 Spectacled Eider nests, 2 King Eider nests, and 1 probable King Eider nest. Smith et al. (1994) used a similar strategy in 1993 with fewer historic locations to search and found two Spectacled Eider nests, five probable Spectacled Eider nests, and one unidentified eider nest. In 1992, when nest searches were restricted to two 10-ha study plots (one on the Outer Delta and one in the Development Area), only one nest was found, which was a Spectacled Eider nest on the Outer Delta (Smith et al. 1993). Eleven Spectacled Eider nests were recorded on the Colville Delta during bird studies conducted from 1981 to 1987 (Renken et al. 1983, Rothe et al. 1983, North et al. 1984b, Nickles et al. 1987, Gerhardt et al. 1988); however, we were able to obtain the location of only four of these nests (M. North, unpubl. data). The earliest records we have found for nests are two Spectacled Eider nests on the Outer Delta in 1958 and four in 1959 (T. Myres, unpubl. data). Four nests were found in 1993 and 1994 on the same lakes as the nests from these earliest records (Figure 5).

Table 6. Numbers and densities (uncorrected) of eiders seen during aerial surveys (100% coverage) of the Transportation Corridor (343 km^2), Colville River Delta, Alaska, 10–14 June 1996.

			Numbers				Density (birds or pairs/km^2)			
			Observed		Indicated		Observed		Indicated	
Species	Males	Females	Total	Pairs	Total[a]	Pairs[b]	Total	Pairs	Total[a]	Pairs[b]
NON-FLYING BIRDS										
Spectacled Eider	0	0	0	0	0	0	0	0	0	0
King Eider	106	58	164	56	212	106	0.48	0.16	0.62	0.31
FLYING BIRDS										
Spectacled Eider	0	0	0	0	0	0	0	0	0	0
King Eider	48	9	57	9	96	48	0.17	0.03	0.28	0.14
NON-FLYING AND FLYING BIRDS										
Spectacled Eider	0	0	0	0	0	0	0	0	0	0
King Eider	154	67	221	65	308	154	0.64	0.19	0.90	0.45
Unidentified eider	1	0	1	0	2	1	<0.01	0	0.01	<0.01

[a] Total indicated = (number of males not associated with a flock × 2) + number of males in flocks (see USFWS 1987b).
[b] Pairs indicated = number of males not associated with a flock (see USFWS 1987b). Flock = group of >4 males.

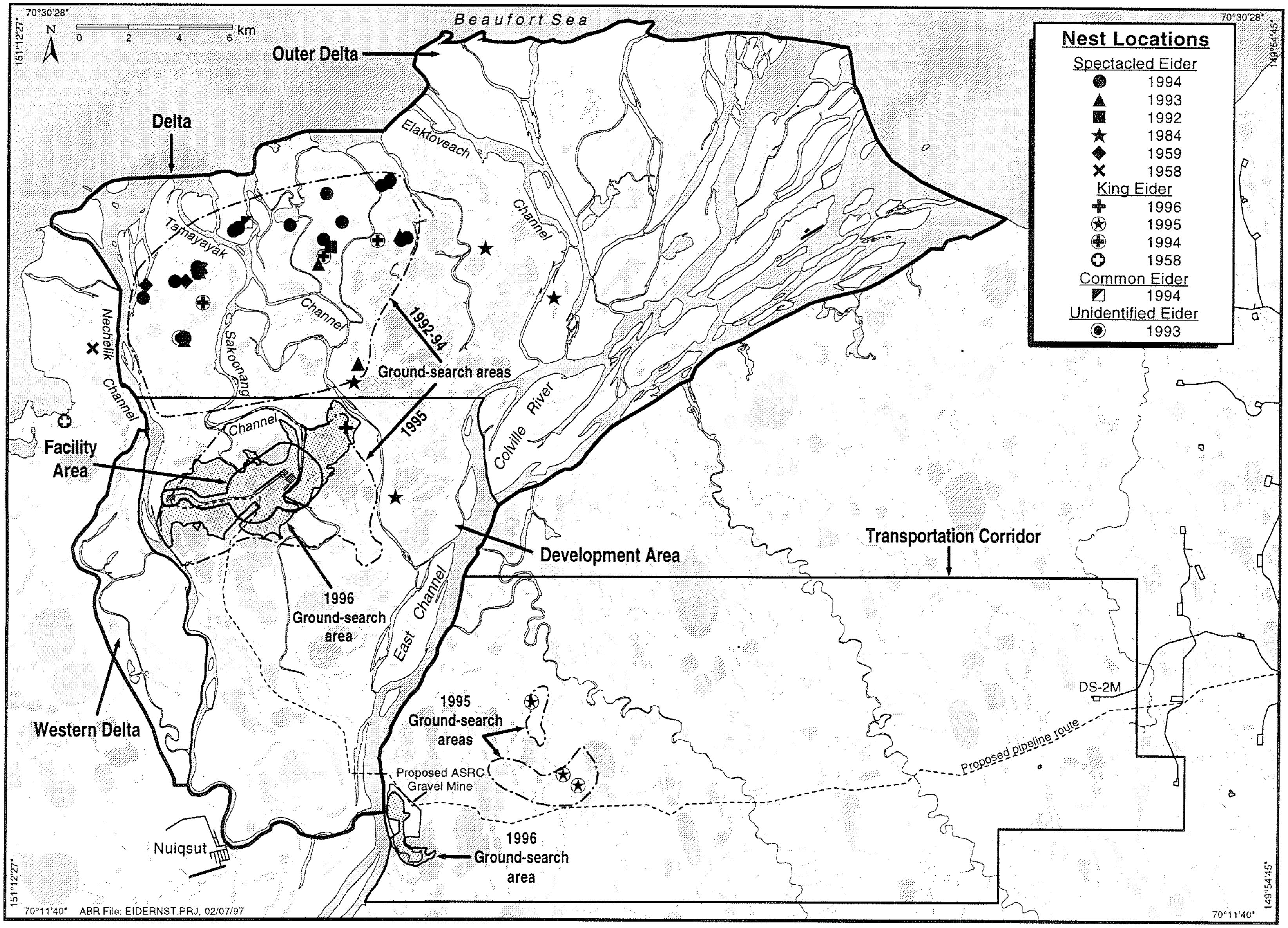

Figure 5. Distribution of eider nests located during ground-based searches in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1958, 1959, 1984, and 1992–1996. Locations are from T. Myres (1958, 1959, unpubl. data), M. North (1984, unpubl. data), Smith et al. (1993, 1994), Johnson (1995), Johnson et al. (1996), and this study.

Possibly because we focused the nest searches on Spectacled Eiders, we found few nests of other eider species on the delta. More probable, though, is that the delta does not support much nesting by other eider species. The same search techniques were used in the Kuparuk oilfield and 54% of the 35 nests found belonged to King Eiders (Anderson et al. 1997). In five years of nest searching on the delta, we have found one Common Eider nest, one unidentified eider nest, and two probable King Eider nests.

Transportation Corridor—In 1996, we searched for eider nests in the Transportation Corridor only at the ASRC Gravel Mine site and found none. During searches for Spectacled Eider nests in 1995, we found three King Eider nests, in areas where nest searches were conducted for the first time (Figure 5). On average, these nests were 1 m from permanent water. However, many more King Eiders undoubtedly nest in the Transportation Corridor, because >150 birds were seen on the pre-nesting surveys in both 1995 and 1996 (Table 5). Furthermore, our nest searches in 1995 and 1996 were conducted in only small portions of the Transportation Corridor, which were not where King Eiders were concentrated during pre-nesting (Figure 4).

Brood-rearing

Delta—In 1996, we saw no broods of Spectacled or King eiders during helicopter or foot surveys of the Facility Area; however, no other areas were searched for broods on the delta. The distribution of broods in 1995 and during previous studies (Figure 6) was similar to the distribution of eiders during pre-nesting surveys (Figures 3 and 4); no broods were observed >13 km from the coast. In 1995, only one Spectacled Eider brood and one King Eider brood were seen during a helicopter survey of the delta, and no eider broods were seen in the Development Area, where survey coverage was 100%. Coverage was 50% for the other survey areas. Brood densities were nearly identical for Spectacled and King eiders on the Delta and Outer Delta survey areas (0.004 and 0.006 broods/km^2, respectively). The number of broods undoubtedly was undercounted because of the cryptic coloration and furtive behavior of female eiders and their young. No brood survey was conducted in 1992 (Smith et al. 1993) or 1994 (Johnson 1995). During ground-based searches for broods in 1993, 11 Spectacled Eider broods with 42 young were found (Smith et al. 1994). One brood with 3 young occurred in the Facility Area, and the remaining 10 broods all occurred in the Outer Delta. Densities reported from helicopter surveys in the Prudhoe Bay area ranged from 0.008 to 0.05 broods/km^2 for 1991–1993 (TERA 1995).

Transportation Corridor—In 1996, we searched only the ASRC Gravel Mine site (on the ground) for eider broods and found none. During helicopter surveys conducted in 1995 in the Transportation Corridor (at 50% coverage), 1 Spectacled Eider brood with 1 young and 51 King Eider broods with 156 young were found, none of which was found at the ASRC Gravel Mine site (Figure 6). We did not conduct brood surveys in that area in previous years. In 1995, King Eider broods were dispersed throughout the Transportation Corridor. Three large creches of King Eiders were observed with 23, 32, and 42 young; average brood size in the corridor was 3.1 young (n = 51, based on number of females).

HABITAT SELECTION

Both Spectacled and King eiders showed strong preferences for waterbodies during all portions of the breeding season, but habitat preferences differed between the two major survey areas as a result of differences in habitat availability. Aquatic Sedge with Deep Polygons, a habitat more typical of the Delta survey area than the Transportation Corridor, was used by more Spectacled Eiders on the delta than any other habitat during pre-nesting and nesting. Young Basin Wetland Complex is nearly absent from the Delta survey area but was preferred by pre-nesting Spectacled Eiders in the Transportation Corridor. King Eiders used River or Stream almost exclusively on the Delta during pre-nesting, but in the Transportation Corridor, where this habitat was less abundant, they primarily used Deep Open Water without Islands and other freshwater lakes.

Pre-nesting

Delta—Based on four years (1993–1996) of aerial surveys on the delta, pre-nesting Spectacled Eiders preferred (i.e., use was disproportionately greater than availability) 5 of 23 habitats that were available, and King Eiders preferred only 1 habitat

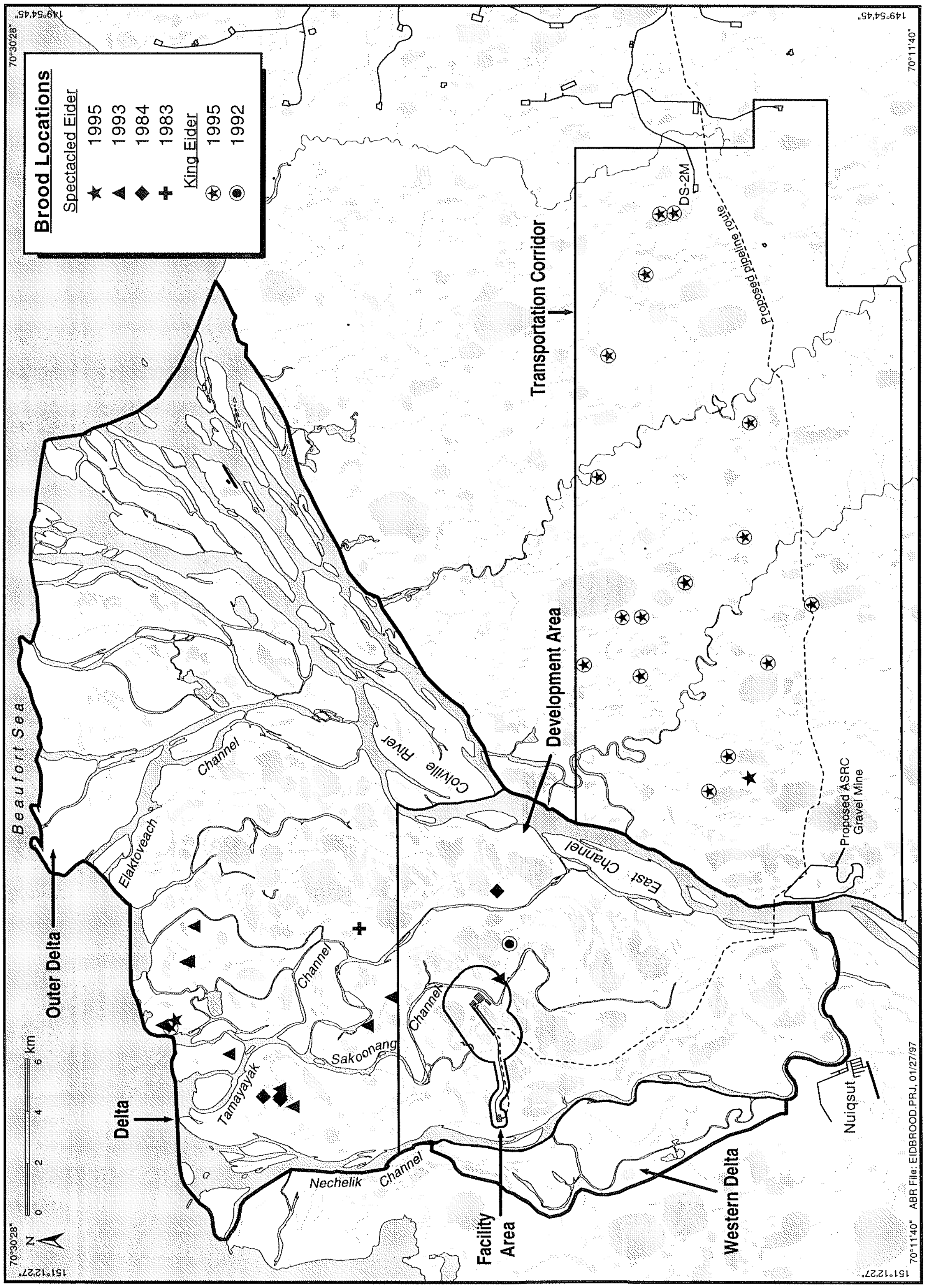

Figure 6. Distribution of Spectacled and King eider broods observed during aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1983, 1984, 1992, 1993, and 1995. Locations are from M. North (1983, 1984, unpubl. data), Smith et al. (1993, 1994), and Johnson et al. (1996).

(Tables 7 and 8). Measures of habitat selection for Spectacled and King eiders in 1996 are reported in Appendix Table C1, and previous years were presented in Johnson et al. (1996). On the delta, Spectacled Eiders preferred Aquatic Sedge with Deep Polygons, Brackish Water, Salt Marsh, Salt-killed Tundra, and Shallow Open Water with Islands or Polygonized Margins (Table 7). All of the preferred habitats except Shallow Open Water with Islands or Polygonized Margins were coastal in distribution (Figure 2). Shallow Open Water with Islands or Polygonized Margins was preferred despite being used by only two groups of Spectacled Eiders; the significant preference for this habitat, however, reflected its low availability (0.1% of the Delta survey area).

The greatest use (in terms of number of groups) during pre-nesting was of Aquatic Sedge with Deep Polygons (16 groups), Salt-Killed Tundra (8 groups), Wet Sedge-Willow Meadow (8 groups), and Salt Marsh (7 groups). River or Stream, Barrens, and Tidal Flat were avoided (i.e., use was disproportionately less than availability), but among these habitats, only Tidal Flat was not used by Spectacled Eiders.

Elsewhere, studies have emphasized the importance of emergent vegetation in waterbodies to eider habitat use. West of the Colville Delta in the NPR–A, Spectacled Eiders were found in shallow *Arctophila* ponds and deep open lakes in June, with shallow *Carex* ponds becoming more important through the summer (Derksen et al. 1981). East of the Colville River in the Kuparuk

Table 7. Habitat selection (pooled among years) by Spectacled Eiders during pre-nesting in the Delta survey area, Colville River Delta, Alaska, 1993–1996 (Johnson et al. 1996, this study). See Appendix Table C1 for 1996 results.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	0	0	1.8	-1.00	ns
Brackish Water	22	7	10.1	1.3	0.78	prefer
Tapped Lake w/ Low-water Connection	12	4	5.8	4.1	0.17	ns
Tapped Lake w/ High-water Connection	8	5	7.2	3.7	0.32	ns
Salt Marsh	13	7	10.1	3.2	0.52	prefer
Tidal Flat	0	0	0	9.8	-1.00	avoid
Salt-killed Tundra	15	8	11.6	4.9	0.40	prefer
Deep Open Water w/o Islands	3	2	2.9	4.2	-0.18	ns
Deep Open Water w/ Islands or Polygonized Margins	2	1	1.4	1.0	0.20	ns
Shallow Open Water w/o Islands	2	1	1.4	0.4	0.54	ns
Shallow Open Water w/ Islands or Polygonized Margins	2	2	2.9	0.1	0.93	prefer
River or Stream	4	1	1.4	14.8	-0.82	avoid
Aquatic Sedge Marsh	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	30	16	23.2	2.6	0.80	prefer
Aquatic Grass Marsh	1	1	1.4	0.2	0.72	ns
Young Basin Wetland Complex	0	0	0	<0.1	-1.00	ns
Old Basin Wetland Complex	0	0	0	<0.1	-1.00	ns
Nonpatterned Wet Meadow	12	5	7.2	7.8	-0.04	ns
Wet Sedge-Willow Meadow	23	8	11.6	18.0	-0.22	ns
Moist Sedge-Shrub Meadow	0	0	0	2.3	-1.00	ns
Moist Tussock Tundra	0	0	0	0.4	-1.00	ns
Riverine or Upland Shrub	0	0	0	4.6	-1.00	ns
Barrens (riverine, eolian, lacustrine)	2	1	1.4	14.7	-0.82	avoid
Artificial (water, fill, peat road)	0	0	0	<0.1	-1.00	ns
Total	151	69	100	100		

[a] Ivlev's E = (use - availability)/(use + availability); calculated from groups only.

[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Table 8. Habitat selection (pooled among years) by King Eiders during pre-nesting in the Delta survey area, Colville River Delta, Alaska, 1993–1996 (Johnson et al. 1996, this study). See Appendix Table C1 for 1996 results.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	9	1	2.8	1.8	0.20	ns
Brackish Water	0	0	0	1.3	-1.00	ns
Tapped Lake w/ Low-water Connection	4	2	5.6	4.1	0.15	ns
Tapped Lake w/ High-water Connection	2	1	2.8	3.7	-0.14	ns
Salt Marsh	0	0	0	3.2	-1.00	ns
Tidal Flat	2	1	2.8	9.8	-0.56	ns
Salt-killed Tundra	5	3	8.3	4.9	0.26	ns
Deep Open Water w/o Islands	0	0	0	4.2	-1.00	ns
Deep Open Water w/ Islands or Polygonized Margins	0	0	0	1.0	-1.00	ns
Shallow Open Water w/o Islands	0	0	0	0.4	-1.00	ns
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0	0.1	-1.00	ns
River or Stream	84	21	58.3	14.8	0.59	prefer
Aquatic Sedge Marsh	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	2	1	2.8	2.6	0.03	ns
Aquatic Grass Marsh	0	0	0	0.2	-1.00	ns
Young Basin Wetland Complex	0	0	0	<0.1	-1.00	ns
Old Basin Wetland Complex	0	0	0	<0.1	-1.00	ns
Nonpatterned Wet Meadow	1	1	2.8	7.8	-0.48	ns
Wet Sedge-Willow Meadow	7	4	11.1	18.0	-0.24	ns
Moist Sedge-Shrub Meadow	0	0	0	2.3	-1.00	ns
Moist Tussock Tundra	0	0	0	0.4	-1.00	ns
Riverine or Upland Shrub	0	0	0	4.6	-1.00	ns
Barrens (riverine, eolian, lacustrine)	1	1	2.8	14.7	-0.68	ns
Artificial (water, fill, peat road)	0	0	0	<0.1	-1.00	ns
Total	117	36	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated from groups only.

[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Oilfield, most of the pre-nesting Spectacled Eiders were found in aquatic grass (*Arctophila)*, basin wetland complex, and aquatic sedge (*Carex*) habitats (Anderson et al. 1996). Bergman et al. (1977) found most Spectacled Eiders at Storkersen Point in deep *Arctophila* wetlands. In Prudhoe Bay, pre-nesting Spectacled Eiders used flooded terrestrial habitats, but preferred ponds with emergent vegetation (both *Arctophila* and *Carex*) and impoundments (Warnock and Troy 1992). Lakes with emergents are not abundant on the Colville Delta; however, Aquatic Sedge with Deep Polygons and Wet Sedge-Willow Meadow, both of which contain polygonal ponds with emergent sedge are probably analogous to the *Carex* ponds described elsewhere, and they were two of the most often used habitats by Spectacled Eiders on the delta.

King Eiders primarily used open-water habitats during pre-nesting (Table 8), which (in combination with a lower proportion of singles and pairs than of flocks [see Distribution and Abundance]) suggested that they had not yet dispersed to breeding areas. The only preferred and the most used habitat was River or Stream: 21 groups (58% of the total) containing 84 King Eiders were counted in this habitat. None of the habitats was significantly avoided by King Eiders on the delta. At Storkersen Point, where King Eiders nest in relatively high densities, they preferred shallow and deep *Arctophila* wetlands, basin complexes, and coastal wetlands during pre-nesting and nearly the same habitats during nesting (Bergman et al. 1977). Nest densities also are high at Prudhoe Bay, where pre-nesting King Eiders used almost all habitats but preferred wet, aquatic nonpatterned; aquatic strangmoor; and water with and without emergents (Warnock and Troy 1992). King Eiders appear to nest in low densities on the delta; therefore, the difference in habitat use found in this study probably reflects their use of the delta as a stopover on their way to nesting habitat elsewhere.

Transportation Corridor—In three years of pre-nesting surveys in the Transportation Corridor (1993, 1995, and 1996), we saw only 11 Spectacled Eiders (6 groups) and none in 1996, suggesting that this area is less important for breeding than is the delta. Two habitats in the Transportation Corridor were preferred by Spectacled Eiders, and both were different from those preferred in the Delta survey area (Table 9). Those two preferred habitats in the Transportation Corridor were Young Basin Wetland Complex (used by 2 groups) and Deep Open Water without Islands (used by 2 groups). Moist Sedge-Shrub Meadow and Nonpatterned Wet Meadow were the only other habitats used by Spectacled Eiders. No habitats were significantly avoided. In the Kuparuk Oilfield, which is adjacent to the Transportation Corridor and probably is more similar in habitat composition to the Transportation Corridor than is the delta, basin wetland complexes followed by aquatic grass and aquatic sedge were the most frequently used habitats by pre-nesting Spectacled Eiders during three years of surveys (Anderson et al. 1996). Neither Aquatic Grass Marsh nor Aquatic Sedge Marsh were abundant in the Transportation Corridor (each occupied <1%

Table 9. Habitat selection (pooled among years) by Spectacled Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993, 1995, and 1996 (Johnson et al. 1996, this study). No Spectacled Eiders were seen in 1996.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	-	-	-	0	-	-
Brackish Water	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0	0	0	<0.1	-1.00	ns
Salt Marsh	-	-	-	0	-	-
Tidal Flat	-	-	-	0	-	-
Salt-killed Tundra	-	-	-	0	-	-
Deep Open Water w/o Islands	4	2	33.3	9.3	0.57	prefer
Deep Open Water w/ Islands or Polygonized Margins	0	0	0	1.7	-1.00	ns
Shallow Open Water w/o Islands	0	0	0	3.3	-1.00	ns
Shallow Open Water w/ Islands or Polygonized Margins	0	0	0	2.3	-1.00	ns
River or Stream	0	0	0	0.7	-1.00	ns
Aquatic Sedge Marsh	0	0	0	0.3	-1.00	ns
Aquatic Sedge w/ Deep Polygons	0	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0	0	0	0.2	-1.00	ns
Young Basin Wetland Complex	3	2	33.3	4.6	0.76	prefer
Old Basin Wetland Complex	0	0	0	10.7	-1.00	ns
Nonpatterned Wet Meadow	2	1	16.7	7.4	0.38	ns
Wet Sedge-Willow Meadow	0	0	0	5.8	-1.00	ns
Moist Sedge-Shrub Meadow	2	1	16.7	23.8	-0.18	ns
Moist Tussock Tundra	0	0	0	26.6	-1.00	ns
Riverine or Upland Shrub	0	0	0	2.4	-1.00	ns
Barrens (riverine, eolian, lacustrine)	0	0	0	0.6	-1.00	ns
Artificial (water, fill, peat road)	0	0	0	0.2	-1.00	ns
Total	11	6	100	100		

[a] Ivlev's E = (use - availability)/(use + availability); calculated from groups only.
[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

of the area), and neither was used by Spectacled Eiders (Table 9).

Unlike Spectacled Eiders, we saw large numbers of King Eiders (382 adults) on the ground in the Transportation Corridor (Table 10). Selection data for 1996 are presented in Appendix Table C2, and previous years were presented in Johnson et al. (1996). In three years of surveys (1993, 1995, and 1996), King Eiders preferred 4 of 18 available habitats (Table 10). Both types of Shallow Open Water without Islands, Deep Open Water without Islands, and River or Stream were significantly preferred. The three most frequently used habitats were Deep Open Water without Islands (27% of all groups), Shallow Open Water without Islands (22%), and Shallow Open Water with Islands or Polygonized Margins (11%). All three habitats that were significantly avoided by King Eiders did receive some use: Moist Sedge-Shrub Meadow (9 groups), Moist Tussock Tundra (5 groups), and Wet Sedge-Willow Meadow (1 group). Although both Moist Sedge-Shrub Meadow and Moist Tussock Tundra were used by multiple groups, they were used less than expected given their large availability (each occupied >20% of the Transportation Corridor). Bergman et al. (1977) found pre-nesting King Eiders preferred different habitats—shallow and deep *Arctophila*, basin complexes, and coastal wetlands—than our study, but this may be explained by differences in study area and differences in scale between the two classifications. For example, coastal wetlands were not present in the Transportation Corridor. Also, because we delineated waterbody types ≥0.25 ha in size, a waterbody could contain

Table 10. Habitat selection (pooled among years) by King Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1993, 1995, and 1996 (Johnson et al. 1996, this study). See Appendix Table C2 for 1996 results.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	-	-	-	0	-	-
Brackish Water	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0	0	0	<0.1	-1.00	ns
Salt Marsh	-	-	-	0	-	-
Tidal Flat	-	-	-	0	-	-
Salt-killed Tundra	-	-	-	0	-	-
Deep Open Water w/o Islands	135	32	26.7	9.1	0.49	prefer
Deep Open Water w/ Islands or Polygonized Margins	9	4	3.3	1.8	0.30	ns
Shallow Open Water w/o Islands	66	26	21.7	3.2	0.74	prefer
Shallow Open Water w/ Islands or Polygonized Margins	44	13	10.8	2.3	0.65	prefer
River or Stream	8	5	4.2	0.7	0.72	prefer
Aquatic Sedge Marsh	2	1	0.8	0.3	0.47	ns
Aquatic Sedge w/ Deep Polygons	0	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0	0	0	0.2	-1.00	ns
Young Basin Wetland Complex	27	5	4.2	4.4	-0.03	ns
Old Basin Wetland Complex	22	9	7.5	10.6	-0.17	ns
Nonpatterned Wet Meadow	27	8	6.7	7.3	-0.05	ns
Wet Sedge-Willow Meadow	2	1	0.8	5.8	-0.75	avoid
Moist Sedge-Shrub Meadow	30	9	7.5	24.2	-0.53	avoid
Moist Tussock Tundra	8	5	4.2	27.0	-0.73	avoid
Riverine or Upland Shrub	1	1	0.8	2.3	-0.47	ns
Barrens (riverine, eolian, lacustrine)	1	1	0.8	0.6	0.17	ns
Artificial (water, fill, peat road)	0	0	0	0.1	-1.00	ns
Total	382	120	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated from groups only.

[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

more than one type; therefore, the Deep Open Water and Shallow Open Water types where we found the most King Eiders could have *Arctophila* margins that were delineated separately. Waterbodies with these combinations of habitats probably would be classified as the deep and shallow *Arctophila* or basin complexes in the classification system of Bergman et al. (1997).

Nesting

Delta—We conducted nesting surveys on the ground because of the difficulty in finding eider nests from the air. Consequently, complete surveys of large portions of habitats in remote areas such as the Colville Delta are time-consuming and logistically difficult. We chose to search areas that either maximized our chances of finding nests (1992, 1993, and 1994) or that included proposed development sites (1995 and 1996). Thus, we did not search a representative sample of habitats from which selection could be calculated; instead, we used the nesting data to summarize habitat associations.

Nesting Spectacled Eiders used many of the same habitats that were preferred during pre-nesting. Between 1992 and 1994, 7 (28%) of 25 nests (total includes 5 nests identified by contour feathers) on the delta were found in Aquatic Sedge with Deep Polygons (Table 11). Other important nesting habitats were Brackish Water, Nonpatterned Wet Meadow, and Salt-killed Tundra, which together contained 52% of all nests. We did not find eiders nesting on water, but those that nested on islands could be classified as nesting in a waterbody habitat at the scale of our digital mapping. Spectacled Eider nests were strongly associated with waterbodies in all habitats in which they occurred, averaging 1 m (range = 0.1–10 m, n = 25) from permanent water (Smith et al. 1994, Johnson et al. 1996). Brackish Water was the nearest waterbody class to 44% of the nests, and Deep Open Water without Islands was the nearest to 20% of the nests (Table 11). We found no nests in 1995 or 1996, when the search was concentrated in the vicinity of the Facility Area (Figure 5).

Similar habitat associations were reported for other locations. Nests on the Yukon-Kuskokwim Delta were an average of 2.1 m from water (Dau 1974). Spectacled Eiders in the Kuparuk Oilfield also nested close to waterbodies: average distances ranged from 2 to 9.6 m over 4 years, and the

Table 11. Habitat use by Spectacled Eiders during nesting in the Delta survey area, Colville River Delta, Alaska, 1992–1996 (Johnson et al. 1996, this study). Nests were found during ground-based searches of selected portions of the study area. No nests were found in 1996.

Habitat	No. of Nests	Use (%)
HABITAT USED		
Brackish Water	5	20
Tapped Lake w/ High-water Connection	1	4
Salt Marsh	1	4
Salt-killed Tundra	3	12
Shallow Open Water w/o Islands	1	4
Aquatic Sedge w/ Deep Polygons	7	28
Nonpatterned Wet Meadow	5	20
Wet Sedge-Willow Meadow	2	8
Total	25	100
NEAREST WATERBODY HABITAT		
Brackish Water	11	44
Tapped Lake w/ High-water Connection	4	16
Deep Open Water w/o Islands	5	20
Deep Open Water w/ Islands or Polygonized Margins	2	8
Shallow Open Water w/o Islands	1	4
Shallow Open Water w/ Islands or Polygonized Margins	2	8
Total	25	100

waterbodies closest to nests were primarily basin wetland complexes, shallow and deep open lakes, and water with emergents (both *Carex* and *Arctophila*) (Anderson et al. 1997). Spectacled Eiders at Storkersen Point preferred the same habitat (deep *Arctophila*) for nesting as they did during pre-nesting (Bergman et al. 1977). In the NPR–A, Spectacled Eiders used shallow *Carex* ponds during summer (Derksen et al. 1981). In the Kuparuk Oilfield, the most common nesting habitats were basin wetland complexes, aquatic grass with islands, low-relief wet meadows, and nonpatterned wet meadows (Anderson et al. 1997). In Prudhoe Bay, nests were found in *Carex* ponds and wet nonpatterned tundra (Warnock and Troy 1992). As mentioned earlier, waterbodies with emergent vegetation are not abundant on the Colville Delta with the exception of Aquatic Sedge with Deep Polygons; therefore, nesting habitat on the delta differs somewhat from areas with abundant *Carex* and *Arctophila* waterbodies.

We found only four King Eider nests (two were identified by contour feathers) during five years of ground-based searches on the delta. Three of these nests were in Aquatic Sedge with Deep Polygons, and the other was in Salt-killed Tundra (Table 12). The distance from permanent water was greater and more variable ($\bar{x}$ = 20 m, range = 0.5–80 m) than for nests of Spectacled Eiders. The nearest waterbodies were both types of Tapped Lakes, Deep Open Water without Islands, and Shallow Open Water without Islands. Anderson et al. (1996, 1997) found King Eiders in the Kuparuk Oilfield nesting near basin wetland complexes, aquatic grass, shallow open water, and aquatic sedge. At Storkersen Point, nesting King Eiders preferred shallow and deep *Arctophila* and coastal wetlands (Bergman et al. 1977). Farther east in Prudhoe Bay, King Eiders used a wider array of non-aquatic habitats than did Spectacled Eiders and preferred moist, wet low-centered polygons and wet strangmoor (Warnock and Troy 1992).

Table 12. Habitat use by King Eiders during nesting in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992–1996 (Johnson et al. 1996, this study). Nests were found during ground-based searches of selected portions of the study area.

Survey Area/Habitat	No. of Nests	Use (%)
DELTA		
HABITAT USED		
Salt-killed Tundra	1	25.0
Aquatic Sedge w/ Deep Polygons	3	75.0
Total	4	100
NEAREST WATERBODY HABITAT		
Tapped Lake w/ Low-water Connection	1	25.0
Tapped Lake w/ High-water Connection	1	25.0
Deep Open Water w/o Islands	1	25.0
Shallow Open Water w/o Islands	1	25.0
Total	4	100
TRANSPORTATION CORRIDOR		
HABITAT USED		
Young Basin Wetland Complex	1	33.3
Nonpatterned Wet Meadow	1	33.3
Moist Tussock Tundra	1	33.3
Total	3	100
NEAREST WATERBODY HABITAT		
Shallow Open Water w/o Islands	1	33.3
Young Basin Wetland Complex	2	66.7
Total	3	100

Transportation Corridor—We found no Spectacled Eider nests in the Transportation Corridor in 1995 or 1996, which were the only years small portions of that survey area (locations where Spectacled Eiders were seen on pre-nesting aerial surveys) were searched for nests. Three nests of King Eiders were found in 1995 in areas where pre-nesting surveys indicated Spectacled Eiders might be nesting. Those nests were in Young Basin Wetland Complex, Nonpatterned Wet Meadow, and Moist Tussock Tundra (Table 12). The nests were an average of 1 m from two types of waterbodies—Young Basin Wetland Complex (2 nests) and Shallow Open Water without Islands (1 nest)—which were similar to the two types that King Eiders most often nested near in the adjacent Kuparuk Oilfield (Anderson et al. 1996, 1997).

Brood-rearing

Delta—We did not conduct aerial surveys for eider broods in 1996. In 1995, only one Spectacled Eider brood was found during the systematic aerial survey conducted on the delta during brood-rearing (Johnson et al. 1996). That brood was in Shallow Open Water with Islands or Polygonized Margins. During ground-based searches in 1993, 10 brood groups (one group contained 2 adults with young) were located (Table 13). Most were associated with Salt-killed Tundra (36% of all locations) and Brackish Water (27%), suggesting a strong attraction to coastal habitats. A similar attraction was exhibited by broods for coastal lakes; most broods (64%) were seen nearest to Brackish Water ($\bar{x}$ = 0.03 km, n = 7). In the NPR–A, Spectacled Eider broods primarily used shallow *Carex* ponds, deep open lakes, and deep *Arctophila* (Derksen et al. 1981). Post-nesting adults without broods at Storkersen Point also preferred deep *Arctophila* (Bergman et al. 1977).

One King Eider brood also was seen on the delta during the aerial survey in 1995. This brood was in Aquatic Sedge with Deep Polygons approximately 0.02 km from Brackish Water (Johnson et al. 1996). During ground-based searches in 1992, one King Eider brood was found in Wet Sedge-Willow Meadow 0.07 km from Deep Open Water without Islands.

Transportation Corridor—One Spectacled Eider brood was found in 1995 during an aerial survey of the Transportation Corridor (Johnson et al. 1996).

Table 13. Habitat use by Spectacled Eiders and distance to nearest waterbody during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1993, 1995, and 1996 (Johnson et al. 1996, this study). Broods were located during both aerial and ground-based surveys. No broods were found in 1996.

Habitat	No. of Brood Groups	No. of Young	Use[a] (%)	Mean Distance to Waterbody[b] (km)
HABITAT USED				
Brackish Water	3	11	27.3	
Salt-killed Tundra	4	22	36.4	
Shallow Open Water w/o Islands	1	3	9.1	
Aquatic Grass Marsh	1	4	9.1	
Wet Sedge-Willow Meadow	2	7	18.2	
Total	11	47	100	
NEAREST WATERBODY HABITAT				
Brackish Water	7	33	63.6	0.03
Tapped Lake w/ High-water Connection	1	3	9.1	0.08
Deep Open Water w/o Islands	1	4	9.1	0.24
Shallow Open Water w/o Islands	1	3	9.1	0
Aquatic Grass Marsh	1	4	9.1	0
Total	11	47	100	0.05

[a] Use is calculated from number of brood groups only.
[b] Distance to waterbody was measured from the digital map and may not be as accurate as measurement on ground.

That brood occurred in Shallow Open Water with Islands or Polygonized Margins. On the same aerial survey, 16 King Eider brood groups were found in 6 habitats, 3 of which were preferred: Deep Open Water without Islands and both types of Shallow Open Water (Table 14). These three habitats also were used by the largest numbers of brood groups. Moist Sedge-Shrub Meadow and Moist Tussock Tundra were unused by King Eiders and significantly avoided. King Eider broods at Storkersen Point preferred shallow *Carex* (equivalent to Aquatic Sedge Marsh), as well as deep *Arctophila* (Bergman et al. 1977).

TUNDRA SWANS

BACKGROUND

Tundra Swans arrive on the Colville Delta in mid- to late May (Simpson et al. 1982, Hawkins 1983). The occupation of breeding territories and nest initiation both begin soon after arrival, although poor weather can delay the process (Lensink 1973, McLaren and McLaren 1984). Preferred nesting habitat is characterized by numerous lakes and associated wetlands (King and Hodges 1980, Monda et al. 1994). Tundra Swans are traditional in their selection of nesting sites, in that they often use the same nest mounds in successive years (Palmer 1976, Monda 1991, Monda et al. 1994). Incubation begins after egg-laying is completed, and hatching occurs 30–35 days later (Palmer 1976). Families then stay on or near their breeding territories until the young are fledged, after 8–10 weeks of brood-rearing (Bellrose 1978, Rothe et al. 1983, Monda and Ratti 1990). Tundra Swans leave northern Alaska by late September or early October on an easterly migration route for wintering grounds in eastern North America (Johnson and Herter 1989). Poor weather in early autumn can hasten their departure and can result in the mortality of young swans (Lensink 1973, Monda and Ratti 1990).

Table 14. Habitat selection by King Eiders during brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1995 (Johnson et al. 1996).

Habitat	Area (km^2)	No. of Brood Groups	No. of Young	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	-	0	-	-
Brackish Water	0	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	0	<0.1	-1.00	ns
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	25.59	5	76	31.3	9.3	0.54	prefer
Deep Open Water w/ Islands or Polygonized Margins	4.30	1	6	6.3	1.6	0.60	ns
Shallow Open Water w/o Islands	9.32	4	23	25.0	3.4	0.76	prefer
Shallow Open Water w/ Islands or Polygonized Margins	6.73	3	41	18.8	2.5	0.77	prefer
River or Stream	1.97	0	0	0	0.7	-1.00	ns
Aquatic Sedge Marsh	0.90	1	4	6.3	0.3	0.90	ns
Aquatic Sedge w/ Deep Polygons	0.02	0	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0.63	0	0	0	0.2	-1.00	ns
Young Basin Wetland Complex	13.21	2	6	12.5	4.8	0.44	ns
Old Basin Wetland Complex	30.40	0	0	0	11.1	-1.00	ns
Nonpatterned Wet Meadow	20.85	0	0	0	7.6	-1.00	ns
Wet Sedge-Willow Meadow	15.98	0	0	0	5.8	-1.00	ns
Moist Sedge-Shrub Meadow	64.76	0	0	0	23.6	-1.00	avoid
Moist Tussock Tundra	71.03	0	0	0	25.9	-1.00	avoid
Riverine or Upland Shrub	6.49	0	0	0	2.4	-1.00	ns
Barrens (riverine, eolian, lacustrine)	1.67	0	0	0	0.6	-1.00	ns
Artificial (water, fill, peat road)	0.42	0	0	0	0.2	-1.00	ns
Total	274.38	16	156	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated for groups only.
[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

DISTRIBUTION AND ABUNDANCE

Nesting

Delta—With minor exceptions, the distribution of Tundra Swan nests on the delta has been relatively consistent among areas and among years (Figure 7, Table 15). We located 45 Tundra Swan nests during aerial surveys of the delta in 1996, which is the greatest number of swan nests located by aerial survey on the Colville Delta since we began surveys in 1992. Ground searchers located an additional 7 nests (this study and S. Earnst, unpubl. data), for a total of 52 nests. From 1992 to 1996, the number of nests also increased markedly across the Arctic Coastal Plain between the Kuparuk and Colville rivers (Anderson et al. 1997). In addition to increases in nests, we counted more than twice as many swans (579) in 1996 as in each of the three previous years of nesting surveys (208–249). The increase in numbers of swans can be attributed to two large flocks of nonbreeders. During the aerial survey (20 June), a flock of approximately 230 swans was counted on the outer delta, and another flock of about 140 swans was counted in a large tapped lake immediately south of the Facility Area and adjacent the Sakoonang Channel. That same tapped lake contained approximately 160 swans and 600 ducks (primarily Northern Pintails) when counted on 19 June by a ground crew working. An estimated 250 swans were seen in this tapped lake on 28 June during a helicopter survey for fox dens. As a result of the large number of nonbreeders present, only 12% of the total number of swans were associated with nests in 1996 (Table 16).

Although we counted the largest number of nests on the delta during the aerial survey in 1996, higher densities of nests have been found on the delta during intensive ground-based searches. In 1982, 48 nests were found on the northern 80% of the delta (Simpson et al. 1982), and in 1981, 32 swan nests were found on ~80% of the delta (Rothe et al. 1983). Nest densities on the delta ranged from 0.03 to 0.08 nests/km^2 for the four years that we have flown surveys. Nest densities determined from aerial surveys of other areas on the coastal plain have been in the same range of values: 0.04–0.06 nests/km^2 on the eastern Arctic Coastal Plain (Platte and Brackney 1987) and 0.01–0.05 nests/km^2 in the Kuparuk Oilfield and adjacent areas (Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993; Anderson et al. 1995, 1996, 1997).

In 1996, disproportionately more nests occurred in the Development Area than on the rest of the delta. The density of nests within the Development Area in 1996 (0.10 nests/km^2) was higher than that estimated for the entire Delta survey area (0.08 nests/km^2; Table 15). Seventeen (38%) of the 45 nests located during aerial surveys on the delta occurred in the Development Area. Ground-based observers found another three nests, resulting in a combined count of 20 nests for the Development Area. Although only 5–12 nests were found on aerial surveys in the Development Area in previous years, the density of nests was the same as that for the entire delta until 1996.

In the Facility Area in 1996, we found three swan nests on aerial and ground-based surveys, which was the same number found on the aerial survey in 1995. We conducted only aerial surveys in the Facility Area prior to 1995. We saw no swan nests in that area in 1993 and saw only one in 1992.

On the Outer Delta, we located 25 swan nests during aerial surveys in 1996, and ground-based observers located an additional 4 nests (S. Earnst, unpubl. data). The density of nests in 1996 was similar to the density in 1995, but densities were much lower in 1992 and 1993 (Table 15). In all years but 1996, the density of nests was the same on the Outer Delta and Development Area. On the Western Delta in 1996, we located three swan nests during aerial surveys (Figure 7, Table 15). One nest was found in this area in 1993 and none in 1992 or 1995.

Transportation Corridor—In 1996, we located 19 swan nests (0.06 nests/km^2) in the Transportation Corridor (Figure 7, Table 15). During the previous 7 years, numbers of nests located in the Transportation Corridor ranged from 6 to 18 (Table 15). Since 1989, the number of nests in the Transportation Corridor has increased annually except in 1991 and 1993.

Similar to the increase in the number of nests found in the Transportation Corridor, the total number of swans found there during the nesting season has grown steadily each year except between 1995 and 1996 (Table 16). Although the proportion of swans associated with nests generally

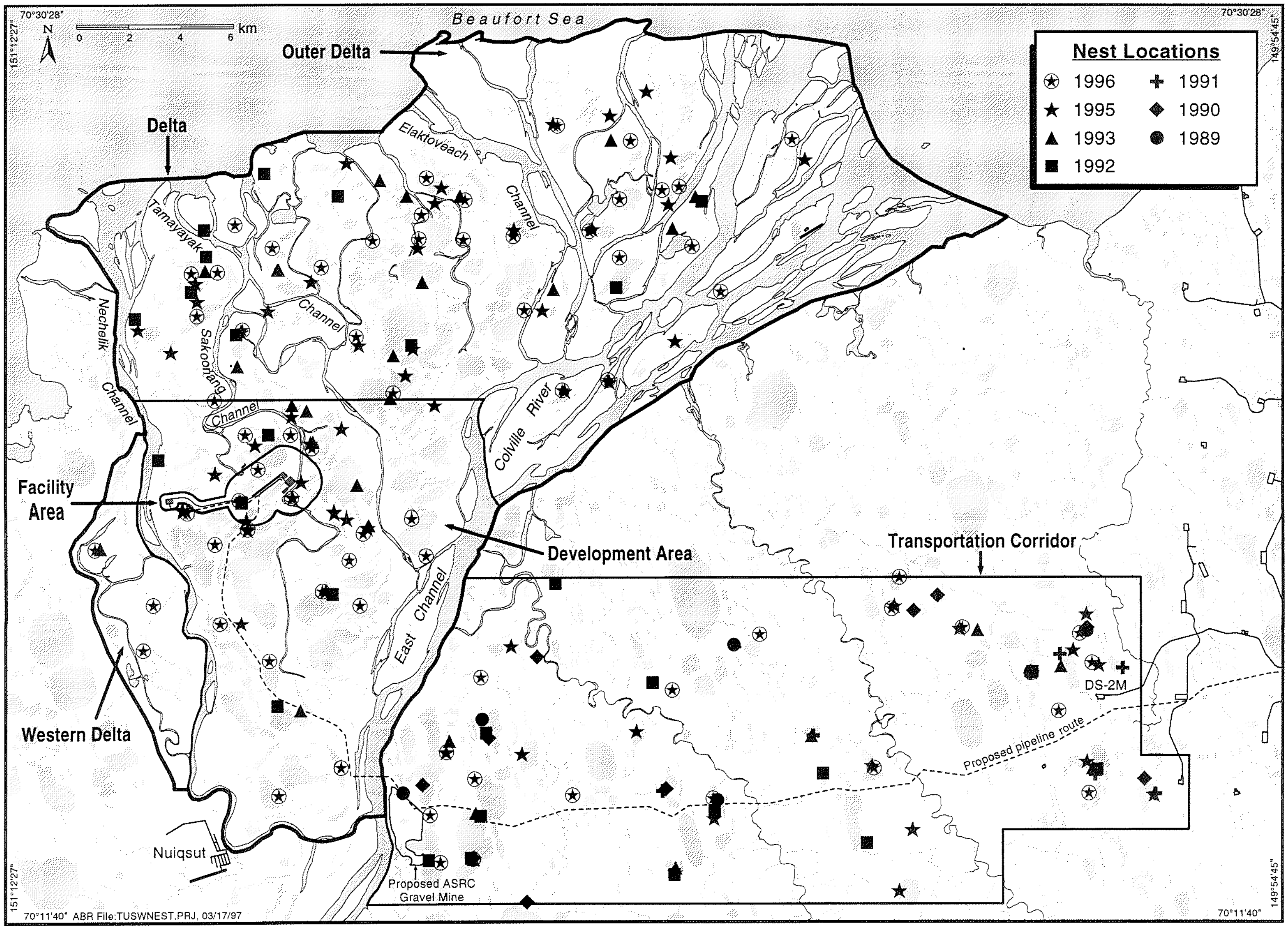

Figure 7. Distribution of Tundra Swan nests observed during aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993, 1995, and 1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

Table 15. Numbers and densities of Tundra Swan nests and broods counted on aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1996 (Johnson et al. 1996, this study). See Figure 1 for survey areas.

		Nests		Broods		Mean Brood
Survey Area	Year	No.	No./km^2	No.	No./km^2	Size
Delta (551 km^2)	1996	45	0.08	32	0.06	3.4
	1995	38	0.07	25	0.05	3.7
	1993	20	0.04	14	0.03	2.6
	1992	14	0.03	16	0.03	2.4
Development Area (169 km^2)	1996	17	0.10	14	0.08	3.5
	1995	12	0.07	6	0.04	3.7
	1993	6	0.04	3	0.02	2.0
	1992	5	0.03	6	0.04	1.8
Facility Area (9 km^2)	1996	1	0.12	3	0.35	3.7
	1995	3	0.35	0	0	0
	1993	0	0	0	0	0
	1992	1	0.12	1	0.12	1.0
Outer Delta (352 km^2)	1996	25	0.07	16	0.05	3.3
	1995	26	0.07	17	0.05	3.8
	1993	13	0.04	10	0.03	2.7
	1992	9	0.03	9	0.03	2.4
Western Delta (31 km^2)	1996	3	0.1	2	0.06	3.0
	1995	0	0	2	0.06	3.0
	1993	1	0.03	1	0.03	4.0
	1992	0	0	1	0.03	5.0
Transportation Corridor (343 km^2)	1996	19	0.06	16	0.05	3.0
	1995	18	0.05	10	0.03	2.7
	1993	10	0.03	10	0.03	2.3
	1992	12	0.03	15	0.04	2.2
	1991	7	0.02	6	0.02	2.8
	1990	11	0.03	14	0.05	3.2
	1989	6	0.02	2	0.01	3.0

has increased over the previous seven years, the trend has not been consistent each successive year.

Brood-rearing

Delta—Tundra Swan broods were distributed evenly throughout the Colville Delta (Figure 8). Brood counts on the delta in mid-August 1996 indicated that approximately 71% of the 45 nests were successful (Table 15). Similar nesting success rates were estimated from nest and brood surveys in 1995 (66%) and 1993 (70%), whereas we counted more broods than nests in 1992 (success = 114%). Clearly, nests were undercounted and/or some broods may have immigrated to the delta in 1992. In 1996, average brood size was 3.4 young/brood (range = 1–5), and the density was 0.06 broods/km^2. Although average brood size was slightly larger in 1995 (3.7 young/brood) than in 1996, the number of broods and the total number of young swans was higher in 1996 than in 1992, 1993, or 1995 (Table 16). Two earlier studies on the delta, both based on intensive ground-based surveys, provide comparative data. Rothe et al. (1983) reported a nesting success rate of 91% ($n = 32$ nests) and a mean of 2.1 young/brood for the "Colville Delta" in late July 1981. In 1982, nesting success was 71% ($n = 48$ nests), and average brood size in mid-August was 2.5 young/brood (Simpson et al. 1982). In a three year (1988–1990) study of swans nesting on the Canning and Kongakut river deltas, the overall nest success was 76% ($n = 110$ nests) (Monda et al. 1994).

Table 16. Numbers of Tundra Swans counted on aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1996 (Johnson et al. 1996, this study).

		Nesting		Brood-rearing					Fall Staging
Survey Area	Year	Total Swans	Swans with Nests (%)	Total Swans	No. of Adults	No. of Young	Adults with Broods (%)	Young (%)	Total Swans
Delta									
	1996	579	12	358	250	108	25	30	355
	1995	208	31	261	169	92	29	35	64[a]
	1993	240	12	237	200	37	13	17	295
	1992	249	7	297	259	38	13	13	0
Transportation Corridor									
	1996	52	67	105	57	48	53	46	-
	1995	87	40	93	66	27	30	29	5
	1993	50	32	83	60	23	33	28	-
	1992	46	48	105	72	33	43	31	-
	1991	40	25	84	67	17	18	20	-
	1990	33	52	101	56	45	50	45	-
	1989	38	24	69	63	6	6	8	-

[a] Western Delta (31 km^2) was not surveyed.

Productivity (as indicated by nesting success and average brood size) on the delta during the four years that we conducted aerial surveys was similar to or greater than values reported in other studies of swans on the Arctic Coastal Plain. Aerial surveys between the Kuparuk and Colville rivers (1988–1993, 1995, 1996) recorded average brood sizes of 2.1–2.8 young/brood and densities of 0.02–0.04 broods/km^2 (Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993; Anderson et al. 1996, 1997). Platte and Brackney (1987) estimated 0.04 broods/km^2 on portions of the Arctic Coastal Plain during 1982–1985. Average brood size for those 4 years was 2.5 young/brood, and nesting success during 1983–1985 ranged from 63% to 85%.

The large number of nests found in 1996, in combination with large brood sizes, resulted in young swans representing 30% of all swans present in August. In 1995 and 1996, the percentage of young swans on the delta was higher than previous years (Table 16) but within the range of values reported for the Kuparuk Oilfield. The percentage of young swans on the delta in mid-August 1982 was 26% (Simpson et al. 1982). In the adjacent Kuparuk Oilfield, the proportion of young swans has ranged from 21 to 34% since 1988 (Anderson et al. 1997).

In the Development Area, we found 14 broods during the aerial survey in 1996, more than twice the number of broods found in other years (Table 15). In the Facility Area, we found three broods in 1996, which again was the highest number seen among years.

The annual trend in the distribution of swan broods between the Development Area and the Outer Delta was similar to that found for nests; that is, densities in the two areas were similar in all years except for 1996, when densities of broods and nests were highest in the Development Area. On the Outer Delta, we found 16 broods in 1996, similar to the count in 1995 (Table 15). Brood counts in 1992 and 1993 were lower.

Transportation Corridor—The range of densities of Tundra Swan broods in the Transportation Corridor during seven years of surveys (0.01–0.05 broods/km^2) was nearly the same as on the delta (0.03–0.06 broods/km^2; Table 15). In 1996, we found 16 broods, which was the highest number of broods since we began our surveys in this area in 1989.

As on the delta, the number of Tundra Swan young that we counted in the Transportation Corridor was higher in 1996 than in any previous year that we conducted surveys. We counted 48 young with 57 adult swans in the Transportation Corridor in August 1996 (Table 16); 53% of all adult swans were with broods. Overall, the swan population using the Transportation Corridor has exhibited considerable annual variation in nesting

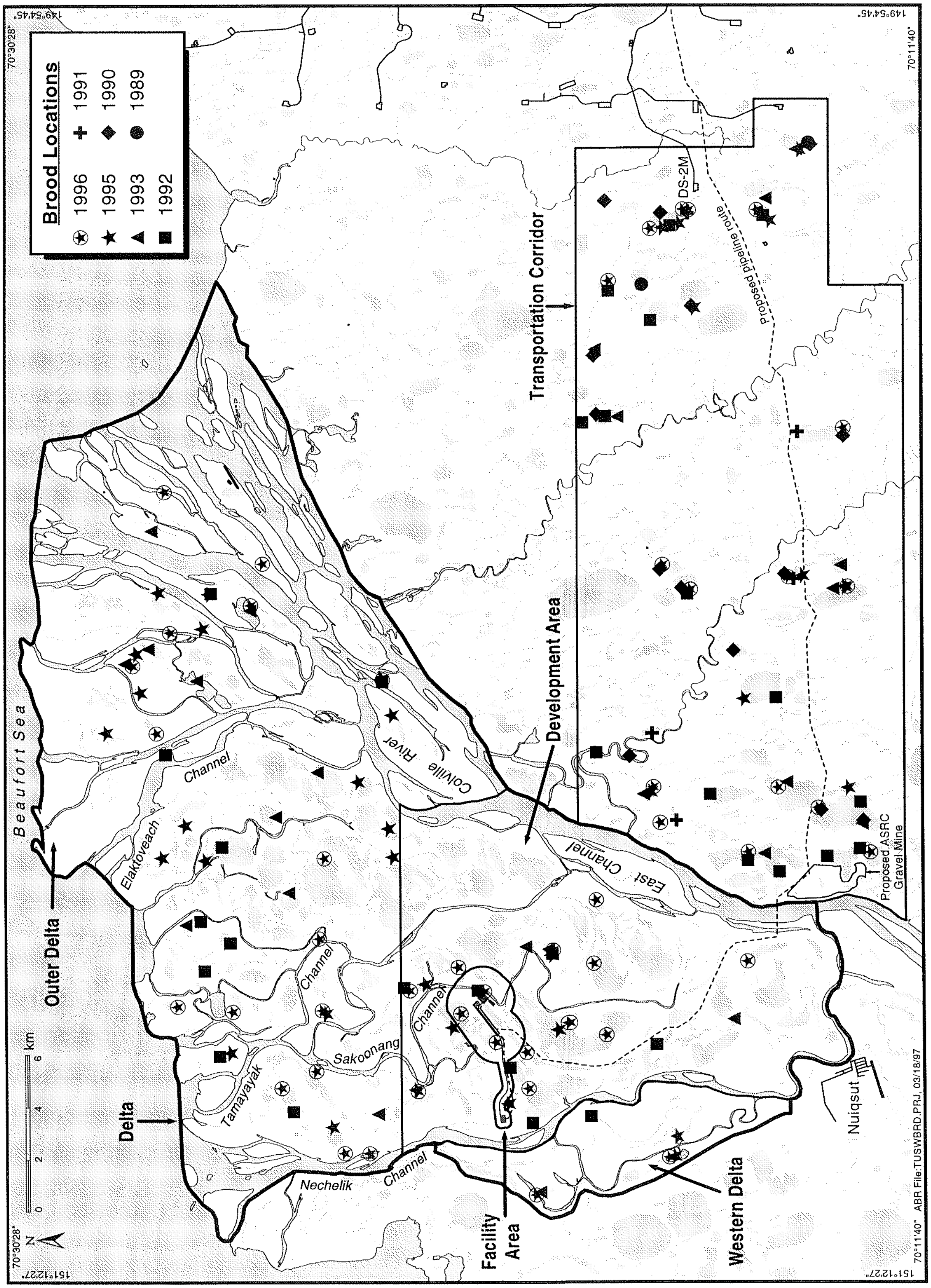

Figure 8. Distribution of Tundra Swan broods observed during aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993, 1995, and 1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

effort, nesting success, and brood size (Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993; Anderson et al. 1995, 1996, 1997). Regionally, 1996 was a productive year for Tundra Swans. The numbers of nests and young swans counted on the coastal plain between the Kuparuk and Colville rivers (an area that includes the Transportation Corridor) were the highest recorded for that area since surveys began in 1988 (Anderson et al. 1997).

Fall Staging

Delta—Tundra Swans present on the delta during our fall-staging surveys have been widely distributed. However, the majority of swans generally occur in several large flocks that occupy river channels on the Outer Delta (Figure 9). Our aerial survey on 6 September 1996 was earlier in the season than in previous years, and resulted in the largest count of swans (355) recorded on our surveys (Table 16). In addition to the swans located on the delta, we found ≥400 swans near the confluence of Miluveach Creek and the Colville River, just outside of the study area.

In previous years, we have recorded highly variable use of the delta during staging surveys. For example, on 19 September 1995, only 64 swans were counted, most of which were in small family groups distributed throughout the delta. Weather at that time was exceptionally mild over most of the Arctic Coastal Plain. In contrast, on 15 September 1993, we saw 295 swans in that same area (Table 16). An early freeze in 1992 before the fall-staging survey (17 September) may have resulted in an early departure, leaving no swans on the delta (Smith et al. 1993). Thus, in 1992, as in 1995, most swans had vacated the delta prior to the fall-staging survey, although under different weather conditions. These few observations suggest that the departure of most swans from the delta may be triggered in some years by factors other than fall weather conditions. Surveys in two of the four years considered here documented staging by large numbers of swans prior to migration: Campbell et al. (1988) also reported large numbers of swans on the Colville Delta in fall.

Although the Colville Delta is an important fall-staging area for swans, the origins of the birds staging there remain unclear. Swans nest in moderate to high densities from the delta northwest to Teshekpuk Lake (Derksen et al. 1981) and from the delta east to the Kuparuk River (Ritchie et al. 1989, 1990, 1991; Stickney et al. 1992, 1993; Anderson et al. 1995, 1996, 1997). Although swans from surrounding nesting areas may be staging on the delta, we have been unable to detect seasonal changes in numbers on the delta that might suggest use by swans that nest elsewhere. Our counts of swans during staging surveys have not indicated an increase over the total counts of swans occupying the delta during the brood-rearing period (Table 16).

Transportation Corridor—Because of poor weather, we were unable to fly a staging survey over the Transportation Corridor in 1996. During the 1995 aerial survey, a single group (2 adults with 3 young) was recorded. Because this survey took place after most of the swans had departed the delta and because staging surveys in the corridor were not flown in previous years, we have limited information on the importance of this area to swans during fall staging.

HABITAT SELECTION

Nesting

Delta—Tundra Swans used a wide range of habitats for nesting. During 4 years of surveys on the delta, swan nests were located in 13 of 23 habitats that were available (Table 17). Four habitat types were preferred, and four were avoided. We found 89 nests (76% of the total) in preferred habitats, and these habitats together composed 33% of the Delta survey area. Annual habitat selection measurements for previous years can be found in Johnson et al. (1996); habitat selection for 1996 is presented in Appendix Table C3.

Most nests (49; 42% of the total) were located in Wet Sedge-Willow Meadow, the most widely available habitat (19% of the area) in the Delta survey area (Table 17). The second-highest number of nests (17) occurred in Nonpatterned Wet Meadow (8% of the delta). Both these habitats were significantly preferred. No other habitat type in the Delta survey area contained >15 nests. Salt-killed Tundra (5% of the delta; 14 nests) and Aquatic Sedge with Deep Polygons (3% of the delta; 8 nests) also were preferred. Nesting swans avoided Tidal Flat, Riverine or Upland

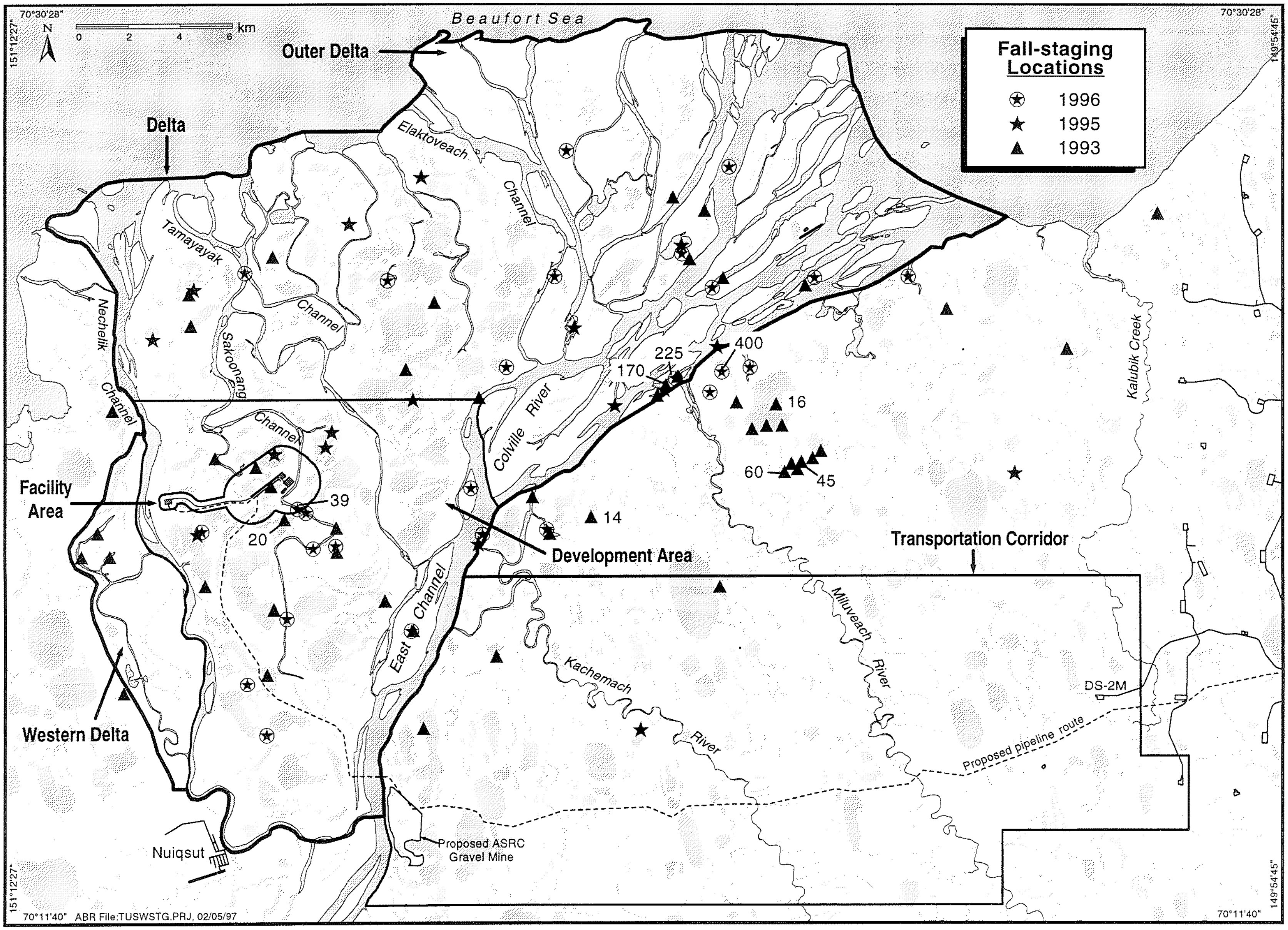

Figure 9. Distribution of Tundra Swan fall-staging groups observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1993, 1995, and 1996. Numbers indicate size of groups greater than 10. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

Table 17. Habitat selection (pooled among years) by nesting Tundra Swans in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996 (Johnson et al. 1996, this study). See Appendix Table C3 for 1996 results.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	ns
Brackish Water	6.50	0	0	1.2	-1.00	ns
Tapped Lake w/ Low-water Connection	21.42	2	1.7	3.9	-0.39	ns
Tapped Lake w/ High-water Connection	20.36	2	1.7	3.7	-0.37	ns
Salt Marsh	16.73	7	6.0	3.0	0.33	ns
Tidal Flat	55.90	2	1.7	10.1	-0.71	avoid
Salt-killed Tundra	25.63	14	12.0	4.6	0.44	prefer
Deep Open Water w/o Islands	23.31	4	3.4	4.2	-0.11	ns
Deep Open Water w/ Islands or Polygonized Margins	5.13	2	1.7	0.9	0.30	ns
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	ns
River or Stream	81.76	0	0	14.8	-1.00	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	8	6.8	2.5	0.47	prefer
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	ns
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	ns
Nonpatterned Wet Meadow	41.98	17	14.5	7.6	0.31	prefer
Wet Sedge-Willow Meadow	102.23	49	41.9	18.5	0.39	prefer
Moist Sedge-Shrub Meadow	13.10	5	4.3	2.4	0.29	ns
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	ns
Riverine or Upland Shrub	27.40	1	0.9	5.0	-0.71	avoid
Barrens (riverine, eolian, lacustrine)	79.01	4	3.4	14.3	-0.61	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	ns
Total	551.25	117	100	100		

[a] Ivlev's E = (use – availability)/(use + availability).
[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Shrub, and Barrens. These habitats comprised 44% of the Delta survey area.

Overall, swans appeared to be attracted to nest sites near lakes and ponds. The average distance of swan nests to the nearest waterbody was 0.10 km (Table 18). In decreasing order of use, the three waterbody types most commonly found close to swan nests on the delta were Deep Open Water without Islands, Tapped Lake with Low-water Connections, and Brackish Water.

Transportation Corridor—Swans also used a wide array of habitats during the 7 years we conducted surveys in the Transportation Corridor, in that nests were found in 13 of the 18 habitats available (Table 19). Four habitats were preferred, and two were avoided. Twenty-nine nests (35% of the total) occurred in preferred habitats: Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge Marsh, Aquatic Grass Marsh, and Young Basin Wetland Complex. These preferred habitats accounted for only 7% of the Transportation Corridor. The two avoided habitats—Moist Sedge-Shrub Meadow and Moist Tussock Tundra—occupied 52% of the survey area and contained 21 nests. Habitat selection for 1996 is presented in Appendix Table C4; annual habitat selection measurements for previous years can be found in Johnson et al. (1996).

The average distance of nests to the nearest waterbody was 0.06 km in the Transportation Corridor (Table 18). Deep Open Water without Islands was the nearest waterbody to most nests (20). Other waterbody types that were closest to large numbers of nests were Old Basin Wetland Complex (14 nests), Young Basin Wetland Complex (13 nests), Deep Open Water with Islands or Polygonized Margins (11 nests), and Shallow Open Water with Islands or Polygonized Margins (11 nests).

Table 18. Distance to the nearest waterbody of Tundra Swan nests detected on aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993, 1995, and 1996 (Johnson et al. 1996, this study).

	Delta		Transportation Corridor	
Nearest Waterbody Habitat	No. of Nests	Mean Distance[a] (km)	No. of Nests	Mean Distance[a] (km)
Brackish Water	17	0.11	0	-
Tapped Lake w/ Low-water Connection	21	0.09	0	-
Tapped Lake w/ High-water Connection	13	0.13	0	-
Deep Open Water w/o Islands	38	0.10	20	0.05
Deep Open Water w/ Islands or Polygonized Margins	10	0.06	11	0.16
Shallow Open Water w/o Islands	10	0.14	6	0.04
Shallow Open Water w/ Islands or Polygonized Margins	2	0.04	11	0.06
River or Stream	13	0.14	0	-
Aquatic Sedge Marsh	0	-	4	0.01
Aquatic Grass Marsh	7	0.05	4	0.09
Young Basin Wetland Complex	0	-	13	0.02
Old Basin Wetland Complex	0	-	14	0.03
Total	131	0.10	83	0.06

[a] Distance to waterbody was measured from the digital map and may not be as accurate as measurement on ground.

Table 19. Habitat selection (pooled among years) by nesting Tundra Swans in the Transportation Corridor survey area, Colville River Delta, Alaska, 1989–1993, 1995, and 1996 (Johnson et al. 1996, this study). See Appendix Table C4 for 1996 results.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	ns
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	3	3.6	9.0	-0.43	ns
Deep Open Water w/ Islands or Polygonized Margins	6.52	10	12.0	1.9	0.73	prefer
Shallow Open Water w/o Islands	10.84	4	4.8	3.2	0.21	ns
Shallow Open Water w/ Islands or Polygonized Margins	7.36	2	2.4	2.1	0.06	ns
River or Stream	2.30	0	0	0.7	-1.00	ns
Aquatic Sedge Marsh	0.97	4	4.8	0.3	0.89	prefer
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0.65	1	1.2	0.2	0.73	prefer
Young Basin Wetland Complex	14.23	14	16.9	4.1	0.61	prefer
Old Basin Wetland Complex	35.59	8	9.6	10.4	-0.04	ns
Nonpatterned Wet Meadow	24.47	11	13.3	7.1	0.30	ns
Wet Sedge-Willow Meadow	19.87	2	2.4	5.8	-0.41	ns
Moist Sedge-Shrub Meadow	84.66	9	10.8	24.7	-0.39	avoid
Moist Tussock Tundra	94.60	12	14.5	27.6	-0.31	avoid
Riverine or Upland Shrub	7.74	3	3.6	2.3	0.23	ns
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	ns
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	ns
Total	343.11	83	100	100		

[a] Ivlev's E = (use – availability)/(use + availability).
[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Tundra Swans breeding on the Canning and Kongakut river deltas in northeastern Alaska selected marsh habitats and nested near either large lakes or coastal lagoons (Monda et al. 1994). Because only seven habitats were classified for these deltas and because these deltas differ from the Colville Delta in habitat availability, the habitat use reported by Monda et al. (1994) was not directly comparable with our findings. However, similar to our comparison of swan nesting habitat on the Colville Delta and Transportation Corridor, Monda et al. (1994) found differences between their two study sites, which reflected differences in habitat availability. On the Kongakut delta, 89% of the 36 nests were located <1 km from a coastal lagoon, 42% of the nests were in areas classified as saline graminoid-shrub (probably equivalent to Salt Marsh), and 36% of the nests were ≤10 m from waterbodies. On the Canning delta, 22% of 54 nests were <1 km from a coastal lagoon, 52% of the nests were in graminoid-marsh (probably equivalent to Aquatic Grass and Sedge Marshes), 26% were in graminoid-shrub-water sedge (probably equivalent to Wet Sedge-Willow Meadow), and 63% were ≤10 m from waterbodies.

Brood-rearing

Delta—As was seen during nesting, Tundra Swans with broods used the majority of the habitats on the delta; with broods occurring in 17 of 23 available habitats (Table 20). Four habitats were preferred, and three were avoided. Twenty-six broods were in preferred habitats, and 9 broods were in avoided habitats.

On the delta, swan broods preferred Brackish Water, Tapped Lake with Low-water Connections, Deep Open Water with Islands or Polygonized Margins, and Aquatic Grass Marsh, all of which occupied 6% of the delta (Table 20). Broods avoided Tidal Flat, River or Stream, and Barrens, which combined to comprise 39% of the delta.

Table 20. Habitat selection (pooled among years) by Tundra Swans during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996 (Johnson et al. 1996, this study). See Appendix Table C3 for 1996 results.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	ns
Brackish Water	6.50	8	9.2	1.2	0.77	prefer
Tapped Lake w/ Low-water Connection	21.42	12	13.8	3.9	0.56	prefer
Tapped Lake w/ High-water Connection	20.36	7	8.0	3.7	0.37	ns
Salt Marsh	16.73	6	6.9	3.0	0.39	ns
Tidal Flat	55.90	1	1.2	10.1	-0.80	avoid
Salt-killed Tundra	25.63	7	8.0	4.6	0.27	ns
Deep Open Water w/o Islands	23.31	7	8.0	4.2	0.31	ns
Deep Open Water w/ Islands or Polygonized Margins	5.13	4	4.6	0.9	0.66	prefer
Shallow Open Water w/o Islands	2.32	2	2.3	0.4	0.69	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.55	1	1.2	0.1	0.84	ns
River or Stream	81.76	3	3.4	14.8	-0.62	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	2	2.3	2.5	-0.03	ns
Aquatic Grass Marsh	1.37	2	2.3	0.2	0.80	prefer
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	ns
Nonpatterned Wet Meadow	41.98	5	5.8	7.6	-0.14	ns
Wet Sedge-Willow Meadow	102.23	13	14.9	18.5	-0.11	ns
Moist Sedge-Shrub Meadow	13.10	0	0	2.4	-1.00	ns
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	ns
Riverine or Upland Shrub	27.40	2	2.3	5.0	-0.37	ns
Barrens (riverine, eolian, lacustrine)	79.01	5	5.8	14.3	-0.43	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	ns
Total	551.25	87	100	100		

[a] Ivlev's E = (use – availability)/(use + availability).

[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Waterbodies were used by swans during brood-rearing for foraging and escape habitat. The preference for salt-affected habitats by brood-rearing swans may reflect a seasonal change in distribution or habitat preference (38% of all swan broods on the delta were located in salt-affected habitats, compared with only 21% of all nests). However, swan broods were found only slightly closer to the coast ($\bar{x}$ = 6.6 km, n = 87) than were nests ($\bar{x}$ = 6.8 km, n = 117), suggesting that swans select different habitats between nesting and brood-rearing without making any movement toward the coast.

All swan broods were found near (and often swimming in) waterbodies, and most were associated with saline waterbodies (Table 21). The average distance of broods to a waterbody was 0.05 km. The largest number of broods (23) was near Brackish Water, and most of the remaining broods were near either Tapped Lake with Low-water Connections (21), Deep Open Water without Islands (16), or Tapped Lake with High-water Connections (13).

Transportation Corridor—Unlike on the delta, salt-affected habitats were unavailable or rare in the Transportation Corridor, and habitat use by swan broods reflected this difference in availability. Swan broods were located in 12 of 18 habitats available in the Transportation Corridor (Table 22). Four habitats were preferred and three were avoided. Preferred habitats were Aquatic Sedge Marsh, Aquatic Grass Marsh, Deep Open Water with Islands or Polygonized Margins, and Deep Open Water without Islands. Swan broods avoided Old Basin Wetland Complex, Moist Sedge-Shrub Meadow, and Moist Tussock Tundra. The avoided habitats occupied 63% of the Transportation Corridor, whereas only 11% of the area was in preferred habitats.

Most broods (47; 64% of the total) were found in Deep Open Water habitats (36 in Deep Open Water without Islands and 11 in Deep Open Water with Islands). No other preferred habitat had more than four sightings of broods.

The average distance of broods to the nearest waterbody was 0.06 km in the Transportation Corridor (Table 21). For 73% of all broods, Deep Open Waters (with or without Islands) were the nearest waterbody types; 9 broods were seen near both Shallow Open Water habitats.

Swan broods in northeast Alaska used different habitats and methods of feeding as the brood-rearing season progressed (Monda et al.

Table 21. Distance to the nearest waterbody of Tundra Swan broods detected on aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1989–1993, 1995, and 1996 (Johnson et al. 1996, this study).

	Delta		Transportation Corridor	
Nearest Waterbody Habitat	No. of Broods	Mean Distance[a] (km)	No. of Broods	Mean Distance[a] (km)
Brackish Water	23	0.04	0	-
Tapped Lake w/ Low-water Connection	21	0.06	0	-
Tapped Lake w/ High-water Connection	13	0.08	0	-
Deep Open Water w/o Islands	16	0.04	41	0.07
Deep Open Water w/ Islands or Polygonized Margins	5	0.02	13	0.08
Shallow Open Water w/o Islands	4	0.02	4	0.02
Shallow Open Water w/ Islands or Polygonized Margins	1	<0.01	5	0.04
River or Stream	8	0.08	1	0.08
Aquatic Sedge	0	-	3	0.01
Aquatic Grass Marsh	2	<0.01	2	0.04
Young Basin Wetland Complex	0	-	4	0.01
Old Basin Wetland Complex	0	-	1	0.04
Total	93	0.05	74	0.06

[a] Distance to waterbody was measured from the digital map and may not be as accurate as measurement on ground.

Table 22. Habitat selection (pooled among years) by Tundra Swans during brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1989–1993, 1995, and 1996 (Johnson et al. 1996, this study). See Appendix Table C4 for 1996 results.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	ns
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	36	49.3	9.0	0.69	prefer
Deep Open Water w/ Islands or Polygonized Margins	6.52	11	15.1	1.9	0.78	prefer
Shallow Open Water w/o Islands	10.84	3	4.1	3.2	0.13	ns
Shallow Open Water w/ Islands or Polygonized Margins	7.36	1	1.4	2.1	-0.22	ns
River or Stream	2.30	0	0	0.7	-1.00	ns
Aquatic Sedge Marsh	0.97	4	5.5	0.3	0.90	prefer
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	ns
Aquatic Grass Marsh	0.65	2	2.7	0.2	0.87	prefer
Young Basin Wetland Complex	14.23	2	2.7	4.1	-0.20	ns
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	avoid
Nonpatterned Wet Meadow	24.47	2	2.7	7.1	-0.44	ns
Wet Sedge-Willow Meadow	19.87	2	2.7	5.8	-0.36	ns
Moist Sedge-Shrub Meadow	84.66	7	9.6	24.7	-0.44	avoid
Moist Tussock Tundra	94.60	2	2.7	27.6	-0.82	avoid
Riverine or Upland Shrub	7.74	1	1.4	2.3	-0.24	ns
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	ns
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	ns
Total	343.11	73	100	100		

[a] Ivlev's E = (use – availability)/(use + availability).

[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

1994). Early in the brood-rearing season on the Kongakut River delta, grazing in saline graminoid marsh and aquatic-marsh habitats predominated. Later in the season, surface and sub-surface foraging concentrated more in aquatic-marsh habitat. Changes in habitat and foraging method may be related to nutritive quality of different plants or the ability of older, larger cygnets to feed on submerged vegetation (e.g., pondweeds [*Potamogeton* spp.]) in deeper water.

Spindler and Hall (1991) found swans feeding on various species of the submergent pondweed in late August and September on the Kobuk-Selawik lowlands. Monda et al. (1994) also found that pondweeds were an important component of the diet of swans of the Kongakut and Canning river deltas; pondweeds, along with another important food plant, alkali grass (*Puccinella phryganodes*), grow well in salt-affected environments. Although we did not collect data on feeding swans, the use of salt-affected and aquatic marsh habitats by broods on the Colville Delta and in the Transportation Corridor suggests that some of the same plants are being sought after by swans.

LOONS

BACKGROUND

On the Arctic Coastal Plain of Alaska, Yellow-billed Loons nest primarily between the Colville and Meade rivers, with the highest densities found south of Smith Bay (Brackney and King 1992). The Colville Delta is an important breeding area for Yellow-billed Loons and is one of two known areas in arctic Alaska where nesting is concentrated (North and Ryan 1988). Yellow-billed Loons arrive on the delta just after the first spring meltwater accumulates on the river channels, usually during the last week of May (Rothe et al. 1983), and use openings in rivers, tapped lakes, and in the sea ice before nesting lakes are available in early June (North and Ryan 1988). Nest initiation begins the second week of June, hatching occurs in mid-July, and broods usually are raised in the nesting lake (Rothe et al. 1983); however, broods occasionally move to different lakes (North 1986). North (1986) found most nests on the delta in what he described as deep open lakes and deep lakes with emergent grass.

DISTRIBUTION AND ABUNDANCE

Nesting

Delta—During aerial surveys of the Colville Delta in 1996, most Yellow-billed Loons (87%) and their nests (88%) were found in the central part of the delta, between the Elaktoveach and Sakoonang channels (Figure 10). The few birds and nests found outside this area were located in previously recorded breeding territories of Yellow-billed Loons (North 1986, Johnson et al. 1996). This pattern of use is consistent with the distribution of loons and nests documented for the delta during aerial surveys in 1993 and 1995 (ABR, unpubl. data; Smith et al. 1994; Johnson et al. 1996), and during ground-based studies in 1981, 1983, and 1984 (Rothe et al. 1983, North 1986).

In 1996, we counted 46 Yellow-billed Loons on the aerial nesting survey, 15 of which were associated with 12 nests. The number of loons and nests in 1996 did not differ substantially from counts made in other years in which aerial surveys of the entire delta were conducted (1993 and 1995, Table 23). In 1996, we revisited lakes 6–11 days after the initial aerial survey was completed where we had seen Yellow-billed Loon pairs but did not find nests on that initial survey. We located an additional five nests that either had been missed or were initiated after the first survey. We suspect one nest was undetected in an area where a pair had been found during nest surveys and a brood was found later. Our total count of 18 Yellow-billed Loon nests (including one nest assumed from a brood location) for the delta in 1996 was similar to the number of nests found during intensive ground-based studies in 1983 and 1984 (19 and 20 nests, respectively) by North and Ryan (1989). The similarity among years in the distribution and abundance of Yellow-billed Loons and their nests suggests that the breeding population on the delta has been fairly stable during the past decade.

Yellow-billed Loon densities on the Colville Delta ranged from 0.10 to 0.15 birds/km^2 between 1992 and 1996 (Table 23). Similar densities have been reported for other Yellow-billed Loon nesting areas on the North Slope of Alaska: Square Lake in the National Petroleum Reserve-Alaska (0.14 birds/km^2, Derkson et al. 1981) and the Alaktak region south of Smith Bay (0.16 birds/km^2, McIntyre 1990).

In the Development Area, we counted 29 Yellow-billed Loons and 11 nests in 1996. Nine nests were concentrated in the eastern Development Area between the Sakoonang and East channels (Figure 10). The distribution of nests was similar in 1992 (for the sample plot in this area), 1993, and 1995. In 1996, however, we found five nests south of the Facility Area in locations that had not had documented use since 1984, when nests were found by North et al. (1984a). Nest densities in the Development Area were similar among years, unless the additional nests found on revisits in 1996 were included in the calculations; including those additional nests resulted in a nest density nearly twice as high in 1996 as in previous years (Table 23).

During aerial nesting surveys in the Facility Area in 1996, we saw three Yellow-billed Loons: a pair attending a nest and a single bird resting on a lake (nest shown in Appendix Figure D1). The lake occupied by a nest in 1996 also contained a nest in both 1993 and 1995 (Figure 10). The Facility Area was not surveyed in 1992. In 1996, we saw another pair of loons just outside of the Facility Area on a lake that is bisected by the area boundary line. A nest was not found on that lake, but a brood was seen there in July, suggesting that nesting did occur on the lake (Appendix Figure D2). A nest also was found on that lake in 1983 (North et al. 1983). Yearly reoccupation of territories on the Colville Delta by the same Yellow-billed Loons was suspected by North and Ryan (1988), so possibly these two lakes will be occupied by nesting loons in future years.

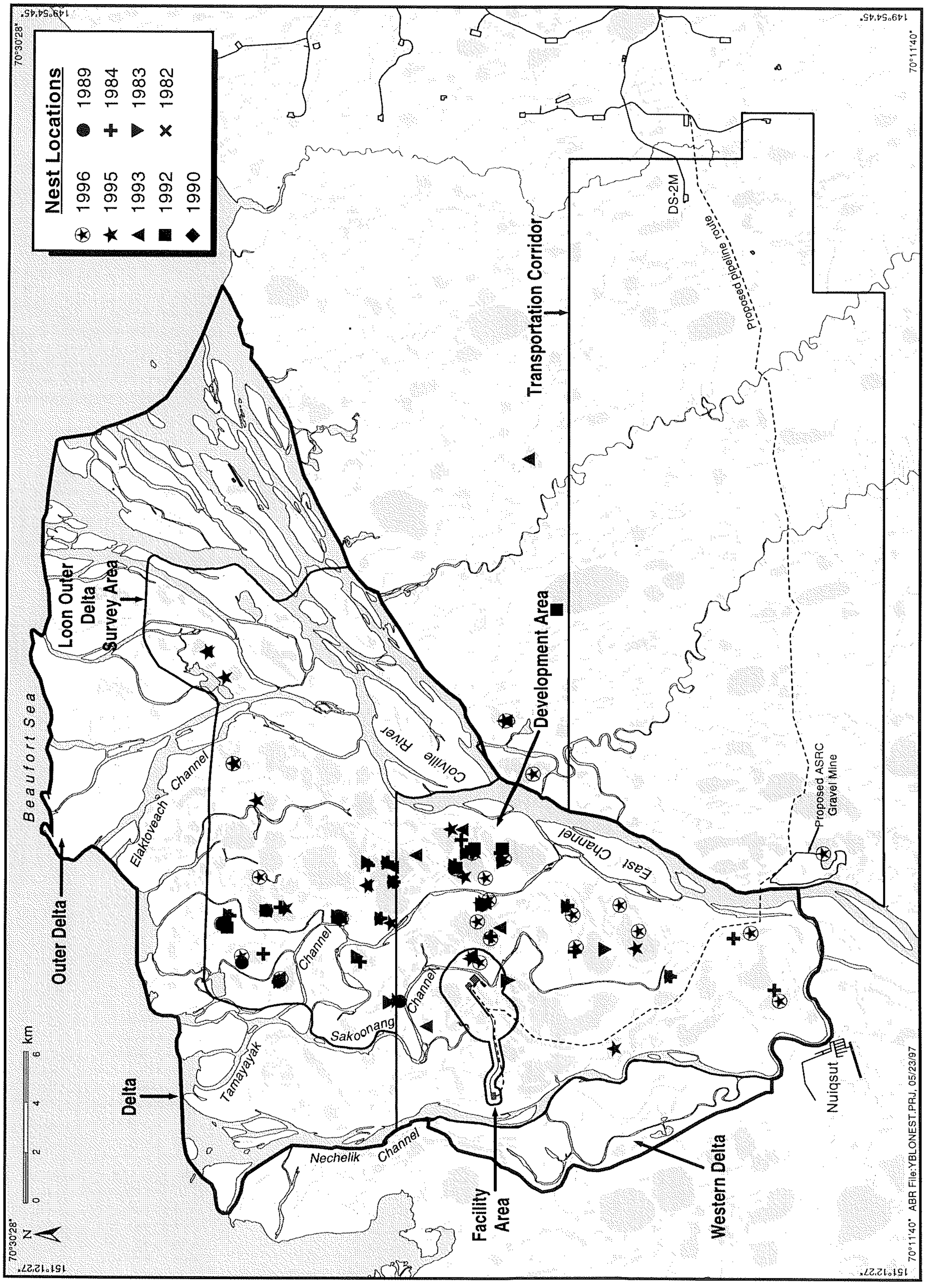

Figure 10. Distribution of Yellow-billed Loon nests observed during aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1982–1984, 1989, 1990, 1992, 1993, 1995, and 1996. Locations are from M. North (1982–1984, 1989, 1990, unpubl. data), Smith et al. (1993, 1994), S. Earnst (1995, unpubl. data), Johnson et al. (1996), and this study.

Table 23. Numbers and densities of loons and their nests counted on aerial surveys conducted by fixed-wing aircraft in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, in 1992, 1993, 1995, and 1996 (Johnson et al. 1996, this study). See Figure 1 for survey areas.

		Yellow-billed Loons				Pacific Loons[a]		Red-throated Loons[a]	
		Number		Density (no./km²)		Number		Number	
Area	Year	Birds	Nests	Birds	Nests	Birds	Nests	Birds	Nests
Delta (324 km²)									
	1996	46	12 (17)[b]	0.14	0.04 (0.05)[b]	79	25	4	2
	1995	39	11	0.12	0.03	62	10	11	0
	1993	50	11	0.15	0.03	130	24	44	0
	1992[c]	12	2	0.10	0.02	5	3	2	0
Development Area (169 km²)									
	1996	29	8 (11)[b]	0.17	0.05 (0.07)[b]	64	20	1	0
	1995	24	5	0.14	0.03	33	4	8	0
	1993	28	7	0.17	0.04	81	17	12	0
	1992[c]	4	1	0.15	0.04	0	0	0	0
Facility Area (9 km²)									
	1996	3	1	0.35	0.12	7	3	0	0
	1995	1	1	0.12	0.12	0	0	0	0
	1993	2	1	0.23	0.12	10	1	0	0
Outer Delta[d] (155 km²)									
	1996	17	4 (6)[b]	0.11	0.03 (0.04)[b]	15	5	3	2
	1995	15	6	0.10	0.04	29	6	3	0
	1993	22	4	0.14	0.03	49	7	32	0
	1992[c]	8	1	0.09	0.01	5	3	2	0
Transportation Corridor (343 km²)									
	1996	5	0 (1)[b]	0.01	0 (<0.01)[b]	31	14	0	0
	1995[e]	4	0	0.01	0	88	7	0	0
	1993	0	0	0	0	140	10	7	0
ASRC Gravel Mine site (2 km²)									
	1996	0	0	0	0	1	1	0	0
	1995	0	0	0	0	0	0	0	0
	1993	0	0	0	0	0	0	0	0

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and survey intensity varied among years.

[b] Number or density of nests found on initial survey and in parentheses, cumulative number or density found after revisiting locations where loons, but no nests, were seen.

[c] In 1992, three plots were sampled; 119 km² were surveyed on the Delta, 93 km² were surveyed on the Outer Delta, 26 km² were surveyed in the Development Area, and the Transportation Corridor and the Facility Area were not surveyed.

[d] Portion of the Outer Delta described as the Loon Outer Delta survey area in Figure 10.

[e] In 1995, the Transportation Corridor included 274 km².

On the Outer Delta in 1996, the distribution of Yellow-billed Loons and nests was confined to the area between the Tamayayak and Elaktoveach channels (Figure 10). In 1993 and 1995, we also found most birds and nests between these two channels, with nests concentrated near the Tamayayak Channel. We calculated densities for the area that was surveyed in common in 1993, 1995, and 1996 (Loon Outer Delta survey area, Figure 10); densities of nests were similar among years except for 1992, when only one nest was found in one of the two survey plots on the Outer Delta (Table 23). The density of Yellow-billed Loons on the Outer Delta was slightly higher in 1993 than in other years, possibly reflecting a higher number of nonbreeders.

Our surveys focused on Yellow-billed Loons, which tend to nest on large lakes; consequently, the survey route flown did not provide complete coverage of smaller waterbodies, which are frequented by Pacific and Red-throated loons. Opportunistic counts of Pacific and Red-throated loons reflect their general distribution among areas but are not indicative of the relative abundance of these species (due to biases in species detectability) or annual changes in abundance (because of annual variation in survey intensity) (Figure 11, Table 23). Therefore, we have not calculated densities for these two species.

Relative to Yellow-billed Loons, Red-throated and Pacific loons were undercounted. Their smaller size and use of smaller lakes with emergent vegetation decrease their detectability from aircraft. We flew the lake-to-lake survey pattern at a higher intensity (i.e., smaller lakes were surveyed) during the nesting season in 1993 than in 1995 or 1996. This difference in survey intensity is reflected in the higher counts of Pacific and Red-throated loons in 1993 and resulted in a more accurate representation of the distribution and abundance of these two species that year. Pacific Loons were the most abundant loon species on the delta during each year of study and nesting was most common west of the Elaktoveach Channel (Figure 11, Table 23). Rothe et al. (1983) also found Pacific Loons to be most common in the western and central delta and suggested that Pacific and Red-throated loon densities on the Colville Delta were comparable to other areas in the Arctic Coastal Plain. Rothe et al. (1983), who conducted ground-based surveys on the delta in 1981 using sample plots, estimated Pacific Loons densities at 1.5 birds/km^2 and Red-throated Loon densities at 0.6 birds/km^2. Bergman and Derksen (1977) found similar Pacific Loon densities (1.6 birds/km^2) and higher Red-throated Loon densities (1.2–1.6 birds/km^2) at Storkersen Point, 70 km east of the Colville Delta (densities represent the average for five years of study).

In 1996, we surveyed the Facility Area intensively during aerial and ground-based nesting surveys and recorded nest locations for Pacific and Red-throated loons (Appendix Figure D1). Within the Facility Area (9 km^2) in 1996, we found seven Pacific Loons and three nests, and one Red-throated Loon with a nest. In the same area in 1995, we found one Red-throated Loon nest, and in 1993, we found ten Pacific Loons and one nest. Within the larger ground-search area (17 km^2) in 1996, which includes the Facility Area, we found 13 Pacific Loon nests and 2 Red-throated Loon nests. We assumed from the number of broods seen in that area that four additional Red-throated loon nests were in the area. The nest density of Pacific and Red-throated loons in this area was 0.8 nests/km^2 and 0.4 nests/km^2, respectively. Identical nest densities were reported by Bergman and Derksen (1977) for Pacific Loons and Red-throated Loons at Storkersen Point from 1971 to 1973.

Transportation Corridor—We found one Yellow-billed Loon nest in the Transportation Corridor during the 1996 aerial surveys (Figure 10). That nest was the first found in the Transportation Corridor during three years of study (1993, 1995, and 1996; Table 23). We found the nest on 4 July during a revisit to a large lake near the ASRC Gravel Mine site (Appendix Figure D3). North of the Transportation Corridor in 1996, we found two Yellow-billed Loon nests, each on a lake near the East Channel (Figure 10). One of these lakes also supported a Yellow-billed Loon nest in both 1993 and 1995 (Smith et al. 1994, ABR, unpubl. data). In 1992, we found a nest just outside the boundaries of the Transportation Corridor on a large lake in the north central part of the corridor during a survey for Brant (the Transportation Corridor was not surveyed for loons in 1992). We saw five Yellow-billed Loons in the Transportation Corridor in 1996: one on a nest, two singles on a lake just north of the ASRC Gravel Mine site, and

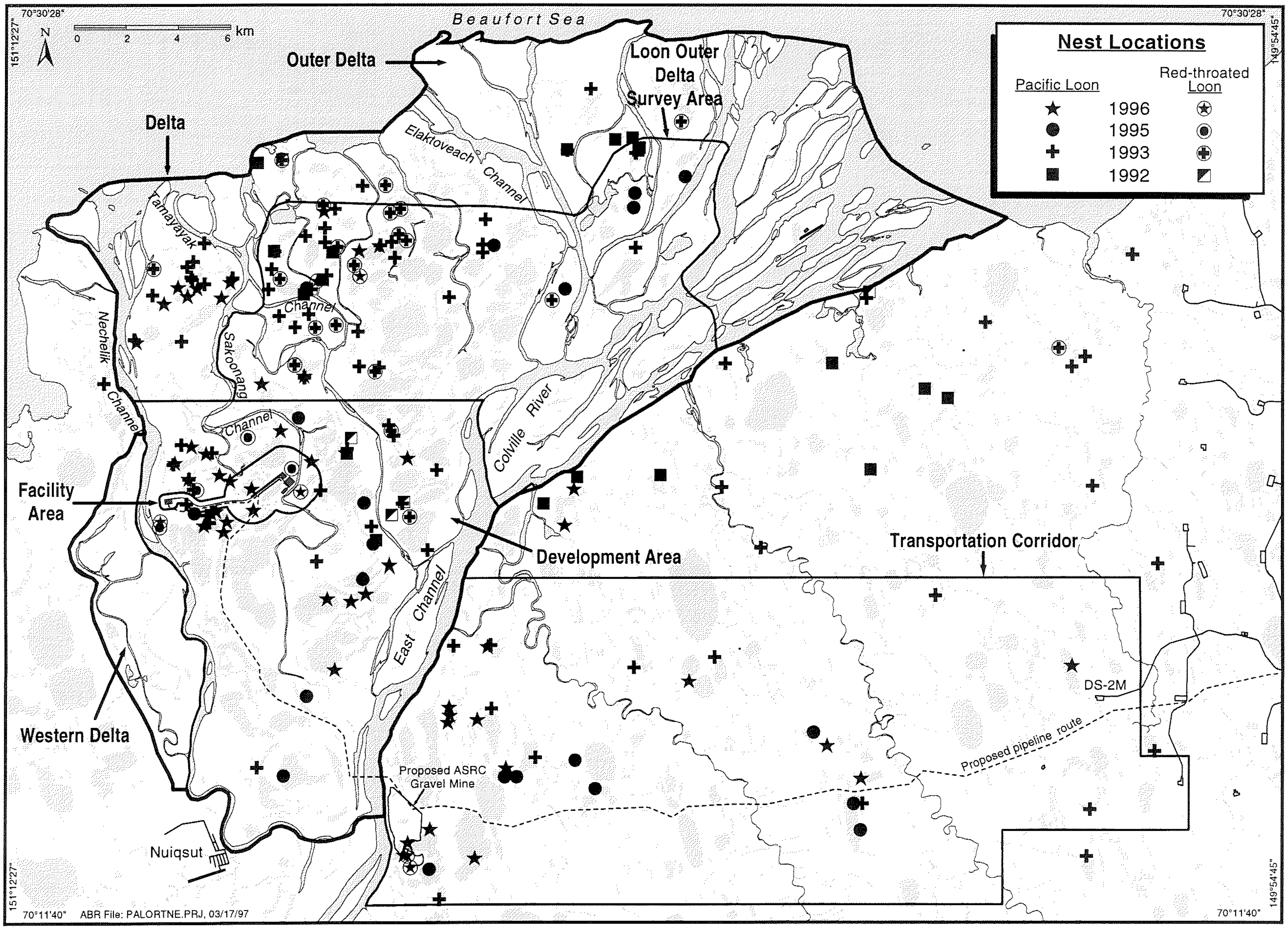

Figure 11. Distribution of Pacific and Red-throated loon nests observed during aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

a pair on the lake containing a nest in 1992. We did not see any Yellow-billed Loons in the Transportation Corridor during the nesting survey in 1993. In 1995, four Yellow-billed Loons were observed in the Transportation Corridor, all of which were on two lakes north of the ASRC Gravel Mine site.

Pacific Loons and their nests were common in the Transportation Corridor in 1996, whereas Red-throated Loons were not seen on the aerial survey (Figure 11, Table 23). Survey intensity varied among years and between the delta and the Transportation Corridor, therefore, we cannot compare the distribution and abundance of these loon species among years within the Transportation Corridor, nor can we compare between the delta and the Transportation Corridor. In 1995 and 1996, we selectively surveyed large lakes in the Transportation Corridor and, consequently, we undercounted these species. In 1993, we included smaller lakes in the aerial survey and recorded 5× as many Pacific Loons as in 1996 but found 3 fewer nests. Whether the high number of loons and low number of nests in 1993 represented a large nonbreeding population is unknown. At the ASRC Gravel Mine site, we did not observe Pacific or Red-throated loons during the 1996 aerial surveys, but we did find one nesting pair of each species during the ground-based survey in late June (Appendix Figure D3). On the large lake just east of the ASRC Gravel Mine site boundary, we found two additional Pacific Loon nests, and one additional Red-throated Loon nest slightly farther inland.

Brood-rearing

Delta—The distribution of Yellow-billed Loons on the Colville Delta during the brood-rearing surveys in 1996 was similar to the distribution of loons during the nesting survey (Figures 11 and 12). Other researchers have found that adults with young remain at or near the nest lake during brood-rearing (North and Ryan 1989) and that non-nesting and failed breeders maintain their territories throughout the summer (North and Ryan 1988). We counted 62 adult Yellow-billed Loons and 6 broods on the 1996 brood-rearing survey; all broods were associated with nesting lakes located during the nesting survey. Brood density on the delta was relatively stable during the four years of surveys; it ranged from 0.01 to 0.03 broods/km^2 (Table 24). The most productive year for both nesting and brood-rearing was 1995, which was the only year in which broods of more than one young were observed. According to North and Ryan (1988), hatching on the delta occurs between 11 and 28 July, which puts chicks at 4 to 6 weeks of age at the time of our brood-rearing surveys. In 1984, North (1986, derived from Table 10) conducted a brood survey when chicks were of similar age and found 12 broods on the delta, similar in number to our highest brood count of 11 in 1995.

The density of Yellow-billed Loons on the delta during brood-rearing in 1995 and 1996 was nearly twice the density in 1992 and 1993 (Table 24). In 1995 and 1996, we conducted intensive surveys that used a helicopter, rather than a fixed-wing aircraft, as the survey platform; this difference possibly contributed to the higher bird count in those years. Additionally, we observed flocks of loons (5–11 birds each) during the brood-rearing surveys in 1995 and 1996, which were not observed in 1992 or 1993; these flocks contributed to the increase in density in 1995 and 1996. Flocks of Yellow-billed Loons have been observed in August during other studies on the delta (North et al. 1984a, Gerhardt et al. 1988) and may represent post-breeding birds that have dispersed from other nesting areas to stage on the delta before migration. Sage (1971) reported that post-breeding dispersal of Yellow-billed Loons in his study area, which was >117 km south of the delta, was north towards the coast.

We counted 30 adult Yellow-billed Loons and three broods in the Development Area during the 1996 brood-rearing survey, representing nearly half of the total number of loons and broods for the Delta survey area (Table 24). In the years when we surveyed the Development Area in its entirety, the density of Yellow-billed Loons increased from 1993 to 1996. This increase may have been due to the change in the survey platform from fixed-wing aircraft to helicopter. The highest density of loons (0.30 birds/km^2) was based on the number of loons seen in 1992 within a 26-km^2 survey plot, which was not representative of the entire Development Area (169 km^2). Brood density was the same for all years (0.02 broods/km^2), except for 1992, when no broods were found.

In 1996, we did not see Yellow-billed Loon broods in the Facility Area during the aerial survey

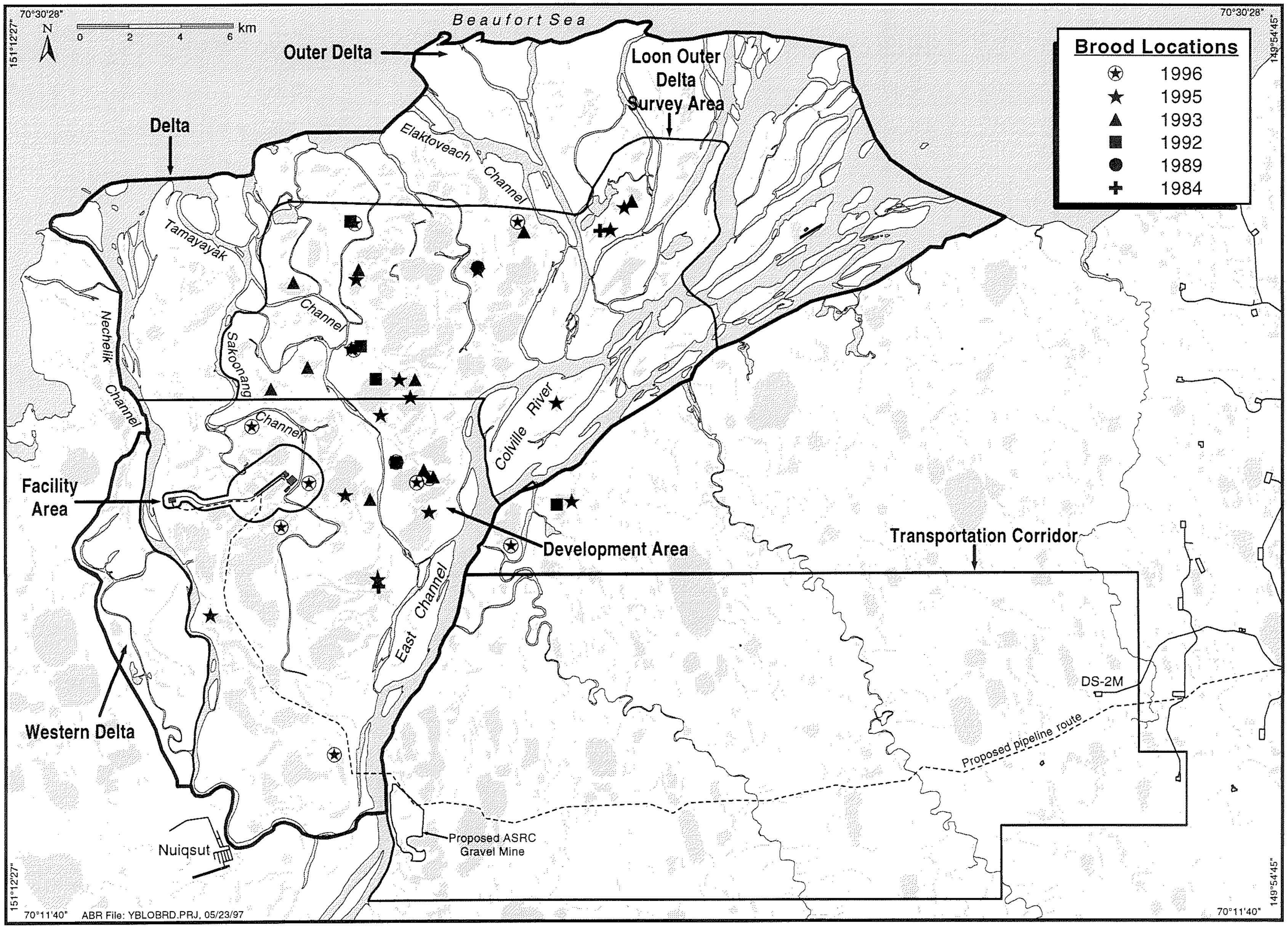

Figure 12. Distribution of Yellow-billed Loon broods observed during aerial and ground-based surveys in the Delta survey area, Colville River Delta, Alaska, 1984, 1989, 1992, 1993, 1995, and 1996. Locations are from M. North (1984, 1989, unpubl. data), Smith et al. (1993, 1994), S. Earnst (1996, unpubl. data), Johnson et al. (1996), and this study.

Table 24. Numbers and densities of loons and their broods counted on aerial surveys conducted by fixed-wing aircraft in 1992 and 1993, and by helicopter in 1995 and 1996, in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska (Johnson et al. 1996, this study). See Figure 1 for survey areas.

		Yellow-billed Loons					Pacific Loons[a]			Red-throated Loons[a]		
		Number			Density (no./km²)		Number			Number		
Area	Year	Adults	Broods	Young	Birds	Broods	Adults	Broods	Young	Adults	Broods	Young
Delta (324 km²)												
	1996	62	6	6	0.19	0.02	89	25	30	19	6	9
	1995	49	11	15	0.15	0.03	182	33	39	49	7	9
	1993	29	7	7	0.09	0.02	38	2	2	0	0	0
	1992[b]	11	1	1	0.09	0.01	21	6	6	21	0	0
Development Area (169 km²)												
	1996	30	3	3	0.18	0.02	69	21	26	13	5	8
	1995	25	4	6	0.15	0.02	90	12	14	5	1	1
	1993	15	3	3	0.09	0.02	17	1	1	0	0	0
	1992[b]	8	0	0	0.30	0	10	1	1	7	0	0
Facility Area (9 km²)												
	1996	0	0	0	0	0	8	2	3	1	0	0
	1995	0	0	0	0	0	5	2	3	0	0	0
	1993	1	0	0	0.07	0	0	0	0	0	0	0
Outer Delta[c] (155 km²)												
	1996	32	3	3	0.21	0.02	20	4	4	6	1	1
	1995	24	7	9	0.15	0.05	92	21	25	44	6	8
	1993	14	4	4	0.09	0.03	21	1	1	0	0	0
	1992[b]	3	1	1	0.03	0.01	11	5	5	14	0	0
Transportation Corridor (343 km²)												
	1996	3	0	0	0.01	0	42	11	14	0	0	0
	1995[d]	7	0	0	0.03	0	185	15	18	9	0	0
	1993	0	0	0	0	0	0	0	0	0	0	0
ASRC Gravel Mine site (2 km²)												
	1996	0	0	0	0	0	2	1	2	0	0	0
	1995	0	0	0	0	0	0	0	0	0	0	0

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and survey intensity varied among years.
[b] In 1992, three plots were sampled; 119 km² were surveyed on the Delta, 93 km² were surveyed on the Outer Delta, 26 km² were surveyed in the Development Area, and the Transportation Corridor and the Facility Area were not surveyed.
[c] Portion of the Outer Delta described as the Loon Outer Delta survey area in Figure 10.
[d] In 1995, the Transportation Corridor included 274 km².

(Table 24), but we did find one brood during the ground-based survey in late July (Appendix Figure D2). This brood was on the same lake in the Facility Area where a nest was found in late June. We found another brood during the ground-based survey on a lake ~0.5 km south of the Facility Area boundary. This brood probably was associated with the pair of loons that we saw on the same lake during the nesting survey, but no nest was detected then.

On the Outer Delta (i.e., Loon Outer Delta survey area, Figure 12), Yellow-billed Loon densities were higher during brood-rearing in 1996 than in any previous year (Table 24). Loon densities from 1992 to 1996 grew from 0.03 to 0.21 birds/km². Brood densities also increased from 1992 to 1995 (0.01 to 0.05 broods/km²), but declined in 1996 (0.02 broods/km²).

In 1996, we found Pacific Loons and their broods distributed throughout the Delta survey area

(Figure 13, Table 24). The number of birds (89) and broods (25) counted on the aerial brood-rearing survey was similar to the number of birds (79) and nests (25) found during the aerial nesting survey. In contrast, we saw few Red-throated Loons (19) and broods (6). These counts, however, were not representative of the actual number of Pacific and Red-throated loons with broods. These loon species can rear their young on smaller waterbodies than Yellow-billed Loons and our survey did not include all waterbodies. Because our survey intensity for these smaller waterbodies varied among years and survey coverage was never complete, we cannot compare annual abundance or calculate densities for these two species.

In the Facility Area in 1996, we saw 10 adult Pacific Loons and 4 broods on aerial and ground-based surveys combined (Appendix Figure D2). On the same surveys, we also found six adult Red-throated Loons and three broods. In the larger ground-search area (17 km^2) that included the Facility Area, we saw a total of 12 Pacific and 6 Red-throated loon broods. In 1995 in the Facility Area, we saw 15 adult Pacific Loons and 5 broods and 2 adult Red-throated Loons on aerial and ground-based surveys combined. In 1993, only five adult Pacific Loons and one brood and a pair of Red-throated Loons with a brood were seen during a ground-based survey in the Facility Area; no aerial survey was flown in that year.

Transportation Corridor—We followed the same aerial survey route during the 1996 brood-rearing survey in the Transportation Corridor that we did during the nesting survey. Three adult Yellow-billed Loons were seen, but none had broods (Table 24). One adult was on the large lake that borders the eastern boundary of the ASRC Gravel Mine site, and a pair was on a large lake north of there. None of these birds actually occurred at the ASRC Gravel Mine site, however. We did not see broods in the Transportation Corridor in previous years. During aerial surveys in 1992, 1995, and 1996, one Yellow-billed Loon brood was seen north of the Transportation Corridor near the East Channel of the Colville River. These broods were seen on lakes where we observed nesting in 1993, 1995 and 1996 (Figures 11 and 12).

We saw 42 adult Pacific Loons and 11 broods in the Transportation Corridor during an aerial survey in 1996 (Figure 13, Table 24). This count represents only the number that we encountered opportunistically along our survey route and does not represent the total using the Transportation Corridor in 1996. In 1995, when we conducted an intensive survey in the Transportation Corridor during the brood-rearing season, we saw 185 adult Pacific Loons and 15 broods. Although the number of broods was similar in both years, the number of adults was 4× greater in 1995 than in 1996, and may have included a large number of nonbreeding or staging individuals. In 1993, only a cursory search of the Transportation Corridor was conducted, and no Pacific Loons were seen. The Transportation Corridor was not surveyed in 1992. During the 1996 aerial and ground-based surveys, we found a pair of Pacific Loons with a brood at the ASRC Gravel Mine site, and two Pacific Loon broods on the large lake that lies directly east of this site (Appendix Figure D3). We did not see Red-throated Loons at the ASRC Gravel Mine site during brood-rearing surveys in 1996, nor did we see any in the rest of the Transportation Corridor in 1996.

HABITAT SELECTION

Nesting

Delta—During three years of aerial surveys on the delta (1993, 1995, and 1996), 39 Yellow-billed Loon nests were found in 7 of 19 available habitats (Table 25). Habitat selection values for 1996 are reported in Appendix Table C5, and values for previous years were reported by Johnson et al. (1996). Three habitats were preferred: Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Tapped Lake with High-water Connection. These three preferred habitats accounted for 17 (44%) of the 39 nests. Nests were built on islands, peninsulas, shorelines, or in emergent vegetation, all of which could be classified as part of a waterbody at the scale of our habitat map. The habitat most frequently used for nesting (12 nests, 31% of the total), Wet Sedge-Willow Meadow, was used approximately in proportion to its availability, and it was the most abundant habitat on the delta (25% of total available habitats). A larger sample of nests (combined from aerial and ground-based surveys) confirmed the importance of Wet Sedge-Willow Meadow; it was used 2.5× as much

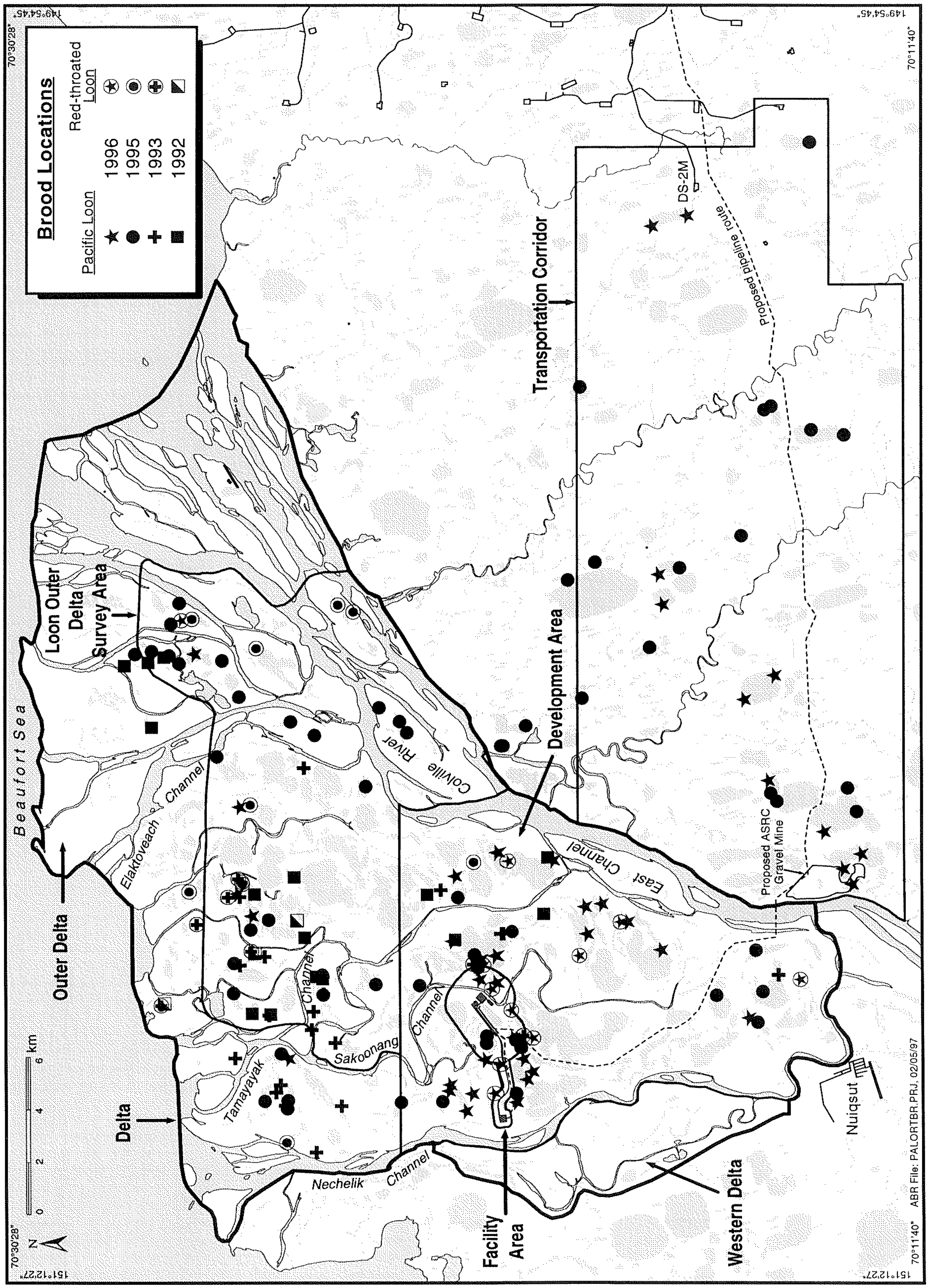

Figure 13. Distribution of Pacific and Red-throated loon broods observed during aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

Table 25. Habitat selection (pooled among years) by nesting Yellow-billed Loons in the Delta survey area, Colville River Delta, Alaska, 1993, 1995, and 1996 (Johnson et al. 1996, this study). See Appendix Table C5 for 1996 results.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	1.22	0	0	0.4	-1.00	ns
Tapped Lake w/ Low-water Connection	19.38	0	0	6.0	-1.00	ns
Tapped Lake w/ High-water Connection	19.57	7	17.9	6.1	0.49	prefer
Salt Marsh	5.64	0	0	1.7	-1.00	ns
Tidal Flat	0.06	0	0	<0.1	-1.00	ns
Salt-killed Tundra	7.48	0	0	2.3	-1.00	ns
Deep Open Water w/o Islands	21.09	6	15.4	6.5	0.41	ns
Deep Open Water w/ Islands or Polygonized Margins	3.58	5	12.8	1.1	0.84	prefer
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	ns
River or Stream	38.33	0	0	11.9	-1.00	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	10.00	5	12.8	3.1	0.61	prefer
Aquatic Grass Marsh	1.20	1	2.6	0.4	0.73	ns
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	3	7.7	9.2	-0.09	ns
Wet Sedge-Willow Meadow	80.84	12	30.8	25.0	0.10	ns
Moist Sedge-Shrub Meadow	9.10	0	0	2.8	-1.00	ns
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	ns
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	ns
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	avoid
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	39	100	100		

[a] Ivlev's E = (use – availability)/(use + availability).

[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

(38% of all nests) as any other habitat (Table 26). Two habitats were significantly avoided by nesting Yellow-billed Loons: River or Stream and Barrens.

Because Yellow-billed Loons usually raise broods in the same lake on which they nest, forage in lakes within their territories, and use lakes for escape habitat, waterbodies adjacent to nest sites are probably more important than the habitats on which the nests actually are built. To evaluate which waterbodies were used most commonly by Yellow-billed Loons during nesting, we measured the distance from the nest to the nearest waterbody on the digitized map and summarized the distance by waterbody type (Table 26). Average distance to the nearest waterbody habitat was 0.01 km (polygon ponds were not mapped individually, and, therefore, are not included as waterbodies). Nests were found at similar distances to water during three other Yellow-billed Loon studies on the Arctic Coastal Plain (Sage 1971, Sjolander and Agren 1976, North and Ryan 1989). Nests found during our study occurred most commonly near Deep Open Water without Islands (49% of all nests), Tapped Lake with High-water Connection (29%) and Deep Open Water with Islands or Polygonized Margins (18%).

Table 26. Habitat use by nesting Yellow-billed Loons and distance to nearest waterbody from aerial and ground-based surveys in the Delta and Transportation Corridor survey area, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996 (S. Earnst 1995, unpubl. data; Johnson et al. 1996; this study).

Habitat	No. of Nests	Use (%)	Mean Distance to Waterbody[a] (km)
HABITAT USED			
Tapped Lake w/ High-water Connection	9	15	
Deep Open Water w/o Islands	7	11	
Deep Open Water w/ Islands or Polygonized Margins	7	11	
Aquatic Sedge w/ Deep Polygons	8	13	
Aquatic Grass Marsh	1	2	
Nonpatterned Wet Meadow	5	8	
Wet Sedge-Willow Meadow	23	38	
Moist Sedge-Shrub Meadow	1	2	
Total	61	100	
NEAREST WATERBODY HABITAT			
Tapped Lake w/ High-water Connection	18	29	<0.01
Deep Open Water w/o Islands	30	49	0.01
Deep Open Water w/ Islands or Polygonized Margins	11	18	<0.01
Shallow Open Water w/o Islands	1	2	<0.01
Aquatic Grass Marsh	1	2	0
Total	61	100	0.01

[a] Distance to waterbody was measured from the digital map and may not be as accurate as measurements on the ground.

Waterbody types important to nesting Yellow-billed Loons on the Colville Delta in 1983 and 1984 (North 1986) were similar to those found in this study. Eleven of 23 (48%) nests were on Deep-*Arctophila* lakes, 9 (39%) were on Deep-Open lakes, and 1 (0.04%) each was on ponds <0.5 ha, ponds from 0.5 to 1.0 ha, and shallow lakes >1.0 ha with emergent sedge or grass. Deep lakes as described by North (1986) include the two Deep Open Water types and Tapped Lakes with High-water Connections that we have described. Although North and Ryan (1988) reported that Yellow-billed Loons did not nest on tapped lakes, they did not identify Tapped Lakes with High-water Connections, which may appear to be untapped because they commonly are connected to channels by low, vegetated areas that do not flood every year. The small waterbodies where North (1986) found nests probably correspond to Aquatic Sedge with Deep Polygons, Shallow Open Water without Islands, and Aquatic Grass Marsh. Consistent with our observations, North (1986) found that nests on small waterbodies (<10 ha) always were near (<70 m) larger waterbodies.

Transportation Corridor—We found one Yellow-billed Loon nest in the Transportation Corridor in 1996. That nest was in Nonpatterned Wet Meadow and was 0.02 km from Deep Open Water without Islands. Nests have not been found in the Transportation Corridor in previous years, although nests were found north of this area (Figure 10).

Brood-rearing

During aerial surveys in 1995 and 1996, we found 17 Yellow-billed Loon broods in three habitats on the delta (both types of Deep Open Water and Tapped Lake with High-water Connection), of which only the two types of Deep Open Water were preferred (Table 27). Wet Sedge-Willow Meadow was the only habitat avoided during brood-rearing on the delta. We found no broods in the Transportation Corridor. The two preferred types—Deep Open Water with Islands or Polygonized Margins and Deep Open Water without Islands—were similar in selection index, yet Deep Open Water without Islands was used 6× more often (71% vs. 12% of all broods, respectively). The concurrence of habitats used

Table 27. Habitat selection (pooled among years) by Yellow-billed Loons during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1995, and 1996 (Johnson et al. 1996, this study). See Appendix Table C5 for 1996 results.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	1.22	0	0	0.4	-1.00	ns
Tapped Lake w/ Low-water Connection	19.38	0	0	6.0	-1.00	ns
Tapped Lake w/ High-water Connection	19.57	3	17.6	6.1	0.49	ns
Salt Marsh	5.64	0	0	1.7	-1.00	ns
Tidal Flat	0.06	0	0	<0.1	-1.00	ns
Salt-killed Tundra	7.48	0	0	2.3	-1.00	ns
Deep Open Water w/o Islands	21.09	12	70.6	6.5	0.83	prefer
Deep Open Water w/ Islands or Polygonized Margins	3.58	2	11.8	1.1	0.83	prefer
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	ns
River or Stream	38.33	0	0	11.9	-1.00	ns
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	10.00	0	0	3.1	-1.00	ns
Aquatic Grass Marsh	1.20	0	0	0.4	-1.00	ns
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	0	0	9.2	-1.00	ns
Wet Sedge-Willow Meadow	80.84	0	0	25.0	-1.00	avoid
Moist Sedge-Shrub Meadow	9.10	0	0	2.8	-1.00	ns
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	ns
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	ns
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	ns
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	17	100	100		

[a] Ivlev's E = (use – availability)/(use + availability).

[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

during nesting and brood-rearing reaffirms the importance of large, deep waterbodies to breeding Yellow-billed Loons. North (1986) found that similar lake types were used during brood-rearing in 1983 and 1984. Small lakes (<13.4 ha) were not used during brood-rearing, but Coastal Wetlands (probably equivalent to our Tapped Lake with High-water Connection or Brackish Water) were used by two broods (North 1986).

BRANT

BACKGROUND

The Colville Delta is an important staging area for migrating Brant in early spring (Simpson et al. 1982, Renken et al. 1983) and supports the largest concentration of nesting Brant on the Arctic Coastal Plain of Alaska (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983). Brant arrive on the Colville Delta during late May and early June, and nest initiation begins as soon as suitable nesting habitat is available (Kiera 1979, Rothe et al. 1983). Most Brant nests (>950; Martin and Nelson 1996) on the delta are located within a colony-complex consisting of at least nine islands centered around Anachlik Island (hereafter, the Anachlik Colony-complex) at the mouth of the East Channel (Simpson et al. 1982, Renken et al. 1983, Martin and Nelson 1996). Brant began nesting at the Anachlik Colony-complex in the 1960s, nesting first on Anachlik Island, but expanding to Char, Brant, and Eskimo islands by the late 1970s-early 1980s (J. Helmericks, pers. comm. in Martin and Nelson 1996). These four islands remain the core of the colony-complex, but Brant now nest in limited numbers on at least five additional islands. Additional nesting locations for Brant are scattered across the northern half of the delta (Smith et al. 1993, 1994; Johnson et al. 1996).

After eggs hatch in early July, most Brant brood-rearing groups move from nesting areas to salt marshes along the coast. A large, but unknown, percentage of brood-rearing groups from the Anachlik Colony-complex moves northeast towards Oliktok and Milne points (Stickney et al. 1994, Anderson et al. 1997). Many remain on Anachlik Island, and another portion moves northwest of the East Channel (J. Helmericks, pers. comm.). Brant from the smaller colonies probably use salt marshes from the Elaktoveach Channel to as far west as the mouth of the Tingmeachsiovik River (Smith et al. 1994), outside of our study area.

The fall migration of Brant along the arctic coast of Alaska usually begins in mid–late August (Johnson and Herter 1989). Major river deltas, such as the Colville Delta, provide important resting and feeding areas for Brant at that time (Johnson and Richardson 1981). These fall-staging Brant tend to use areas along the coast that are similar, but not limited, to those used by brood-rearing groups (Smith et al. 1994).

DISTRIBUTION AND ABUNDANCE

Nesting

Delta—During aerial and ground-based surveys of the Delta survey area in 1996, we counted 41 Brant nests at 11 locations, excluding the Anachlik Colony-complex (Figure 14). We saw 107 Brant on the delta, 105 of which were counted during the aerial survey and 2 of which were seen on the ground-based survey. Our count of nests was 21% greater in 1996 than in 1995 (Johnson et al. 1996), although the counts of adults were similar between the two years. In 1996, Brant occupied 8 of 15 previously identified nest colony locations on the delta (excluding the Anachlik Colony-complex) and 3 new colony locations. The increase in the total number of nesting colonies in 1996 probably represents annual variation in nesting activity by Brant.

We recorded five Brant nesting colonies in the Development Area during aerial and ground-based surveys in 1996, compared to six in 1995, one in 1993, and two in 1992. One colony, which was used in all four years, had an estimated 18 nests in 1996. We found one Brant colony (1 nest) in the Facility Area in 1996 and two (3 nests total) just outside of its boundary (Appendix Figure D4). In 1995, 3 colonies containing 10 nests were just outside the Facility Area boundary (Appendix Figure D4).

In 1996, half (6) of the Brant nesting colonies, excluding the Anachlik Colony-complex, occurred in the Outer Delta survey area (Figure 14). In this area, we found Brant at five colonies in 1995, at seven in 1993, and at two in 1992. The distributional patterns that we have observed in all years on the delta are consistent with longer-term studies conducted between the Colville and Kuparuk rivers; those studies indicated that most (≥75%) Brant nest within 5 km of the coast (Stickney et al. 1994).

Transportation Corridor—Few Brant nested in the Transportation Corridor in 1992–1996 (Figure 14). In 1996, we counted a total of 10 Brant and found 4 nests at one colony in the Transportation Corridor; we found no Brant or nests at the ASRC Gravel Mine site. Only two nesting colonies are known in the corridor, and another colony is located just outside of the eastern border. In our four years of study, we have never found >4 nests at any location.

Brood-rearing

Delta—In 1996, we counted 993 Brant (478 adults/subadults and 515 goslings) at 7 locations along the coast of the delta (Figure 15). The size of brood-rearing groups ranged from 16 to 290 birds, and the percentage of goslings ranged from 40% to 60% ($\bar{x}$ = 53%, n = 7). A multi-year banding study in the neighboring Kuparuk Oilfield indicated that brood-rearing groups of Brant from the Colville Delta disperse as far east as Beechey Point (Anderson et al. 1996, Martin and Nelson 1996); work in 1993 also found dispersal to occur as far west as the Tingmeachsiovik River (Smith et al. 1994).

The total number of Brant observed in 1996 in brood-rearing groups on the delta was the second largest count since surveys were started by USFWS in 1988 (Table 28; Bayha et al. 1992; Smith et al. 1993, 1994), and reflected both the steady growth of the Anachlik Colony-complex and moderate productivity in 1996. The largest count of adults and goslings occurred in 1995 when 1,480 birds were seen; this was twice the number

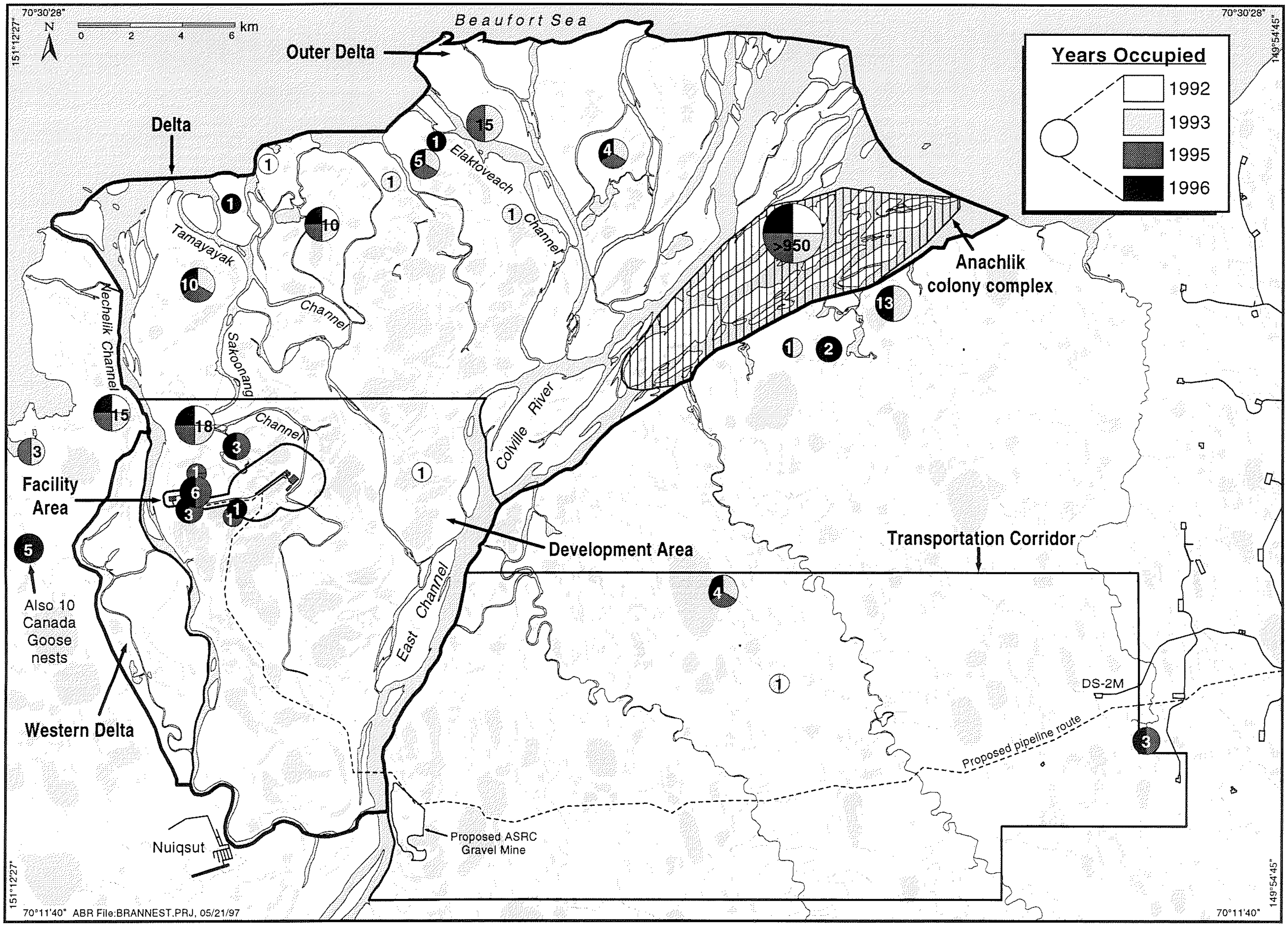

Figure 14. Distribution and nest counts of Brant colonies located during aerial and ground-based surveys in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study. The number in each circle represents the maximal number of nests counted during the four years of study.

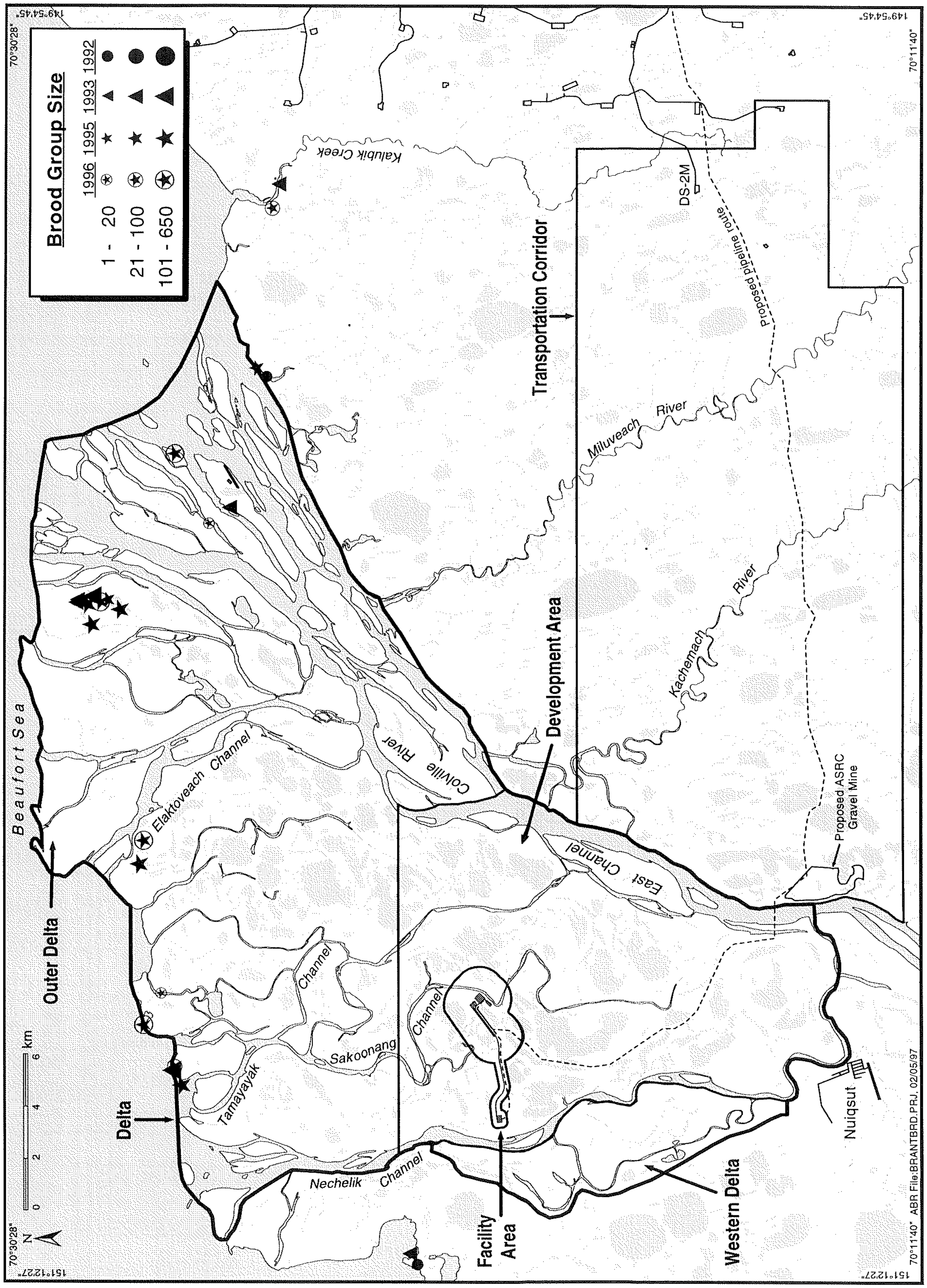

Figure 15. Distribution and size of Brant brood-rearing groups observed during aerial surveys in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

Table 28. Abundance and distribution of Brant in brood-rearing groups during late July-early August on the Colville Delta, Alaska. Data for years prior to 1992 are from Bayha et al. (1992); data for 1993, 1995, and 1996 are from ABR (unpubl. data) and this study.

Year	East Channel to Elaktoveach Channel	Elaktoveach Channel to Nechelik Channel	Total
1996	490	503	993
1995	1,175	305	1,480
1993	590	130	720
1992	0	45	45
1991[a]	410	100	510
1990[a]	433	195	628
1988[a]	70	103	173

[a] Counts are an average of two surveys except in 1991, between the Elaktoveach and Nechelik channels, where one survey was done.

of the 1993 count and one-third greater than the 1996 count. In 1992, only 45 adults were seen and no goslings. The absence of goslings in 1992 was due, in part, to predation of the Anachlik Colony-complex by a bear (J. Helmericks, pers. comm.).

In 1996, the mean percentage of goslings (53%; n = 7 groups) was similar to 1995 (50%; n = 6), but less than 1993 (60%; n = 5). The number of Brant in brood-rearing groups on the delta in 1996 was lower than the number in the adjacent region between the Kuparuk River and Kalubik Creek (1,299 birds) (Anderson et al. 1997), which is another destination for brood-rearing groups from the large Anachlik Colony-complex. However, the mean percentage of goslings in groups on the delta was slightly higher than in this adjacent region (48%).

The Development Area was not surveyed during brood-rearing in 1996. Brant have never been seen in this area during surveys in previous years, however, it is possible that small, inland groups may have been missed. Brant studies between the Sagavanirktok and Colville rivers indicate that >99% of all Brant rear their broods along the coast (Stickney and Ritchie 1996).

The distribution of brood-rearing birds along the Outer Delta showed similar patterns in most of the years surveyed since 1988 (Table 28). In all years except 1988 and 1992, most Brant occurred on the delta between the East Channel and the Elaktoveach Channel; in 1996, the numbers were similar between the East and Elaktoveach channels and the Elaktoveach and Nechelik channels.

Transportation Corridor—In the years during which surveys were conducted in the Transportation Corridor, no brood-rearing groups of Brant were seen (Figure 15). We did not survey for Brant in the Transportation Corridor in 1996, and we flew only partial surveys in other years because this area has none of the salt-adapted vegetation that Brant prefer during brood-rearing. The small number of birds that do nest in this area may move to salt marshes between Kalubik Creek and the Miluveach River. The ASRC Gravel Mine site also was not surveyed specifically for Brant, but ground-based surveys conducted there for other species found no Brant.

Fall Staging

Delta—During fall staging in 1996, most Brant groups (11 of 17) occurred east of the Elaktoveach Channel, a distribution similar to that observed in both 1992 and 1993 (Figure 16), and also seen in 1989 (Bayha et al. 1992). In 1995, however, most groups occurred west of the Elaktoveach Channel. In 1996, we saw 1,327 Brant at 17 locations on the Colville Delta; group sizes ranged from 15 to 350 birds ($\bar{x}$ = 78 birds). The number of Brant counted on the delta during fall staging in 1996 was higher than in 1995 (469 birds), 1993 (355 birds), and 1992 (377 birds).

Although we saw most fall-staging birds near the coast in 1996, two groups (20 and 16 birds) were seen in river channels in the Development Area (Figure 16). No groups were seen in the Facility Area in 1996, but one group was seen just south of the Facility Area in 1995.

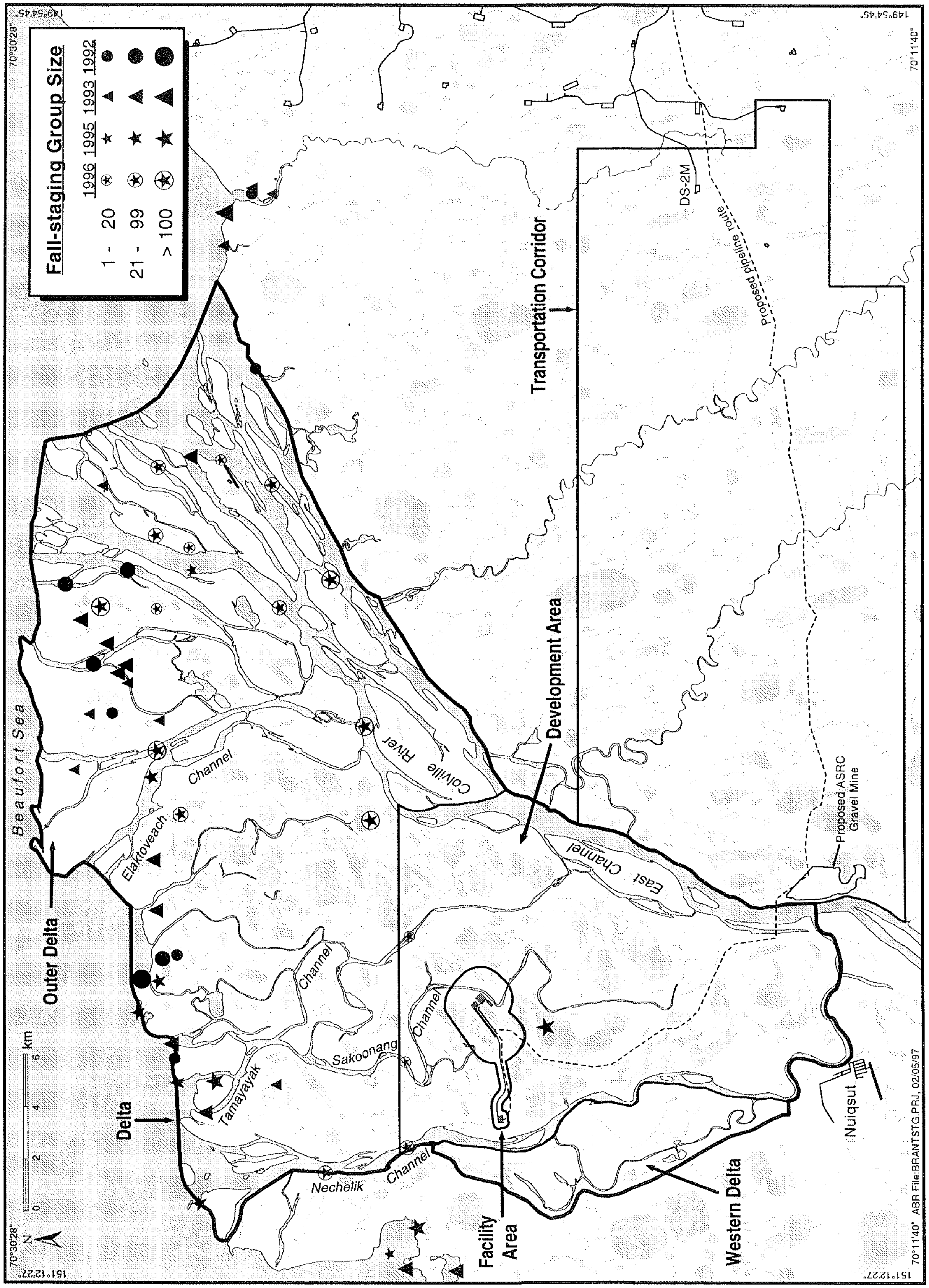

Figure 16. Distribution and size of Brant fall-staging groups observed during aerial surveys in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

Transportation Corridor—We know of no records of Brant in the Transportation Corridor during fall staging. However, we have never conducted systematic surveys in the Transportation Corridor, because this area lacks the salt-affected habitats that Brant associate with during this season.

HABITAT SELECTION

Brant use primarily coastal areas during nesting, brood-rearing, and fall staging (Figures 14–16). Although we have found small nesting colonies or single nests in the Development Area and Transportation Corridor, surveys of these areas have been intermittent and sample sizes were inadequate for an analysis of habitat selection (low numbers in these areas may result from a lack of suitable habitat). Therefore, we restricted our analysis to those portions of the Outer Delta that we surveyed completely in 1992, 1993, 1995, and 1996 during nesting and in 1993, 1995, and 1996 during brood-rearing.

Nesting

Ten colonies (excluding the Anachlik Colony-complex) have been used by Brant for nesting in that part of the Outer Delta that was surveyed in 1992, 1993, 1995, and 1996 (Table 29). Nesting Brant used 6 of the 21 available habitats: Aquatic Grass Marsh, Brackish Water, Deep Open Water with Islands or Polygonized Margins, Salt-killed Tundra, Salt Marsh, and Wet Sedge-Willow Meadow. Two of these habitats—Brackish Water and Aquatic Grass Marsh—were preferred. Although Aquatic Grass Marsh was preferred, it contained only one colony with 10 nests. Brackish Water and Salt-killed Tundra contained the most colonies (3 each), but Wet Sedge-Willow Meadow contained more nests (15) than all other habitats. Basin Wetland Complexes, which typically are preferred by Brant elsewhere on the Arctic Coastal Plain, were not available in the Outer Delta survey area. No habitats were avoided.

Table 29. Habitat selection by nesting Brant (based on the cumulative locations of colonies) in the Outer Delta survey area, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996 (Johnson et al. 1996, this study).

Habitat	Area (km^2)	Maximal Estimate of Nests	No. of Colonies	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	0	-	-	4.2	-	ns
Brackish Water	6.41	7	3	30	2.6	0.84	prefer
Tapped Lake w/ Low-water Connection	5.54	0	0	0	2.2	-1.00	ns
Tapped Lake w/ High-water Connection	2.20	0	0	0	0.9	-1.00	ns
Salt Marsh	13.11	1	1	10	5.2	0.31	ns
Tidal Flat	55.89	0	0	0	22.3	-1.00	ns
Salt-killed Tundra	23.25	5	3	30	9.3	0.53	ns
Deep Open Water w/o Islands	2.07	0	0	0	0.8	-1.00	ns
Deep Open Water w/ Islands or Polygonized Margins	2.64	10	1	10	1.1	0.81	ns
Shallow Open Water w/o Islands	0.70	0	0	0	0.3	-1.00	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.26	0	0	0	0.1	-1.00	ns
River or Stream	49.41	0	0	0	19.7	-1.00	ns
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	7.62	0	0	0	3.1	-1.00	ns
Aquatic Grass Marsh	0.37	10	1	10	0.2	0.97	prefer
Young Basin Wetland Complex	0	-	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	-	0	-	-
Nonpatterned Wet Meadow	15.33	0	0	0	6.1	-1.00	ns
Wet Sedge-Willow Meadow	16.55	15	1	10	6.6	0.20	ns
Moist Sedge-Shrub Meadow	2.49	0	0	0	0.1	-1.00	ns
Moist Tussock Tundra	1.68	0	0	0	0.7	-1.00	ns
Riverine or Upland Shrub	1.25	0	0	0	0.5	-1.00	ns
Barrens (riverine, eolian, lacustrine)	32.99	0	0	0	13.2	-1.00	ns
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	-
Total	250.25	48	10	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated for colony locations only.
[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

The islands in the Anachlik Colony-complex, which contain >950 nests, consist of large proportions of Barrens (including partially vegetated areas), Wet Sedge-Willow Meadow, and Tidal Flat (which periodically is flooded and not available for nesting) and smaller proportions of Nonpatterned Wet Meadow, Moist Sedge-Shrub Meadow, Salt-killed Tundra, Salt Marsh, Aquatic Sedge with Deep Polygons, and both types of deep and shallow lakes (Table 30). No quantitative information is available on the location of nests in these habitats, so they were not included in our selection analysis. The large proportion of Barrens on several islands that support large colonies is notable because Brant did not nest in this habitat elsewhere on the delta (Table 29).

Surveys of Brant nesting from Prudhoe Bay west as far as Kasegaluk Lagoon, indicate that islands at the mouth of river deltas have supported larger numbers of Brant than have mainland colonies (Ritchie 1996; ABR, unpubl. data). In the oilfields in particular, the largest colonies (100–250 nests) are located on islands at the mouth of the Kuparuk River delta, and on Howe and Duck islands, near the mouth of the Sagavanirktok River delta. These islands tend to be isolated from the mainland during spring breakup; this isolation provides some protection from terrestrial predators such as arctic foxes and may be more important to nesting Brant than the habitats occupying the islands. Isolated barrier islands also are used by Brant nesting in Kasegaluk Lagoon in northwest Alaska (Divoky 1978, Lehnhausen and Quinlan 1981, Ritchie 1996), as well as Brant nesting off the coast of the oilfields at Niakuk and other areas of the arctic coast (Johnson and Herter 1989; Ritchie et al. 1990; ABR, unpubl. data). These islands usually are sand or gravel in nature, with minimal vegetation, similar to the Barrens habitat used by Brant in the Anachlik colony-complex.

We collected detailed information on the habitat use of 17 individual nests located during ground-based searches in the Development Area in 1995 and 1996 (Table 31). Nearly half of the nests were located in Deep Open Water with Islands or Polygonized Margins, but additional nests were in Shallow Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, Nonpatterned Wet Meadow, and Wet Sedge-Willow Meadow. The largest colony located during ground-based searches in 1995 (6 nests) straddled two different habitat types (Deep Open Water with Islands or Polygonized Margins and Aquatic Sedge with Deep Polygons). All nests were located <1 m from permanent water, either Deep Open Water (both types) or Shallow Open Water with Islands or Polygonized Margins.

Brood-rearing

During brood-rearing in 1993, 1995, and 1996, we saw 28 groups of Brant in 9 different habitats, with salt-affected habitats receiving the greatest use (Table 32). Measures of habitat selection in 1996 are reported in Appendix Table C6 and previous years are in Johnson et al. (1996). Over all years, Brackish Water was used by the most Brant brood groups (7) and was the only preferred habitat on the delta. The other habitats used included Open Nearshore Water (4 groups), Salt Marsh (3 groups), Tidal Flat (4 groups), and River or Stream (2 groups). Brood-rearing groups frequently moved into nearby water when disturbed by our survey aircraft, so the use of waterbodies probably is the result of broods moving from adjacent Salt Marsh as our aircraft approached.

In addition to the brood-rearing groups in the Delta survey area, four groups (2 along the East Channel and 2 west of the Nechelik Channel) occurred just outside of the survey area boundaries (Figure 15). The habitats used by these groups (Table 33) were not appreciably different than those used on the delta (Table 32), but confirmed the importance of salt-affected habitats to Brant during the brood-rearing season. Brood-rearing groups tended to be close to three types of waterbody habitats: Brackish Water (17 of 32 groups), River or Stream (9 groups), and Open Nearshore Water (6 groups; Table 33). The average distance of brood-rearing groups from the nearest waterbody was 0.12 km.

GREATER WHITE-FRONTED GEESE

BACKGROUND

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

Table 30. Habitat availability for islands in the Anachlik Brant Colony-complex, Colville River Delta, Alaska. Brant nests were counted during ground-based searches in 1993 by Martin and Nelson (1996). The colonies at Seal Island and Snow Goose Lake were not in areas classified for habitat.

	Availability (%)								
Habitat	Anachlik (278 nests)	Brant (194 nests)	Char (128 nests)	Dune (29 nests)	Eskimo (103 nests)	Plover (63 nests)	Swan (61 nests)	Turnstone (37 nests)	White-front (29 nests)
Open Nearshore Water (marine)	0	0	0	0	0	0	0	0	0
Brackish Water	0	0.7	0	0	0	0	0.5	0	0
Tapped Lake w/ Low-water Connection	0	0	0	0	0	0	0	0	0
Tapped Lake w/ High-water Connection	0	0	0	0	0	0	0	0	6.4
Salt Marsh	0.3	0	3.9	0	0	1.5	8.3	11.9	0
Tidal Flat	14.5	96.1	88.9	0	0	0	0	0	0
Salt-killed Tundra	2.0	0	0	3.7	30.7	0	0	0	3.4
Deep Open Water w/o Islands	0	0	0	4.3	0	0	1.0	0	0.1
Deep Open Water w/ Islands or Polygonized Margins	7.0	0	0	6.7	0	0	0	0	0.6
Shallow Open Water w/o Islands	1.1	0	0	0.7	0	0.2	0	0	0.2
Shallow Open Water w/ Islands or Polygonized Margins	1.3	0	0	0.8	0	0	0	0	0.9
River or Stream	0	0	0	0	0	0	0	0	0
Aquatic Sedge Marsh	0	0	0	0	0	0	0	0	0
Aquatic Sedge w/ Deep Polygons	6.1	0	0	8.8	0	0	0	0	7.1
Aquatic Grass Marsh	0	0	0	0	0	0	0	0	1.8
Young Basin Wetland Complex	0	0	0	0	0	0	0	0	0
Old Basin Wetland Complex	0	0	0	0	0	0	0	0	0
Nonpatterned Wet Meadow	32.3	0	0	14.4	0	0	7.8	0	9.8
Wet Sedge-Willow Meadow	20.4	0	0	32.4	0	0	0	0	52.7
Moist Sedge-Shrub Meadow	3.4	0	0	0	29.3	0	10.6	0	0
Moist Tussock Tundra	0	0	0	0	0	0	0	0	0
Riverine or Upland Shrub	1.0	0	0	2.3	0	0.9	0	3.3	0.1
Barrens (riverine, eolian, lacustrine)	10.1	3.2	7.3	25.9	40.0	97.4	71.8	84.8	16.9
Artificial (water, fill, peat road)	0.6	0	0	0	0	0	0	0	0
Total	100	100	100	100	100	100	100	100	100
Total area (km^2)	4.0	2.4	1.0	4.4	0.5	1.2	1.4	0.9	3.0

Table 31. Habitat use and nearest waterbody habitat of individual Brant nests located during ground searches in the Development Area, Colville River Delta, Alaska, 1995 and 1996 (Johnson et al. 1996, this study).

Habitat	No. of Nests	Use (%)
HABITAT USED		
Deep Open Water w/ Islands or Polygonized Margins	8	47.0
Shallow Open Water w/ Islands or Polygonized Margins	4	23.5
Aquatic Sedge w/ Deep Polygons	3	17.7
Nonpatterned Wet Meadow	1	5.9
Wet Sedge-Willow Meadow	1	5.9
Total	17	100
NEAREST WATERBODY HABITAT		
Deep Open Water w/o Islands	1	5.9
Deep Open Water w/ Islands or Polygonized Margins	12	70.6
Shallow Open Water w/ Islands or Polygons	4	23.5
Total	17	100

Table 32. Habitat selection (pooled among years) by Brant brood-rearing groups in the Outer Delta survey area, Colville River Delta, Alaska, 1993, 1995, and 1996 (Johnson et al. 1996, this study). See Appendix Table C6 for 1996 results.

Habitat	Area (km^2)	No. of Brood Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	4	14.3	4.8	0.50	ns
Brackish Water	6.29	7	25.0	2.9	0.79	prefer
Tapped Lake w/ Low-water Connection	5.17	0	0	2.4	-1.00	ns
Tapped Lake w/ High-water Connection	2.06	0	0	0.9	-1 00	ns
Salt Marsh	12.61	3	10.7	5.8	0.30	ns
Tidal Flat	55.89	4	14.3	25.5	-0.28	ns
Salt-killed Tundra	22.22	3	10.7	10.2	0.03	ns
Deep Open Water w/o Islands	0.69	0	0	0.3	-1.00	ns
Deep Open Water w/ Islands or Polygonized Margins	1.78	0	0	0.8	-1.00	ns
Shallow Open Water w/o Islands	0.53	0	0	0.2	-1.00	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.20	0	0	0.1	-1.00	ns
River or Stream	43.15	2	7.1	19.7	-0.47	ns
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	6.41	1	3.6	2.9	0.10	ns
Aquatic Grass Marsh	0.19	0	0	0.1	-1.00	ns
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	9.76	0	0	4.5	-1.00	ns
Wet Sedge-Willow Meadow	9.33	1	3.6	4.3	0.08	ns
Moist Sedge-Shrub Meadow	1.73	0	0	0.8	-1.00	ns
Moist Tussock Tundra	1.68	0	0	0.8	-1.00	ns
Riverine or Upland Shrub	0.80	0	0	0.4	-1.00	ns
Barrens (riverine, eolian, lacustrine)	28.08	3	10.7	12.8	-0.09	ns
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	ns
Total	219.06	28	100	100		

[a] Ivlev's E = (use - availability)/(use + availability); use calculated from the number of groups.
[b] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Table 33. Habitat use by Brant and distance to nearest waterbody during brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1992, 1993, 1995 and 1996 (Johnson et al. 1996, this study). Brood-rearing groups were located during aerial surveys and include groups located just outside the Delta survey area boundaries.

Habitat	No. of Brood Groups	Use (%)	Mean Distance to Waterbody[a] (km)
HABITAT USED			
Open Nearshore Water (marine)	5	15.6	-
Brackish Water	8	25.0	-
Salt Marsh	3	9.4	-
Tidal Flat	4	12.5	-
Salt-killed Tundra	4	12.5	-
River or Stream	3	9.4	-
Aquatic Sedge w/ Deep Polygons	1	3.1	-
Wet Sedge-Willow Meadow	1	3.1	-
Barrens (riverine, eolian, lacustrine)	3	9.4	-
Total	32	100	
NEAREST WATERBODY HABITAT			
Open Nearshore Water (marine)	6	18.8	0.01
Brackish Water	17	53.1	0.20
River or Stream	9	28.1	0.03
Total	32	100	0.12

[a] Distance to waterbody was measured from the digital map and may not be as accurate as measurement on the ground.

DISTRIBUTION AND ABUNDANCE

Nesting

We did not conduct searches specifically for the nests of White-fronted Geese in 1996, although we located 38 nests during the ground-based searches for Spectacled Eider nests in selected areas within the Development Area and Transportation Corridor. We located 35 nests (2.04 nests/km^2) during searches in the Development Area and three nests (1.73 nests/km^2) during searches in the vicinity of the ASRC Gravel Mine site. The density of nests found within the Development Area was slightly higher than that reported previously for other areas of the delta (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983). The majority of nests (27 of 38, 71%) found in 1996 were located in Wet Sedge-Willow Meadow; other habitats used for nesting included Moist Sedge-Shrub Meadow (5 nests, 13%), Nonpatterned Wet Meadow (4 nests, 11%), and Aquatic Sedge with Deep Polygons (2 nests, 5%). Within these habitats, most nests (76%) were located on polygon ridges or small hummocks, microsites similar to the nesting sites reported by Simpson and Pogson (1982). The average clutch size in 1996 was 3.7 eggs (n = 30 nests), similar to the range reported for other studies on the Colville Delta (Simpson and Pogson 1982; Simpson 1983; Smith et al. 1993, 1994; Johnson et al. 1996).

We found 13 White-fronted Goose nests (1.5 nests/km^2) in the Facility Area in 1996 (Figure 17) and 2 nests (0.84 nests/km^2) at the ASRC Gravel Mine site (1 additional nest was outside the boundary) (Figure 18). In the Facility Area, nests were located in the four habitats noted previously. At the ASRC Gravel Mine site, nests were only located in Wet Sedge-Willow Meadow. In the Facility Area, the distance of nests to the nearest permanent waterbody ranged from <1 to 150 m ($\bar{x}$ = 35 m). Nests in the ASRC Gravel Mine site were located much farther from permanent waterbodies ($\bar{x}$ = 325 m, range = 250–400 m).

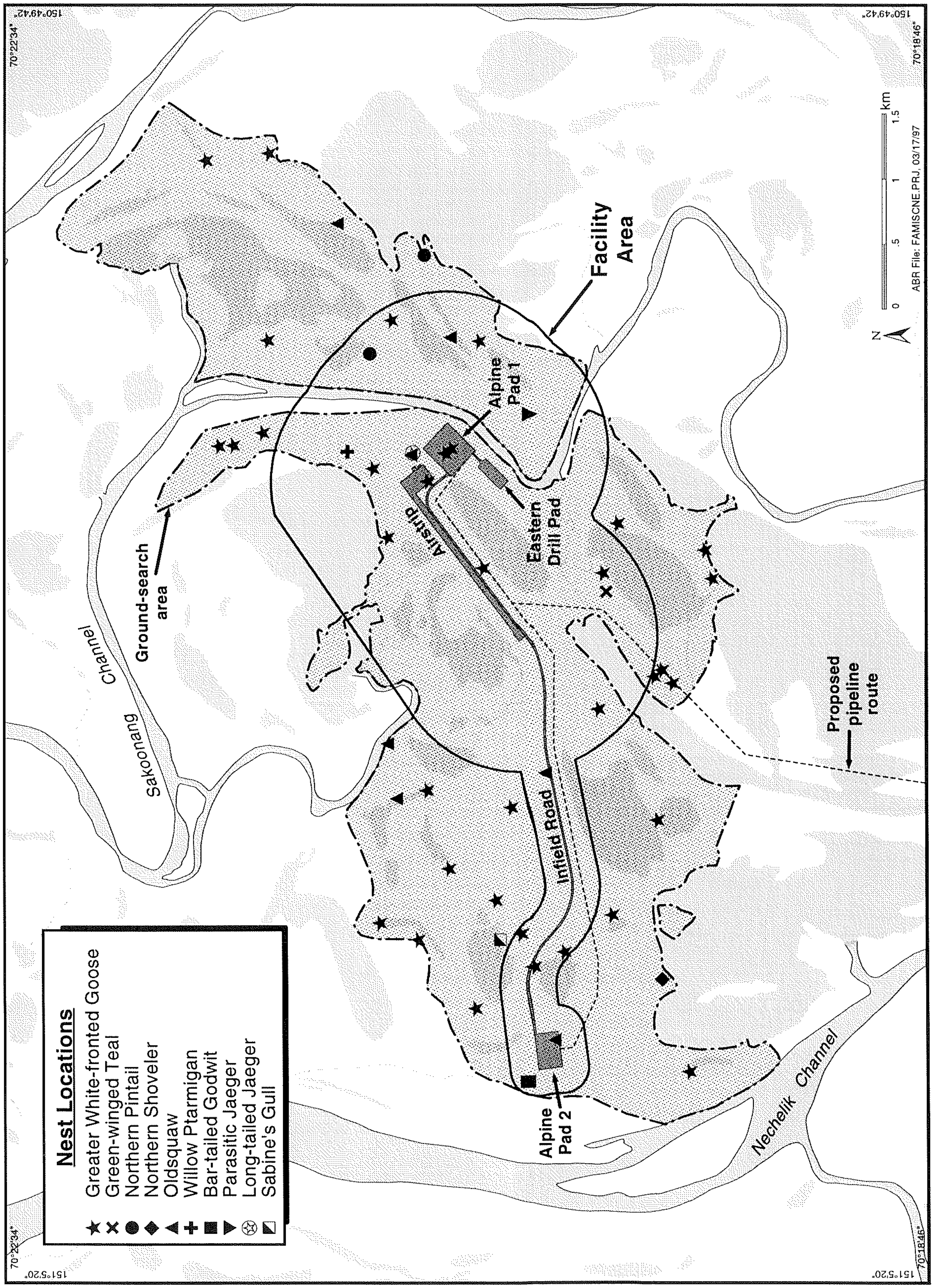

Figure 17. Nest locations of selected birds observed during ground-based surveys in the vicinity of the proposed Facility Area, Colville River Delta, Alaska, late June 1996. The search area encompassed 17 km^2.

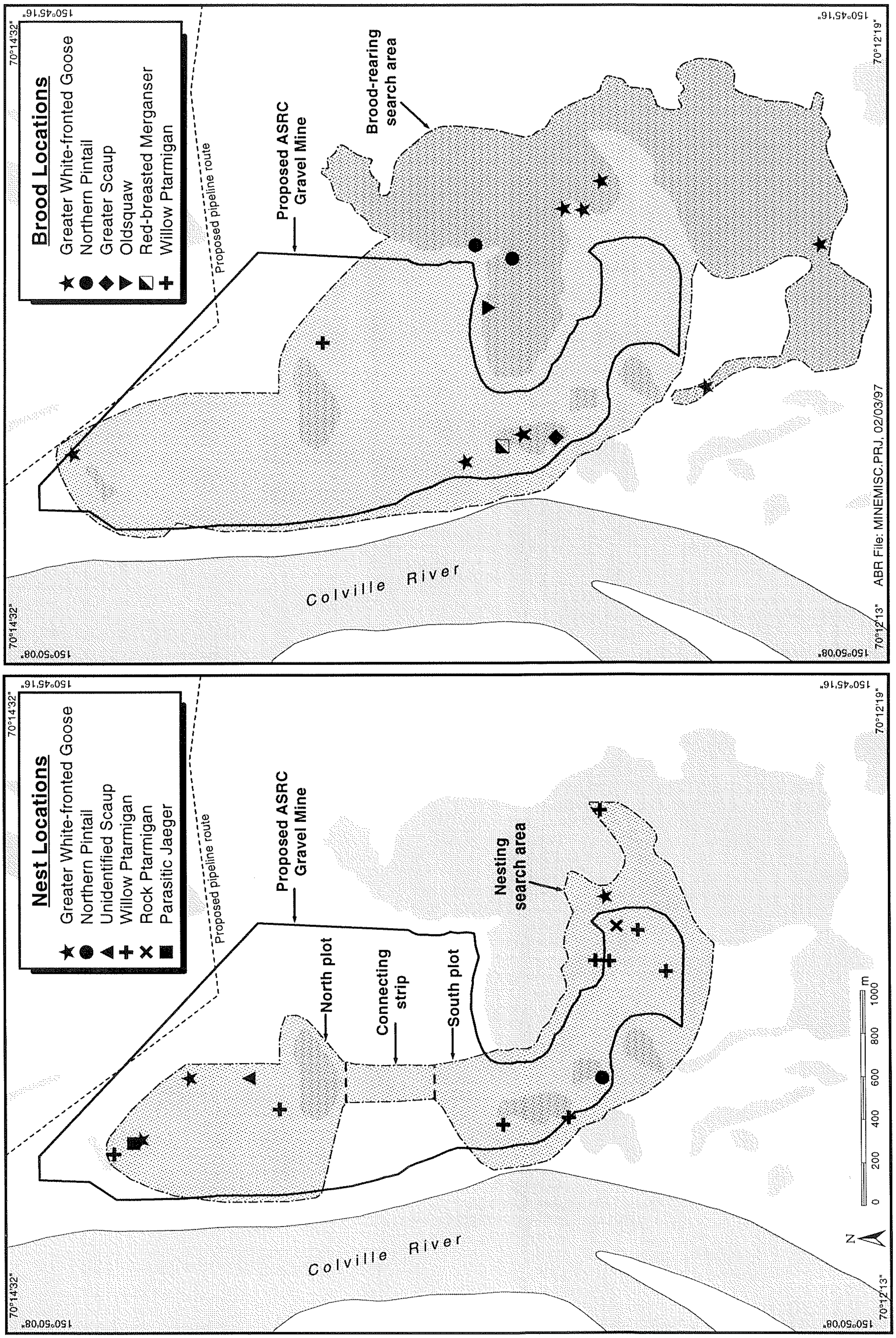

Figure 18. Nest and brood locations of selected birds observed during ground-based surveys in the vicinity of the proposed ASRC Gravel Mine site, Colville River Delta, Alaska, 1996. A helicopter was used to survey the large lake during brood-rearing. The nesting search area encompassed 1.7 km^2 and the brood-rearing search area encompassed 4.3 km^2.

Brood-rearing

In 1996, we conducted a systematic aerial survey (25% coverage) to collect information on the distribution and group sizes of brood-rearing and molting White-fronted Geese (Table 2). In previous years, brood-rearing information for White-fronted Geese was collected opportunistically during aerial surveys conducted for Brant and eiders. In 1996, we saw 553 White-fronted Geese in 16 groups in both the delta and Transportation Corridor. Group sizes ranged between 7 and 106 individuals ($\bar{x}$ = 34.6 birds).

Delta—On the aerial survey in late July 1996, we saw 379 White-fronted Geese in 12 groups on the delta (Figure 19). These groups generally were distributed throughout the study area and typically were in or near either Brackish Water or both types of Deep Open Water. Goslings composed 55% of the total number of birds (208 of 379). In the Development Area (25% coverage of 169 km^2), we counted 145 White-fronted Geese in 3 groups; none of which occurred in the Facility Area. However, on a ground-based survey covering 18 km^2 of the Development Area, we observed 154 White-fronted Geese (57% goslings) in 17 groups, 3 of which were in the Facility Area (Figure 20). During the aerial survey on the Outer Delta, we recorded 177 geese in 7 groups, and on the Western Delta, we saw 57 geese in 2 groups.

Transportation Corridor—We saw 174 White-fronted Geese in 4 groups in the Transportation Corridor during an aerial survey on 26 July 1996 (Figure 19). None of these groups occurred at the ASRC Gravel Mine site. The overall percentage of goslings for groups in the Transportation Corridor was 47%.

During the ground-based survey on 22 July 1996 at the ASRC Gravel Mine site, we saw three groups of White-fronted Geese, all of which were single-family groups, with the largest consisting of two adults and seven young (Figure 18). In addition, we saw five more groups in the large lake adjacent to the mine site. The total number of geese observed in the vicinity of the mine site was 49 birds, of which 33 (67%) were goslings.

Fall Staging

Delta—During fall staging in 1996, large numbers of White-fronted Geese were concentrated around river channels and large lakes; this pattern was unlike that seen during brood-rearing, when numbers were smaller and broods were distributed fairly evenly (Figures 19 and 21). White-fronted Geese did not concentrate near the coast, as did Brant, and were abundant inland in the Development Area. On the aerial survey (25% coverage) specifically for fall-staging geese, we saw 1,356 birds in 28 groups on the delta. In previous years, we did not conduct systematic surveys specifically for geese, instead, we made observations opportunistically during surveys for focal species (Johnson et al. 1996). Hence, the level of effort devoted to recording White-fronted Geese varied among years. Counts of fall-staging White-fronted Geese on the delta were recorded opportunistically during Tundra Swan surveys in 1991, 1992, and 1995, when we counted 555, 1,800, and 491 geese, respectively (Appendix Figure D5). In addition, 2,250 geese were seen on the coastal survey for Brant in 1992. Our data are insufficient to determine whether this annual variation in numbers was due to differences in survey timing and intensity or to actual changes in abundance.

In the Development Area, we saw 10 groups containing 737 White-fronted Geese during the fall-staging survey in 1996 (Figure 21). In 1991, 1992, and 1995, we counted 194, 20, and 130 birds, respectively, in the Development Area (Appendix Figure D5).

Few White-fronted Geese occurred in the Facility Area during 3 of 4 years that we recorded geese on staging surveys. In 1996, we saw 1 group of 35 birds in the Facility Area (Figure 21); this number was similar to the 1 group of 25 birds in 1995 (Appendix Figure D5). No White-fronted Geese were seen in the Facility Area in 1992, and 35 were seen there in 1991.

On the Outer Delta, we saw 564 White-fronted Geese in 16 groups during the fall-staging survey in 1996 (Figure 21). In 1995, we saw 361 geese on a swan survey. The largest numbers were seen in 1992, when we counted 1,800 and 2,230 White-fronted Geese on surveys for swans and Brant, respectively. In 1991, we saw 361 geese on the Outer Delta during a swan survey.

Transportation Corridor—During fall staging in 1996, we saw 6 groups totaling 399 White-fronted Geese during a systematic survey in the

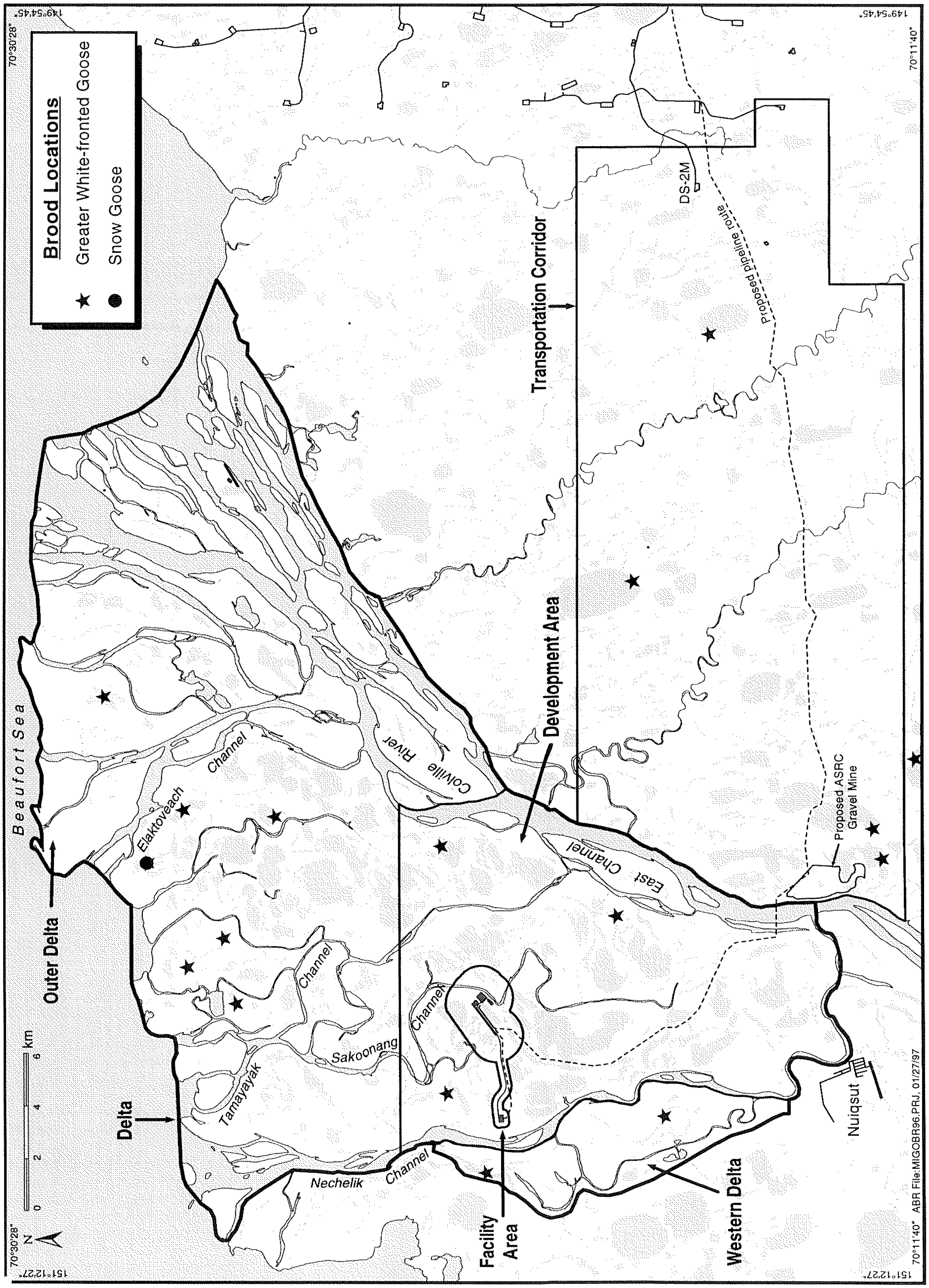

Figure 19. Distribution of brood-rearing and molting groups of Greater White-fronted and Snow geese observed during aerial surveys (25% coverage) in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, July 1996.

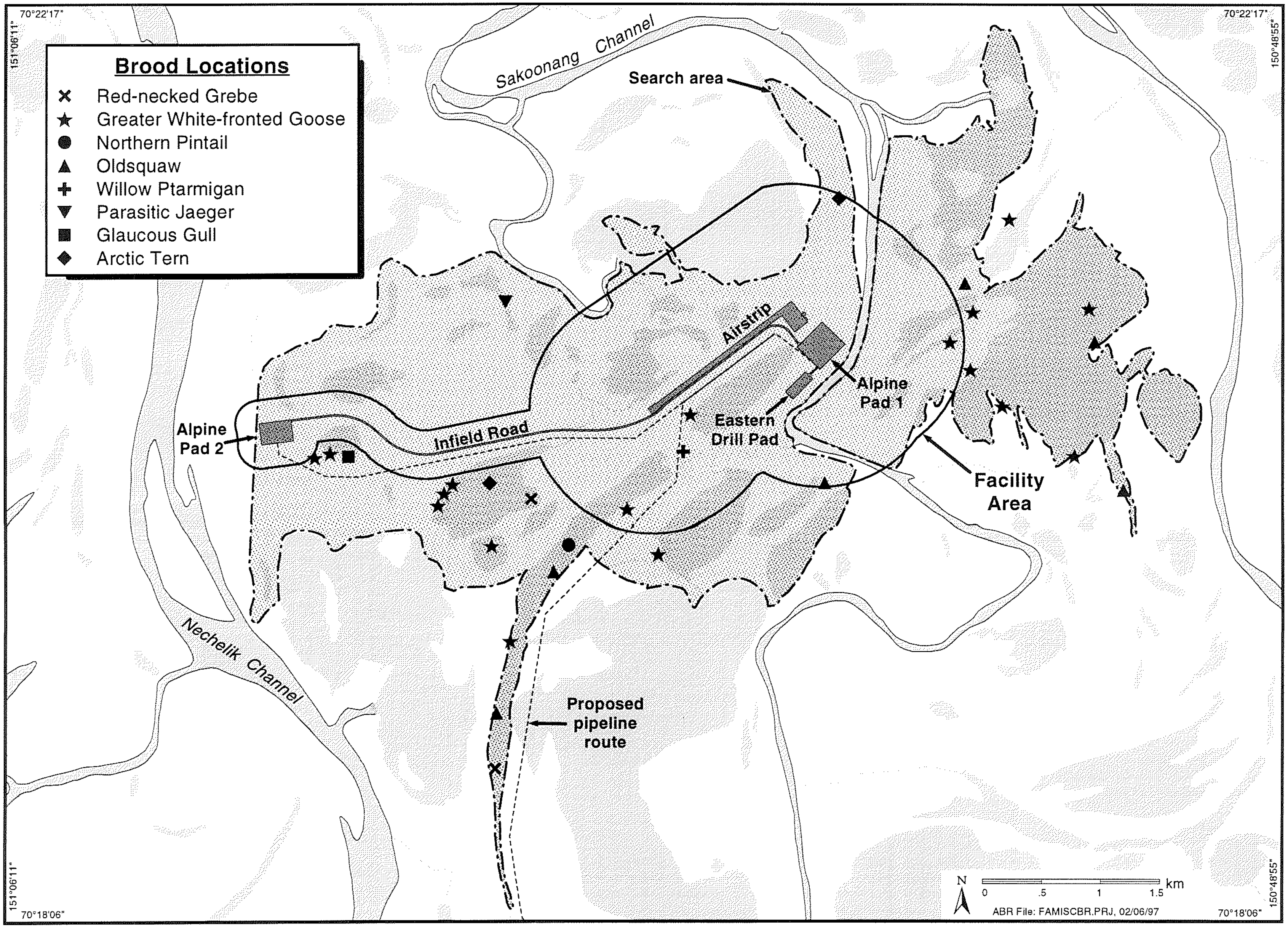

Figure 20. Brood locations of selected birds observed during ground-based surveys in late July and late August in the vicinity of the proposed Facility Area, Colville River Delta, Alaska, 1996. A helicopter was used to survey large waterbodies. The search area encompassed 18 km^2.

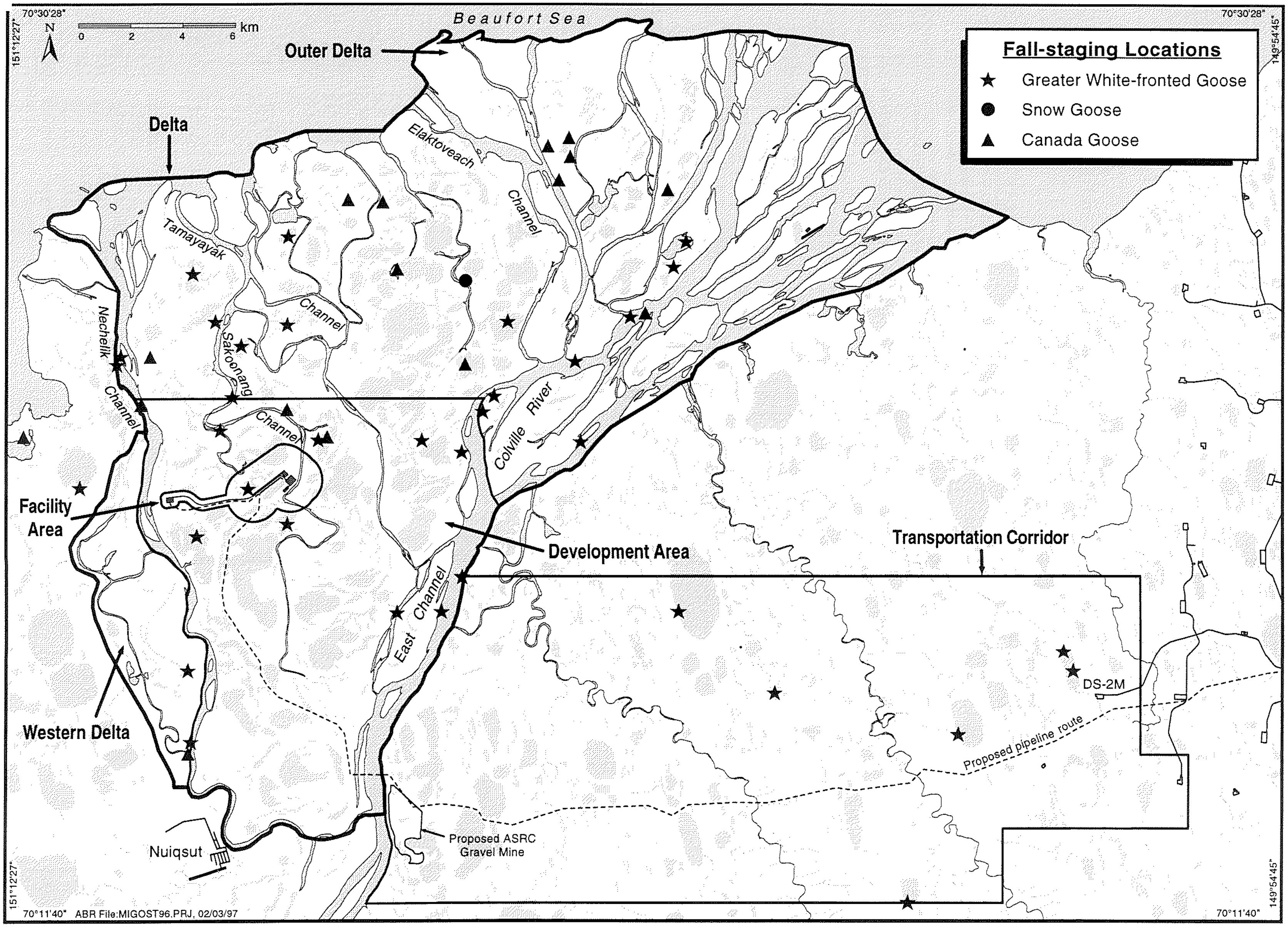

Figure 21. Distribution of fall-staging groups of selected goose species observed during an aerial survey (25% coverage) in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, August 1996.

Transportation Corridor (Figure 21). In 1995, only one group of 30 birds was recorded incidentally on a Tundra Swan survey in the same area. On aerial surveys for Tundra Swans in 1988, 1990, and 1991, we counted 18–354 geese in the Transportation Corridor (Johnson et al. 1996).

SNOW GEESE

BACKGROUND

Snow Geese may have nested commonly along portions of the Arctic Coastal Plain early in this century (Anderson 1913, Bailey 1948, Gabrielson and Lincoln 1959). In the past few decades, however, only small numbers have nested sporadically along the Beaufort Sea coast, generally west of the Sagavanirktok River Delta (Derksen et al. 1981; Simpson et al. 1982; R. J. King, USFWS, pers. comm.). Three small but notable colonies (26 to ≤400 nests) are known from the Sagavanirktok, Ikpikpuk, and Kukpowruk river deltas (Ritchie and Burgess 1993). In addition, small numbers of Snow Geese and a few nests have been recorded from the area between the Kuparuk Oilfield and Kasegaluk Lagoon (ABR, unpubl. data; King 1970; Ritchie and Burgess 1993). Currently in Alaska, large numbers of Snow Geese occur during fall staging only in the Arctic National Wildlife Refuge (Johnson and Herter 1989). In the past, molting and brood-rearing areas for Snow Geese may have been more widespread in the western Beaufort Sea region (Bailey 1948).

DISTRIBUTION AND ABUNDANCE

Nesting

In 1996, we found no Snow Goose nests on the Colville Delta, although we saw a few scattered nests just west of the delta, near the mouth of Fish Creek. In 1995, one Snow Goose nest was seen during the aerial nesting survey for Tundra Swans; in both 1993 and 1994, two nests were found during ground-based searches (Johnson et al. 1996). All of these nests were located <5 km from the coast in the Outer Delta survey area.

Brood-rearing

In 1996, we saw one group of Snow Geese (2 adults, 4 goslings) during the aerial survey for brood-rearing geese (Figure 19), and we saw another group of 18 geese (6 adults, 12 goslings) opportunistically during the aerial survey for brood-rearing Brant (Appendix Figure D6). Both of those brood-rearing groups were on the Outer Delta. In 1995, 12 Snow Geese (all without broods) were seen during a brood-rearing survey of the Outer Delta. No brood-rearing Snow Geese were recorded during surveys in 1992 and 1993, however.

Fall Staging

In late August 1996, we saw three Snow Geese in one group on the Outer Delta (Figure 21). During fall-staging surveys in 1995, we counted 20 Snow Geese on the Outer Delta and 12 birds in the Transportation Corridor. In 1991, six Snow Geese were seen in the Transportation Corridor (Appendix Figure D5). No Snow Geese were seen during staging surveys in 1992 and 1993.

CANADA GEESE

BACKGROUND

Several hundred Canada Geese nest along the banks and bluffs of the upper Colville River (Kessel and Cade 1958); however, prior to 1996, Canada Geese were not reported nesting either on the Colville Delta or in the NPR–A. They do, however, nest in scattered locations on the Arctic Coastal Plain east of the Colville River (ABR, unpubl. data; Ritchie et al. 1991) and commonly nest on islands in wetlands in the Prudhoe Bay area (Troy 1985, Murphy and Anderson 1993). A major molting area for these geese is located near Teshekpuk Lake, west of the Colville Delta (Derksen et al. 1979). Although, the delta itself has not been identified as an important molting or brood-rearing area for Canada Geese, it is important during fall migration (Smith et al. 1994), when geese traveling along the Beaufort Sea coast stop to rest and feed (Johnson and Richardson 1981, Garner and Reynolds 1986).

DISTRIBUTION AND ABUNDANCE

Nesting

During the Brant nesting aerial survey in June 1996, we saw 10 Canada Goose nests at a Brant nesting location just west of the delta in the NPR–A (Figure 14). Canada Geese are not known to nest in the NPR–A (Johnson and Herter 1989), and this is the first record of them nesting close to the delta.

Brood-rearing

In 1996, we found no Canada Geese during aerial surveys conducted in late July, when they would have been molting or rearing young. The only year molting Canada Geese were seen on the delta was 1993, when a group of 30 was seen during a ground-based survey on the Outer Delta (Appendix Figure D6).

Fall Staging

During fall staging, Canada Geese occurred in large numbers and used coastal areas of the Outer Delta more than other areas on the delta. In 1996, we recorded 1,486 Canada Geese in 15 groups on the delta (Figure 21). The number seen in 1996, which was the only year when we conducted a systematic survey for geese during fall staging, was greater than that incidentally seen in 1995 (923 birds), in 1993 (825 birds), and in 1991 (310 birds), but was considerably less than in 1992 (10,950 birds) (Appendix Figure D5). It is unclear what influences the annual variability in numbers of Canada Geese and their use of the delta during fall staging, but some of this variability may be an artifact of the timing of aerial surveys.

In 1996, we saw 426 Canada Geese (3 groups) in the Development Area, but none of these groups was in the Facility Area (Figure 21). In 1995, only one group of 75 birds was observed in the Development Area, just southeast of the Facility Area (Appendix Figure D5). The only other observation of this species in the Development Area was in 1991, when 65 geese were seen, 30 of which occurred in the Facility Area.

On the Outer Delta in 1996, we counted 1,050 Canada Geese in 11 groups (Figure 21). In 1993 and 1992, all Canada Geese seen on the delta were in the Outer Delta survey area (Appendix Figure D5). In 1991, 245 geese were in the Outer Delta.

In 1996, we observed one group of 10 Canada Geese in the Western Delta study area; this was the first record of this species in this area during our surveys (Figure 21). No staging groups of Canada Geese occurred in the Transportation Corridor in any year.

OTHER BIRDS

BACKGROUND

The Colville River Delta provides varied and productive habitats for many bird species for feeding, breeding, molting, and staging (Seaman et al. 1981, Meehan 1986). In spring, the early availability of open water and snow-free areas draw many migrants and breeding birds to the delta (Rothe et al. 1983, Meehan 1986). Diving ducks feed and loaf on flooded tapped lakes, and geese and dabbling ducks use vegetated areas inundated by high water (Rothe et al. 1983). Shorebirds, passerines, and ptarmigan concentrate along river channels; jaegers, gulls, and terns feed in the nearshore waters of the outer delta (Rothe et al. 1983, Seaman et al. 1981). Breeding birds can begin nesting 1–1.5 weeks earlier on the delta than at inland sites nearby, which are still frozen and snow-covered (Rothe et al. 1983). Egg-laying for all species occurs from early June to early July, and hatching occurs from late June through late July. By August, nonbreeding waterfowl have regained flight after the molt and form pre-migratory flocks. Waterfowl with broods remain in protective wetlands on the delta through August, until the young are capable of flight. Shorebirds are attracted to the salt marshes and tidal flats of the delta, particularly during the post-breeding season in August, because of high invertebrate abundance and the large amount of exposed shoreline at that time (Andres 1989). The prolonged presence of open water on the delta during fall provides resources for late migrants and may be critical to the survival of some juvenile waterbirds (Markon et al. 1982).

DISTRIBUTION AND ABUNDANCE

We recorded the presence and location of breeding bird species in proposed development sites within the Facility Area by conducting an intensive ground-based survey on 22 June 1996. We distinguished between flying birds and birds on the ground (non-flying). Because this survey was conducted late in the nesting period of shorebirds and passerines, we did not attempt to locate nests for the birds observed because the number found would have underestimated the actual number of nesting attempts. We found the greatest number of birds (flying and non-flying combined) at the Airstrip (184), followed by Alpine Pad 1 (79), the

Infield Road (73), the Eastern Drill Pad (20), and Alpine Pad 2 (15) (Table 34; for pad locations, see Figure 17). The number of birds seen at the Airstrip was over twice as great as at both Alpine Pad 1 and the Infield Road; the difference was due solely to larger numbers of the three most common species: Lapland Longspur, Semipalmated Sandpiper, and Pectoral Sandpiper. We recorded the same number of species (20) at the Airstrip, Alpine Pad 1, and the Infield Road, with slight variation in the species seen. At both the Eastern Drill Pad and Alpine Pad 2, we found both low abundance (14 non-flying birds at each site) and low diversity (6 and 3 species, respectively). Flying birds added another 1–6 species to the total number of species seen at each site. The flying birds we typically saw were jaegers, Glaucous Gulls, Arctic Terns, Yellow Wagtails, and small flocks of waterfowl. Species richness for all sites combined in the Facility Area was greatest for shorebirds (11 species), followed by waterfowl (8), passerines (3), jaegers (2), ptarmigan (2), gulls (1), and terns (1).

Our survey area at the ASRC Gravel Mine site was based on maps submitted with a permit application in 1991; the mine footprint was modified in the most recent permit application (see Public Notice of Application for Permit, U.S. Army Corps of Engineers, Reference no. 4-960869), after our breeding-season surveys were completed. Thus, our survey area and the mine site overlap, but our survey provided only partial coverage of the proposed site (Figure 18).

Table 34. Numbers and locations of birds counted during the intensive ground-based breeding bird survey of proposed development sites in the Facility Area of the Alpine Development, Colville River Delta, Alaska, 22 June 1996. Sites are shown in Figure 17.

	Airstrip		Infield Road		Alpine Pad 1		Alpine Pad 2		Eastern Drill Pad		All Areas	
Species	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]
Pacific Loon	0	0	0	0	0	2	0	0	0	0	0	2
Tundra Swan	0	0	2	2	0	5	0	0	0	0	2	7
Greater White-fronted Goose	2	2	0	1	2	3	0	0	0	0	4	6
Northern Pintail	1	3	2	16	1	1	0	0	0	0	4	20
American Wigeon	0	0	0	2	0	0	0	0	0	0	0	2
Greater Scaup	0	0	2	2	0	0	0	0	0	0	2	2
Lesser Scaup	0	2	0	0	0	0	0	0	0	0	0	2
Oldsquaw	2	2	3	3	3	3	0	0	0	0	8	8
Willow Ptarmigan	1	1	0	0	1	1	0	0	0	0	2	2
Rock Ptarmigan	1	1	0	0	1	1	0	0	0	0	2	2
Black-bellied Plover	1	1	0	0	1	2	0	0	0	0	2	3
American Golden Plover	4	4	2	2	2	2	0	0	0	0	8	8
Bar-tailed Godwit	0	0	1	3	4	4	0	0	0	0	5	7
Semipalmated Sandpiper	57	57	1	2	7	8	0	0	0	0	65	67
Pectoral Sandpiper	20	20	8	9	8	8	0	0	3	3	39	40
Dunlin	7	8	0	0	3	3	0	0	0	0	10	11
Stilt Sandpiper	2	4	0	0	1	2	0	0	0	0	3	6
Long-billed Dowitcher	0	0	1	1	1	5	0	0	2	2	4	8
Common Snipe	0	0	1	1	0	0	0	0	0	0	1	1
Red-necked Phalarope	5	5	2	2	4	4	0	0	0	0	11	11
Red Phalarope	1	1	1	1	2	2	0	0	0	0	4	4
Unidentified shorebird	0	0	0	2	0	0	0	0	0	0	0	2
Parasitic Jaeger	0	2	0	1	0	0	0	0	0	2	0	5
Long-tailed Jaeger	0	0	0	2	3	3	0	0	0	0	3	5
Glaucous Gull	0	1	0	1	0	0	0	1	0	0	0	3
Arctic Tern	0	3	0	0	0	0	0	0	0	3	0	6
Yellow Wagtail	0	4	0	0	0	1	0	0	0	1	0	6
Savannah Sparrow	1	1	5	5	0	0	6	6	0	0	12	12
Lapland Longspur	60	62	15	15	17	19	8	8	9	9	109	113
Total birds	165	184	46	73	61	79	14	15	14	20	300	371
Total species	15	20	14	20	17	20	2	3	3	6	21	29

[a] Total includes non-flying and flying birds.

Therefore, our bird counts reflect the general abundance and species richness of the area but probably underestimate the actual abundance and species richness for the mine site specifically. At the ASRC Gravel Mine site, we recorded both the greatest species richness and the largest number of birds in the South Plot (Table 35). We saw twice as many non-flying birds in the South Plot (123) as in the North Plot (66), and four times as many as in the Connecting Strip (34). The South Plot has several small waterbodies, where we saw a variety of waterfowl species that were not seen in the other portions of the ASRC Gravel Mine site. Willow Ptarmigan also were common in the South Plot. Only a few species sighted on the ground commonly occurred in all three plots: Oldsquaw, Pectoral Sandpiper, Willow Ptarmigan, Yellow Wagtail, Savannah Sparrow, and Lapland Longspur. We saw flocks of White-fronted Geese, Northern Pintails, and Bar-tailed Godwits (including ~60 in a single flock at the North Plot) flying over the mine site.

Table 35. Numbers and locations of birds counted during the intensive ground-based breeding bird survey in the proposed ASRC Gravel Mine site, Colville River Delta, Alaska, 24–25 June 1996. Sites are shown in Figure 18.

	North Plot		South Plot		Connecting Strip		All Areas	
Species	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]	Non-flying	Total[a]
Red-throated Loon	0	0	3	3	0	0	3	3
Pacific Loon	0	0	2	2	0	0	2	2
Greater White-fronted Goose	2	6	8	24	0	2	10	32
Green-winged Teal	0	0	1	1	0	0	1	1
Mallard	0	0	2	2	2	2	4	4
Northern Pintail	0	3	6	6	1	1	7	10
Northern Shoveler	0	0	1	1	0	0	1	1
Greater Scaup	0	0	3	3	0	0	3	3
Oldsquaw	2	2	1	1	1	1	4	4
Red-breasted Merganser	0	0	1	1	0	0	1	1
Willow Ptarmigan	4	4	16	16	1	1	21	21
Rock Ptarmigan	0	0	1	1	0	0	1	1
Bar-tailed Godwit	0	60	0	0	1	1	1	61
Semipalmated Sandpiper	2	2	2	2	0	0	4	4
Pectoral Sandpiper	12	12	10	10	7	7	29	29
Stilt Sandpiper	2	2	0	0	0	0	2	2
Long-billed Dowitcher	10	10	2	2	0	0	12	12
Common Snipe	0	0	1	1	0	0	1	1
Red-necked Phalarope	0	0	20	20	0	0	20	20
Parasitic Jaeger	1	1	0	0	0	0	1	1
Long-tailed Jaeger	1	1	0	2	0	4	1	7
Glaucous Gull	0	1	0	4	0	0	0	5
Short-eared Owl	0	0	1	1	0	0	1	1
Yellow Wagtail	4	4	7	10	2	2	13	16
Savannah Sparrow	7	7	11	11	8	8	26	26
Lapland Longspur	19	19	22	22	11	11	52	52
Common Redpoll	0	0	1	1	0	0	1	1
Total birds	66	134	122	147	34	40	222	321
Total species	12	15	22	24	9	11	26	27

[a] Total includes non-flying and flying birds.

Nesting

During ground-based surveys for nesting eiders in the vicinity of the Facility Area and at the ASRC Gravel Mine Site in June 1996, we found nests of many bird species other than the focal species (selected species shown in Figures 17 and 18). Within the Facility Area, we found nests of Green-winged Teal, Northern Pintails, Northern Shovelers, Oldsquaws, and Willow Ptarmigan, as well as nests of shorebirds, songbirds, and avian predators (Table 36). Notable for shorebirds was one Bar-tailed Godwit nest near the site of Alpine Pad 2 (Figure 17). We saw courtship displays and suspected nesting in the area by Black-bellied Plovers, Common Snipe, and Yellow Wagtails. Because our eider nesting surveys were not designed to locate nests of other birds, and because some habitats may have been searched less intensively than others, these nest locations should only be considered an indication of the presence of the birds in the area and not an accurate estimate of their abundance.

At the ASRC Gravel Mine site, we found fewer nests than at the Facility Area. Most of the nests were of shorebirds and ptarmigan (Table 36). Nesting Willow Ptarmigan were most numerous in the South Plot, where Wet Sedge-Willow Meadow and Riverine or Upland Shrub habitat types occur (Figure 18). Willow Ptarmigan nested on polygon ridges and among shrubby willows, which were common in those habitats. Rothe et al. (1983) documented similar patterns of habitat use by Willow Ptarmigan on the Colville Delta.

The area covered during our 1996 ground-based nesting survey of the Facility Area and vicinity overlapped extensively with the 1995

Table 36. Numbers and locations of bird nests and broods of selected species found during ground-based surveys of the proposed Facility Area and ASRC Gravel Mine site, Colville River Delta, Alaska, 1996. Boundaries are displayed in Figures 17, 18, and 20.

	Number of Nests				Number of Broods			
Species	Facility Area ($8.6\ km^2$)	Facility Search Area ($17.1\ km^2$)	Mine Site[a] ($2.4\ km^2$)	Mine Site Search Area[b] ($1.7\ km^2$)	Facility Area ($8.6\ km^2$)	Facility Search Area ($18.0\ km^2$)	Mine Site[a] ($2.4\ km^2$)	Mine Site Search Area[b] ($4.3\ km^2$)
Red-necked Grebe	0	0	0	0	0	2	0	0
Greater White-fronted Goose	13	35	2	3	3	17	3	8
Green-winged Teal	1	1	0	0	0	0	0	0
Northern Pintail	1	2	1	1	0	1	0	2
Northern Shoveler	0	1	0	0	0	0	0	0
Greater Scaup	0	0	0	0	0	0	1	1
Unidentified scaup	0	0	1	1	0	0	0	0
Oldsquaw	4	7	0	0	1	6	0	1
Red-breasted Merganser	0	0	0	0	0	0	1	1
Willow Ptarmigan	1	1	7	9	1	1	1	1
Rock Ptarmigan	0	0	1	1	0	0	0	0
American Golden Plover	1	1	0	0	0	0	0	0
Bar-tailed Godwit	1	1	0	0	0	0	0	0
Semipalmated Sandpiper	16	27	0	0	1	1	0	0
Pectoral Sandpiper	6	6	3	3	0	0	0	0
Dunlin	2	3	0	0	0	0	0	0
Stilt Sandpiper	4	4	0	0	0	0	0	0
Long-billed Dowitcher	1	2	0	0	0	0	0	0
Red-necked Phalarope	9	23	2	2	0	0	0	0
Red Phalarope	5	9	0	0	0	0	0	0
Parasitic Jaeger	1	1	1	1	0	1	0	0
Long-tailed Jaeger	1	1	0	0	0	0	0	0
Glaucous Gull	0	0	0	0	0	1	0	0
Sabine's Gull	0	1	0	0	0	0	0	0
Arctic Tern	0	0	0	0	1	2	0	0
Short-eared Owl	0	1	0	0	0	0	0	0
Savannah Sparrow	1	1	2	2	no data	no data	no data	no data
Lapland Longspur[c]	no data	no data	no data	no data	no data	no data	no data	no data

[a] Mine Site = ASRC Gravel Mine site.
[b] Mine Site Search Area = ASRC Gravel Mine site search area.
[c] Lapland Longspur nests and broods were numerous, but numbers of nests and broods found were not recorded.

survey area (Johnson et al. 1996). In 1995, however, only nests of waterfowl, gulls, and terns were recorded during ground-based surveys. Nests of White-fronted Geese, Northern Pintails, Oldsquaws, and Sabine's Gulls were found in both 1995 and 1996. We found four additional species (Green-winged Teal, Northern Shoveler, Parasitic Jaeger, and Long-tailed Jaeger) nesting within the search area in 1996 (Figure 17). It is likely that these species nested in the Facility Area in 1995 but probably went undetected because their nests are difficult to find. In 1996, we did not find nests for two species, Glaucous Gull and Arctic Tern, for which we found nests in 1995. However, we did find broods for both of these species in 1996, indicating that they probably nested within the Facility Area.

During the 1996 aerial survey for pre-nesting eiders, we saw a nesting Red-necked Grebe in the southern part of the Development Area between the Nechelik and Sakoonang Channels. During ground-based nesting surveys in 1996, we repeatedly saw up to three Red-necked Grebes on the one lake in the Facility Area (see the Brood-rearing section for more observations). In 1995, we saw four Red-necked Grebes (a pair and two singles) in the southern part of the Development Area and a pair in the northwestern corner of the Transportation Corridor (Appendix Figure D6). To our knowledge, there are no other records of Red-necked Grebes nesting on the Colville Delta, although a nest was found nearby at the junction of the Itkillik and Colville Rivers in July 1949 (Nelson 1953). The Red-necked Grebe was classified by Gerhardt et al. (1988) as a visitant ("a nonbreeding species without a definable seasonal pattern") to the delta. Red-necked Grebes are not common on the Arctic Coastal Plain (Brackney and King 1994), but the delta probably contains suitable nesting habitat to support a small breeding population. Nests of Red-necked Grebes consist of a floating vegetation mat and occur in lakes with extensive amounts of emergent grasses or sedges; consequently, their nests may easily be overlooked.

Brood-rearing

We conducted two ground-based surveys during brood-rearing in 1996 (20–22 July and 27–28 August) in the vicinity of the Facility Area and at the ASRC Gravel Mine site (Table 2). In the Facility Area, the ground-search area was slightly smaller for the brood-rearing survey than for the nesting survey. However, during the brood-rearing survey, we also used a helicopter to search large lakes with favorable brood-rearing habitat (Figures 18 and 20). Broods we observed in the Facility Area included Oldsquaws, Arctic Terns, and Willow Ptarmigan (Table 36). Within the area searched surrounding the Facility Area, we also found two broods of Red-necked Grebes and broods of other waterbirds and songbirds (Table 36). A third Red-necked Grebe brood with two young was seen in the southern part of the Development Area during the aerial brood-rearing survey for loons (see Appendix Figure D6). These three broods plus the nest found in the Development Area during eider pre-nesting surveys suggest that at least four pairs of Red-necked Grebes nested on the Colville Delta in 1996.

At the ASRC Gravel Mine site, we saw broods of Greater Scaup, Red-breasted Mergansers, and Willow Ptarmigan (Table 36). In the large lake to the east of the site, we saw broods of Northern Pintails and Oldsquaws (Figure 18).

In 1995, two scaup broods and two Oldsquaw broods were seen on ground-based surveys in the Facility Area; the ASRC Gravel Mine site was not surveyed by ground-based observers. Helicopter surveys of lakes for broods other than the focal species were not flown in 1995 in the Facility Area and at the ASRC Gravel Mine site.

Fall Staging

We recorded sightings of ducks opportunistically during aerial and ground-based surveys in late August 1996. We saw ~200 American Wigeons and ~500 Northern Pintails feeding in three tapped lakes near the Facility Area (Appendix Figure D5). On the Outer Delta, we saw two large groups of unidentified ducks (50 and 400 birds each) at two different tapped lakes. We also counted 15 Oldsquaws on the Outer Delta. These sightings were incidental and do not represent complete counts of the delta for fall-staging ducks in 1996. In 1995, we saw similar numbers of Northern Pintails in the Development Area, large groups of Greater Scaup in the Outer Delta, and fall-staging Oldsquaws in the Transportation Corridor.

CARIBOU

BACKGROUND

The Colville Delta lies at the western edge of the summer range of the Central Arctic Herd (CAH) of caribou, and at the eastern edge of the summer range of the Teshekpuk Lake Herd (TLH). The CAH generally ranges between the Colville and Itkillik rivers on the west and the Canning and Tamayariak rivers on the east (Cameron and Whitten 1979, Lawhead and Curatolo 1984, Shideler 1986). The distribution of caribou varies seasonally, as virtually the entire herd moves onto the coastal plain in summer and into the Brooks Range and its northern foothills in winter (Cameron and Whitten 1979, Carruthers et al. 1987). Pregnant cows of the CAH disperse widely across the coastal plain during calving season, which begins in late May and ends in mid-June; peak calving typically occurs in the first week of June (Curatolo and Reges 1984, Whitten and Cameron 1985). The TLH calves and summers in a core area surrounding Teshekpuk Lake (Silva 1985), about 80 km west of the Colville Delta, and disperses across the coastal plain in winter (Carroll 1992).

The Colville Delta was not surveyed routinely during the caribou calving season until our Colville wildlife studies began in 1992. Except for partial (33%) coverage in 1981 and one other year in the 1978–1980 period, calving surveys of the CAH by ADFG ended at or east of the East Channel of the Colville River (Whitten and Cameron 1985, Lawhead and Cameron 1988). Survey coverage in the area of the Transportation Corridor during the calving season in the late 1970s and 1980s was much lower than in the Kuparuk Oilfield, which has been the focus of intensive survey efforts (e.g., Cameron et al. 1988, Lawhead and Cameron 1988). Similarly, past surveys of the TLH stopped at the western bank of the Nechelik Channel (Reynolds 1982). Complete surveys of the Colville Delta during calving season were conducted in 1992 (Smith et al. 1993), 1993 (Smith et al. 1994), and 1995 (Johnson et al. 1996).

By the calving season, caribou of the CAH separate into western and eastern segments, which tend to remain on their respective sides of the Sagavanirktok River and Prudhoe Bay Oilfield throughout the summer (Lawhead and Curatolo 1984). The CAH caribou that occur on the Colville Delta are from the western segment of the herd.

Caribou movements during midsummer are influenced predominantly by mosquitoes (*Aedes* spp.) and oestrid flies (*Hypoderma tarandi* and *Cephenemyia trompe*) (White et al. 1975, Roby 1978). Mosquitoes typically emerge in abundance near the coast by the end of June or beginning of July and persist to the end of July. Mosquito activity is lowest at the coast due to low ambient air temperature and elevated wind speeds near the Beaufort Sea (White et al. 1975, Dau 1986), so caribou normally move to the coast to escape mosquito harassment. Mosquito-harassed caribou will move coastward and upwind, but only as far as is necessary to reach insect-free habitat (Lawhead and Curatolo 1984, Dau 1986). When insect harassment declines or ceases due to low temperatures or windy weather, CAH caribou move inland to the south or southwest (White et al. 1975, Lawhead and Curatolo 1984). CAH caribou generally remain within 30 km of the coast throughout the mosquito season (Lawhead and Curatolo 1984).

Harassment of caribou by oestrid flies typically lasts from mid-July into August (Dau 1986). Fly-harassed caribou use unvegetated and elevated sites as relief habitat, such as pingos, mud flats, river bars, gravel pads, and roads. By the beginning of August, CAH caribou begin to disperse southward after mosquito harassment abates and coastal habitat becomes less important (Lawhead and Curatolo 1984, Dau 1986). This inland dispersal continues through September and into the breeding season (rut) in October.

Use of the Colville Delta by CAH caribou for relief from insect harassment during midsummer has been observed sporadically since 1983 (Lawhead and Curatolo 1984, Cameron et al. 1995). Use of the delta for insect relief has been greatest when insect harassment occurred during periods of westerly winds (Cameron et al. 1989, Smith et al. 1993). The frequency of use of the delta by radio-collared CAH caribou appeared to increase during the late 1980s (R. Cameron, unpubl. ADFG data), when the herd was increasing. In addition, telemetry surveys in the 1990s demonstrated that some TLH caribou occasionally use the delta during periods of mosquito harassment (G. Carroll, ADFG, pers. comm.). The extent of contact and exchange of individuals between these two herds has not been quantified, but a limited amount of interchange of collared caribou has occurred (G. Carroll, pers. comm.).

The most recent photo-census of the CAH in July 1995 resulted in a count of 18,093 caribou (ADFG, unpubl. data), 23% lower than the previous count of 23,444 caribou in July 1992. The herd grew at a high rate during the 1970s and early 1980s (Whitten and Cameron 1983), but growth had slowed by the late 1980s (Cameron 1994). The TLH also declined by 1995, albeit much less than the CAH. The most recent photo-census of the TLH in July 1995 totaled approximately 26,300 caribou (K. Whitten, ADFG, pers. comm.), down from the high count of 27,686 caribou in July 1993 (Hicks 1994).

CALVING SEASON

Snow cover in the Colville–Kuparuk region was unusually low during the calving season in 1996. Snow melt occurred earlier than normal and snow cover was essentially absent (0–5%) for both the early and mid-June surveys. Therefore, it was not necessary to apply the sightability correction factor developed by Smith et al. (1994) to compensate for caribou obscured by patchy snow cover during the spring melt.

Delta

Very few caribou were found on the Colville Delta during the 1996 calving season (Figures 22–25, Table 37). On 2 June, we saw 13 caribou in the transect strips, which we extrapolated to an estimate of 58 ± 35 caribou and a density of 0.1 caribou/km^2 over the entire Colville Delta survey area (637 km^2). This area was not sampled on the second set of calving surveys (9–13 June) because the entire delta was censused on 13 June during the eider pre-nesting survey; we found 10 caribou on that survey (0.02 caribou/km^2). A single calf on 13 June was the only one seen on the delta in the 1996 calving season.

The small number of caribou found on the Colville Delta during calving is consistent with previous observations. Few adults and no calves were seen on the delta in the 1992, 1993, or 1995 calving seasons (Smith et al. 1993, 1994; Johnson et al. 1996). Two transect surveys of portions of the Colville Delta during 1979–1981 found very few caribou; instead, most of the small number found in this general area (0–12 on each of 5 transects) occurred more than 16 km inland (Whitten and Cameron 1985). Whitten and Cameron suggested that the low occurrence of caribou on the Colville Delta during calving probably reflected avoidance of flooding during spring breakup. In addition, we suspect that the low availability of tussock tundra—the habitat type most preferred by cow caribou during calving (Kuropat and Bryant 1980)—on the delta contributes to the low density of caribou at that time of year.

East of the Colville River

In contrast to the small number of caribou seen on the Colville Delta, a large number of caribou were found east of the delta in 1996 (Table 37). Caribou were concentrated in the Kuparuk South survey area and in the eastern portion of the Colville East survey area (Figures 22–25). Caribou density was substantially (up to 3.7 times) higher in Kuparuk South than in the Colville East or Kuparuk Field survey areas. Counts from the first survey (2–5 June) were extrapolated to estimates of 3,573 ± 406 caribou for Kuparuk South and 800 ± 112 caribou for Colville East; the corresponding density estimates were 6.0 and 0.6 caribou/km^2, respectively. By 9–13 June, caribou density increased in both areas, particularly Colville East; the estimated numbers were 4,344 ± 521 caribou for Kuparuk South (7.3 caribou/km^2) and 2,670 ± 314 caribou for Colville East (2.0 caribou/km^2). In the adjacent Kuparuk Field survey area (Lawhead et al. 1997), caribou density on 11 June (2.2 caribou/km^2) was similar to that in Colville East on 12–13 June. Most calving evidently occurred in the Kuparuk South area, where the density of calves on the second survey (2.6 calves/km^2) exceeded the total caribou density in the Colville East and the Kuparuk Field areas.

Comparison of our 1996 results with those from previous years (Smith et al. 1993, 1994; Johnson et al. 1996) revealed annual increases in peak numbers and densities in the survey areas east of the Colville River. The total density of 7.3 caribou/km^2 in Kuparuk South in mid-June 1996 was the highest recorded in these 4 years, up from the previous high of 5.1 caribou/km^2 in the same area in 1995. Calf density was more than twice as high in 1996 as in 1995 (2.6 vs. 1.0 calves/km^2). Total density has consistently been lower in

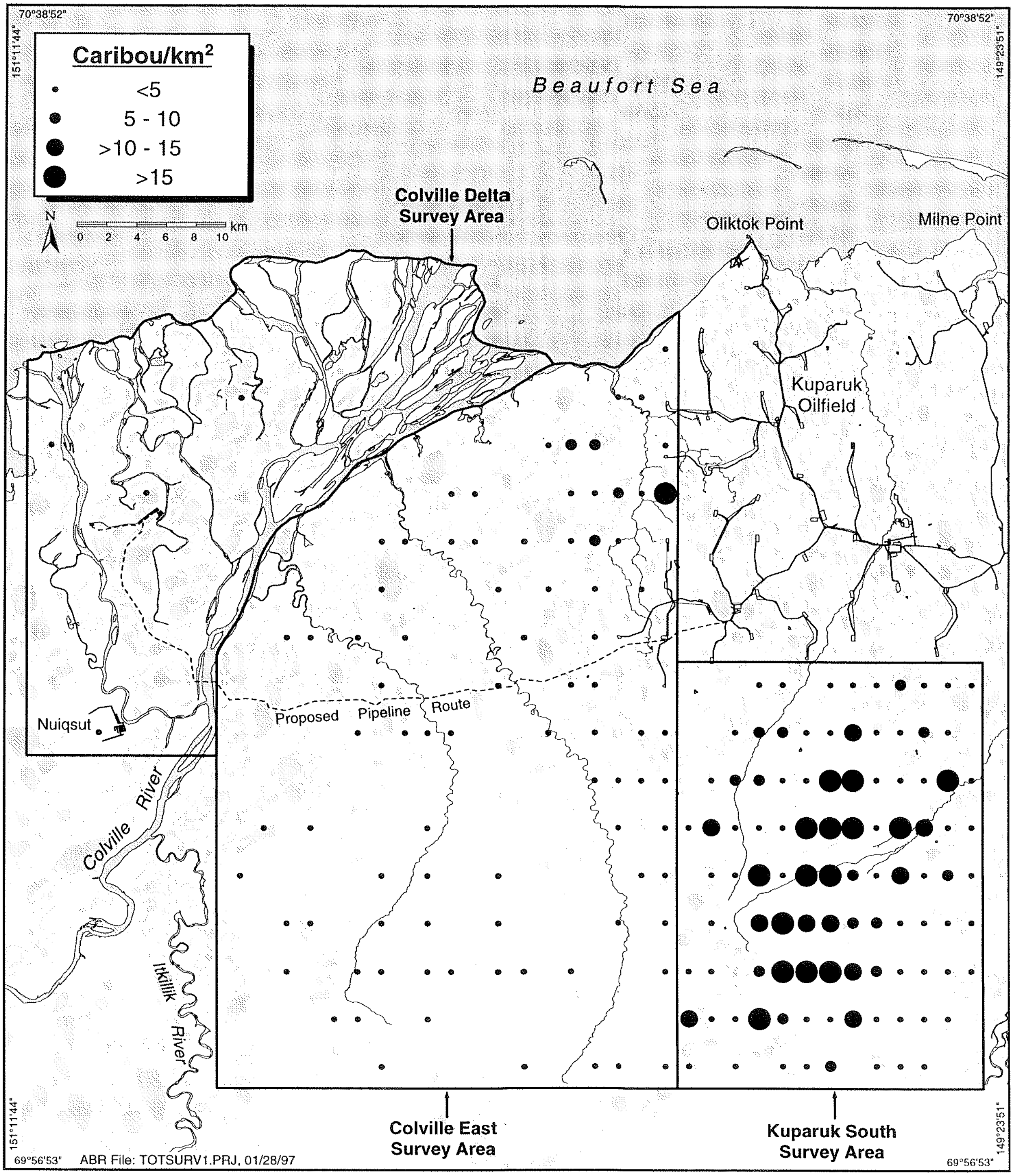

Figure 22. Distribution and density of caribou (adults and calves) observed in the Colville and Kuparuk South survey areas, Alaska, 2–5 June 1996. Dots represent centers of 3.2-km-long transect segments in which caribou were counted.

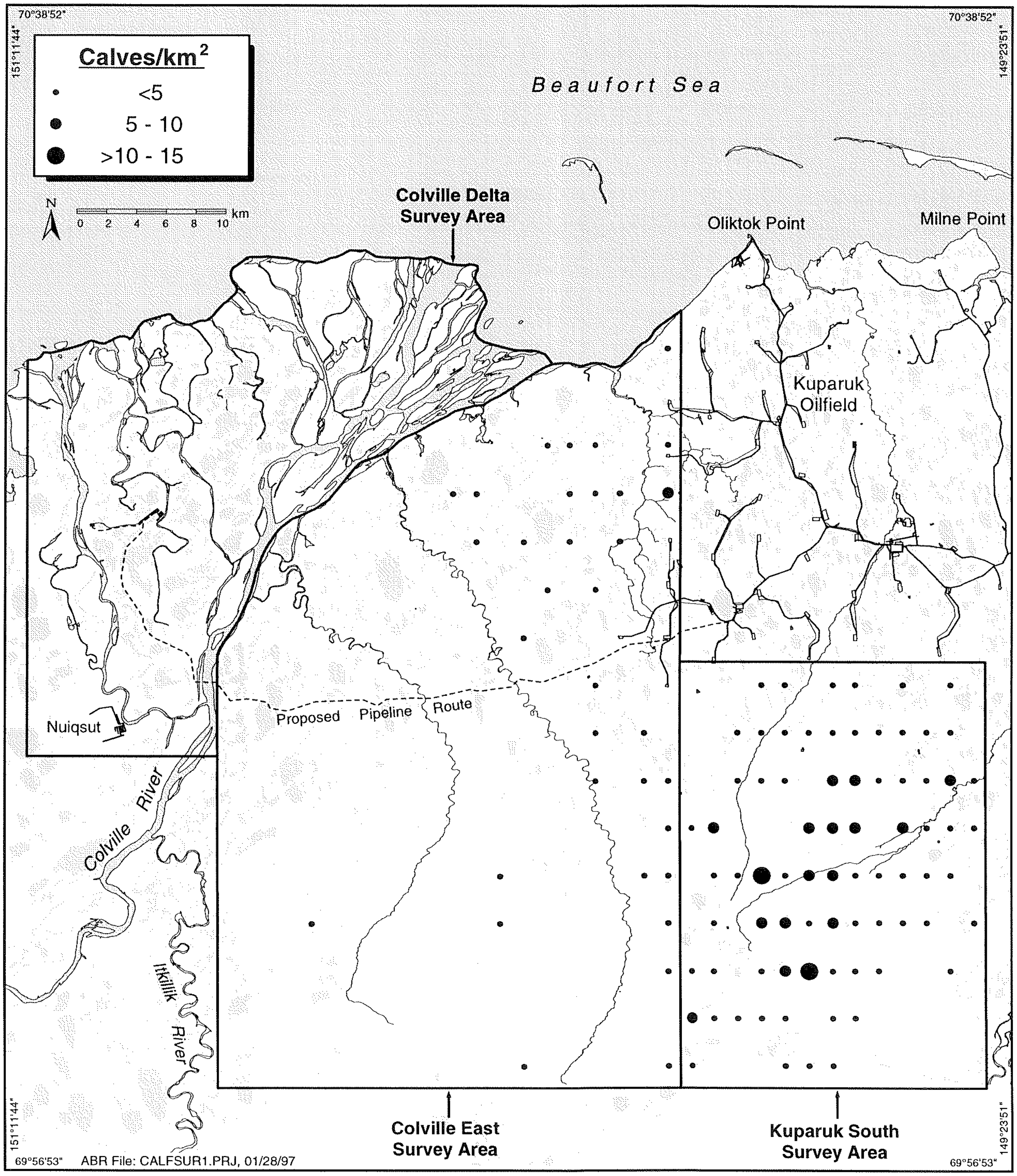

Figure 23. Distribution and density of calf caribou observed in the Colville and Kuparuk South survey areas, Alaska, 2–5 June 1996. Dots represent centers of 3.2-km-long transect segments in which caribou were counted.

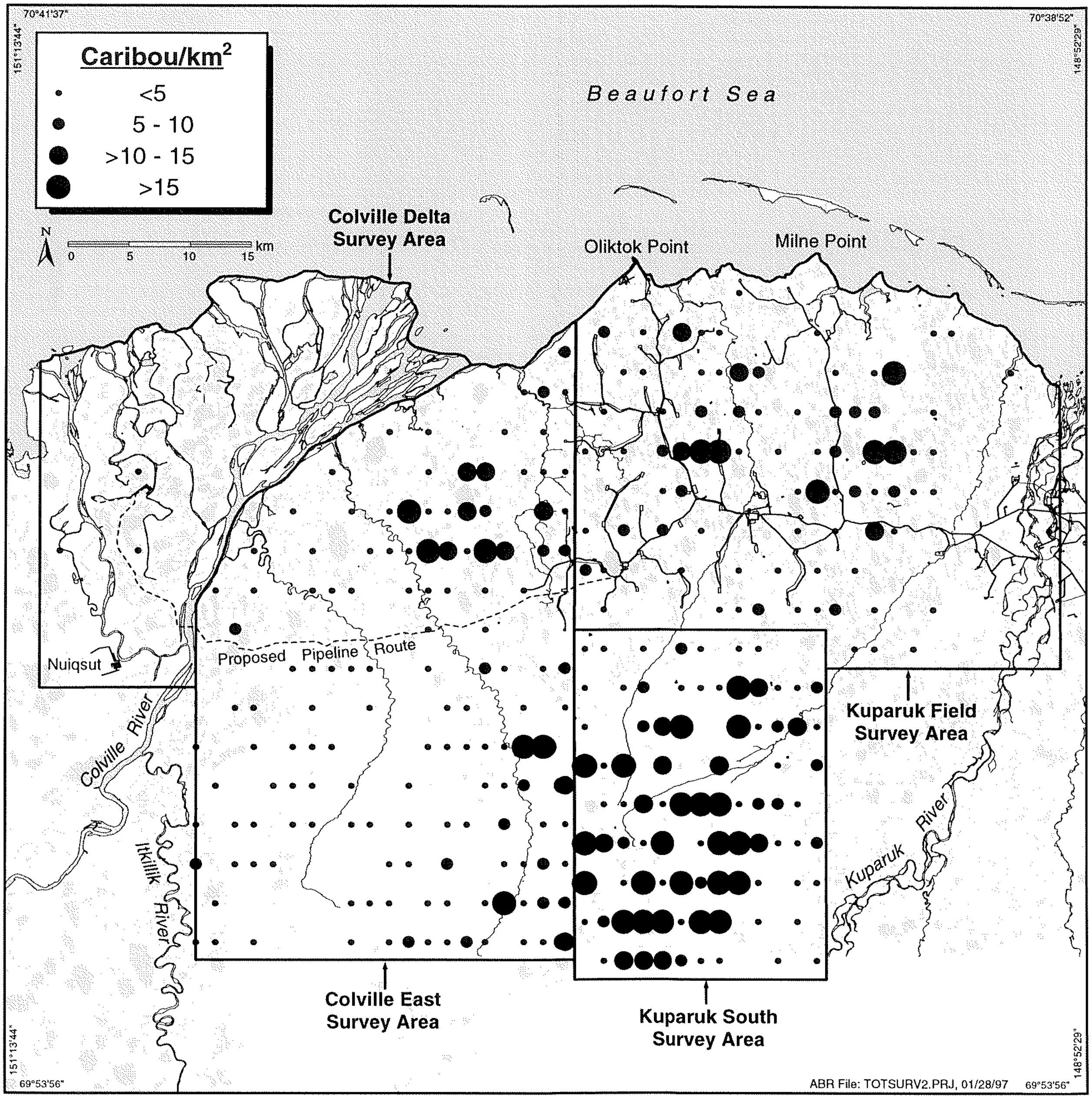

Figure 24. Distribution and density of caribou (adults and calves) observed in the Colville and Kuparuk survey areas, Alaska, 9–13 June 1996. Dots represent centers of 3.2-km-long transect segments in which caribou were counted.

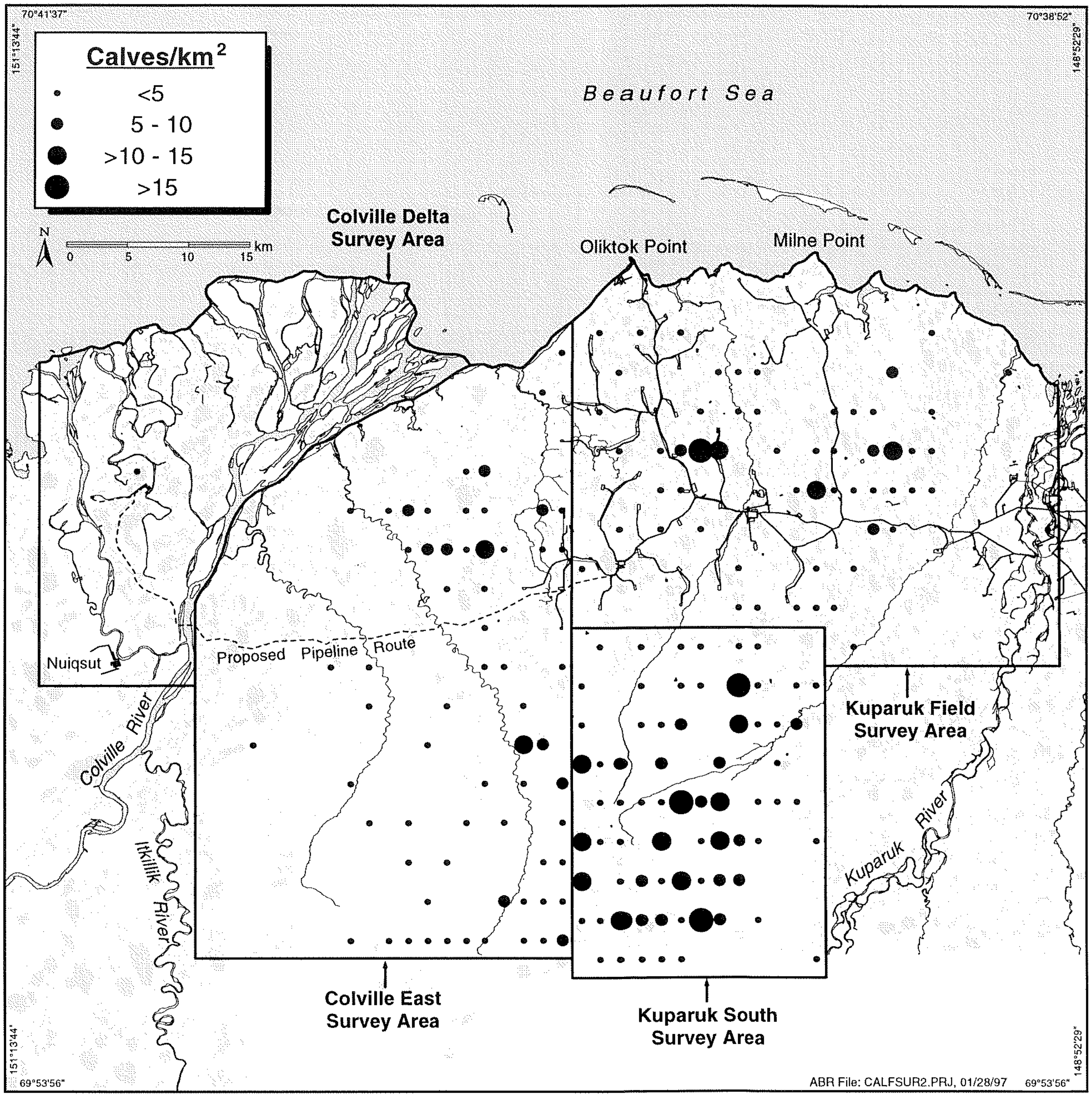

Figure 25. Distribution and density of calf caribou observed in the Colville and Kuparuk survey areas, Alaska, 9–13 June 1996. Dots represent centers of 3.2-km-long transect segments in which caribou were counted.

Table 37. Counts and population estimates (±80% CI) of caribou during the 1996 calving season in the vicinity of the Colville River Delta and Kuparuk Oilfield, Alaska.

		Area	Total			Population Estimate[e]			
		Surveyed[b]	Area[c]	Counts		Total		Calves	
Survey Area[a]	Date	(km^2)	(km^2)	Total[d]	Calves	No.	±CI	No.	±CI
Colville Delta	2 June	142	637	13	0	58	35	0	-
	13 June	637	637	10	1	10	-	1	-
Colville East	3–4 June	685	1,362	402	80	800	112	159	36
	12–13 June	677	1,358	1,331	392	2,670	314	786	121
Kuparuk South[f]	4 June	301	598	1,800	526	3,573	406	1,044	136
	9–10 June	301	598	2,391	865	4,344	521	1,572	207
Kuparuk Field[g]	11 June	554	1,137	1,197	437	2,458	410	897	164

[a] Refer to Figure 24 for locations.
[b] Total area of all transect segments that were surveyed, rounded to the nearest km^2.
[c] Area within boundaries of the survey area, rounded to the nearest km^2.
[d] Total = (cows + calves + yearlings + bulls).
[e] Counts of caribou in the area surveyed, extrapolated to the total area and rounded to the nearest integer.
[f] Survey area was shifted south 1 mile after the 4 June survey, to eliminate overlap with the Kuparuk Field survey area.
[g] Kuparuk Field survey is described by Lawhead et al. (1997).

Colville East: 2.0 caribou/km^2 in 1996, 1.5 caribou/km^2 in 1995, 2.4 caribou/km^2 in 1993, and 2.0 caribou/km^2 in 1992 (in a smaller survey area).

The number of caribou in the areas we surveyed in the 1995 and 1996 calving seasons represented high percentages of the total CAH. In 1996, our mid-June estimates for all 4 survey areas combined (Table 37) totaled 9,482 caribou, of which approximately 34% were calves. This total represents 52% of the July 1995 herd size of 18,093 caribou. In 1995, the total number estimated in 3 of the 4 survey areas (no Kuparuk Field survey was done that year) was 4,828 caribou (27% of the 1995 herd size); the comparable figure for these 3 areas in 1996 was 7,024 caribou (39% of the 1995 herd size). These percentages represent approximate proportions of the herd using these calving survey areas and are not meant to imply that herd size has remained static since July 1995.

From 1978 (when systematic surveys began) to 1987, calving by the CAH tended to be concentrated in two general locations: between the Colville and the Kuparuk rivers west of Prudhoe Bay (the "Kuparuk concentration area" in the vicinity of the Kuparuk and Milne Point oilfields) and between the Shaviovik and Canning rivers east of Prudhoe Bay (Lawhead and Curatolo 1984, Whitten and Cameron 1985, Lawhead and Cameron 1988, Cameron et al. 1992). However, the area between the Colville River and the western edge of the Kuparuk Oilfield has become increasingly important for calving by the western segment of the CAH since 1987 (Smith and Cameron 1992; R. Cameron, ADFG, pers. comm.). The pattern seen in 1993, 1995, and 1996, in which the highest densities occurred south and west of the Kuparuk Oilfield and east of the Colville River, is generally consistent with a shift in calving distribution from the Kuparuk concentration area. This shift in distribution does not mean that caribou have abandoned the traditional Kuparuk concentration area, however. A large number of caribou used the Kuparuk Field survey area during the 1996 calving season (estimated at 2,458 caribou on 11 June; Lawhead et al. 1997), even though most of the caribou calving in the Colville–Kuparuk region were located south of the Kuparuk Oilfield.

Sex and Age Composition

Observers on the composition survey on 13 June counted 2,155 caribou, including 1,068 calves (43.1%), in the Kuparuk South survey area (Table 38). Based on this composition count, our estimate of the standard ratio used to assess production of calves (the number of calves per 100 cows) was 87 calves:100 cows. A composition survey (*n* = 998 caribou) on 14 June in the adjacent Kuparuk Field survey area obtained the same calf:cow ratio; the combined sample for these two surveys was 3,153 caribou (Table 38). This ratio was the highest recorded for the CAH since the mid-1980s and was among the highest since surveys began in 1978 (Figure 26). The highest calf:cow ratios for the CAH during 1978–1992 were recorded in 1983 (91:100), 1984 (89:100), and 1985 (88:100) (Fancy et al. 1992, Woolington 1995), when the herd was growing rapidly. High calf production in 1996 contrasts sharply with other recent years such as 1995 and 1993, when the ratio was about 50 calves:100 cows (Smith et al. 1994, Johnson et al. 1996). In general, herd productivity decreased in the late 1980s and early 1990s (Cameron 1994).

The percentage of calves in the Kuparuk South and Kuparuk Field survey areas increased from the 9–11 June surveys (36.3% of the combined total of 3,588 caribou in Table 37) to the 13–14 June composition surveys (43.1% of 3,153 caribou; Table 38). These increases probably resulted from continued calving in the intervening days between surveys and from higher sightability of calves as a result of the lower aircraft altitude on the latter date. The percentages of all sex and age groups except bulls are comparable with composition percentages reported by ADFG for previous years in which calf production was high (Woolington 1995). Bulls evidently were undercounted in our 1996 composition surveys (0.2% overall), judging from comparison with the average of 5.6% (range 2–14%) in ADFG surveys during 1978–1992 (Woolington 1995). Misclassification of some bulls as cows would have caused our estimate of the calf:cow ratio to be slightly underestimated, however, and therefore does not affect our conclusion of high initial calf production in 1996.

Yearlings constituted 7.3% of the composition sample, for a ratio of 15 yearlings:100 cows, in the Kuparuk South survey area. These figures are slightly higher than those calculated from the combined composition sample (*n* = 3,153 caribou) for both the Kuparuk Field and Kuparuk South survey areas: 6.9% yearlings and 14 yearlings:100 cows (Table 38). The percentage of yearlings varies substantially among years (range 5–22%; Woolington 1995), however, depending on calf production in the preceding year and on overwinter survival (Whitten and Cameron 1983). The low number of yearlings counted on our 1996 surveys reflected the low calf production observed in 1995 (Johnson et al. 1996). The same pattern has occurred in previous years following poor calf production (11 yearlings:100 cows in 1990 after 48 calves:100 cows in 1989, and 12 yearlings:100 cows in 1992 after 45 calves:100 cows in 1991; Woolington 1995).

Table 38. Sex and age composition of caribou groups observed in the Kuparuk South and Kuparuk Field survey areas during helicopter surveys in the 1996 calving season.

		Total	Cows		Calves		Yearlings		Bulls		Unclass.[a]		Calf	Yrlg.
Survey Area	Date	No.	No.	%	No.	%	No.	%	No.	%	No.	%	Ratio[b]	Ratio[c]
Kuparuk South	13 June	2,155	1,068	49.6	928	43.1	157	7.3	1	0.05	1	0.05	86.9	14.7
Kuparuk Field	14 June	998	496	49.7	432	43.3	60	6.0	5	0.5	5	0.5	87.1	12.1
Overall		3,153	1,564	49.6	1,360	43.1	217	6.9	6	0.2	6	0.2	87.0	13.9

[a] Unclassified adults.
[b] Calves:100 cows.
[c] Yearlings:100 cows.

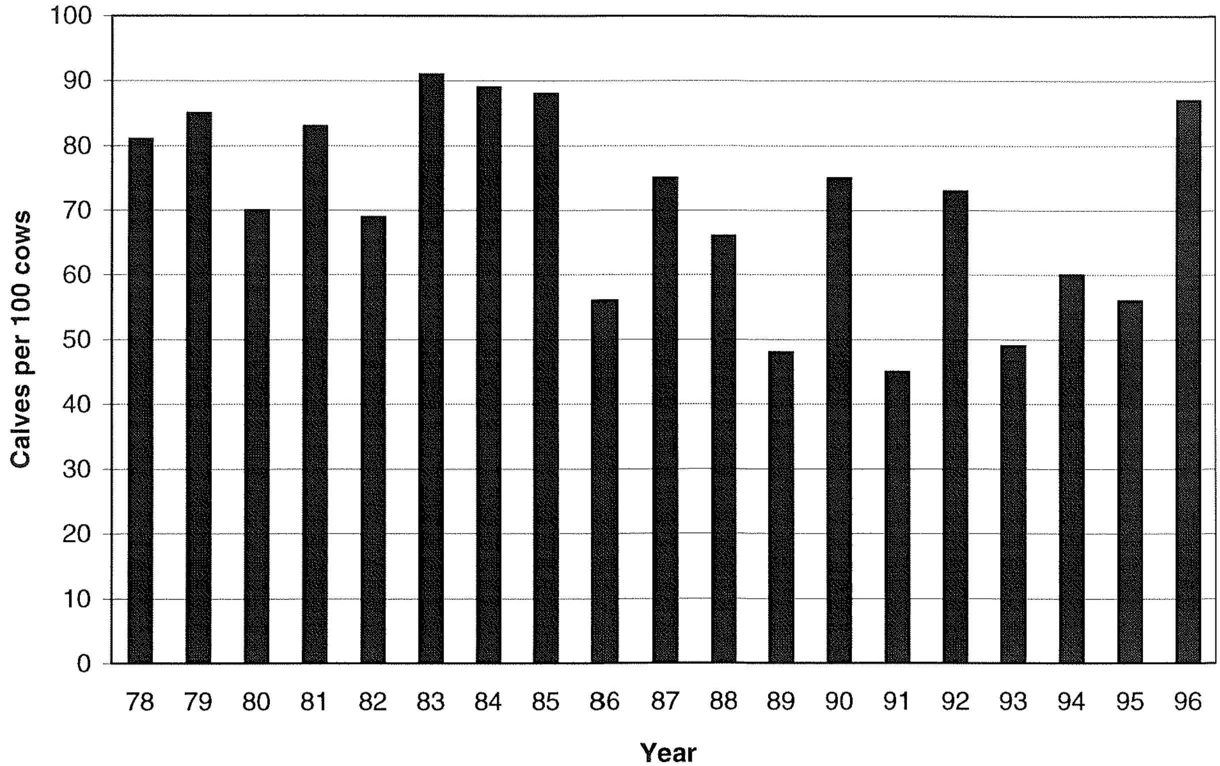

Figure 26. Estimated initial production of calf caribou (calf:cow ratio) for the Central Arctic Herd, based on aerial surveys in June 1978–1996. Ratios are from Fancy et al. (1992) for 1978–1990, Woolington (1995) for 1991 and 1992, Smith et al. (1994) for 1993, Cameron (1994) for 1994, Cameron (pers. comm.) for 1995, and this study for 1996.

INSECT SEASON

Surveys during the insect season in 1995 and 1996 concentrated on the Development Area, Western Delta, and Transportation Corridor survey areas, which are located south of the outer portions of the Colville Delta that were surveyed most often in 1992 and 1993. In 1996, aerial surveys of caribou (both systematic transects and nonsystematic reconnaissance) were flown between 18 June and 25 July. During this period, transect surveys were flown on 20 days between 26 June and 23 July (Table 39). The greatest use of the Colville Delta and Transportation Corridor by caribou occurred between 8 and 18 July, as large numbers moved into the survey areas (Figure 27).

Insect harassment began early in the 1996 season. Mosquito activity was noted as early as 15 June at Nuiqsut (L. Chinn, Kuukpik Corp., pers. comm.), and mosquitoes were active on the central Colville Delta on 18 June. Mosquito harassment also began 19 June in 1995 (Johnson et al. 1996). These mid-June dates are 10–14 days earlier than were noted in the 1980s and early 1990s in the Kuparuk Oilfield (Lawhead and Flint 1993, Lawhead et al. 1994). Warm temperatures (reaching 24° C) and light winds during 17–21 June resulted in moderate to severe mosquito harassment, which drove caribou to aggregate (5,700–7,000 on 20–21 June) near the coast between Milne Point and the Kuparuk River, ≥30 km east of the Colville Delta. Very few caribou were seen in the Transportation Corridor or on the Colville Delta during 17–21 June (although systematic surveys were not done). No observations were made during 22–25 June.

In late June and the first week of July, most caribou in the western segment of the CAH were distributed east of the Colville survey areas. By 26–27 June, cool weather and declining mosquito harassment resulted in inland movements by caribou; only 13 caribou were seen in the

Table 39. Numbers of caribou observed during aerial surveys of strip transects (1.6-km spacing) in the Delta (Development Area and Western Delta) and Transportation Corridor survey areas during the 1996 insect season, Colville River Delta, Alaska. Complete systematic coverage of survey areas was not attempted on each survey.

	Development Area and Western Delta			Transportation Corridor		
Date	Groups	Caribou	Lines Surveyed[a]	Groups	Caribou	Lines Surveyed[a]
26 June	-	-	0	0	0	4
27 June	-	-	0	3	13	9
28 June	0	0	8	0	0	3
29 June	0	0	3	0	0	2
5 July	-	-	0	2	101	3
7 July	0	0	3	0	0	5
8 July	1	2	3	4	873	4
9 July	-	-	0	48	6,406	8
10 July	-	-	0	85	4,258	8
12 July	1	1	6	2	4	5
14 July	1	1	2	0	0	1
15 July	0	0	7	7	2,313	5
16 July	5	1,350	6	1	50	5
17 July	5	1,950	6	0	0	3
18 July[b]	6	736	6	2	250	3
19 July	1	3	6	2	127	5
20 July	0	0	6	6	182	3
21 July	1	3	6	7	153	5
22 July	4	128	6	9	72	5
23 July	4	82	6	4	36	4

[a] Total of 11 transect lines in the Development Area and Western Delta and 9 transect lines in the Transportation Corridor.

[b] Only survey on which caribou (2 groups, 190 caribou) were seen on the Western Delta.

Transportation Corridor at that time (Table 39). On 28 June, however, the weather warmed and mosquitoes drove caribou northward through the Kuparuk Oilfield; ≥2,000 caribou (not mapped in Figure 27) were seen in the northwestern portion of the oilfield that afternoon, northeast of the Transportation Corridor. Caribou groups moved to the coast and into the easterly breeze as mosquito harassment continued on 29 June. On a reconnaissance survey that day, 3,200 caribou were distributed along the coast from Oliktok Point to Milne Point, but only 2 caribou (not mapped in Figure 27) were seen on the outer Colville Delta.

Persistent easterly winds and frequent mosquito harassment during 30 June–6 July kept most of the caribou in the western segment of the CAH near the Kuparuk River floodplain and nearby coastline. Up to 5,000 caribou were seen in that area on 2–3 July, whereas fewer than 10 were seen on the outer Colville Delta. The largest group seen in the Colville survey areas during this period numbered 100 caribou in the Transportation Corridor on 5 July. An aerial reconnaissance survey on 2 July along the coast of Harrison Bay west of the Colville Delta did not locate any caribou, although recent tracks of several hundred caribou (probably from the Teshekpuk Lake Herd) were found at the mouth of the Kalikpik River, about 24 km west of the Colville Delta.

Westerly winds and warm temperatures (15–20° C) on 6–7 July caused a change in caribou distribution. Mosquito harassment forced caribou to the coast on 6 July, and westward movements began when the wind shifted to the west that evening. By the evening of 7 July, 3,300–3,500 caribou had moved west through the Milne Point Oilfield and into the northwestern Kuparuk Oilfield. Mosquito activity abated during 8–10 July

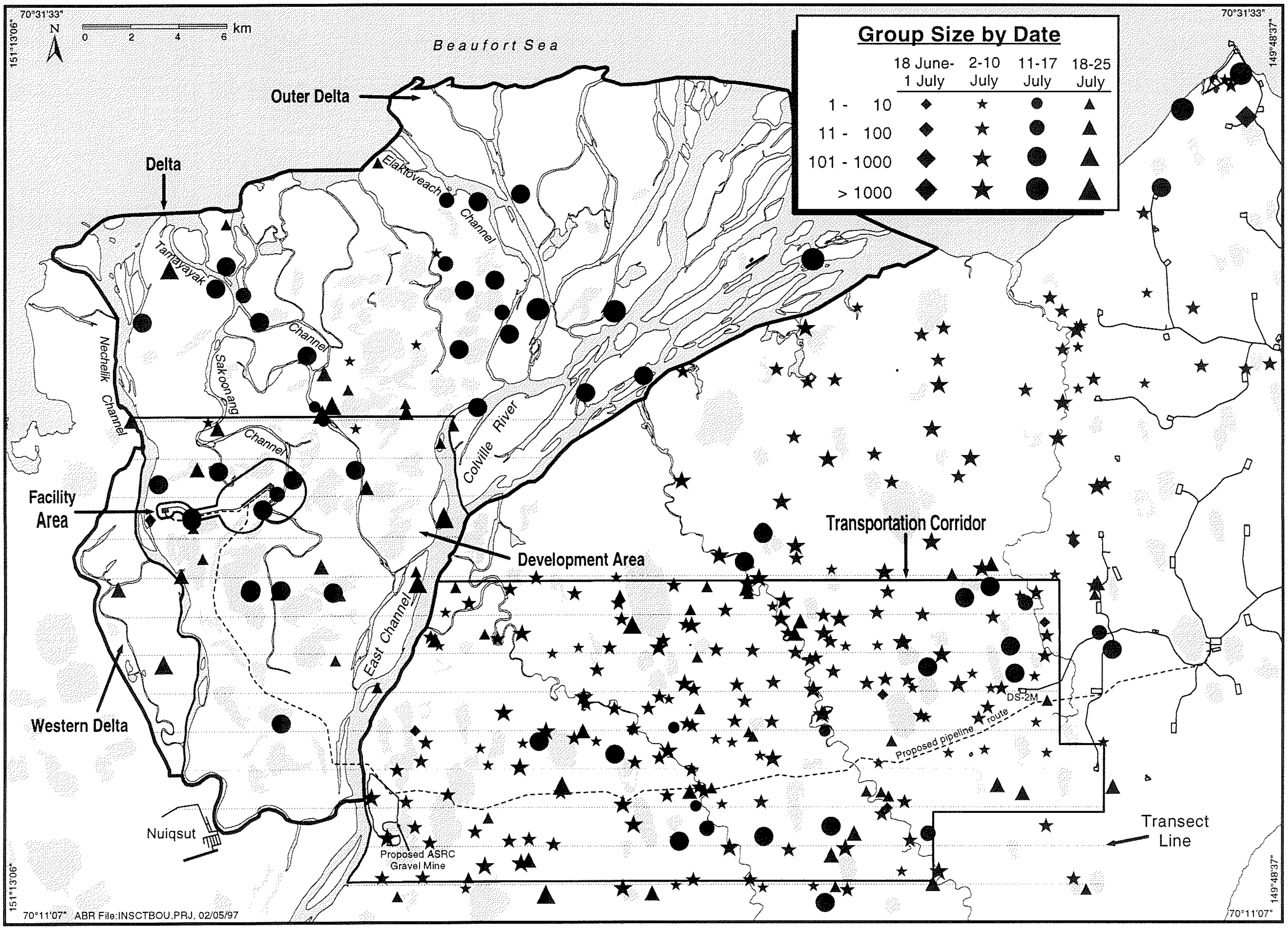

Figure 27. Distribution of caribou observed on systematic and opportunistic aerial surveys in the vicinity of the Development Area and Transportation Corridor during the insect season, Colville River Delta, Alaska, 18 June–25 July 1996.

as the temperature cooled and the wind switched back to the northeast, resulting in inland movements. The greatest use of the Transportation Corridor in 1996 occurred during this period. Caribou began entering the Transportation Corridor from the northeast on 8 July, reaching a peak of 6,406 caribou in 48 groups on 9 July (Table 39), with another 400 caribou just outside the corridor; only 11 caribou were seen on the delta on this date. Groups continued to disperse inland on 10 July, when 4,258 caribou in 85 groups were seen in the corridor.

With warm weather and variable winds on 11 July, the resurgence of mosquito harassment and the onset of oestrid fly harassment caused a shift in caribou distribution from the Transportation Corridor to the Colville Delta. At least 2,250 caribou in 7 groups moved north into the Transportation Corridor by midday, but variable winds resulted in variable upwind movements. Winds were westerly near the Colville River but northeasterly in the eastern corridor and Kuparuk Oilfield, causing insect-harassed groups of caribou to move in different directions. The weather remained warm overnight, and some groups moved onto the eastern delta. The following 3 days (12–14 July) were warm with light winds, and insect harassment caused large groups to move toward the coast, including the Outer Delta. On 12 July, 2,050 caribou in 2 groups moved onto islands in the East Channel and 1,900–2,400 caribou moved to Oliktok Point; exceptions to this coastward movement were groups of 500 and 600 caribou just north of the Transportation Corridor. On 13 July, at least 2,700 caribou in 3 groups were found along the Elaktoveach Channel on the Outer Delta, and at least 3,100 caribou in 3 groups were at the coast between Oliktok and Milne Points. On 14 July, 3,340 caribou in 9 groups gathered near the Elaktoveach Channel on the Outer Delta, while groups east of the delta evidently moved eastward.

Despite continuing warm temperatures, stronger winds during 15–17 July reduced insect harassment to milder levels. On 15 July, six groups totaling 1,550 caribou were distributed around the Tamayayak Channel north of the Development Area and 2,800 caribou were found in the eastern Transportation Corridor and just outside of it, moving west. Caribou moved south from the Outer Delta into the Development Area by 16 July, when 5 groups totaling 1,350 animals were found between the Sakoonang and Nechelik channels. The largest number of caribou (1,950 animals in 5 groups) in the Development Area was seen on 17 July; none was seen in the Transportation Corridor that day.

Caribou numbers in the survey areas decreased over the last week of our observations. The period of 18–25 July was characterized by intermittent periods of mosquito harassment, when caribou usually sought relief by moving into the wind rather than moving to the coast. Six groups totaling 736 caribou were seen in the Development Area and Western Delta on 18 July, some of them moving east (upwind) in response to insect harassment. On 19 July, 600 caribou remained on the delta just north of the Development Area. Group sizes decreased during 20–22 July as caribou dispersed throughout the Transportation Corridor, and local movements into the wind occurred during brief periods of mosquito activity. On 25 July, insect harassment forced 180 caribou onto tidal flats in the Outer Delta, but no large aggregations of caribou were seen on the coast to the east.

CAH caribou frequently use the outer fringes of major river deltas for insect relief during the periods of most intense harassment (Cameron 1983, Lawhead and Curatolo 1984). From our 4 years of surveys (1992, 1993, 1995, 1996) and from discussions with local residents and incidental observations in past years (e.g., Lawhead and Curatolo 1984), it is evident that the Colville Delta is used annually by CAH caribou for insect relief. The numbers moving onto the delta vary each year, however, in response to changing weather and insect activity. These numbers are impossible to predict, but our surveys provide a range of what can be expected. The largest numbers in our 4 years of surveys were seen in 1996 (3,340 caribou near the Elaktoveach Channel on 14 July) and 1992 (3,300 caribou near the Kupigruak Channel on 18 July; Smith et al. 1993). In most years, the Outer Delta is used by the largest groups, probably because the barrens and tidal flats close to the ocean offer the most effective relief from insect harassment.

The largest numbers using the Development Area (1,950 caribou) were seen on 17 July 1996, as caribou were drifting south in the absence of insect harassment. Our observations to date suggest that use of the Development Area by large groups (>1,000 animals) of insect-harassed caribou is rare. The value of the Development Area to caribou probably increases in the second half of July and early August, as small groups and individuals seek relief from oestrid fly harassment on elevated landforms, river and lake barrens, and dunes.

Use of the Transportation Corridor by caribou during the 1996 insect season was greater than in 1995, as a result of the influx of approximately 7,000 caribou during 8–10 July 1996. Southwesterly movements in mid-July 1995 and 1996 resulted in use of the corridor by a large number of caribou. The corridor was traversed by moving groups of insect-harassed caribou and was used for feeding and resting during periods when insect harassment abated. Because the corridor is located fairly far inland from the coast (compared with the normal range of daily movements by caribou during the insect season), it is more likely to be used by small groups for feeding and resting during insect-free periods than it is to be used throughout the insect season by large aggregations of insect-harassed caribou. At the beginning of the insect season, however, insect-harassed caribou can be expected to cross the Transportation Corridor as small groups coalesce in the first major coastward movement of the season. Although this type of movement was not seen in 1996 (due to the early onset of mosquito harassment immediately following calving), it occurred in 1995 and also may have occurred in 1992 and 1993.

FOXES

BACKGROUND

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Red foxes are common in the foothills and mountains of the Brooks Range, but are much less common than the arctic fox on the Arctic Coastal Plain, where they are restricted largely to major drainages such as the Colville and Sagavanirktok rivers (Eberhardt 1977). Red foxes are aggressive toward arctic foxes and will displace them from feeding areas and den sites (Schamel and Tracy 1986, Hersteinsson and Macdonald 1992).

Arctic foxes in northern Alaska breed in March or April, and most pups are born in May or June, 7–8 weeks after mating (Chesemore 1975). Dens are occupied from late spring until pups disperse in August (Chesemore 1975). Throughout the species range, litters average 4–8 pups but can reach or exceed 12 pups in years when food is abundant (Chesemore 1975, Follmann and Fay 1981). Survival of arctic fox pups to weaning is highest in years when small mammals are abundant (Macpherson 1969). Mortality factors of pups include predation, starvation, and sibling aggression (Macpherson 1969, Garrott and Eberhardt 1982, Burgess et al. 1993). For both arctic and red foxes, small mammals are the most important year-round prey, supplemented by caribou and marine mammal carcasses and, in summer, by nesting birds, their eggs, and arctic ground squirrels; garbage is eaten when available (Chesemore 1968, Eberhardt 1977, Garrott et al. 1983b).

Several studies of arctic foxes in and near the North Slope oilfields have been conducted since the late 1970s (Eberhardt 1977; Eberhardt et al. 1982, 1983; Fine 1980; Burgess et al. 1993). Besides the previous surveys by ABR (Smith et al. 1993, 1994; Johnson et al. 1996), the research of greatest relevance on the Colville Delta was that by Garrott (1980; also see Garrott et al. 1983a), who studied arctic foxes in the Colville Delta region in the late 1970s.

DISTRIBUTION AND ABUNDANCE OF DENS

In 1996, we flew systematic transect surveys to search for dens in the Transportation Corridor and Delta Area (Development Area and Western Delta) on 27–28 June, when green-up of vegetation at den sites contrasted with the adjacent tundra. The disturbance and fertilization by foxes at den sites results in a characteristic, lush flora that makes the sites easily visible from the air after green-up (Chesemore 1969, Garrott et al. 1983a). We conducted opportunistic searches by helicopter of suitable-looking habitats in late June and early July to locate additional sites.

After 4 years of surveys and contacts with other observers, we have located 44 arctic fox dens and 5 red fox dens between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield (Figure 28). We obtained approximate locations of nine dens historically used by arctic foxes from R. Garrott (unpubl. data), who conducted fox research on the delta in the late 1970s (Garrott 1980). M. North (unpubl. data) provided the locations of seven dens occupied in

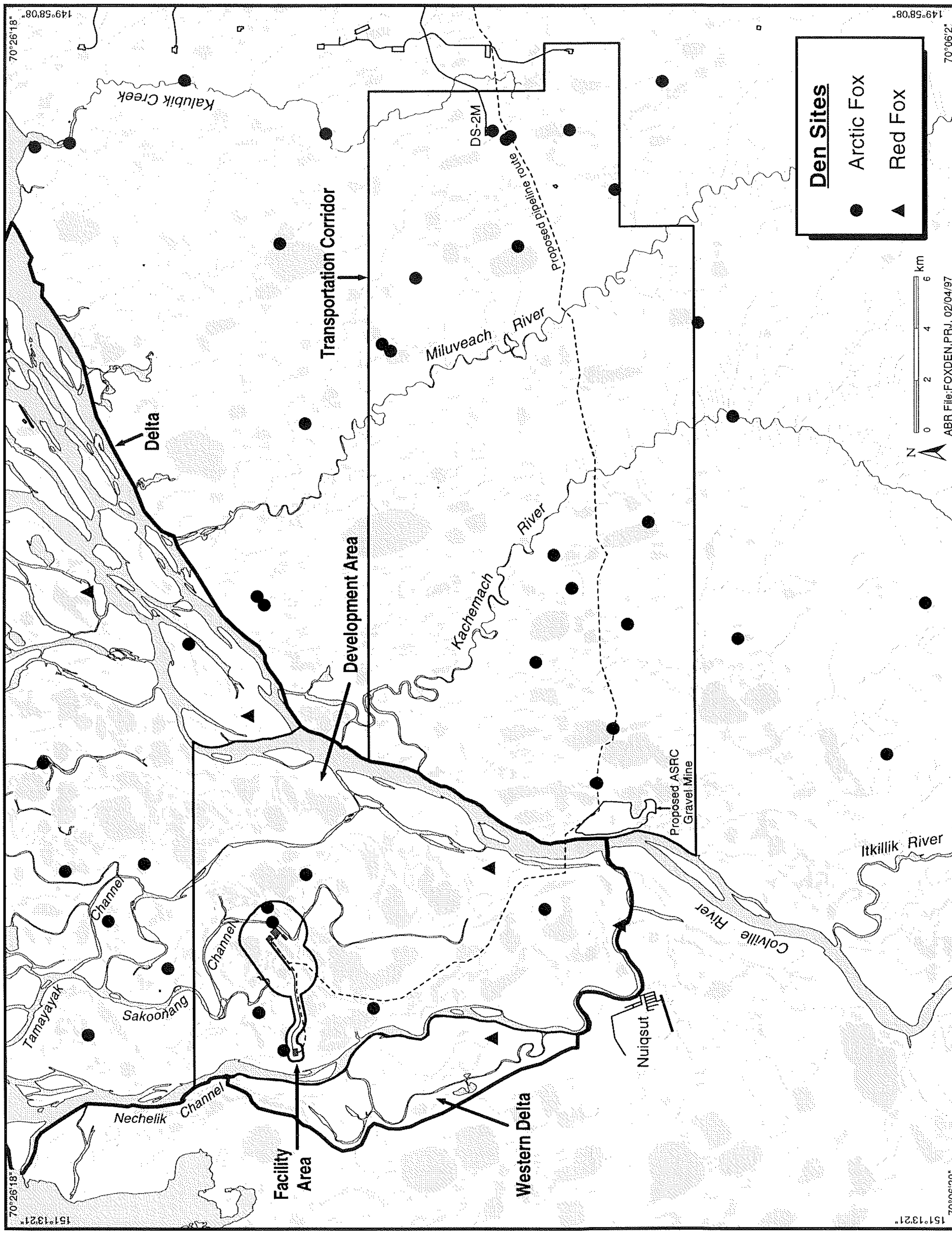

Figure 28. Distribution of arctic and red fox dens found during aerial and ground-based surveys in 1992, 1993, 1995, and 1996 in the vicinity of the Development Area and Transportation Corridor, Colville River Delta, Alaska.

1983–1984, five of which had been located during our surveys in 1992, 1993, and 1995. J. Helmericks (pers. comm.) provided the approximate location of another den historically used by red foxes. Increased survey effort in each year of our studies resulted in increased sample size, from 6 dens in 1992 to 23 in 1993, 40 in 1995, and 49 in 1996. Although we expect that more sites will be found with further survey effort, the rate at which new sites are being added to the database is declining. We examined one new den on the Colville Delta in 1996, a site that was reported by M. North (pers. comm.); we did not find the other den reported by North and were unable to search for the red fox den reported by Helmericks. Because most search effort in previous years has focused on the Colville Delta, 1996 was the first year that the Transportation Corridor was searched completely using a systematic survey. One new den was found in the corridor on a caribou calving survey, four were found (plus one just outside the corridor) on the aerial survey for fox dens, and one was found during a ground-based habitat survey (R. Burgess, ABR, pers. comm.). We located a new den north of the corridor during a ground check at a known den.

Fourteen of the arctic fox dens and all five of the red fox dens are on the Colville Delta, 16 arctic fox dens are in the Transportation Corridor, and the remaining 14 arctic fox dens are located north and south of the corridor (Table 40). Based on a survey of 43 arctic fox dens in late June and mid-July, we concluded that pups were present at 29 (67%), including 24 natal dens (56%) and 4 secondary dens (9%) (one den with pups was found too late in the season to categorize). The remaining 14 arctic fox dens (33%) showed signs of use by adults only or were completely inactive. Pups were present at 69% of the arctic fox dens on the delta, 69% in the Transportation Corridor, and 64% outside these survey areas.

Den occupancy in 1996 was approximately double that of 1993 and 1995 and was the highest reported for the Colville area. In 1995, pups were present at 13 (38%) of 34 arctic fox dens examined, including 9 (26%) natal dens and 4 (12%) secondary dens (Johnson et al. 1996). In 1993, 9 dens (38%) were active, including 5 natal dens (21%) (Smith et al. 1994). The number of active dens recorded in 1992 was too low to calculate meaningful percentages due to low-intensity survey coverage late in the season. Den occupancy can vary substantially among years and regions in relation to food abundance (Macpherson 1969, Chesemore 1975, Garrott 1980, Eberhardt et al. 1983). We attribute the high occupancy in 1996 to a high population of lemmings (see following discussion of pup production).

Eberhardt et al. (1983) reported that the percentage of dens containing pups (comparable to our natal and secondary categories combined) in their Colville study area ranged from 6% to 55% in a 5-year period, whereas 56–67% showed signs of activity by adults alone. Burgess et al. (1993) estimated that 45–58% of the dens in their study area in the Prudhoe Bay Oilfield produced litters in 1992, although only 21% still were occupied by families at the time of ground visits in late July–early August. Despite a high density of dens on Herschel Island in the northern Yukon (Smith et al. 1992), only 3–19% of a sample of 32 dens examined over 5 years were used as natal dens in any one year (Smits and Slough 1993). Judging from our data and these reports, the percentage of active (natal + secondary) dens in the Colville study area in 1996 was exceptional.

The overall density of arctic fox dens (active and inactive) in the combined Delta and Transportation Corridor survey areas is 1 den/30 km^2. The density in the Delta area (1 den/39 km^2) is approximately half that in the Transportation Corridor (1 den/21 km^2), due to the low density of dens in the Outer Delta (Table 41). The overall density is similar to the 1 den/34 km^2 reported by Eberhardt et al. (1983) for their Colville study area. The densities we found are intermediate between those reported for developed areas of the Prudhoe Bay Oilfield (1 den/12–13 km^2; Eberhardt et al. 1983, Burgess et al. 1993) and undeveloped areas nearby (1 den/72 km^2; Burgess et al. 1993), and are similar to average densities reported for large areas of tundra in the Northwest Territories and Siberia (Table 41). Including the historically used site reported by Helmericks, the density of red fox dens in the Delta area was 1 den/110 km^2; few data for this species are available for comparison from other arctic tundra areas.

Our estimates of pup production must be considered minimal because of the amount of time required to obtain reliable counts of pups, which

Table 40. Landforms, activity status, and numbers of pups at arctic and red fox dens on the Colville River Delta and adjacent coastal plain during the 1992, 1993, 1995, and 1996 seasons.

Site No.[a]	Location[b]	Landform[c]	1996 Status[d]	No. of Pups[e] (1996)	1995 Status[f]	1993 Status[f]	1992 Status[f]
ARCTIC FOX							
1	CD	old dune	natal	6	inactive	natal	inactive
2	CD	old dune	inactive	-	natal	natal	natal
4	TC	pingo	natal	≥2	secondary	adults only	not checked
5	TC	pingo	natal	n.d.	natal	inactive	not checked
6	out	pingo	natal	≥3	inactive	inactive	not checked
7	out	pingo	inactive	-	natal	secondary	not checked
8	TC	stream bank	natal	≥2	natal	natal	-
10	CD	dune/lake bank	natal	3	inactive	natal	-
11	CD	lake bank	natal	4	inactive	inactive	-
15	out	pingo	natal	6	inactive	inactive	-
16	out	stream bank	natal	≥1	inactive	natal	-
26	CD	dune/lake bank	inactive	-	inactive	inactive	-
30	out	dlb bank	inactive	-	inactive	inactive	-
33	CD	dune/lake bank	natal	6	natal	inactive	-
34	CD	dune/lake bank	natal	5	secondary?	adults only	-
35	TC	dlb bank	inactive	-	inactive	secondary	-
36	TC	pingo	inactive	-	inactive	inactive	-
37	TC	lake bank	natal	≥2	natal	secondary	-
38	TC	lake bank	natal	9	inactive?	secondary	-
39	out	dlb bank	natal	≥3	inactive?	secondary	-
42	out	old gravel pad	inactive	-	inactive	inactive	-
43	TC	low ridge	inactive	-	inactive	secondary	-
44	TC	low ridge	inactive	-	inactive	secondary	-
45	CD	dune ridge	natal	7	natal	-	-
50	out	lake bank	natal?	n.d.	inactive?	-	-
51	out	stream bank	inactive	-	natal	-	-
52	out	stream bank	inactive	-	inactive	-	-
53	TC	dlb bank	inactive	-	inactive	-	-
54	CD	dune mound	inactive	-	inactive	-	-
56	out	stream bank	natal	≥3	inactive	-	-
57	out	dlb bank	natal	≥3	natal	-	-
58	CD	dune/cutbank	natal	5	secondary	-	-
59	CD	dune/cutbank	inactive	-	inactive	-	-
61	CD	low ridge	secondary?	5	secondary?	-	-
62	CD	low dune ridge	secondary	6	not checked	-	-
63	CD	unknown	not found	-	not checked	-	-
64	TC	lake bank	natal	15	-	-	-
66	TC	terrace bank	secondary	5	-	-	-
67	TC	low mound	natal	6	-	-	-
68	TC	terrace bank	natal	≥3	-	-	-
69	TC	lake bank	natal	≥2	-	-	-
70	out	dlb bank	natal?	n.d.	-	-	-
71	out	dlb bank	secondary	≥3	-	-	-
72	TC	dlb bank	active	4	-	-	-
RED FOX							
48	CD	sand dunes	inactive	-	natal	-	-
49	CD	sand dunes	natal	≥2	secondary?	-	-
55	CD	river cutbank	natal	≥1	natal	-	-
60	CD	sand dune	natal	5	natal	-	-
73	CD	unknown	not checked	-	-	-	-

[a] Sites 62 and 63 were added after the 1995 field season, based on information provided by M. North (pers. comm., 1995); site 73 was added late in the 1996 field season, based on information provided by J. Helmericks (pers. comm., 1996).
[b] CD = Colville Delta survey area; TC = Transportation Corridor; out = either north or south of the Transportation Corridor.
[c] dlb = drained lake basin.
[d] Based on observations between 20 June and 28 July (27 June–17 July for most dens); question mark indicates uncertainty regarding status; Den 72 was located too late in season to determine natal vs. secondary status.
[e] Minimal number of pups counted; ≥ sign indicates counts suspected to be incomplete; n.d. = no data on litter size.
[f] Sources: 1995—Johnson et al. (1996); 1993—Smith et al. (1994); 1992—Smith et al. (1993).

Table 41. Densities of arctic fox dens in the Delta survey area and Transportation Corridor, compared with data from other tundra areas. Table was modified from Burgess et al. (1993: Table 3); Russian sources were cited in Macpherson (1969) and Garrott (1980). Sizes of study areas were not available for all references.

Location	Den Density[a] (1 den/x km^2)	Source
Colville Delta	39	This study
Development Area	24	
Western Delta	0	
Outer Delta	50	
Transportation Corridor	21	
Colville Delta and adjacent areas	42	Garrott 1980
Colville Delta and adjacent areas	34	Eberhardt et al. 1983
Prudhoe Bay Oilfield	12	Eberhardt et al. 1983
Prudhoe Bay Oilfield (developed areas)	13	Burgess et al. 1993
Undeveloped tundra near Prudhoe Bay	72	Burgess et al. 1993
Sagavanirktok River delta, Alaska	25	Burgess and Stickney 1992
Okpilak River (ANWR), Alaska	13	Spindler 1978
Yukon Territory coastal plain	22	Smith et al. 1992
Herschel Island, Yukon Territory	3	Smith et al. 1992
Banks Island, Northwest Territories	22–141	Urquhart 1973
Keewatin, Northwest Territories	36	Macpherson 1969
Yukon–Kuskokwim Delta, Alaska	1	Anthony et al. 1985
Taimyr Peninsula, Russia	0.5	Sdobnikov 1958
Bol'shezemel'skaya tundra, Russia	2	Danilov 1958
Bol'shezemel'skaya tundra, Russia	16	Dementyiev 1958
Siberia ("tundra zone")	32	Boitzov 1937
Turukhansk region, Russia	50	Boitzov 1937

[a] x = number listed in column; e.g., den density is 1 den/39 km^2 on the Colville Delta.

often remain underground for extended periods. We expended ~100 hours of effort, primarily during 10–15 July, in observations on the ground at 23 arctic fox dens and 4 red fox dens, and obtained what we judged to be complete litter counts at 15 arctic fox dens and 1 red fox den. Because of the high percentage of active dens in 1996, however, we were not able to obtain complete counts of pups at all active dens. Pup counts were most successful during early morning and evening, when foxes were active.

We counted 119 pups at 26 active dens of arctic foxes (Table 40), but were unable to count all the pups at each den. At the 15 dens where we obtained complete counts, the average litter size was 6.1 pups (range = 3–15). The average number of pups seen at the 3 active red fox dens was 2.7, but only one count was judged to include an entire litter (5 pups). The average litter size for arctic foxes calculated in 1993 and 1995 was 3.1 pups each year (Smith et al. 1994, Johnson et al. 1996). In 1978, a year when small mammals were relatively abundant on the delta, Garrott (1980) closely observed 7 litters (from a total of 23 active dens), which averaged 6.1 pups (range = 2–8 pups). In contrast, he observed only one litter the year before (from two active dens), when small mammals were scarce, and was unable to obtain a reliable count. Thus, both the occupancy rate of dens and the number of pups produced were high for arctic foxes in 1996.

Arctic fox litters were larger in 1996 than in previous years, which we attribute to an apparently high density of lemmings (primarily brown lemmings) in the Colville study area. Our observers reported more incidental sightings of lemmings than in previous years, and local residents confirmed that the population of brown lemmings was higher than normal (T. Helmericks, pers. comm.). Lemming remains were noted at 14 of 27 arctic fox dens examined on our initial checks during 27 June–2 July.

In general, estimates of pup production are confounded by the use of secondary dens, which may result in splitting of litters among several dens by one family (Garrott 1980, Eberhardt et al. 1983). Garrott (1980) noted that movements from natal dens to secondary dens typically occurred after early to mid-July when the young were 5–7 weeks old, and that interchange of young between dens occurred after the initial move. Such movements probably occurred in 1996 between two pairs of natal and secondary dens in the Transportation Corridor (Dens 68 and 66) and north of it (Dens 39 and 71). In addition, one litter in 1996 may have been split between Dens 45 and 61, which are located approximately 2 km apart just north of the Facility Area. On 14 July, three adults and seven pups were present at Den 45 and five pups were present at Den 61. Although no splitting of the largest litter (15 pups at Den 64) was observed, three adults were present at that den in late June. The extra adults at these dens may have been nonbreeding "helpers," as has been recorded elsewhere for arctic foxes (Hersteinsson and Macdonald 1982, Frafjord 1991, Kullberg and Angerbjörn 1992). Another possibility is that two litters were present at one den site, a rare occurrence that has been reported for arctic foxes (Frafjord 1991), red foxes (Hersteinsson and Macdonald 1982), and gray foxes (*Urocyon cinereoargenteus*) (Gerhardt and Gerhardt 1995).

HABITAT SELECTION

Because both arctic and red foxes have similar denning requirements and will use the same den sites, we included both in our analysis of habitat selection. In both the Delta survey area and Transportation Corridor, foxes preferred Riverine or Upland Shrub for denning (Tables 42 and 43). Dens in Moist Sedge-Shrub Meadows were located in small patches of higher microrelief that were below the minimal size of habitat area mapped. Small numbers of dens occurred in other habitats, but these dens also were located in sites with higher microrelief. This observation underscores the fact that the primary habitat requirement for den construction is well-drained soil with a texture conducive to burrowing, conditions that occur at elevated microsites within a variety of larger habitat types.

Delta

Thirteen arctic fox dens and 4 red fox dens constituted our sample for the Delta survey area; we were unable to assign habitats to 1 arctic fox den and 1 red fox den that were reported to us from other sources. Dens were located in only 4 of 13 types of available habitat (Table 42). Twelve dens (71% of total) were located in Riverine or Upland Shrub, which was the only preferred denning habitat (all of these dens occurred in upland shrub habitat rather than riverine shrub). The other habitats used by denning foxes on the delta were Wet Sedge-Willow Meadow (3 dens), Moist Sedge-Shrub Meadow (1 den), and Nonpatterned Wet Meadow (1 den). None of the habitats on the delta were significantly avoided.

Transportation Corridor

Sixteen arctic fox dens were found in the Transportation Corridor (Table 43), but no red fox dens were found in this area. Dens were located in 4 of 10 available habitats. The most dens (8) were located in Moist Sedge-Shrub Meadow; three were in Riverine or Upland Shrub (all were in upland shrub), three were in Moist Tussock Tundra, and two were in Old Basin Wetland Complex. As on the delta, Riverine or Upland Shrub was the only preferred habitat; in the Transportation Corridor, this type constituted only 2.7% of the area of terrestrial habitats. In contrast, Moist Sedge-Shrub Meadow was the second most available habitat in the Transportation Corridor (29.9% of total area), after Moist Tussock Tundra (33.4%). No habitats were significantly avoided by denning foxes in the Transportation Corridor.

The presence of permafrost in arctic tundra forces foxes to dig dens in locations that have the greatest depth of seasonally thawed soils. Foxes locate dens on raised landforms with well-drained soil; ridges, dunes, lake and stream shorelines, and pingos all are used on the Arctic Coastal Plain (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993). On the Colville Delta and Transportation Corridor, the landforms used most are banks of streams and lakes (including banks of drained-lake basins), dunes, ridges, and pingos (Table 40; Garrott 1980, Eberhardt et al. 1983). Pingos commonly were used as den sites in the Prudhoe Bay area (Burgess et al. 1993) but accounted for only a small percentage of the

Table 42. Habitat selection by foxes for denning in the Delta survey area, Colville River Delta, Alaska, 1996. The sample analyzed included active and inactive dens of arctic foxes (n = 13 dens) and red foxes (n = 4 dens), because both species may use the same dens in different years.

Habitat	Area (km^2)	No. of Fox Dens	Use (%)	Availability[a] (%)	Selection Index (Ivlev's E)[b]	Monte Carlo Results[c]
Open Nearshore Water (marine)	10.46	-	-	0	-	-
Brackish Water	6.50	-	-	0	-	-
Tapped Lake w/ Low-water Connection	21.42	-	-	0	-	-
Tapped Lake w/ High-water Connection	20.36	-	-	0	-	-
Salt Marsh	16.73	0	0	4.4	–1.00	ns
Tidal Flat	55.90	0	0	14.8	–1.00	ns
Salt-killed Tundra	25.63	0	0	6.8	–1.00	ns
Deep Open Water w/o Islands	23.31	-	-	0	-	-
Deep Open Water w/ Islands or Polygonized Margins	5.13	-	-	0	-	-
Shallow Open Water w/o Islands	2.32	-	-	0	-	-
Shallow Open Water w/ Islands or Polygonized Margins	0.55	-	-	0	-	-
River or Stream	81.76	-	-	0	-	-
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	0	0	3.6	–1.00	ns
Aquatic Grass Marsh	1.37	-	-	0	-	-
Young Basin Wetland Complex	<0.01	0	0	<0.1	–1.00	ns
Old Basin Wetland Complex	0.01	0	0	<0.1	–1.00	ns
Nonpatterned Wet Meadow	41.98	1	5.9	11.1	–0.31	ns
Wet Sedge–Willow Meadow	102.23	3	17.6	27.0	–0.21	ns
Moist Sedge–Shrub Meadow	13.10	1	5.9	3.5	0.26	ns
Moist Tussock Tundra	2.49	0	0	0.7	–1.00	ns
Riverine or Upland Shrub	27.40	12	70.6	7.2	0.81	prefer
Barrens (riverine, eolian, lacustrine)	79.01	0	0	20.9	–1.00	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	–1.00	ns
Total[d]	551.3	17	100	100		

[a] Aquatic habitats were assigned zero availability for fox dens.
[b] Ivlev's E = (use – availability)/(use + availability).
[c] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.
[d] Total area excluding aquatic habitats = 378.1 km^2.

known sites in the Colville area (Eberhardt et al. 1983). In the Teshekpuk Lake area west of the Colville Delta, low mounds are used most often for den sites (Chesemore 1969).

POLAR BEARS

BACKGROUND

Polar bears have a circumpolar distribution and are relatively common within 300 km of the arctic coast of Alaska (Amstrup and DeMaster 1988). Polar bears occur annually in the coastal zone in the vicinity of the Colville Delta and North Slope oilfields and occasionally feed on refuse at the North Slope Borough landfill in the Prudhoe Bay Oilfield (Shideler and Hechtel 1993). Although the species is classified as a marine mammal (under the Marine Mammal Protection Act of 1972, as amended), it also inhabits terrestrial habitats for denning.

The distribution and movements of polar bears are dictated largely by seasonal ice movements. As seasonal ice forms and spreads southward from the polar pack ice in fall, polar bears move with it, usually appearing along the Beaufort coast in October (Lentfer 1972). Polar bears are most numerous along the coast in years when multi-year pack ice moves near the shoreline. Adult males and non-pregnant females do not use dens, except as temporary shelters during poor weather. Pregnant females enter winter dens in October or November, emerging again in late March or April (Lentfer and Hensel 1980, Amstrup and Gardner 1994). Cubs are born in December and January (Lentfer and Hensel 1980); litters range from one to three cubs.

Table 43. Habitat selection by arctic foxes for denning in the Transportation Corridor survey area, Colville River Delta, Alaska, 1996. The sample analyzed included active and inactive dens.

Habitat	Area (km^2)	No. of Fox Dens	Use (%)	Availability[a] (%)	Selection Index (Ivlev's E)[b]	Monte Carlo Results[c]
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	-	-	0	-	-
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	-	-	0	-	-
Deep Open Water w/ Islands or Polygonized Margins	6.52	-	-	0	-	-
Shallow Open Water w/o Islands	10.84	-	-	0	-	-
Shallow Open Water w/ Islands or Polygonized Margins	7.36	-	-	0	-	-
River or Stream	2.30	-	-	0	-	-
Aquatic Sedge Marsh	0.97	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	–1.00	ns
Aquatic Grass Marsh	0.65	-	-	0	-	-
Young Basin Wetland Complex	14.23	0	0	5.0	–1.00	ns
Old Basin Wetland Complex	35.59	2	12.5	12.5	0.00	ns
Nonpatterned Wet Meadow	24.47	0	0	8.6	–1.00	ns
Wet Sedge–Willow Meadow	19.87	0	0	7.0	–1.00	ns
Moist Sedge–Shrub Meadow	84.66	8	50.0	29.9	0.25	ns
Moist Tussock Tundra	94.60	3	18.8	33.4	–0.28	ns
Riverine or Upland Shrub	7.74	3	18.8	2.7	0.75	prefer
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.7	–1.00	ns
Artificial (water, fill, peat road)	0.47	0	0	0.2	–1.00	ns
Total	343.1	16	100	100		

[a] Aquatic habitats were assigned zero availability for fox dens; total area excluding aquatic habitats = 283.6 km^2.
[b] Ivlev's E = (use – availability)/(use + availability).
[c] Significance calculated from 500 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Of 90 dens occupied by pregnant female polar bears from the Beaufort Sea population, 42% were on land, 53% were on drifting pack ice, and 4% were on shorefast ice (Amstrup and Gardner 1994). The proportion of bears denning on land in the Beaufort Sea region is increasing, probably as a result of population recovery following prohibition of sport hunting in 1972 (Stirling and Andriashek 1992, Amstrup and Gardner 1994). Females do not reuse the same den sites annually, but they do tend to return to the same general area and to den in the same type of habitat (Amstrup and Gardner 1994).

DISTRIBUTION AND ABUNDANCE

The amount of information on the distribution of polar bear maternity dens in the Beaufort Sea region is relatively small and has accumulated slowly over several decades. Information drawn from several sources indicates low occurrence of polar bear dens in the vicinity of the Colville Delta. S. Amstrup (Biol. Resour. Div., pers. comm.) provided the approximate locations of several dens reported over the years in terrestrial and nearshore areas from the Colville Delta to Oliktok Point (Figure 29). Recent interviews with seven hunters from Nuiqsut (USFWS 1995: Appendix A) provided additional descriptions (but no map locations) of dens in the immediate vicinity of the delta, some of which dated from the 1920s, 1940s, and 1950s: Woods Point; the mouths of Kupigruak and Nechelik channels; 8 km south and 5–8 km northeast of Nuiqsut; and the Oliktok Point area. R. Shideler (ADFG, pers. comm.) reported a polar bear den on lower Kalubik Creek, at the eastern edge of our study area, in the winter of 1991–1992; this record is the most recent one found for our

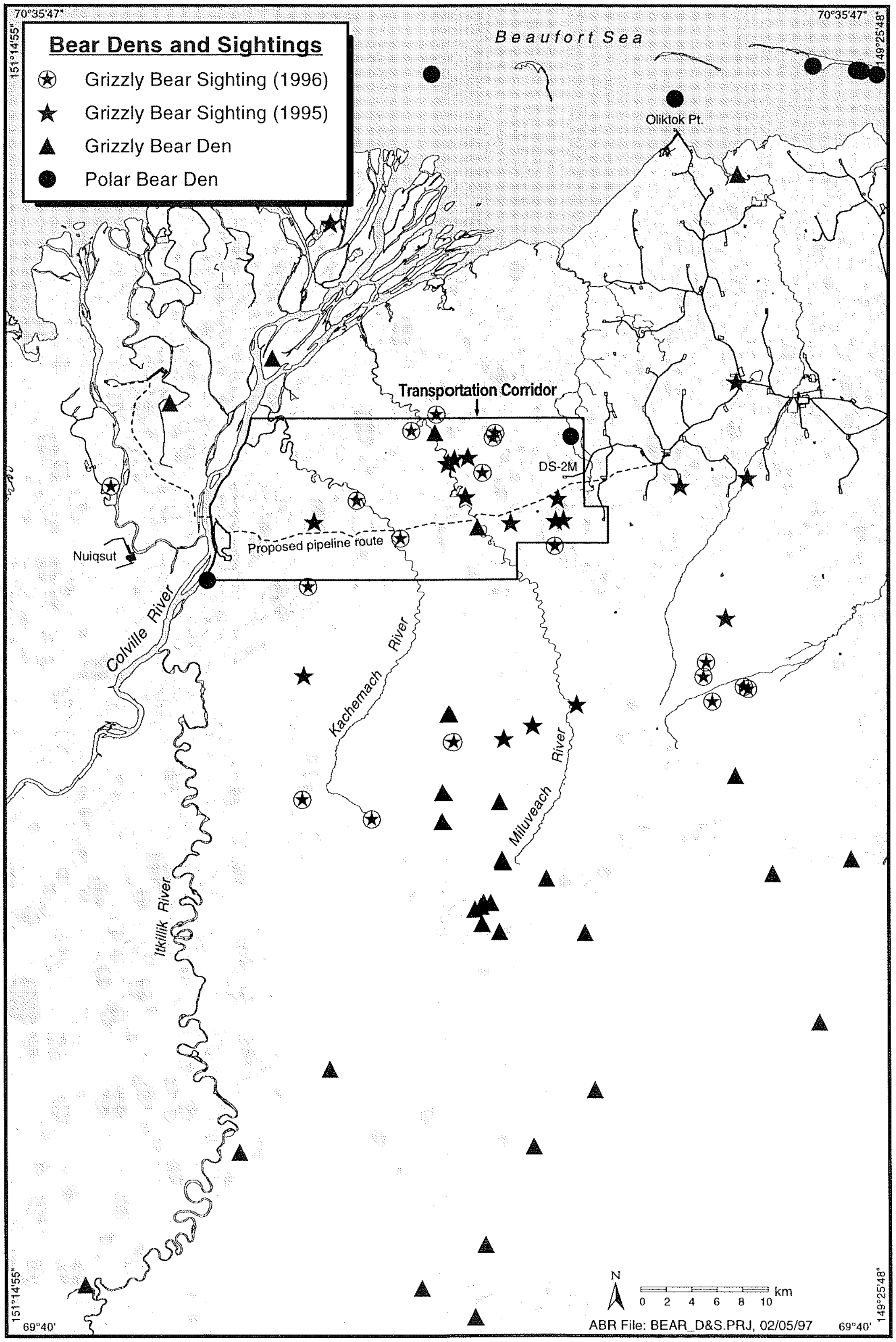

Figure 29. Distribution of winter dens of polar and grizzly bears (records from USFWS and ADFG databases) and incidental sightings of grizzly bears during aerial surveys in June–August 1995 and 1996 in the vicinity of the Colville River Delta, Alaska.

study area. Seaman et al. (1981: Figure 7) showed 12 locations of dens and females with cubs recently out of dens between the lower Itkillik River and Kalubik Creek, plus five locations in the Beaufort Sea within 30 km of the mouth of the Colville River; the dates of these records were not stated, but presumably were in the 1960s and 1970s. Lentfer and Hensel (1980) reported two dens and two observations of females with cubs recently out of dens along the east side of the Colville River.

The best denning habitat on the coastal plain is terrain that accumulates and sustains deep snowdrifts through the winter. Examination of 25 den sites used by radio-collared bears revealed strong selection for bluffs along rivers, streams, and lake banks having slopes of at least 40° and at least 1 m of vertical relief (S. Amstrup, pers. comm.). Prevailing winds in winter are from the west and southwest, so landscape features oriented perpendicular to these directions accumulate deep drifts along bluff faces.

GRIZZLY BEARS

BACKGROUND

Grizzly bears (brown bears) are distributed throughout northern Alaska from the Brooks Range to the coast. Population densities are highest in the mountains and foothills and are low on the coastal plain (R. Shideler, pers. comm.). ADFG biologists estimate that a minimum of 40 bears inhabit an area of approximately 17,400 km^2 between the Colville River on the west and the Shaviovik River on the east, and extending inland 80 km to the White Hills (Shideler and Hechtel 1995b; R. Shideler, pers. comm.). Since 1991, ADFG has captured and marked 46 bears in this region (35 currently are radio-collared) in an ongoing study of use by bears of the oilfields, and additional unmarked bears are known to be present.

Mating in northern Alaska peaks in June but can occur anytime from May through July (Garner et al. 1986). Males and females remain separate for most of the year, coming together only briefly to court and mate. As for polar bears, cubs are born in dens during December and January. Litters in northern Alaska range from one to three cubs, averaging two (Reynolds 1979).

Grizzly bears den from early October to late April or May in northern Alaska. Both sexes and all ages occupy winter dens, with females and cubs entering dens earlier and emerging later than males and single females (Garner and Reynolds 1986, Shideler and Hechtel 1995b). On the coastal plain, grizzlies dig dens in pingos, banks of rivers and lakes, dunes, and steep gullies in uplands (Harding 1976; Shideler and Hechtel 1995a; R. Shideler, pers. comm.). Most of the bears studied by ADFG denned within 50 km of the oilfields, although several have denned 100–160 km inland (Shideler and Hechtel 1995a; R. Shideler, pers. comm.).

DISTRIBUTION AND ABUNDANCE

In summer 1996, grizzly bears were observed opportunistically during our surveys for other species, especially during surveys for caribou. Ten of the 18 sightings in 1996 occurred in June, and the remainder occurred during the first half of July (Figure 29). As in 1993 and 1995, several grizzly bears were seen on the caribou calving grounds south of the Kuparuk Oilfield in the first half of June. Most of the later sightings were clumped in the Transportation Corridor, east of the Miluveach River, in the same area where most incidental sightings occurred in 1995. Only one bear sighting (a female with two dependent young) was recorded on the Colville Delta in our 1996 surveys. In all, five of our 1996 sightings involved females with dependent young.

In summer 1995, grizzly bears also were seen more commonly in the Transportation Corridor and the uplands south of it than on the delta (Figure 29). Between early June and early August, 16 sightings were recorded incidentally to other surveys: eight in the Transportation Corridor, six south or east of the corridor, and two on the delta. Half of those sightings involved more than one bear, and five were of females with dependent young. The sighting records indicate that at least 14 different animals (including dependent young) were seen in the vicinity of the Colville Delta during the 1995 season. Grizzly bears were observed in the vicinity of the Colville Delta five times in 1993 (Smith et al. 1994) and once in 1992 (Smith et al. 1993). The increase in sightings over this time period primarily represents increased observation effort from 1992 to 1996. Nevertheless, use of the delta region by grizzlies can be expected to increase as the population in the vicinity of the oilfields continues to expand.

Thirty-four dens have been located by ADFG in the area between the Kuparuk Oilfield and the

Colville River, south to 69° 40' N (R. Shideler, pers. comm.; Figure 29). Nineteen of these dens were used by 12 different marked bears since the 1992–1993 denning seasons; the other dens are older or were used by unmarked bears. For the first time in the ADFG study, marked bears denned on the Colville Delta in the winter of 1996–1997: one den, containing two young males was located along the Sakoonang Channel approximately 1.5 km south of the Facility Area, and another den, occupied by a single bear, was located in sand dunes on an island in the East Channel (R. Shideler, pers. comm.). In the Transportation Corridor, two marked bears have denned recently on the Miluveach River (one each in 1995–1996 and 1996–1997). Most grizzly bear dens in this area, however, are clustered in the uplands >15 km south of the Transportation Corridor, in the headwaters of the Miluveach and Kachemach rivers and a western tributary of the Kuparuk River (R. Shideler, pers. comm.).

MUSKOXEN

BACKGROUND

Muskoxen were native to Alaska but were extirpated by humans by the late 1800s (Smith 1989b). In the mid-1930s, muskoxen from Greenland were introduced on Nunivak Island in western Alaska, and 64 animals from there subsequently were reintroduced at Barter Island in the Arctic National Wildlife Refuge (ANWR) in 1969 and at the Kavik River (between Prudhoe Bay and ANWR) in 1970. Those introductions established the ANWR population, which grew rapidly and expanded to both the west and east within a decade (Garner and Reynolds 1986). Another population was introduced near Cape Thompson in northwestern Alaska in 1970 and 1977 (Smith 1989b); that population has also expanded, albeit more slowly than the ANWR population. The typical pattern of population expansion has been for solitary bulls to pioneer new areas, followed by groups of mixed sexes and ages (Smith 1989a, Reynolds 1995).

After 1986, the ANWR population stabilized at 350–400 muskoxen, whereas the number west of there increased rapidly (Reynolds 1992b, 1995). Muskoxen that inhabit the Arctic Coastal Plain south of the Kuparuk and Prudhoe Bay oilfields probably originated from the ANWR population. By the mid-1980s, muskox sign had been found in the western Kuparuk Oilfield (P. Kleinleder, ABR, pers. comm.), and lone bulls were seen near the Colville River (Reynolds et al. 1986). Golden (1990) reported that a small number of muskoxen first overwintered in the Colville River area southeast of Nuiqsut in 1988–1989. Stephenson (1993) estimated that 165 muskoxen inhabited the region between the Colville River and ANWR.

DISTRIBUTION AND ABUNDANCE

The largest number of muskoxen seen to date was 84 muskoxen (including 22 calves) in seven groups on 5 June 1996 in the Itkillik uplands, well to the south of the Transportation Corridor (Figure 30). On 5 June 1995, 61 muskoxen (including 7 calves) in four groups were found in the same area of the Itkillik uplands. Although a few muskoxen (mostly lone bulls) have been seen on the Colville Delta, most were seen east or south of the delta during our caribou and waterfowl surveys in the summers of 1992, 1993, 1995, and 1996. Because systematic surveys of this species have not been attempted, reliable estimates of the population using the lower Colville and Itkillik drainages are not available.

The temporal pattern of muskox observations is for larger groups to be seen farther south earlier in summer. This pattern suggests that small groups move north seasonally along the Colville and lower Itkillik rivers and their tributaries. For example, groups of muskoxen have been seen in the vicinity of the Delta and Transportation Corridor only during July and August, despite comprehensive aerial survey coverage of the Colville Delta and Colville East caribou survey areas during early and mid-June. In the first half of July 1996, a mixed-sex group of 20–21 muskoxen (including 7 calves) moved down the Kachemach River. The group remained in riverine shrub habitat along the lower reaches of the Kachemach until 22 July, when it was seen moving southward near the mouth of the Itkillik River. Mixed-sex groups containing calves were seen each summer during 1992, 1993, and 1995 near the mouth of the Itkillik River and along the eastern side of the Colville River north of there; these groups included 14 animals in 1992, 4 in 1993, and ≥13 (incomplete count) in 1995.

Muskox home ranges are larger, and activity and movement rates are much higher, during summer than winter (Reynolds et al. 1986). Long-

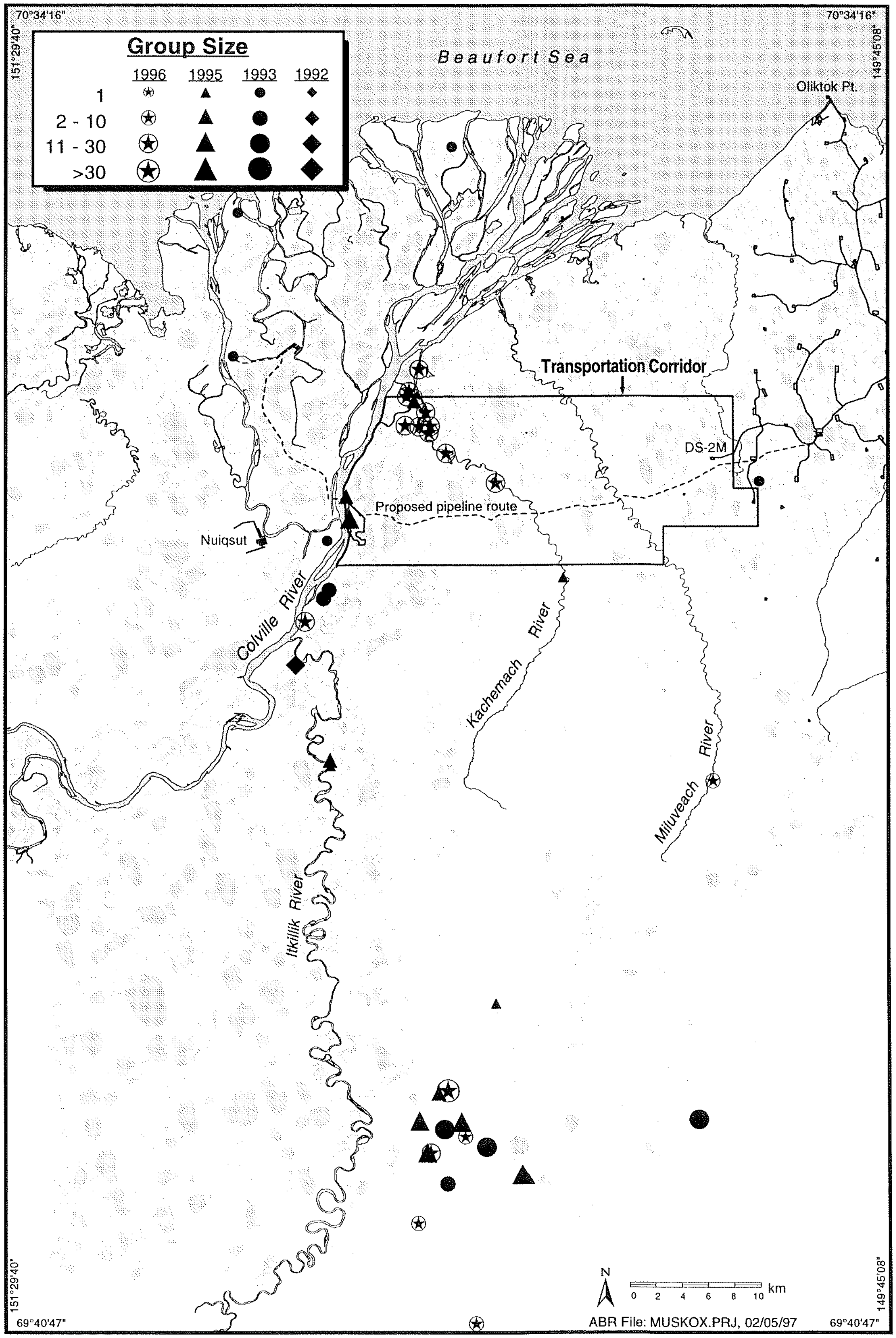

Figure 30. Distribution of incidental sightings of muskoxen during aerial surveys in May–August 1992, 1993, 1995, and 1996 in the vicinity of the Colville River Delta, Alaska.

distance movements from winter to summer range are common in mid–late June, after river breakup and leafing out of willows along drainages (Reynolds 1992a). Group size typically decreases in summer, as the breeding season (rut) approaches in August and September; most groups in ANWR ranged from 10 to 30 animals (Reynolds et al. 1986, Reynolds 1992b). Our limited observations suggest that most of the muskoxen population that resides in the Itkillik–Colville region winters in the uplands east of the Itkillik River, then disperses during summer into smaller groups, some of which move northward along the Itkillik River to the Colville Delta vicinity.

In winter, muskoxen select upland habitats near ridges and bluffs with shallow, soft snow cover that permits easy access to food plants (Klein et al. 1993). In spring, muskoxen use upland tussock tundra and moist sedge–shrub tundra, apparently seeking high-quality flowering sedges (Jingfors 1980, Reynolds et al. 1986). By late spring and summer, muskoxen prefer river terraces, gravel bars, and shrub stands along rivers and tundra streams (Jingfors 1980, Robus 1981), where they eat willow leaves, flowering herbaceous plants, and sedges (Robus 1984, O'Brien 1988). Thus, Riverine or Upland Shrub and Moist Sedge-Shrub Meadows are probably the most important habitats for muskoxen using the Colville Delta and the Transportation Corridor.

SPOTTED SEALS

BACKGROUND

In Alaska, spotted seals occur from Bristol Bay north to the Chukchi Sea and east to the Beaufort Sea (Frost et al. 1982, 1983). In winter, spotted seals inhabit the edge of the sea ice in the Bering Sea, where they pup, breed, and molt during March and April (Quakenbush 1988). As the seasonal ice recedes, spotted seals disperse to nearshore habitats and move northward. In the Chukchi and Beaufort seas, they haul out on land from mid-July through late October (Frost et al. 1993). Favored haulout sites include small islands, spits, and shoals with adjacent deep water (Seaman et al. 1981, Frost et al. 1993). Kasegaluk Lagoon, on the Chukchi Sea coast, is the site of the northernmost major concentration of spotted seals in Alaska during summer and fall, when up to 2,200 seals are seen (Frost et al. 1993). As nearshore waters begin to freeze in early winter, spotted seals move away from the coast, probably because they are incapable of maintaining breathing holes in shorefast ice, and return to the Bering Sea for the winter (Quakenbush 1988).

DISTRIBUTION AND ABUNDANCE

During the aerial survey on 23 August 1996, we saw six spotted seals hauled out on a sand spit on an island near the mouth of the East Channel of the Colville River (Figure 31). No seals were seen elsewhere on the delta during this survey, nor were any seen on or around the barrier islands bordering Simpson Lagoon east of the delta. Approximately 20 spotted seals were seen hauled out on the same spit during a waterfowl survey on 6 September 1996. In late July, approximately 24 seals were seen in the East Channel near the mouth of the Miluveach River (L. Moulton, MJM, pers. comm.).

Although the distribution and abundance of spotted seals from Point Barrow eastward along the Beaufort Sea coast are poorly documented, several reports mention the presence of seals on the Colville Delta during summer and fall. Seaman et al. (1981) reported that ≥150 seals used the delta from late July through fall and identified the delta as the easternmost concentration area for this species in the Beaufort Sea. Satellite tracking of spotted seals demonstrated that individual seals moved from Kasegaluk Lagoon to the Colville Delta as late as August (Lowry et al. 1994).

At Kasegaluk Lagoon, Frost et al. (1993) found that seals left haulouts in response to survey aircraft at distances of 1 km or more and at flight altitudes up to 760 m. In contrast, the spotted seals we observed on the delta did not desert the haulout in response to our aircraft. For example, on our August survey, seals remained on the sand spit while we descended to an altitude of approximately 150 m agl and circled at a horizontal distance of about 1 km from the spit. On 6 September, the aircraft was at an altitude of 215 m agl almost directly above the spit, without eliciting an overt response from the seals.

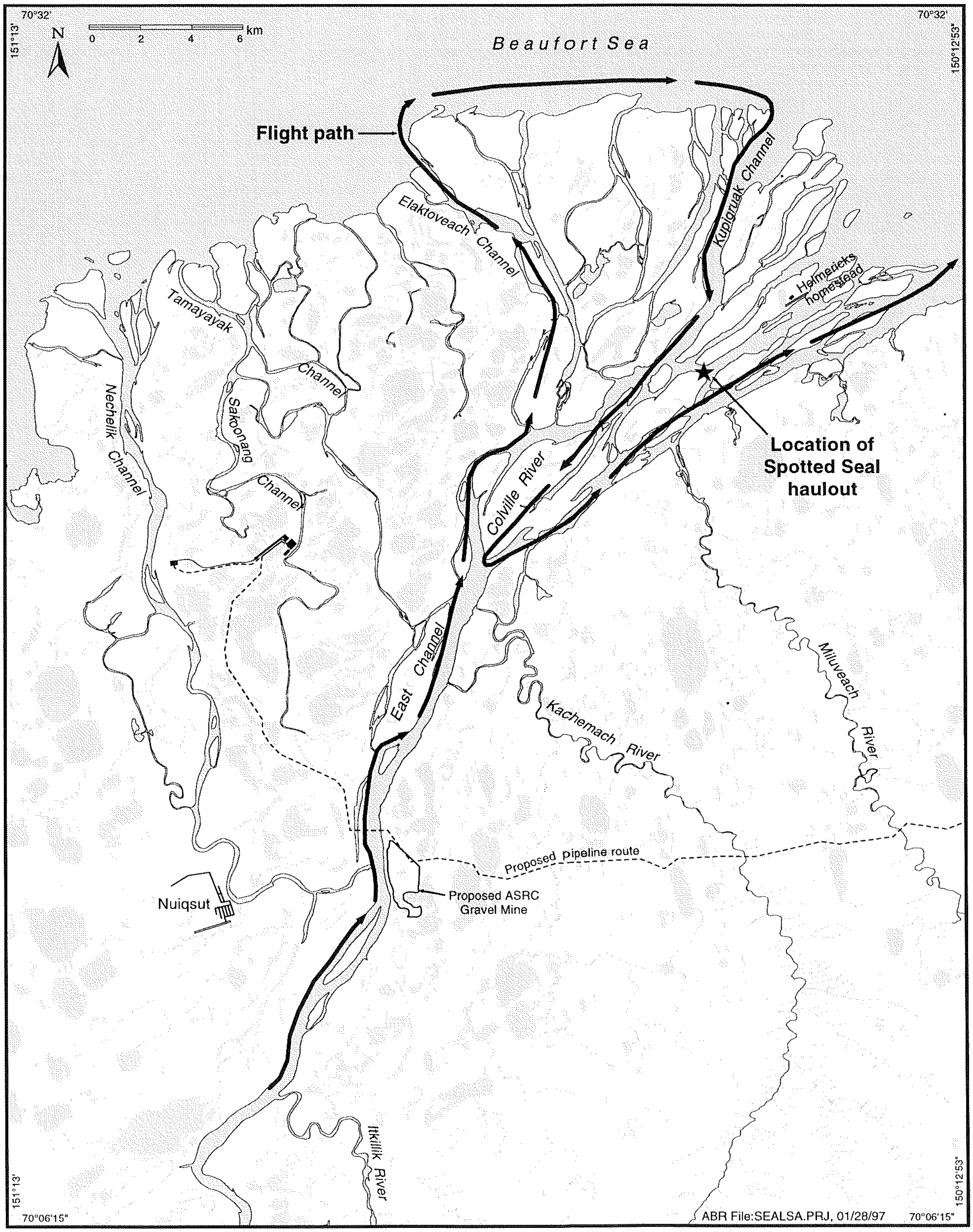

Figure 31. Spotted Seal haulout location and aerial survey route, Colville River Delta, Alaska, 23 August 1996.

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APPENDIX A. Species list of birds and mammals seen near the Colville River Delta, Alaska, 1992–1996.

Table A1. Common and scientific names of birds and mammals seen during the Colville River Delta Wildlife Study, May–October 1992–1996.

BIRDS			
Red-throated Loon	*Gavia stellata*	American Golden-Plover	*Pluvialis dominicus*
Pacific Loon	*Gavia pacifica*	Upland Sandpiper	*Bartramia longicauda*
Yellow-billed Loon	*Gavia adamsii*	Whimbrel	*Numenius phaeopus*
Red-necked Grebe	*Podiceps grisegena*	Bar-tailed Godwit	*Limosa lapponica*
Tundra Swan	*Cygnus columbianus*	Ruddy Turnstone	*Arenaria interpres*
Greater White-fronted Goose	*Anser albifrons*	Semipalmated Sandpiper	*Calidris pusilla*
Snow Goose	*Chen caerulescens*	Least Sandpiper	*Calidris minutilla*
Brant	*Branta bernicla*	White-rumped Sandpiper	*Calidris fuscicollis*
Canada Goose	*Branta canadensis*	Baird's Sandpiper	*Calidris bairdii*
Green-winged Teal	*Anas crecca*	Pectoral Sandpiper	*Calidris melanotos*
Mallard	*Anas platyrhynchos*	Dunlin	*Calidris alpina*
Northern Pintail	*Anas acuta*	Stilt Sandpiper	*Calidris himantopus*
Northern Shoveler	*Anas clypeata*	Long-billed Dowitcher	*Limnodromus scolopaceus*
American Wigeon	*Anas americana*	Common Snipe	*Gallinago gallinago*
Greater Scaup	*Aythya marila*	Red-necked Phalarope	*Phalaropus lobatus*
Lesser Scaup	*Aythya affinis*	Red Phalarope	*Phalaropus fulicaria*
Common Eider	*Somateria mollissima*	Pomarine Jaeger	*Stercorarius pomarinus*
King Eider	*Somateria spectabilis*	Parasitic Jaeger	*Stercorarius parasiticus*
Spectacled Eider	*Somateria fischeri*	Long-tailed Jaeger	*Stercorarius longicaudus*
Steller's Eider	*Polysticta stelleri*	Glaucous Gull	*Larus hyperboreus*
Oldsquaw	*Clangula hyemalis*	Sabine's Gull	*Xema sabini*
Black Scoter	*Melanitta nigra*	Arctic Tern	*Sterna paradisaea*
Surf Scoter	*Melanitta perspicillata*	Snowy Owl	*Nyctea scandiaca*
White-winged Scoter	*Melanitta fusca*	Short-eared Owl	*Asio flammeus*
Red-breasted Merganser	*Mergus serrator*	Horned Lark	*Eremophila alpestris*
Bald Eagle	*Haliaeetus leucocephalus*	Common Raven	*Corvus corax*
		American Robin	*Turdus migratorius*
Northern Harrier	*Circus cyaneus*	Yellow Wagtail	*Motacilla flava*
Rough-legged Hawk	*Buteo lagopus*	Wilson's Warbler	*Wilsonia pusilla*
Golden Eagle	*Aquila chrysaetos*	American Tree Sparrow	*Spizella arborea*
Peregrine Falcon	*Falco peregrinus*	Savannah Sparrow	*Passerculus sandwichensis*
Willow Ptarmigan	*Lagopus lagopus*	Lapland Longspur	*Calcarius lapponicus*
Rock Ptarmigan	*Lagopus mutus*	Snow Bunting	*Plectrophenax nivalis*
Sandhill Crane	*Grus canadensis*	Common Redpoll	*Carduelis flammea*
Black-bellied Plover	*Pluvialis squatarola*		
MAMMALS			
Arctic Ground Squirrel	*Spermophilus parryii*	Ermine	*Mustela erminea*
Brown Lemming	*Lemmus sibiricus*	Wolverine	*Gulo gulo*
Collared Lemming	*Dicrostonyx rubricatus*	Spotted Seal	*Phoca largha*
Arctic Fox	*Alopex lagopus*	Caribou	*Rangifer tarandus*
Red Fox	*Vulpes vulpes*	Muskox	*Ovibos moschatus*
Grizzly Bear	*Ursus arctos*		

APPENDIX B. Descriptions of wildlife habitat types found in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1996.

Table B1. Descriptions of wildlife habitat types found in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1996.

Habitat	Description
Open Nearshore Water (Marine)	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2 m), but storm surges produced by winds may raise sea level as much as 2–3 m. Bottom sediments are mostly unconsolidated mud. Winter freezing generally begins in late September and is completed by late November. This habitat is important for some species of waterfowl during molting and during spring and fall staging, and for loons while foraging.
Brackish Water	Coastal ponds and lakes that are flooded periodically with saltwater during storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate may contain peat, reflecting its freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay.
Tapped Lake with Low-water Connection	Waterbodies that have been partially drained through erosion of banks by adjacent river channels, but which are connected to rivers by distinct, permanently flooded channels. The water typically is brackish and the lakes are subject to flooding every year. Because water levels have dropped, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shorelines. Deeper lakes in this habitat do not freeze to the bottom during winter. Sediments are fine-grained silt and clay with some sand. These lakes provide important overwintering habitat for fish.
Tapped Lake with High-water Connection	Similar to preceding type, except that the connecting channels are dry during low water and the lakes are connected only during flooding events. Water tends to be fresh. Small deltaic fans are common near the connecting channels due to deposition during seasonal flooding. These lakes provide important fish habitat.
Salt Marsh	On the Beaufort Sea coast, arctic Salt Marshes generally occur in small, widely dispersed patches, most frequently on fairly stable mudflats associated with river deltas. The surface has little microrelief, and is flooded irregularly by brackish or marine water during high tides, storm surges, and river-flooding events. Salt Marshes typically include a complex assemblage of small brackish ponds, halophytic sedge and grass wet meadows, halophytic dwarf-willow scrub, and small barren patches. Dominant plant species usually include *Carex subspathacea, C. ursina, Puccinellia phryganodes, Dupontia fisheri, P. andersonii, Salix ovalifolia, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea.* Salt Marsh is an important habitat for brood-rearing and molting waterfowl.
Tidal Flat	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal Flats occur on the seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal Flats frequently are associated with lagoons and estuaries and may vary widely in salinity levels. Tidal Flats are considered separately from other barren habitats because of their importance to estuarine and marine invertebrates and shorebirds.
Salt-killed Tundra	Coastal areas where saltwater intrusions from storm surges have killed much of the original terrestrial vegetation and which are being colonized by salt-tolerant plants. Colonizing plants include *Puccinellia andersonii, Dupontia fisheri, Braya purpurascens, B. pilosa, Cochlearia officinalis, Stellaria humifusa, Cerastium beeringianum,* and *Salix ovalifolia* This habitat typically occurs either on low-lying areas that formerly supported Wet Sedge-Willow Meadows and Basin Wetland Complexes or, less commonly, along drier coastal bluffs that formerly supported Moist Sedge-Shrub Meadows and Upland Shrub. Salt-killed Tundra differs from Salt Marshes in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant colonizing plants. These areas are often polygonized, with the rims less salt-affected than the centers of the polygons.
Deep Open Water without Islands	Deep (≥1.5 m) waterbodies range in size from small ponds in ice-wedge polygons to large open lakes; most have resulted from thawing of ice-rich sediments, although some are associated with old river channels. They do not freeze to the bottom during winter. Lakes usually are not connected to rivers. Sediments are fine-grained silt and clay. Deep Open Waters without Islands are differentiated from those with islands because of the importance of islands to nesting waterbirds.

Table B1. (Continued)

Habitat	Description
Deep Open Water with Islands or Polygonized Margins	Similar to the preceding type, except that these waterbodies have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many species of waterbirds.
Shallow Open Water without Islands	Ponds and small lakes <1.5 m deep with emergent vegetation covering <5% of the waterbody surface. Due to the shallow depth, water freezes to the bottom during winter and thaws by early to mid-June. Maximal summer temperatures are higher than those in deep water. Although these ponds generally are surrounded by wet and moist tundra, ponds located in barren areas also are included in this category. Sediments are fine-grained silt and clay.
Shallow Open Water with Islands or Polygonized Margins	Shallow lakes and ponds with islands or complex shorelines characterized by low-center polygons. Distinguished from Shallow Open Water without Islands because shoreline complexity appears to be an important feature of nesting habitat for many species of waterbirds.
River or Stream	Permanently flooded channels of the Colville River and its tributaries and smaller stream channels in the Transportation Corridor. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The distributaries of the Colville River Delta are slightly saline, whereas streams in the Transportation Corridor are non-saline. During winter unfrozen water in deeper channels can become hypersaline.
Aquatic Sedge Marsh	Permanently flooded waterbodies or margins of waterbodies dominated by *Carex aquatilis*. Typically, emergent sedges occur in water ≤0.3 m deep. Water and bottom sediments of this shallow habitat freeze completely during winter, but the ice melts in early June. The sediments generally consist of a peat layer (0.2–0.5 m deep) overlying fine-grained silt.
Aquatic Sedge with Deep Polygons	Primarily a coastal habitat in which thermokarst of ice-rich soil has produced deep (>1 m), permanently flooded polygon centers. Emergent vegetation, mostly *C. aquatilis,* usually is found around the margins of the polygon centers. Occasionally, centers will have the emergent grass *Arctophila fulva*. Polygon rims are moderately well drained and dominated by sedges and dwarf shrubs, including *Dryas integrifolia*, *Salix reticulata, S. phlebophylla,* and *S. ovalifolia.*
Aquatic Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva*. Due to shallow water depths (<1 m), the water freezes to the bottom in the winter, and thaws by early June. *Arctophila* stem densities and annual productivity can vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in the thaw lake cycle and is more productive than Aquatic Sedge Marsh. This habitat tends to have abundant invertebrates and is important to many waterbirds.
Young Basin Wetland Complex (ice-poor)	Basin wetland complexes (both young and old) occur in drained lake basins and are characterized by a complex mosaic of open water, aquatic sedge and grass marshes, and wet and moist meadows in patches too small (<0.5 ha) to map individually. Deeper basins may be entirely inundated during spring breakup. Water levels gradually recede following breakup. Basins often have distinct upland rims marking the location of old shorelines, although boundaries may be indistinct due to the coalescence of thaw basins and the presence of several thaw-lake stages. Soils generally are fine-grained, organic-rich, and ice-poor in the young type. The lack of ground ice results in poorly developed polygon rims in wetter areas and indistinct edges of waterbodies. Ecological communities within younger basins appear to be much more productive than are those in older basins, which is the reason for differentiating between the two types of basin wetland complexes.

Table B1. (Continued)

Habitat	Description
Old Basin Wetland Complex (ice-rich)	Similar to preceding type, but characterized by well-developed low- and high-center polygons resulting from ice-wedge development and aggradation of segregated ice. The waterbodies in old complexes have smoother, more rectangular shorelines and are not as interconnected as in young complexes. The vegetation types generally include Wet Sedge Willow Meadow, Moist Sedge-Shrub Meadow, and Moist Tussock Tundra. Aquatic Sedge and Grass Marshes are absent. Soils generally have a moderately thick (0.2–0.5 m) organic layer overlying fine-grained silt or sandy silt.
Nonpatterned Wet Meadow	Sedge-dominated meadows that typically occur within young drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims and strangmoor cover <5% of the ground surface. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but remains saturated within 15 cm of the surface throughout the growing season. The uninterrupted movement of water and dissolved nutrients in nonpatterned ground results in more robust growth of sedges than in polygonized habitats. *Carex aquatilis* and *Eriophorum angustifolium* usually dominate, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be present. Low and dwarf willows (*Salix lanata, S. arctica,* and *S. planifolia*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying fine-grained silt.
Wet Sedge-Willow Meadow	Occurs in lowland areas within drained lake basins, level floodplains, and swales on gentle slopes and terraces, associated with low-centered polygons and strangmoor (undulating raised sod ridges). Water depth varies through the season (<0.3 m maximum). Polygon rims and strangmoor interrupt surface and groundwater flow, so only interconnected polygon troughs receive downslope flow and dissolved nutrients; in contrast, the input of water to polygon centers is limited to precipitation. As a result, vegetation growth typically is more robust in polygon troughs than in centers. Vegetation is dominated by the sedges, *Carex aquatilis* and *Eriophorum angustifolium,* although other sedges may be present, including *C. rotundata, C. saxatilis, C. membranacea, C. chordorriza,* and *E. russeolum.* Willows (*Salix lanata, S. arctica,* and *S. planifolia*) usually are abundant.
Moist Sedge-Shrub Meadow (low- or high-relief polygons)	Occurs on better-drained uplands between thaw basins, riverbanks, old stabilized dunes, lower slopes of pingos, and foothill slopes, generally associated with nonpatterned ground, frost scars, and high-centered polygons with low relief. Vegetation is dominated by *C. aquatilis, C. bigelowii, E. angustifolium, S. planifolia,* and *Dryas integrifolia.* The ground is covered with a nearly continuous carpet of mosses. Soils generally have a thin layer (20–30 cm) of organic matter over silt loam.
Moist Tussock Tundra	Similar to preceding type, except that the vegetation is dominated by the tussock-forming sedge *Eriophorum vaginatum.* This type tends to occur on the upper portions of slopes and in better drained conditions than Moist Sedge-Shrub Tundra.
Riverine or Upland Shrub	Both open and closed stands of low (≤1.5 m high) and tall (>1.5 m high) willows along riverbanks and *Dryas* tundra on upland ridges and stabilized sand dunes. Tall willows occur mainly along larger streams and rivers, where the vegetation is dominated by *Salix alaxensis.* Low willow stands are widespread and typically have a canopy of *S. lanata* and *S. glauca.* Understory plants include the shrubs *Arctostaphylos rubra, S. reticulata,* and *D. integrifolia,* and the forbs *Astragalus* spp., *Lupinus arcticus,* and *Equisetum* spp. *Dryas* tundra is dominated by *D. integrifolia* but may include abundant dwarf willows such as *S. phlebophylla.* Common forbs include *Silene acaulis, Pedicularis lanata,* and *Astragalus umbellatus,* and *C. bigelowii* frequently is present. In Riverine Shrub, an organic horizon generally is absent or buried due to frequent sediment deposition. In Upland Shrub, soils generally have a thin (<5 cm) organic horizon.

Table B1. (Continued)

Habitat	Description
Barrens (riverine, eolian, or lacustrine)	Includes barren and partially vegetated (<30% plant cover) areas resulting from riverine, eolian, or thaw-lake processes. Riverine Barrens on river flats and bars are flooded seasonally and can have either silty or gravelly sediments. The margins frequently are colonized by *Deschampsia caespitosa, Elymus arenarius, Chrysanthemum bipinnatum,* and *Equisetum arvense.* Eolian Barrens generally are located adjacent to river deltas and include active sand dunes that are too unstable to support more than a few pioneering plants (<5% cover). Typical pioneer plants include *Salix alaxensis, Elymus arenarius,* and *Deschamspia caespitosa.* Lacustrine Barrens occur along margins of drained lakes and ponds. These areas may be flooded seasonally or can be well drained. On the delta, sediments usually are clay-rich, slightly saline, and are being colonized by salt-marsh plant species. Barrens may receive intensive use seasonally by caribou as insect-relief habitat.
Artificial (water, fill, peat road)	A variety of small disturbed areas, including impoundments, gravel fill, and a sewage lagoon at Nuiqsut. Gravel fill is present at Nuiqsut, and at the Helmericks residence near the mouth of the Colville River. A peat road runs roughly north-south within the Transportation Corridor. Two Kuparuk drill sites (2M and 2K) are included, as are several old exploratory drilling pads.

APPENDIX C. Habitat selection by selected species in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1996.

Table C1. Habitat selection by Spectacled and King Eiders during pre-nesting in the Delta survey area, Colville River Delta, Alaska, 1996.

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
SPECTACLED EIDERS							
Open Nearshore Water (marine)	8.32	0	0	0	1.6	-1.00	8
Brackish Water	6.42	3	6	15	1.2	0.85	3
Tapped Lake w/ Low-water Connection	21.42	0	0	0	4.1	-1.00	8
Tapped Lake w/ High-water Connection	20.29	2	3	10	3.9	0.44	5
Salt Marsh	16.68	4	7	20	3.2	0.72	4
Tidal Flat	37.37	0	0	0	7.1	-1.00	8
Salt-killed Tundra	25.63	0	0	0	4.9	-1.00	8
Deep Open Water w/o Islands	23.31	0	0	0	4.5	-1.00	8
Deep Open Water w/ Islands or Polygonized Margins	5.15	0	0	0	1.0	-1.00	8
Shallow Open Water w/o Islands	2.30	0	0	0	0.4	-1.00	8
Shallow Open Water w/ Islands or Polygonized Margins	0.55	2	2	10	0.1	0.98	1
River or Stream	75.43	0	0	0	14.4	-1.00	8
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.60	7	11	35	2.6	0.86	2
Aquatic Grass Marsh	1.37	0	0	0	0.3	-1.00	8
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	8
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	8
Nonpatterned Wet Meadow	41.92	0	0	0	8.0	-1.00	8
Wet Sedge-Willow Meadow	101.83	1	2	5	19.5	-0.59	7
Moist Sedge-Shrub Meadow	13.10	0	0	0	2.5	-1.00	8
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	8
Riverine or Upland Shrub	27.10	0	0	0	5.2	-1.00	8
Barrens (riverine, eolian, lacustrine)	78.67	1	2	5	15.0	-0.50	6
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	8
Total	522.97	20	33	100	100		
KING EIDERS							
Open Nearshore Water (marine)	8.32	0	0	0	1.6	-1.00	6
Brackish Water	6.42	0	0	0	1.2	-1.00	6
Tapped Lake w/ Low-water Connection	21.42	1	2	7.7	4.1	0.31	4
Tapped Lake w/ High-water Connection	20.29	1	2	7.7	3.9	0.33	3
Salt Marsh	16.68	0	0	0	3.2	-1.00	6
Tidal Flat	37.37	0	0	0	7.1	-1.00	6
Salt-killed Tundra	25.63	2	3	15.4	4.9	0.52	2
Deep Open Water w/o Islands	23.31	0	0	0	4.5	-1.00	6
Deep Open Water w/ Islands or Polygonized Margins	5.15	0	0	0	1.0	-1.00	6
Shallow Open Water w/o Islands	2.30	0	0	0	0.4	-1.00	6
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0	0.1	-1.00	6
River or Stream	75.43	7	24	53.8	14.4	0.58	1
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.60	0	0	0	2.6	-1.00	6
Aquatic Grass Marsh	1.37	0	0	0	0.3	-1.00	6
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	6
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	6
Nonpatterned Wet Meadow	41.92	0	0	0	8.0	-1.00	6
Wet Sedge-Willow Meadow	101.83	2	3	15.4	19.5	-0.12	5
Moist Sedge-Shrub Meadow	13.10	0	0	0	2.5	-1.00	6
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	6
Riverine or Upland Shrub	27.10	0	0	0	5.2	-1.00	6
Barrens (riverine, eolian, lacustrine)	78.67	0	0	0	15.0	-1.00	6
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	6
Total	522.97	13	34	100	100		

[a] Ivlev's E = (use - availability)/(use + availability); calculated from groups only.
[b] Lower numbers indicate higher preference.

Table C2. Habitat selection by King Eiders during pre-nesting in the Transportation Corridor survey area, Colville River Delta, Alaska, 1996.

Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	0	-	-	-	0	-	-
Brackish Water	0	-	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	0	<0.1	-1.00	13
Salt Marsh	0	-	-	-	0	-	-
Tidal Flat	0	-	-	-	0	-	-
Salt-killed Tundra	0	-	-	-	0	-	-
Deep Open Water w/o Islands	30.76	20	89	35.1	9.0	0.59	4
Deep Open Water w/ Islands or Polygonized Margins	6.52	1	2	1.8	1.9	-0.04	6
Shallow Open Water w/o Islands	10.84	16	28	28.1	3.2	0.80	1
Shallow Open Water w/ Islands or Polygonized Margins	7.36	6	21	10.5	2.1	0.66	3
River or Stream	2.30	3	5	5.3	0.7	0.77	2
Aquatic Sedge Marsh	0.97	0	0	0	0.3	-1.00	13
Aquatic Sedge w/ Deep Polygons	0.03	0	0	0	<0.1	-1.00	13
Aquatic Grass Marsh	0.65	0	0	0	0.2	-1.00	13
Young Basin Wetland Complex	14.23	0	0	0	4.1	-1.00	13
Old Basin Wetland Complex	35.59	4	7	7.0	10.4	-0.19	8
Nonpatterned Wet Meadow	24.47	1	1	1.8	7.1	-0.61	10
Wet Sedge-Willow Meadow	19.87	1	2	1.8	5.8	-0.54	9
Moist Sedge-Shrub Meadow	84.66	2	5	3.5	24.7	-0.75	11
Moist Tussock Tundra	94.60	1	2	1.8	27.6	-0.88	12
Riverine or Upland Shrub	7.74	1	1	1.8	2.3	-0.13	7
Barrens (riverine, eolian, lacustrine)	1.93	1	1	1.8	0.6	0.51	5
Artificial (water, fill, peat road)	0.47	0	0	0	0.1	-1.00	13
Total	343.11	57	164	100	100		

[a] Ivlev's E = (use - availability)/(use + availability); calculated from groups only.
[b] Lower numbers indicate higher preference.

Table C3. Habitat selection by Tundra Swans during nesting and brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1996.

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
NESTING						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	10
Brackish Water	6.50	0	0	1.2	-1.00	10
Tapped Lake w/ Low-water Connection	21.42	0	0	3.9	-1.00	10
Tapped Lake w/ High-water Connection	20.36	1	2.2	3.7	-0.25	7
Salt Marsh	16.73	1	2.2	3.0	-0.15	6
Tidal Flat	55.90	0	0	10.1	-1.00	10
Salt-killed Tundra	25.63	6	13.3	4.6	0.48	2
Deep Open Water w/o Islands	23.31	1	2.2	4.2	-0.31	8
Deep Open Water w/ Islands or Polygonized Margins	5.13	0	0	0.9	-1.00	10
Shallow Open Water w/o Islands	2.32	0	0	0.4	-1.00	10
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	10
River or Stream	81.76	0	0	14.8	-1.00	10
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	5	11.1	2.5	0.64	1
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	10
Young Basin Wetland Complex	< 0.01	0	0	<0.1	-1.00	10
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	10
Nonpatterned Wet Meadow	41.98	8	17.8	7.6	0.40	4
Wet Sedge-Willow Meadow	102.23	20	44.4	18.5	0.41	3
Moist Sedge-Shrub Meadow	13.10	2	4.4	2.4	0.30	5
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	10
Riverine or Upland Shrub	27.40	0	0	5.0	-1.00	10
Barrens (riverine, eolian, lacustrine)	79.01	1	2.2	14.3	-0.73	9
Artificial (water, fill, peat road)	0.02	0	0.0	<0.1	-1.00	10
Total	551.25	45	100	100		
BROOD-REARING						
Open Nearshore Water (marine)	10.46	0	0	1.9	-1.00	16
Brackish Water	6.50	1	3.1	1.2	0.45	5
Tapped Lake w/ Low-water Connection	21.42	3	9.4	3.9	0.41	6
Tapped Lake w/ High-water Connection	20.36	4	12.5	3.7	0.54	3
Salt Marsh	16.73	2	6.3	3.0	0.35	7
Tidal Flat	55.90	1	3.1	10.1	-0.53	15
Salt-killed Tundra	25.63	3	9.4	4.6	0.34	8
Deep Open Water w/o Islands	23.31	2	6.3	4.2	0.19	9
Deep Open Water w/ Islands or Polygonized Margins	5.13	1	3.1	0.9	0.54	4
Shallow Open Water w/o Islands	2.32	1	3.1	0.4	0.76	2
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0.1	-1.00	16
River or Stream	81.76	2	6.3	14.8	-0.41	14
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.58	1	3.1	2.5	0.12	10
Aquatic Grass Marsh	1.37	2	6.3	0.2	0.92	1
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	16
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	16
Nonpatterned Wet Meadow	41.98	2	6.3	7.6	-0.10	12
Wet Sedge-Willow Meadow	102.23	5	15.6	18.5	-0.09	11
Moist Sedge-Shrub Meadow	13.10	0	0	2.4	-1.00	16
Moist Tussock Tundra	2.49	0	0	0.5	-1.00	16
Riverine or Upland Shrub	27.40	0	0	5.0	-1.00	16
Barrens (riverine, eolian, lacustrine)	79.01	2	6.3	14.3	-0.39	13
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	16
Total	551.25	32	100	100		

[a] Ivlev's E = (use - availability)/(use + availability).
[b] Lower numbers indicate higher preference.

Table C4. Habitat selection by Tundra Swans during nesting and brood-rearing in the Transportation Corridor survey area, Colville River Delta, Alaska, 1996.

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
NESTING						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	11
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	2	10.5	9.0	0.08	7
Deep Open Water w/ Islands or Polygonized Margins	6.52	1	5.3	1.9	0.47	4
Shallow Open Water w/o Islands	10.84	2	10.5	3.2	0.54	3
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	11
River or Stream	2.30	0	0	0.7	-1.00	11
Aquatic Sedge Marsh	0.97	1	5.3	0.3	0.90	1
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	-1.00	11
Aquatic Grass Marsh	0.65	0	0	0.2	-1.00	11
Young Basin Wetland Complex	14.23	3	15.8	4.1	0.58	2
Old Basin Wetland Complex	35.59	1	5.3	10.4	-0.33	9
Nonpatterned Wet Meadow	24.47	2	10.5	7.1	0.19	6
Wet Sedge-Willow Meadow	19.87	0	0	5.8	-1.00	11
Moist Sedge-Shrub Meadow	84.66	2	10.5	24.7	-0.40	10
Moist Tussock Tundra	94.60	4	21.1	27.6	-0.13	8
Riverine or Upland Shrub	7.74	1	5.3	2.3	0.40	5
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	11
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	11
Total	343.11	19	100	100		
BROOD-REARING						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0.10	0	0	<0.1	-1.00	7
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	30.76	8	50.0	9.0	0.70	3
Deep Open Water w/ Islands or Polygonized Margins	6.52	2	12.5	1.9	0.74	2
Shallow Open Water w/o Islands	10.84	1	6.3	3.2	0.33	4
Shallow Open Water w/ Islands or Polygonized Margins	7.36	0	0	2.1	-1.00	7
River or Stream	2.30	0	0	0.7	-1.00	7
Aquatic Sedge Marsh	0.97	0	0	0.3	-1.00	7
Aquatic Sedge w/ Deep Polygons	0.03	0	0	< 0.1	-1.00	7
Aquatic Grass Marsh	0.65	1	6.3	0.2	0.94	1
Young Basin Wetland Complex	14.23	0	0	4.1	-1.00	7
Old Basin Wetland Complex	35.59	0	0	10.4	-1.00	7
Nonpatterned Wet Meadow	24.47	0	0	7.1	-1.00	7
Wet Sedge-Willow Meadow	19.87	1	6.3	5.8	0.04	5
Moist Sedge-Shrub Meadow	84.66	3	18.8	24.7	-0.14	6
Moist Tussock Tundra	94.60	0	0	27.6	-1.00	7
Riverine or Upland Shrub	7.74	0	0	2.3	-1.00	7
Barrens (riverine, eolian, lacustrine)	1.93	0	0	0.6	-1.00	7
Artificial (water, fill, peat road)	0.47	0	0	0.1	-1.00	7
Total	343.11	16	100	100		

[a] Ivlev's E = (use - availability)/(use + availability).
[b] Lower numbers indicate higher preference.

Table C5. Habitat selection by Yellow-billed Loons during nesting and brood-rearing in the Delta survey area, Colville River Delta, Alaska, 1996.

Habitat	Area (km^2)	No. of Nests or Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
NESTING						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	1.22	0	0	0.4	-1.00	8
Tapped Lake w/ Low-water Connection	19.38	0	0	6.0	-1.00	8
Tapped Lake w/ High-water Connection	19.57	3	17.6	6.1	0.49	4
Salt Marsh	5.64	0	0	1.7	-1.00	8
Tide Flat	0.06	0	0	<0.1	-1.00	8
Salt-killed Tundra	7.48	0	0	2.3	-1.00	8
Deep Open Water w/o Islands	21.09	1	5.9	6.5	-0.05	6
Deep Open Water w/ Islands or Polygonized Margins	3.58	3	17.6	1.1	0.88	1
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	8
Shallow Open Water w/ Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	8
River or Stream	38.33	0	0	11.9	-1.00	8
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	10.00	2	11.8	3.1	0.58	3
Aquatic Grass Marsh	1.20	1	5.9	0.4	0.87	2
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	1	5.9	9.2	-0.22	7
Wet Sedge-Willow Meadow	80.84	6	35.3	25.0	0.17	5
Moist Sedge-Shrub Meadow	9.10	0	0	2.8	-1.00	8
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	8
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	8
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	8
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	17	100	100		
BROOD-REARING						
Open Nearshore Water (marine)	0	-	-	0	-	-
Brackish Water	1.22	0	0	0.4	-1.00	4
Tapped Lake w/ Low-water Connection	19.38	0	0	6.0	-1.00	4
Tapped Lake w/ High-water Connection	19.57	1	16.7	6.1	0.46	3
Salt Marsh	5.64	0	0	1.7	-1.00	4
Tide Flat	0.06	0	0	<0.1	-1.00	4
Salt-killed Tundra	7.48	0	0	2.3	-1.00	4
Deep Open Water w/o Islands	21.09	4	66.7	6.5	0.82	2
Deep Open Water w/ Islands or Polygonized Margins	3.58	1	16.7	1.1	0.88	1
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	4
Shallow Open Water w/ Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	4
River or Stream	38.33	0	0	11.9	-1.00	4
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	10.00	0	0	3.1	-1.00	4
Aquatic Grass Marsh	1.20	0	0	0.4	-1.00	4
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	0	0	9.2	-1.00	4
Wet Sedge-Willow Meadow	80.84	0	0	25.0	-1.00	4
Moist Sedge-Shrub Meadow	9.10	0	0	2.8	-1.00	4
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	4
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	4
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	4
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	6	100	100		

[a] Ivlev's E = (use - availability)/(use + availability).
[b] Lower numbers indicate higher preference.

Table C6. Habitat selection by Brant during brood-rearing in the Outer Delta survey area, Colville River Delta, Alaska, 1996.

Habitat	Area (km^2)	No. of Brood Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
Open Nearshore Water (marine)	10.46	1	14.3	4.8	0.50	1
Brackish Water	6.29	0	0	2.9	-1.00	6
Tapped Lake w/ Low-water Connection	5.17	0	0	2.4	-1.00	6
Tapped Lake w/ High-water Connection	2.06	0	0	0.9	-1 00	6
Salt Marsh	12.61	1	14.3	5.8	0.43	3
Tidal Flat	55.89	0	0	25.5	-1.00	6
Salt-killed Tundra	22.22	2	28.6	10.2	0.48	2
Deep Open Water w/o Islands	0.69	0	0	0.3	-1.00	6
Deep Open Water w/ Islands or Polygonized Margins	1.78	0	0	0.8	-1.00	6
Shallow Open Water w/o Islands	0.53	0	0	0.2	-1.00	6
Shallow Open Water w/ Islands or Polygonized Margins	0.20	0	0	0.1	-1.00	6
River or Stream	43.15	1	14.3	19.7	-0.16	5
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	6.41	0	0	2.9	-1.00	6
Aquatic Grass Marsh	0.19	0	0	0.1	-1.00	6
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	9.76	0	0	4.5	-1.00	6
Wet Sedge-Willow Meadow	9.33	0	0	4.3	-1.00	6
Moist Sedge-Shrub Meadow	1.73	0	0	0.8	-1.00	6
Moist Tussock Tundra	1.68	0	0	0.8	-1.00	6
Riverine or Upland Shrub	0.80	0	0	0.4	-1.00	6
Barrens (riverine, eolian, lacustrine)	28.08	2	28.6	12.8	0.38	4
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	6
Total	219.06	7	100	100		

[a] Ivlev's E = (use - availability)/(use + availability); use calculated from the number of groups.
[b] Lower numbers indicate higher preference.

APPENDIX D. Distribution of birds in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1996.

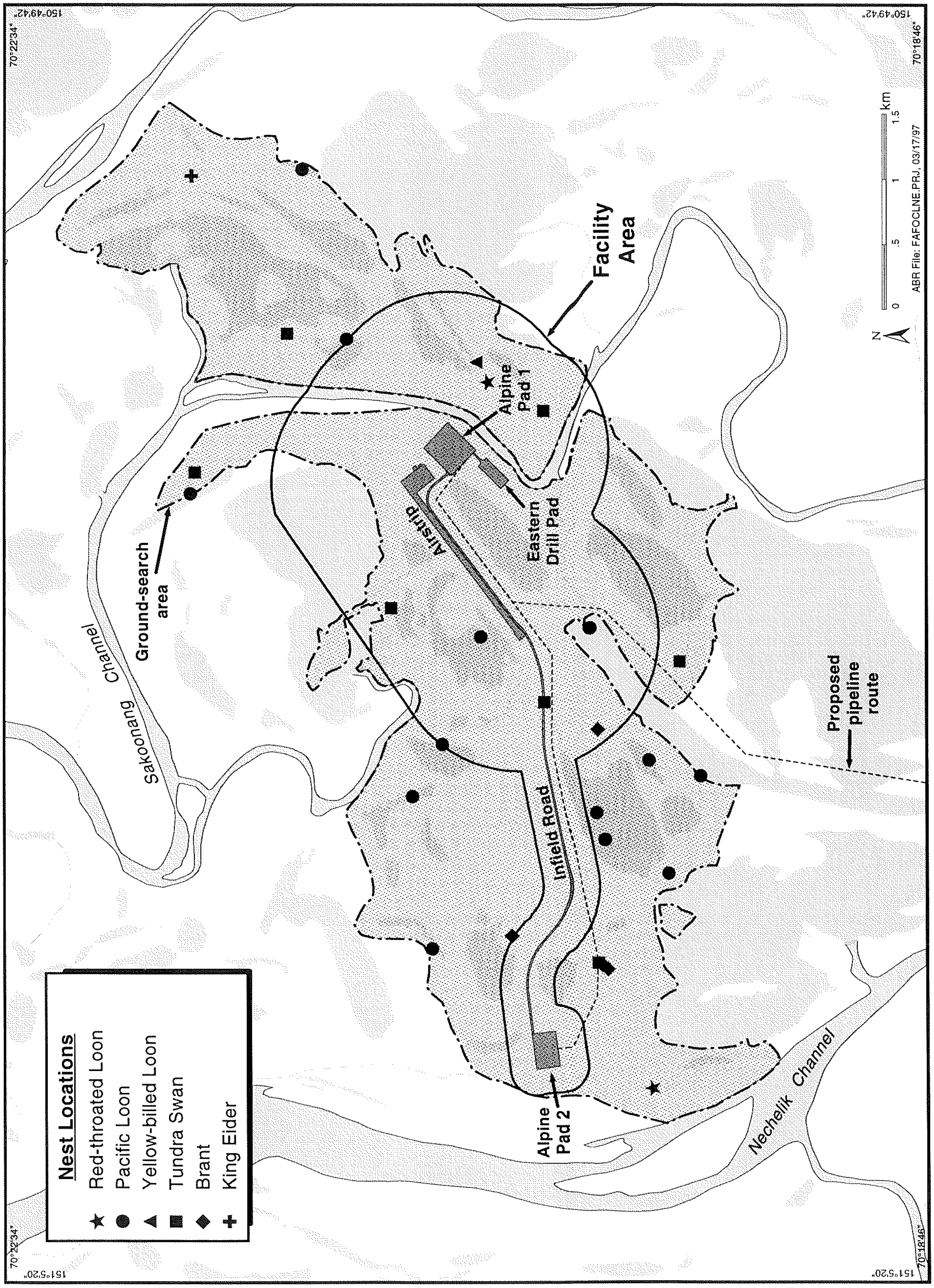

Figure D1. Nest locations of Red-throated, Pacific, and Yellow-billed loons, Tundra Swans, Brant, and King Eiders, observed during aerial and ground-based surveys in the vicinity of the proposed Facility Area, Colville River Delta, Alaska, June 1996. The search are emcompassed 17 km^2.

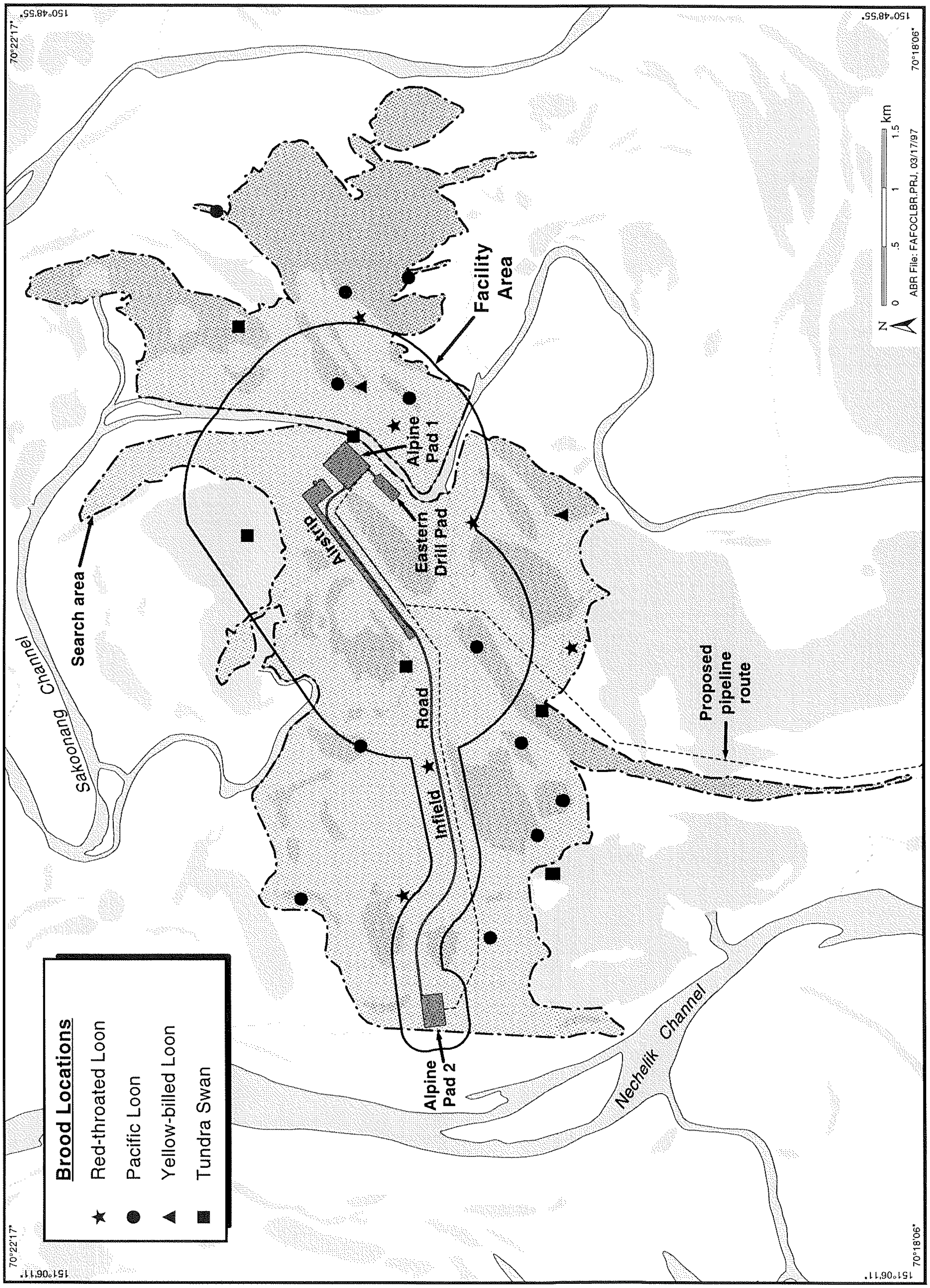

Figure D2. Brood locations of Red-throated, Pacific, and Yellow-billed loons, and Tundra Swans observed during aerial and ground-based surveys in late July and late August in the vicinity of the proposed Facility Area, Colville River Delta, Alaska, 1996. The search area encompassed 18 km^2.

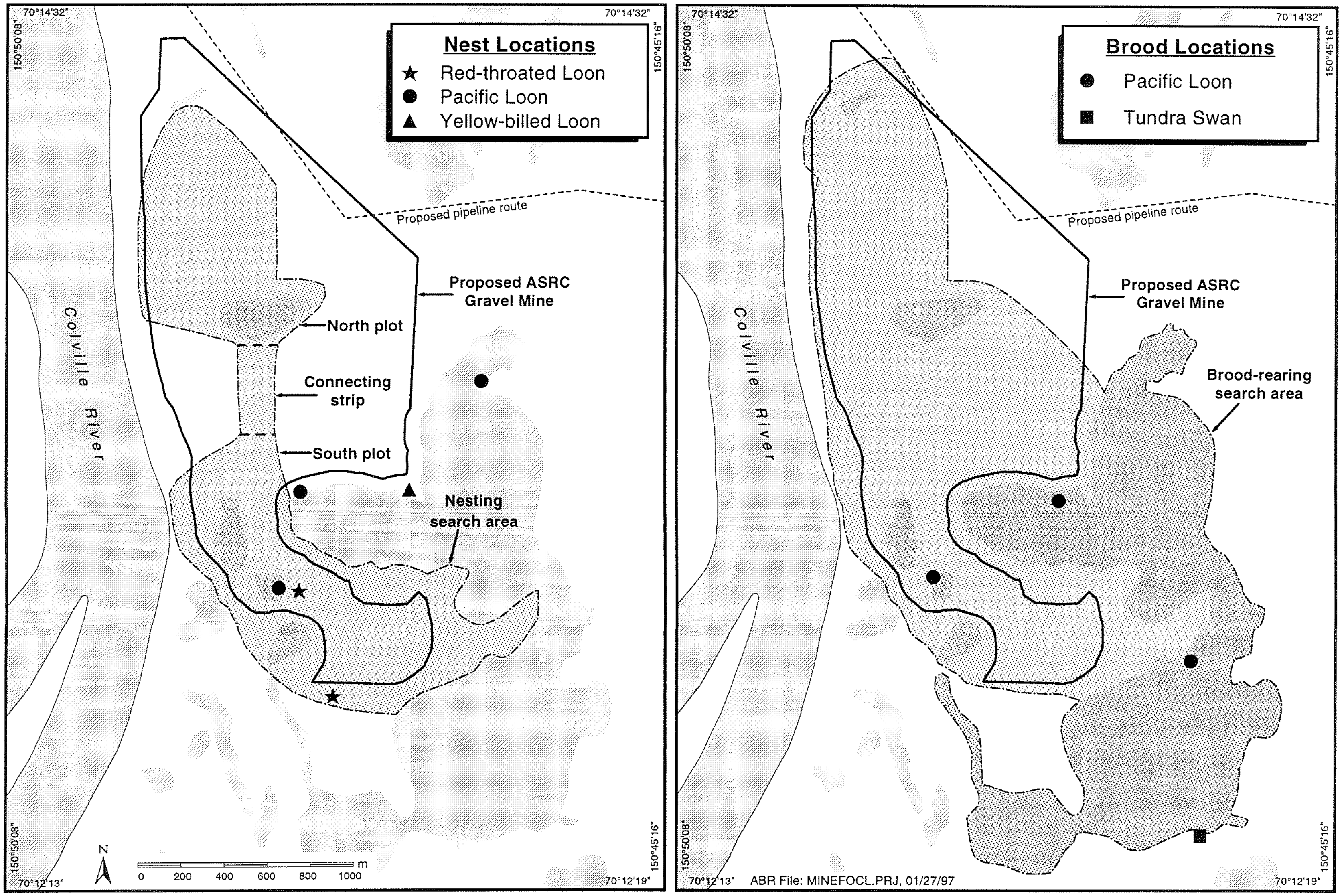

Figure D3. Nest and brood locations of Red-throated, Pacific and Yellow-billed loons, and Tundra Swans observed during aerial and ground-based surveys in the vicinity of the proposed ASRC Gravel Mine site, Colville River Delta, Alaska, 1996. The nest search area encompassed 1.7 km^2 and the brood search encompassed 4.3 km^2.

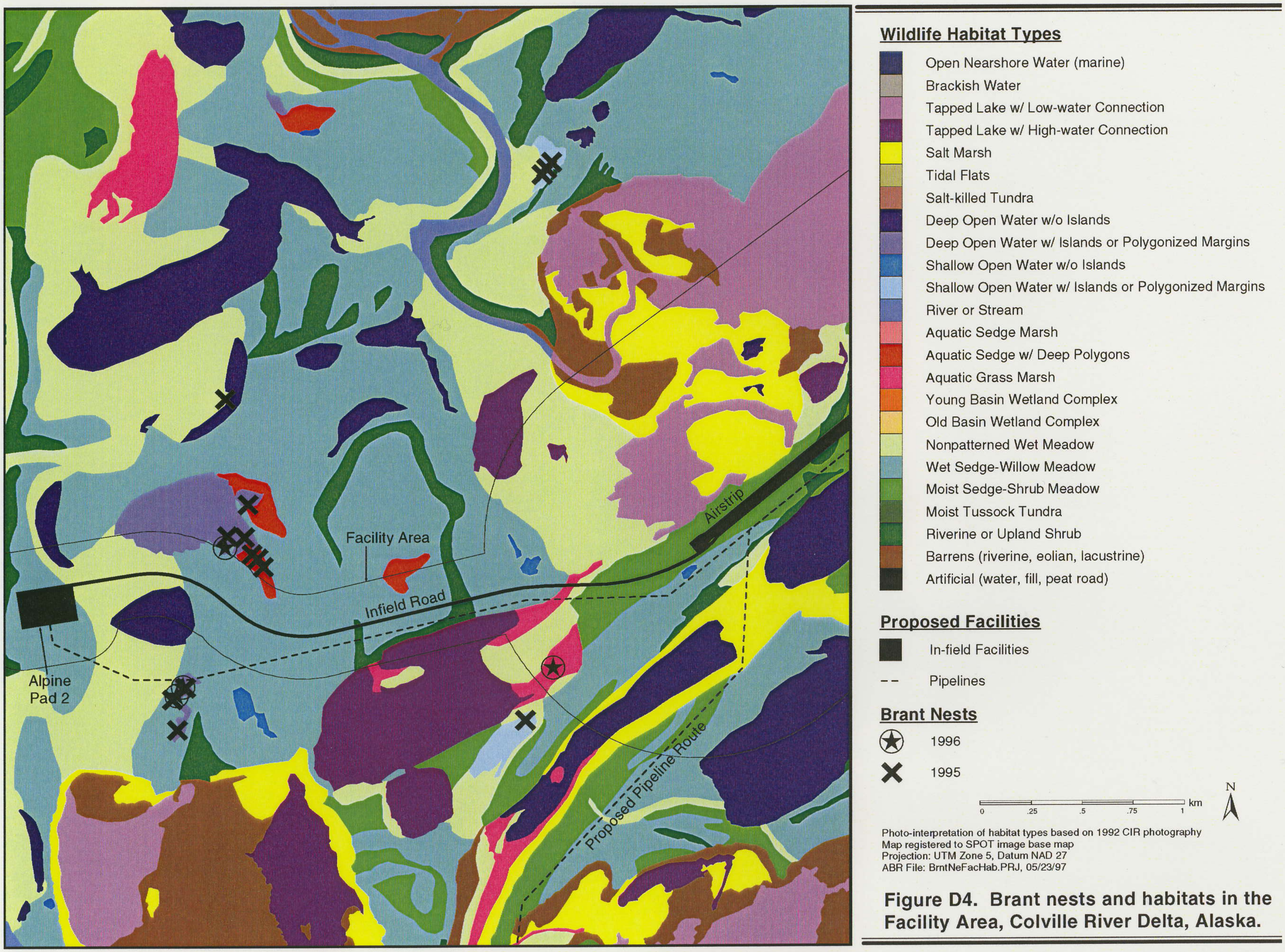

Figure D4. Brant nests and habitats in the Facility Area, Colville River Delta, Alaska.

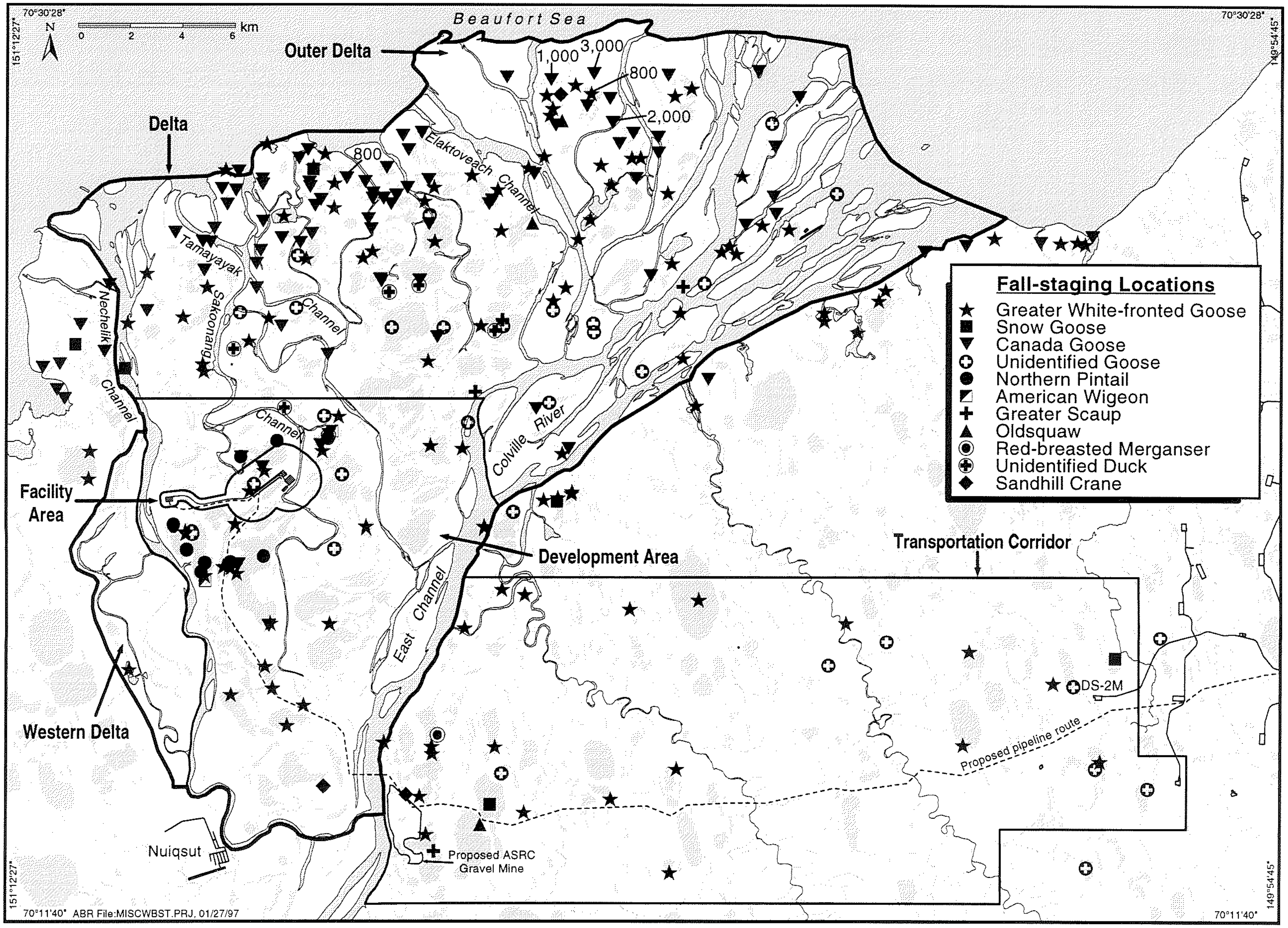

Figure D5. Distribution of fall-staging groups of various waterbird species observed opportunistically during aerial surveys in August for geese and Tundra Swans in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1988, 1990–1993, 1995, and 1996. Numbers indicate size of groups greater than 500. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.

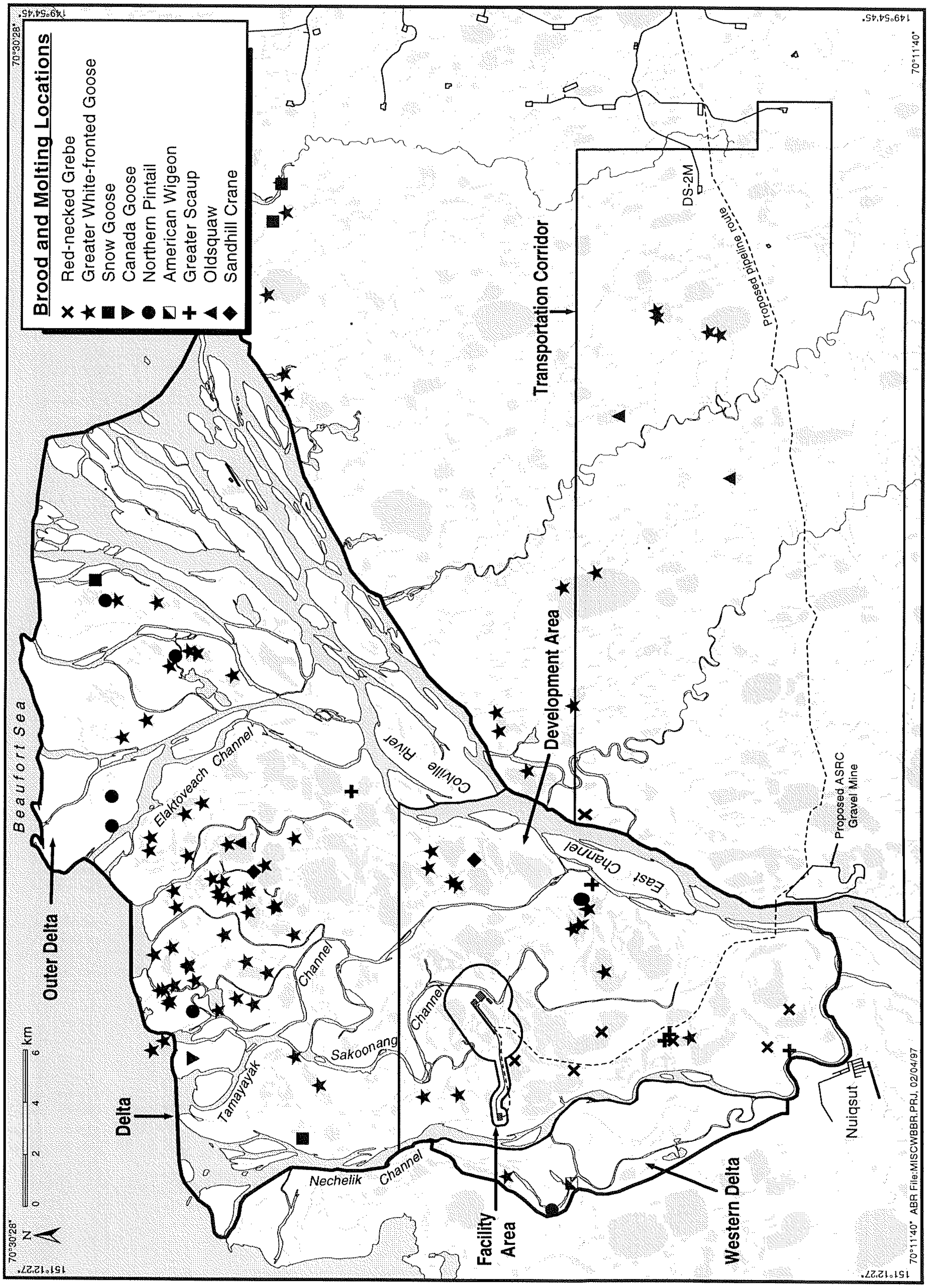

Figure D6. Distribution of brood-rearing and molting groups of various waterbird species observed opportunistically during aerial surveys in July in the Delta and Transportation Corridor survey areas, Colville River Delta, Alaska, 1992, 1993, 1995, and 1996. Locations are from Smith et al. (1993, 1994), Johnson et al. (1996), and this study.