WILDLIFE STUDIES ON THE COLVILLE RIVER DELTA, ALASKA, 1998

Seventh Annual Report

Prepared for

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EXECUTIVE SUMMARY

The Colville River 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 River drains a watershed of ~53,000 km^2, which encompasses ~29% of the Arctic Coastal Plain of Alaska. The high-volume flow and heavy sediment load of the Colville River create a large (551 km^2), dynamic deltaic system containing 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 Swans, Brant, and Spectacled Eiders. 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 feeding and 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 haul-out sites. The Colville Delta contains two permanent human habitations: the Iñupiaq village of Nuiqsut and the Helmericks family homesite, both of which rely heavily on local fish and wildlife resources.

ARCO Alaska, Inc. and its partner Anadarko Petroleum were granted permits for the Alpine Development Project on the central delta on 13 February 1998. ARCO initiated a number of studies in 1992 to examine the biological, physical, and cultural resources of the delta. In this annual report on the 1998 field season, we present the results of our seventh year of study on the wildlife resources of the Colville Delta.

The goal of the 1998 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). The primary species of concern were Spectacled Eiders, King Eiders, Tundra Swans, Brant, Yellow-billed Loons, caribou, and arctic foxes. A combination of aerial and ground surveys were used to collect location data for analysis in a geographic information system. We used wildlife habitats (classified and mapped in 1995) to describe vegetation and landforms on the delta that were used or selected by focal species. We included data from previous years in our assessments of distribution, abundance, and habitat use, where such data were appropriate.

Spectacled Eiders—The pre-nesting distribution of Spectacled Eiders during 1998 was similar to that observed in previous years. Spectacled Eiders are attracted to coastal areas; the average distance of pre-nesting locations from the coastal shoreline in 1998 was 3.7 km (n = 34). Although Spectacled Eider numbers were up from those in 1997, no overall trend is apparent among the six years of counts. In 1998, one Spectacled Eider nest was found during intensive ground searches in the Alpine Facility Area on the central delta; no other areas were searched. Spectacled Eiders preferred 5 of 23 habitats during pre-nesting seasons in 1993–1998: Brackish Water, Salt Marsh, Salt-killed Tundra, Shallow Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons. From 1992 to 1998, Spectacled Eiders nested most often in Aquatic Sedge with Deep Polygons, Brackish Water, Nonpatterned Wet Meadow, and Salt-killed Tundra; nests were never more than 10 m from permanent water.

King Eiders—The delta is less important to breeding King Eiders than areas east of the Colville River. King Eiders were less abundant than Spectacled Eiders on the delta during pre-nesting, but their distribution relative to the coast was similar to that of Spectacled Eiders, averaging 5.5 km (n = 110) from the coast during 1993–1998. Although King Eider numbers in 1998 were the second highest on record, annual changes in King Eider numbers on the delta have been relatively small. From 1993 to 1998, pre-nesting King Eiders on the delta preferred River or Stream habitat and nested in Aquatic Sedge with Deep Polygons and Salt-killed Tundra. No nests of King Eiders were found on the delta in 1998, and only four nests have been found on the delta since 1992.

Tundra Swan—In 1998, Tundra Swans nested on the delta in numbers (31 nests) similar to those in 1997 (32 nests), but declined from the peak number (45 nests) in 1996. In the Alpine Facility Area, we found three swan nests, which was similar to previous years. The number of broods on the delta in 1998 (22 broods) also was similar to that in 1997 (24 broods). The percentage of broods to nests (71%) in 1998 was slightly lower than the long-term average (78%) on the delta. We observed 411 swans during fall staging, the highest number on record; most were

in the East Channel of the Colville River near the Miluveach River. Swans used a wide array of habitats on the delta. During nesting, swans preferred Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, Wet Sedge–Willow Meadow, Nonpatterned Wet Meadow, and Moist Sedge–Shrub Meadow. Swans appeared to be attracted to waterbodies for nesting: average distance to waterbodies was 0.1 km (n = 203). Swans preferred more saline habitats for raising broods: Brackish Water, Tapped Lake with Low-water Connections, Salt Marsh, and both types of Deep Open Water.

Yellow-billed Loons—Nesting locations of Yellow-billed Loons have not changed much since the 1980s; most nests are found in the central delta between the Sakoonang and Elaktoveach channels. In 1998, more nests were found than had been recorded ever before; we found 17 nests during an aerial survey of the delta and an additional 6 nests during follow-up aerial and ground surveys. Two nests occurred on lakes with no previous nesting records. We found 12 broods containing a total of 15 young in 1998, the highest count of broods in six years of surveys. Yellow-billed Loons built nests on peninsulas, shorelines, islands, and in emergent vegetation in six habitats, three of which were preferred: Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Wet Sedge–Willow Meadow. Only three habitats were used during brood-rearing, and all were preferred: Tapped Lake with High-water Connection and both types of Deep Open Water.

Brant—Most Brant nests (>1,100 nests) on the Colville Delta occur near the mouth of the East Channel in what is referred to here as the Anachlik Colony-complex. We report on additional nest sites that were scattered across the delta in other locations. We found 91 nests in 21 locations with a total of 285 Brant in 1998; the Alpine Facility Area contained 2 nests. In 1998, we counted the highest number Brant during brood-rearing on the delta since surveys began in 1988; 1,974 Brant (including 1,138 goslings) were counted at 13 locations. However, by the time of the fall-staging survey, only 293 Brant remained on the delta. Brant nesting outside the Anachlik Colony-complex preferred Salt-killed Tundra and Aquatic Sedge with Deep Polygons. During brood-rearing, Brant used mostly salt-affected habitats, but showed a preference only for Brackish Water.

Other Geese—The Colville Delta is a regionally important nesting area for Greater White-fronted Geese and supports small numbers of nesting Canada and Snow geese. In 1998, we did not conduct nest searches for Greater White-fronted Geese as part of this study (but see Johnson et al. 1999). In 1998, we found two Canada Goose nests in the Development Area. During systematic surveys for goose broods at 50% coverage, we counted 2,389 Greater White-fronted Geese in 49 groups on the delta and goslings composed ~50% of the birds. On those same surveys, we saw 32 adult and 43 gosling Snow Geese and 8 adult and 16 gosling Canada Geese. On systematic surveys during fall staging, we saw 1,656 Greater White-fronted Geese distributed throughout the delta, 30 Snow Geese on the Outer Delta, and 1,276 Canada Geese primarily on the Outer Delta.

Arctic and Red Foxes—During seven years of surveys, we have confirmed the location of 49 arctic fox dens and 5 red fox dens between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield. Fifteen arctic fox dens and 5 red fox dens are on the delta, 20 arctic fox dens are in the Transportation Corridor, and 14 arctic fox dens are north and south of the Transportation Corridor. Den occupancy by litters (23%) in 1998 was relatively low, but similar to occupancy in 1997. Only seven dens had confirmed litters, and four dens were suspected to have litters. Two dens with litters were north of the Transportation Corridor, and the remaining five dens were on the delta. Litter size averaged 3.0 pups at 7 dens where litter counts were complete. In previous years, we have found 11–67% occupancy by litters, with sizes averaging from 3.1 to 6.1 pups. Den sites occurred in elevated microsites where soil was well drained and suitable for burrowing. Riverine and Upland Shrub was the only preferred habitat for fox dens on the delta and in the Transportation Corridor; it was also the most frequently used habitat on the delta, whereas most dens occurred in Moist Sedge–Shrub Meadow in the Transportation Corridor.

Polar Bear—Although polar bears primarily frequent areas of frozen sea ice, a portion of female bears make dens on land. Of 90 dens used by pregnant female polar bears from the Beaufort Sea population, 42% were on land. The Development Area contained a den site in the winter of 1996–1997. Other den sites in the area have been reported from the lower Itkillik River to Lower Kalubik Creek and on the Beaufort Sea within 30 km of the delta. Terrestrial den sites tend to be at bluffs along rivers, streams, or lakes where deep snowdrifts can persist.

Grizzly Bear—Sixty grizzly bear dens have been located by the Alaska Department of Fish and Game between the Colville River and Kuparuk Oilfield. Seventeen different bears used 42 of these dens during the 1992–1993 to 1998–1999 denning seasons. Most dens in this area are located south of the Transportation Corridor near the headwaters of the Miluveach, Kachemach, and Kuparuk rivers. During the winter of 1996–1997, a female bear bore three cubs in a den along the East Channel, and two subadult bears denned along the Sakoonang Channel. In 1997–1998 and 1998–1999, one of these subadult bears returned to den on the delta. During the summer of 1997, we recorded 18 sightings of 21 bears, representing at least 6 different bears.

Muskox—Muskoxen were introduced to the Arctic National Wildlife Refuge in 1969 and 1970 after being extirpated in the late 1800s; subsequently the introduced herds spread west and east. Sign of muskoxen was observed in the western Kuparuk Oilfield in the 1980s. We first saw large numbers in the uplands east of the Itkillik River in May 1993, and the population has grown since then to 99 muskoxen, including 19 calves, in 1997, although we have not conducted comprehensive surveys. In 1998, however, we located only one group of 25 muskoxen, including 4 calves. Muskoxen in the uplands typically move during summer to areas along rivers and streams; in 1998, we repeatedly observed mixed-sex groups of muskoxen (23–24 total) on the east bank of the East Channel of the Colville River and smaller groups along the lower Kachemach River, at the Tarn road, along the Kuparuk River, and at the coast near Milne Point.

Spotted Seal—Spotted seals in Alaska range north from Bristol Bay to the Chukchi Sea and east to the Beaufort Sea. They whelp, breed, and molt on the pack-ice front from March through April and disperse to nearshore waters during summer. They commonly haul-out on islands, sand spits, and shoals from mid-summer to late fall. In 1998, we saw 16 seals hauled out on an island at the mouth of the Kachemach River on 25 August and 4 at the south end of Anachlik Island on 14 September. These counts of seals were the highest since we began recording in 1996.

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ACKNOWLEDGMENTS

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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 fishes 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 occurred intermittently for several decades, only recently have plans to develop the area commercially proceeded beyond the exploration phase. ARCO Alaska, Inc. (hereafter, ARCO) and its partner Anadarko Petroleum Corporation received federal permits for the Alpine Development Project on the central delta on 13 February 1998, and construction began that spring. As part of the planning process, and in recognition of the regional and local importance of the Colville Delta to a variety of interested parties, ARCO initiated studies in 1992 to examine the biological, physical, and cultural resources of the delta. In this annual report on the 1998 field season, we present the results from our seventh year of study of the wildlife resources on the Colville Delta.

The Colville River drains a watershed of ~53,000 km^2, or ~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 lakes, wetlands, and terrestrial habitats. The delta supports a wide array of wildlife and is a regionally important nesting area for Yellow-billed Loons, Tundra Swans, Brant, and Spectacled Eiders (Rothe et al. 1983, North et al. 1984a, Meehan and Jennings 1988; see Appendix A 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 for migrating birds. In fall, the delta's extensive salt marshes and mudflats are used by geese and shorebirds for feeding and 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 both brown and polar bears (see reviews in Johnson et al. 1997).

The primary goal of the Colville wildlife studies 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, although the focal species that were examined and the boundaries of study areas varied over the seven years of study (as better information on the location of the oil reservoir became available). During a meeting with the U.S. Fish and Wildlife Service (USFWS) in spring 1992, we agreed to focus 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, 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 in 1992 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 of habitat use by the focal species (Johnson et al. 1996). We continued with similar surveys in 1996–1998.

The overall goal of the studies in 1998 was to continue the multi-year baseline on the use of the Colville Delta by selected birds and mammals between late spring (May) and early fall (September). A separate study was initiated in 1998 to investigate the effects of aircraft noise and disturbance on bird use of habitats near the Alpine airstrip (Johnson et al. 1999). Our specific objectives for the Colville wildlife studies in 1998 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; and
4. monitor the distribution of other large mammals in the study area.

STUDY AREA

The study area in 1998 comprised several contiguous and overlapping areas in which the distribution of wildlife was monitored. As defined in this report, the Colville Delta survey area encompasses 551 km^2 and refers to that area between the westernmost and easternmost distributary channels of the Colville River; this survey area encompassed the sub-areas described below, except the Transportation Corridor (Figure 1). The entire area within 1,000 m of the Alpine project airstrip and processing facility and within 200 m of the separate drill sites and the connecting road is called the Facility Area (8.7 km^2 total). As a result of better delineation of the oil reservoir and identification of environmental and economic concerns, the location of proposed surface development (Facility Area and pipeline route) has been modified somewhat from the original 1995 proposal (Johnson et al. 1996: Figure 1) and a revised layout in 1996 (Johnson et al. 1997: 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 that 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 Transportation Corridor (343 km^2), so called because it includes the pipeline route.

The geographic extent of the wildlife investigations during 1992–1998 has varied because of 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). That year we conducted intensive surveys for a variety of bird species on 6 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 also 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 (Smith et al. 1994). In 1994, we surveyed for eiders only in a 478-km^2 area consisting of just the delta (Johnson 1995). In 1995–1997, ARCO proposed specific sites for facilities and infrastructure, so the wildlife study area encompassed those proposed sites on the delta and adjacent Transportation Corridor for evaluating regional-scale distributions of wildlife (Johnson et al. 1996, 1997, 1998: Figure 1). In 1998, the entire delta was surveyed, but the Transportation Corridor was eliminated from the study area.

The Colville River has two main distributaries: the Nechelik Channel and the East Channel. These two channels together carry ~90% of the water flowing 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's channels, 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

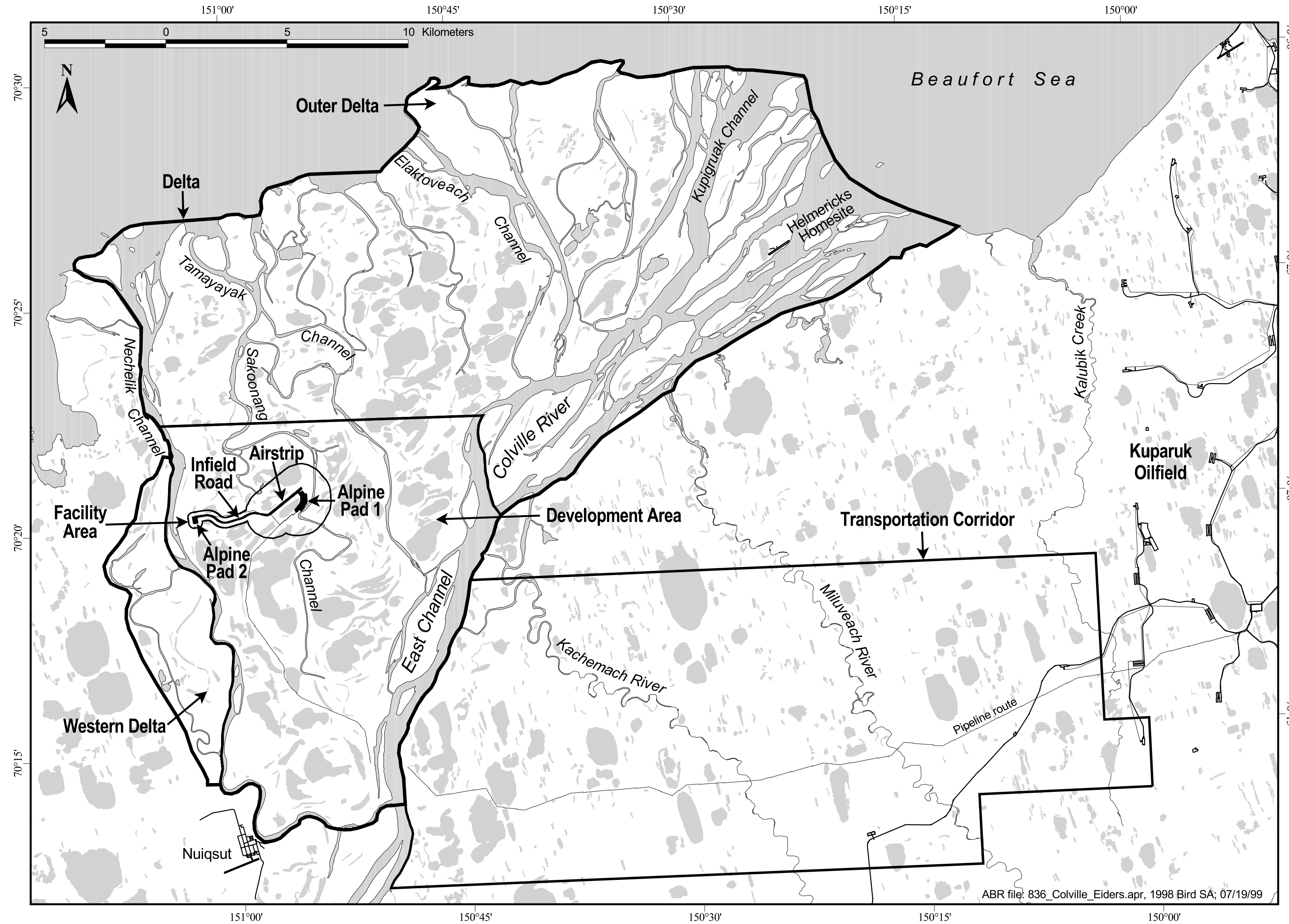

Figure 1. Survey area boundaries for the wildlife studies on the Colville River, Alaska, 1998. Mammal surveys were conducted over larger areas specific to each species.

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, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, and thaw lakes, occur on the delta (Walker 1983).

Many 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 allowing salt water to intrude into some of these lakes. River sediments raise the bottom of these lakes near the channel, eventually exposing previously submerged areas and reducing the flow of riverine water to the most extreme flood events. Because tapped lakes and river channels are the first areas of the delta to become flooded in spring, they constitute important staging habitat for migrating waterfowl in that season (Rothe et al. 1983).

The delta has an arctic maritime climate (Walker and Morgan 1964). Winters last ~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 floodwaters are at maximal levels. Water levels subsequently decrease in the delta throughout the summer, with the lowest 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° C in July and August (North 1986). Summer weather is characterized by low precipitation, overcast skies, fog, and persistent winds that 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 1998, 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. Habitat studies consisted of analyses of habitat selection by a subset of wildlife species; habitat classification and mapping of the Colville Delta were initiated in 1995 (Johnson et al. 1996) and completed in 1996 (Jorgenson et al. 1997). We have included data from previous years in our assessments of distribution, abundance, and habitat use, when such inclusion was 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-oriented 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: food, security (or escape), and shelter. 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 use them or used them to similar extents. Conversely, wildlife use may differ between habitats with similar vegetation based on relief, soil characteristics, associated fauna, or other factors not reflected by 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 illustrated some of the differences among various systems (Johnson et al. 1996: Appendix A8). 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 habitats.

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). Included were several new habitat types (e.g., Aquatic Sedge with Deep Polygons, Deep Open Water with Islands or Polygonized Margins, and various Tapped Lake classes) we added 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 that had both extremely small areas (<0.5% of the total area) and low levels of wildlife use and by combining similar types that apparently had similar levels of use. Combining habitat types was somewhat 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 from 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 groups, bird nests, and fox dens observed during aerial surveys (and ground surveys for fox dens only). For each species, we calculated habitat use for applicable combinations of season (e.g., pre-nesting, nesting, and brood-rearing) and year of survey (different years, depending on the species). 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; and
4. selection index.

We calculated percent use 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 we could not reasonably assume independence of selection among individuals in these groups. For Brant colonies and fox dens (active and inactive combined), both of which generally are static in location, we used the cumulative number of unique locations from all years in the analyses. For all other species, the parameters were calculated for each year of survey. The availability of each habitat was the percentage of that habitat in the total area surveyed. Except where noted, we considered all habitats within a survey area to be available. However, where the survey areas differed among species, years, and/or seasons, the availability of habitats also differed.

We used Ivlev's E ([% use – % availability] / [% use + % availability]; Ivlev 1961) as an index of selection because it generates a value bounded between –1 and +1. Values near 0 indicate that relative use equals relative availability, and values near –1 and +1 indicate use is less than availability and use is greater than availability, respectively. We calculated measures of multi-year selection by first pooling the data for all years under consideration,

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

- **MARINE WATER**
  - 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 Lake (deltas only)
      - Deep
        - with low-water Connection
        - with high-water Connection
      - Shallow
        - with low-water Connection
        - with high-water Connection
  - Coastal Wetland Complex
    - Salt Marsh
      - Halophytic Sedge
      - Halophytic Grass
      - Halophytic Herb
      - Halophytic Dwarf Willow Scrub
  - Barren
    - Coastal Island
    - Coastal Beach
      - Cobble/gravel
      - Sand
    - Coastal Rocky Shore
      - Low
      - Cliffs
    - Tidal Flat
    - Salt-killed Tundra
    - Causeway
- **FRESH WATER**
  - Open Water
    - Deep Open Water
      - Isolated
        - without Islands
        - with Islands
        - with Polygonized Margins
      - Connected
    - Shallow Open Water
      - without Islands
      - with Islands
      - with Polygonized Margins
  - River or Stream
    - 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
- **BASIN WETLAND COMPLEX**
  - Young (ice-poor)
  - Old (ice-rich)
- **MEADOW**
  - 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
- **SHRUBLAND**
  - 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
  - Shrub 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
  - Cliff (rocky)
  - Bluff (unconsolidated)
    - Barren
    - Partially Vegetated
  - Burned Area (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
    - Impoundment
      - Drainage Impoundment
      - Effluent Reservoir
    - Gravel
      - Barren or Partially Vegetated
      - Vegetated
  - Structure or Debris

then recalculating Ivlev's E with those pooled data. 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 waterbodies.

We tested for significant habitat selection (i.e., use ≠ availability) by conducting Monte Carlo simulations (Haefner 1996, Manly 1997) 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 availability 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 1,000 simulations for each species and summarized the frequency distribution by percentiles. We defined habitat preference (i.e., use > 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 (i.e., use < availability) to occur when the observed use was less than the 2.5 percentile of simulated random use. These percentiles were chosen to achieve an alpha level (Type I error) of 5% for a two-tailed test. Habitats with nonsignificant selection (i.e., observed use ≥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.

WILDLIFE SURVEYS

For the 1998 wildlife studies, we used both fixed-wing aircraft and helicopters to fly aerial surveys over the Colville Delta for selected avian and mammalian species (Table 2). In a separate study of the impacts of the Alpine airstrip on birds (Johnson et al. 1999), we conducted ground and helicopter surveys near the Alpine Facility Area. As in previous years, the 1998 avian studies focused on the distribution and abundance of Spectacled Eiders, King Eiders, Tundra Swans, Yellow-billed Loons, Brant, and Greater White-fronted Geese during different seasons (detailed in the methods for each species). During surveys, we collected additional information opportunistically on other waterbirds, such as Canada Geese, Snow Geese, and Pacific and Red-throated loons. We concentrated our surveys for mammals on arctic foxes, but we opportunistically collected information on other species, such as brown bears, moose, and muskoxen. A separate study was conducted for caribou in the western segment of the Central Arctic Herd during 1998 (Lawhead 1999).

EIDERS

In 1998, we flew aerial surveys during the pre-nesting period (Table 2), and, as part of the airstrip monitoring study (Johnson et al. 1999), we conducted ground-based surveys near the Alpine Facility Area to search for eider nests and broods. For the pre-nesting survey, we used the same methods as in previous years (1992–1997), although the survey areas differed in extent from those in some of those years. In 1998, we flew surveys over the entire delta, but did not survey the 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 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 habitat 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 survey area. Following the USFWS (1987a) protocol, the total indicated number of birds was calculated by first doubling the number of males not in groups (a group is defined here as >4 males), then adding this product to the number of birds in groups. The indicated number of pairs was the number of males. Density estimates were not adjusted with a visibility correction factor.

Habitat selection was analyzed for locations of groups (singles, pairs, or flocks) of eiders that were

Table 2. Descriptions of wildlife surveys conducted on the Colville River Delta and adjacent areas, Alaska, 1998.

Species	Survey Type	Phenological Season	Dates	Aircraft[b]	Transect[a]		Aircraft Altitude (m)	Area Surveyed
					Width (km)	Spacing (km)		
BIRDS								
Eiders	Aerial	Pre-nesting	10, 11 June	C185	0.4	0.4	30–35	Delta
Tundra Swans	Aerial	Nesting	18–21 June	C185	1.6	1.6	150	Delta
		Brood-rearing	18–20 August	C185	1.6	1.6	150	Delta
		Fall staging	14 Sep.	206L	n/a	n/a	150	Delta
Loons	Aerial	Nesting	23, 24 June	PA18	n/a	n/a	30–40	Delta
		Brood-rearing	23, 24 August	206L	n/a	n/a	30–70	Delta
Brant	Aerial	Nesting	15 June	PA18	n/a	n/a	50–80[c]	Portions of the Delta
		Brood-rearing	27 July	C185				
		Fall staging	21 August	C185	n/a	n/a	90	Delta
Other geese	Aerial	Brood-rearing	25, 26 July	PA18	0.4	1.6	90	Delta
	Aerial	Fall staging	20, 21 August	C185	0.4	1.6	90	Delta
MAMMALS								
Foxes	Aerial	Denning	26–28 June	206L	n/a	n/a	30–90	Central and western portions of Outer Delta
	Ground	Denning	10–13 July	-	-	-	-	Delta (evaluation of pup production)
Spotted Seals	Aerial	Late-summer	opportunistic	C185	n/a	n/a	450	Colville River East Channel and distributaries south to Itkillik River

[a] n/a = not applicable.
[b] C185 = Cessna 185 fixed-wing airplane; PA18 = Piper "Super Cub" fixed-wing airplane; 206L = Bell "Long Ranger" helicopter.
[c] Colonies were inspected from the lower altitudes.

observed on the ground in the delta. For analysis of selection during the pre-nesting season, we used locations from aerial surveys in 1993-1998. The pre-nesting survey in 1993 was flown at 50% coverage; all other surveys were flown at 100% coverage. For the survey flown at 50% coverage, we calculated habitat availability for the strips that were surveyed.

TUNDRA SWANS

In 1998, we flew aerial surveys for Tundra Swans during the nesting, brood-rearing, and fall-staging seasons (Table 2). During nesting and brood-rearing, we conducted aerial surveys over the entire delta in accordance with USFWS protocols (USFWS 1987b, 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 receiver. 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. The same methods were used for nesting and brood-rearing surveys on the delta in 1993, and 1995–1997 (Smith et al. 1994, Johnson et al. 1998). Beginning in 1995, we photographed each nest with a 35-mm camera for site verification. 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 ~2.4-km intervals.

In 1998, a helicopter was used to fly the fall-staging survey for swans. We flew over all sites previously documented as areas of swan staging activity and also flew roughly parallel north–south paths over the river channels and central portion of the delta; these lines extended from the coast south to roughly 70° 15’ N latitude. We also flew over the embayment lying west of the Nechelik Channel that receives the outflow of the Tingmeachsiovik River and Fish Creek.

We summarized numbers of swans, nests, and broods and calculated densities for each season for the Colville Delta. No corrections were made for sightability. Nesting success was estimated from the ratio of broods to nests counted during aerial surveys. The accuracy of these estimates of nesting success can be affected by a number of factors. First, swan broods are less likely than swan nests to be missed by observers during aerial surveys (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. Immigration and emigration of broods are less of a problem, however, for estimating nesting success in large, well-defined areas, such as the Colville Delta. Thus, estimates based on aerial-survey data 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 Colville Delta for calculating available habitats. We calculated the selection indices from the locations of each nest or brood. Although some of the nest sites 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. None of the nest sites were used in all the years that surveys were conducted. Hawkins (1983) found 21% of the swan nests on a portion of the Colville Delta were on mounds used the previous year. Monda et al. (1994) found that 49% of the nests in the Arctic National Wildlife Refuge were on mounds used previously and that nest sites reused from previous years were slightly more successful than new nest sites. Therefore, to delete multi-year nest sites from the habitat analysis could bias the results towards habitats selected by less experienced and less successful pairs. To avoid potential bias, we have chosen to include all nest sites, while recognizing that all locations may not be annually independent.

LOONS

In 1998, we used a fixed-wing aircraft to survey for nesting loons and a helicopter to survey for brood-rearing loons (Table 2). We used the same methods in 1995–1997 (Johnson et al. 1996, 1997, 1998), whereas we flew both the nesting and brood-rearing surveys in a fixed-wing aircraft in 1992 and

1993 (Smith et al. 1993, 1994). We flew all surveys in a lake-to-lake pattern, concentrating on lakes ~10 ha or larger in size and adjacent smaller lakes; we excluded coastal lakes and tapped lakes with low-water connections to river channels, where Yellow-billed Loons have not been observed to nest (North 1986, Johnson et al. 1997). We used the 10-ha-size criterion in 1995–1998 to concentrate our efforts on Yellow-billed Loons, which typically nest and rear their broods on lakes ≥10 ha (Sjolander and Agren 1976, North and Ryan 1989). During the nesting season in 1996–1998, we revisited with a helicopter those lakes in the Delta survey area where Yellow-billed Loons had been seen but nests were not found on the initial aerial survey to determine whether nesting was occurring. We also 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 frequently are used by these species for nesting and brood-rearing (Bergman and Derksen 1977). We recorded all loon locations on 1:63,630-scale USGS maps.

In 1998, we conducted intensive searches by helicopter (3, 4 July, 24 August) of all waterbodies in the Facility Area for nesting and brood-rearing loons with methods similar to those in 1996 and 1997. We recorded locations of nests and broods of all three loon species on 1:63,360-scale USGS maps.

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. For the Outer Delta, we analyzed data from only that portion of the total area that was surveyed in both the nesting and brood-rearing seasons for 1993 and 1995–1998. Habitat selection was calculated for Yellow-billed Loon nests and broods in the Delta survey area for each year surveyed. We calculated selection indices based on nests found in 1993, 1995–1998 and on broods found in 1995–1998.

BRANT AND OTHER GEESE

In 1998, we flew aerial surveys for Brant during nesting, brood-rearing, and fall staging and for other geese during brood-rearing and fall staging (Table 2). Methods for our Brant surveys were similar to those used since 1989 for surveys of Brant between the Colville and Sagavanirktok rivers (Ritchie et al. 1990, Anderson et al. 1999). The survey area extended up to 15 km inland from the coast on the delta.

Nesting surveys for Brant 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 (>1,100 nests; USFWS, unpubl. data). We recorded a nest wherever we saw either a down-filled bowl or an adult in incubation posture, and mapped all observations on 1:63,360-scale USGS maps. 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. Following the nesting survey, we did a follow-up survey with a helicopter to visually identify the habitat that contained known colonies.

During brood-rearing and fall staging, we collected information on Brant during non-systematic coastal surveys, which followed the shorelines of bays, deltaic islands, and river channels that extend ~10 km inland. The brood-rearing survey was flown at 90 m agl with one observer, and the fall-staging survey was flown at the same altitude with two observers. We tallied the number of Brant observed during all surveys and compared those totals to numbers observed in previous years. No corrections were made for sightability. All locations were added to the GIS database.

We calculated habitat selection values only for that portion of the Outer Delta that was surveyed annually. Because Brant tend to nest in the same colony locations each year, we based habitat selection on the cumulative number of nesting colony (≥1 nest) locations observed for all years surveyed (1992, 1993, and 1995–1998). We used the number of nesting colonies in each habitat in our analysis rather than the number of nests in each colony (although we report the number of nests), because individual nest locations within colonies are unlikely to be independent of each other. We also analyzed habitat selection by brood-rearing Brant for those years with comparable coastal surveys.

In 1996–1998, we also conducted systematic surveys for all geese during the brood-rearing and fall-staging seasons (Table 2). These surveys were flown at 90 m agl on east–west flight lines that were 1.6 km apart. Two observers (including the pilot) searched a 400-m-wide strip on either side of the plane, thereby achieving 50% coverage of the survey area. As during other surveys, we recorded species, numbers, and locations on 1:63,360-scale USGS maps. Coverage in 1996 was equivalent to 25% of the study area (one observer), whereas coverage in 1997 and 1998 was 50% (two observers). In addition to these surveys, we opportunistically collected information on geese during surveys for eiders, swans, and loons.

FOXES

We used aerial and ground-based surveys to evaluate the distribution and status of arctic and red fox dens on the Colville Delta and Transportation Corridor in 1998 (Table 2). We assessed den status and pup presence at known dens on helicopter-supported ground visits during 26–28 June, and then returned to active dens during 10–13 July to count pups. Most of our survey effort focused on checking dens found in previous years, although we also searched opportunistically for dens along banks of drained-lake basins and other suitable denning habitats while transiting between known dens. On 28 June 1998, we conducted a systematic survey for fox dens in the Outer Delta survey area (west of the Kupigruak Channel), an area lightly surveyed in our previous years of study. Soil disturbance and fertilization by foxes at den sites results in a characteristic, lush flora that makes perennially used sites easily visible from the air after "green-up" of vegetation (Chesemore 1969, Garrott et al. 1983a). Green-up occurs earlier on traditionally used den sites than on surrounding tundra, a difference that is helpful in locating dens as early as the third week of June.

During ground visits, we evaluated evidence of use by foxes and confirmed the species using the den. Following Garrott (1980), we used the following fox sign to assess den status: presence or absence of adult and pup foxes; presence and appearance of droppings, diggings, and tracks; trampled vegetation in play areas or beds; shed fur; prey remains; and signs of predation (e.g., pup remains). We classified dens into four categories (following Burgess et al. 1993); the first three of which are considered to be "occupied" dens:

1) natal—dens at which young were whelped, characterized by abundant adult and pup sign early in the current season;
2) secondary—dens 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);
3) active—dens showing evidence of consistent, heavy use, and suspected to be natal or secondary dens, but at which pups were not seen; or
4) inactive—dens 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. As we have since 1996, we invested a fair amount of effort to confirm den occupancy and to count pups. Based on our initial assessment of den activity, observations during 10–13 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 2.5–4 h. Observations usually were conducted early and late in the day, when foxes tend to be more active.

Denning habitat selection was calculated using Monte Carlo simulations based on the total number of dens located for both arctic and red foxes during 1992–1998 in the Delta and Transportation Corridor survey areas. We used the total area of all terrestrial habitats in our measure of habitat availability, excluding waterbodies and other aquatic habitats that obviously could not be used for denning. In the selection analysis, no distinction was made between active (including natal and secondary) and inactive dens, because den status can change annually. Only sites that we visited, confirmed, and mapped on aerial photographs were included in the habitat selection analysis.

OTHER MAMMALS

Incidental observations of grizzly bears, muskoxen, and other mammals were recorded during aerial and ground-based surveys for waterbirds, fox dens, and caribou (Lawhead 1999). On 2 June 1998, we flew a reconnaissance (non-systematic) survey specifically for muskoxen in the uplands east of the Itkillik River with a fixed-wing airplane. Den locations of grizzly bears and polar bears were obtained from agency biologists (R. Shideler, ADFG, Fairbanks; S. Schliebe, USFWS Marine Mammals Management, Anchorage; and S. Amstrup, USGS Biological Resources Division, Anchorage) and from existing literature.

RESULTS AND DISCUSSION

HABITAT CLASSIFICATION AND MAPPING

We aggregated the 195 classes (terrain unit, surface-form, and vegetation combinations; see Johnson et al. 1996) identified by the ecological land classification into a set of 23 wildlife habitat types for the Delta survey area and 18 habitat types for the Transportation Corridor; the latter area was not surveyed in 1998 (Figure 2, Table 3). This aggregation resulted in 12 waterbody, 10 terrestrial, and 2 wetland-complex types. The habitats are described in Appendix B, and a list of plant taxa found within them are reported in Johnson et al. (1996).

On the delta, the most abundant habitats were Wet Sedge–Willow Meadow (19% of the total area), River or Stream (15%), Barrens (14%), and Tidal Flat (10%) (Table 3). Other habitats that were less common but were unique to the delta included Brackish Water (1%), Tapped Lake with Low-water Connection (4%), Salt Marsh (3%), Salt-killed Tundra (5%), and Aquatic Sedge with Deep Polygons (2%). The area and percent availability of some habitats differs from those presented in earlier reports (Johnson et al. 1996, 1997, 1998) as a result of conforming the wildlife base map to a more detailed map of the Facility Area. The total area of the delta increased 0.02% as a result of the remapping, and individual habitats changed from 0 to 0.19 km^2 in size.

Basin Wetland Complexes were rare on the delta but were particularly important features of the Transportation Corridor, where they were composed of a variety of moist, wet, and aquatic habitats. In our usage, Basin Wetland Complexes are portions of thaw-lake basins that encompass areas containing a complex mosaic of habitat patches, the components of which were smaller than 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, and the areas calculated for these 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 a wide variety of stages occur in thaw-basin evolution that could confound analyses of habitat use.

Because of our interest in reducing the number of habitats to facilitate analyses and their 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 such a small percentage (0.1%) of the total area. Similarly, we combined several ELC classes with different surface-forms 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).

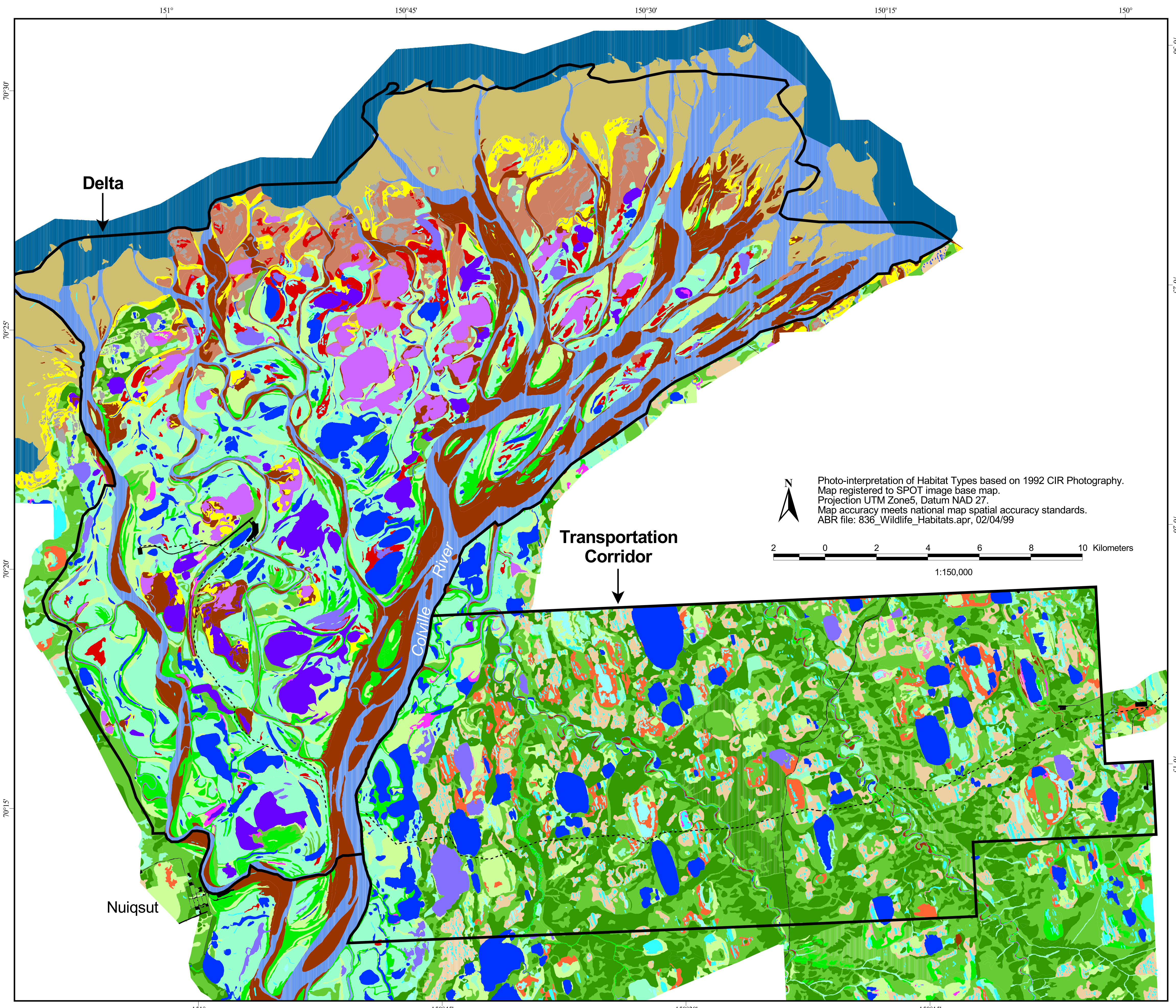

Figure 2. Habitat map of the Delta and Transportation Corridor survey areas, Colville River, Alaska.

Table 3. Availability of wildlife habitat types in the Delta survey area, Colville River, Alaska, 1998.

Habitat	Area (km^2)	Availability (%)
Open Nearshore Water (marine)	10.28	1.9
Brackish Water	6.50	1.2
Tapped Lake w/ Low-water Connection	21.40	3.9
Tapped Lake w/ High-water Connection	20.40	3.7
Salt Marsh	16.36	3.0
Tidal Flat	55.99	10.2
Salt-killed Tundra	25.62	4.6
Deep Open Water w/o Islands	23.32	4.2
Deep Open Water w/ Islands or Polygonized Margins	5.15	0.9
Shallow Open Water w/o Islands	2.30	0.4
Shallow Open Water w/ Islands or Polygonized Margins	0.54	0.1
River or Stream	81.88	14.8
Aquatic Sedge Marsh	0	0
Aquatic Sedge w/ Deep Polygons	13.59	2.5
Aquatic Grass Marsh	1.37	0.2
Young Basin Wetland Complex	<0.01	<0.1
Old Basin Wetland Complex	0.01	<0.1
Nonpatterned Wet Meadow	41.92	7.6
Wet Sedge–Willow Meadow	102.37	18.6
Moist Sedge–Shrub Meadow	13.40	2.4
Moist Tussock Tundra	2.53	0.5
Riverine or Upland Shrub	27.42	5.0
Barrens (riverine, eolian, lacustrine)	79.03	14.3
Artificial (water, fill, peat road)	0.02	<0.1
Total	551.42	100

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, and tend to concentrate on 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 dates for the first nest in different years 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 at 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, Johnson 1995). 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, Johnson et al. 1998); a pair was seen on a pre-nesting survey in 1992 (Smith et al. 1993), and one nest was found on an island in the outermost delta in 1994 (Johnson 1995). Recent records of Steller's Eiders east of Point Barrow are scant (Johnson and Herter 1989). Five Steller's Eiders were seen briefly on the delta in June 1995 (J. Bart, Boise State University, pers. comm.).

DISTRIBUTION AND ABUNDANCE

Pre-nesting

In 1998, we conducted our pre-nesting survey on 10 and 11 June, during the same time period the surveys were flown in previous years (10-14 June), with the exception of 1997 (12–20 June; Johnson et al. 1998). The early snow melt in 1998 was similar to that in 1996, but in sharp contrast to the late snow melt in 1997. Snow cover was essentially gone (small remnants persisted where snow had drifted along banks of streams or lakes) by the first week of June in 1998 and 1996, whereas snow cover ranged from 25 to 30% in the second week of June 1997. Although we did not monitor nest initiation dates, the early snow melt and thawing of lakes probably resulted in relatively normal timing for nest initiation compared to the last six years. In the nearby Kuparuk Oilfield, Spectacled Eider nests hatched on 10 July 1996 (one nest) and 11 July 1998 (two nests), but hatch was delayed till 14, 17, and 20 July for three nests in 1997 (Anderson et al. 1999).

The timing of the pre-nesting survey appeared to be slightly earlier in 1998 than in most previous years with regard to the disintegration of flocks into breeding pairs. Most (79%) of the Spectacled Eider groups were singles or pairs, suggesting that many of the birds that had dispersed to breeding habitat. On previous pre-nesting surveys, the proportion of groups of Spectacled Eiders that were either singles or pairs ranged from 73% to 100% ($\bar{x}$ = 86%, *n* = 5). In 1998, as in previous years, we found a higher percentage of single birds and pairs for Spectacled Eiders than for King Eiders. The percentage of King Eider groups that were single birds or pairs was 62% in 1998 and has ranged from 46% to 78% ($\bar{x}$ = 65%, *n* = 5) on past surveys.

The distribution of both Spectacled and King eiders in 1998 was similar to that recorded on surveys flown in 1993-1997 (Figures 3 and 4). Spectacled and King eiders on the Colville Delta were closely associated with coastal areas in all years (Figures 3 and 4). During pre-nesting in 1998, groups (singles, pairs, or flocks) of Spectacled Eiders were found no farther than 9.7 km from the coastline, and the mean distance was 3.7 km (*n* = 34 groups). From 1993 to 1998, the farthest inland Spectacled Eiders were seen during pre-nesting was 14.0 km, and the mean distance was 4.0 km (*n* = 175 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 inland 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 1998 was 14.2 km, and the mean was 5.5 km (*n* = 101 groups).

In 1998, Spectacled Eiders were the numerically dominant eider species during the pre-nesting survey on the delta. We counted 71 Spectacled Eiders (54%), 57 King Eiders (44%), and 3 (2%) unidentified eiders (Table 4). The relative species composition on the delta in 1998 was similar to that in 1994, 1995, and 1997, when Spectacled Eiders comprised the majority of eiders seen (Johnson 1995, Johnson et al. 1996). In 1993 and 1996, however, Spectacled Eiders were the minority species, representing 44% and 39%, respectively, of all eiders counted on the delta (Smith et al. 1994, Johnson et al. 1997). For the first time since 1992, we observed Common Eiders on an aerial survey of the delta; we saw three pairs and a lone male in three different locations in 1998.

Densities of Spectacled Eiders in 1998 were similar to those in 1993–1995 and 1997, and no trend was apparent in densities during the last six pre-nesting seasons (Figure 5). In 1998, 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 0.14 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,

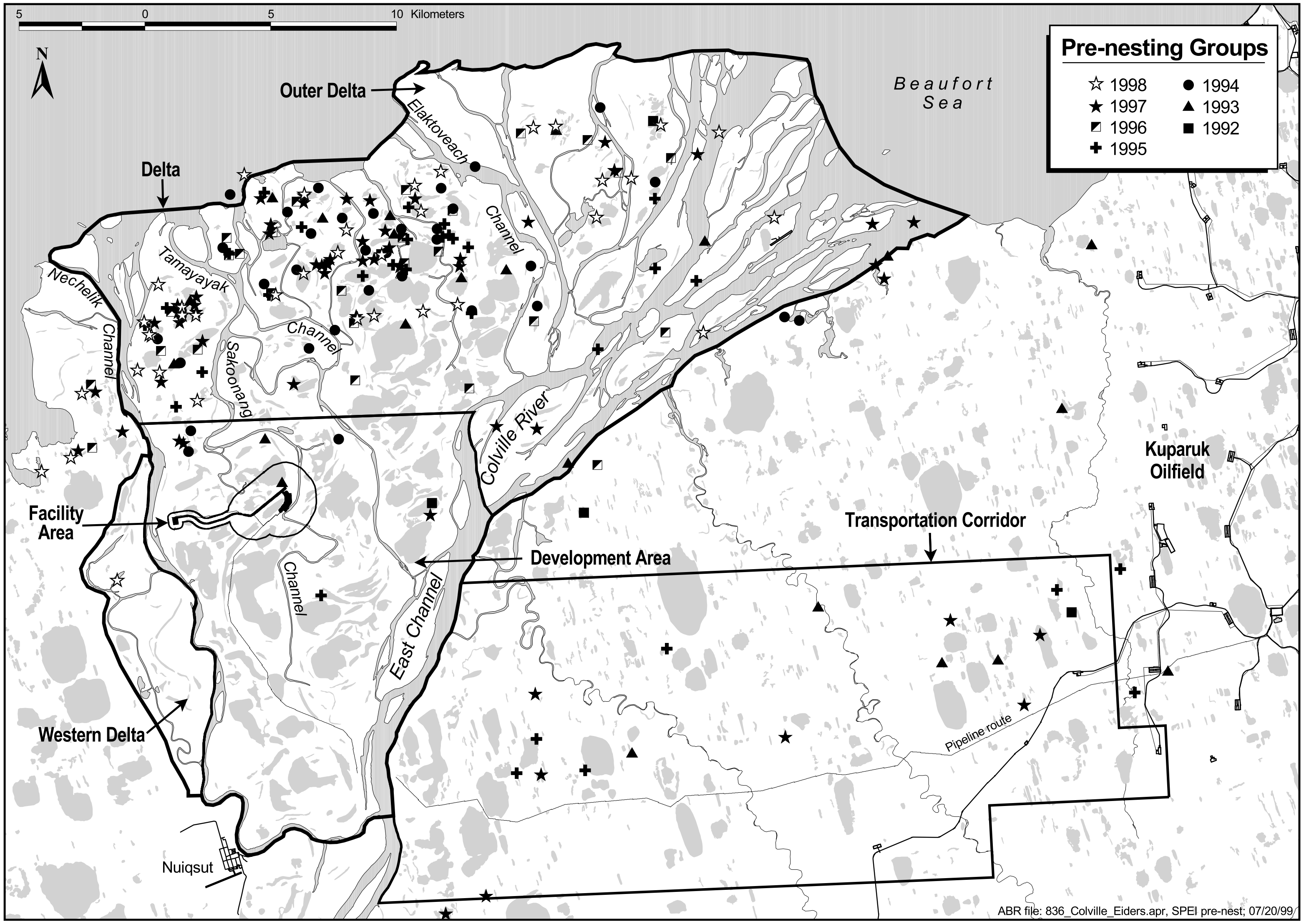

Figure 3. Distribution of Spectacled Eider groups observed during pre-nesting aerial surveys in the Delta survey area, Colville River, Alaska, 1992–1998. The Transportation Corridor was surveyed in 1993 and 1995-1997. Locations are from Smith et al. (1993, 1994), Johnson et al. (1998), and this study.

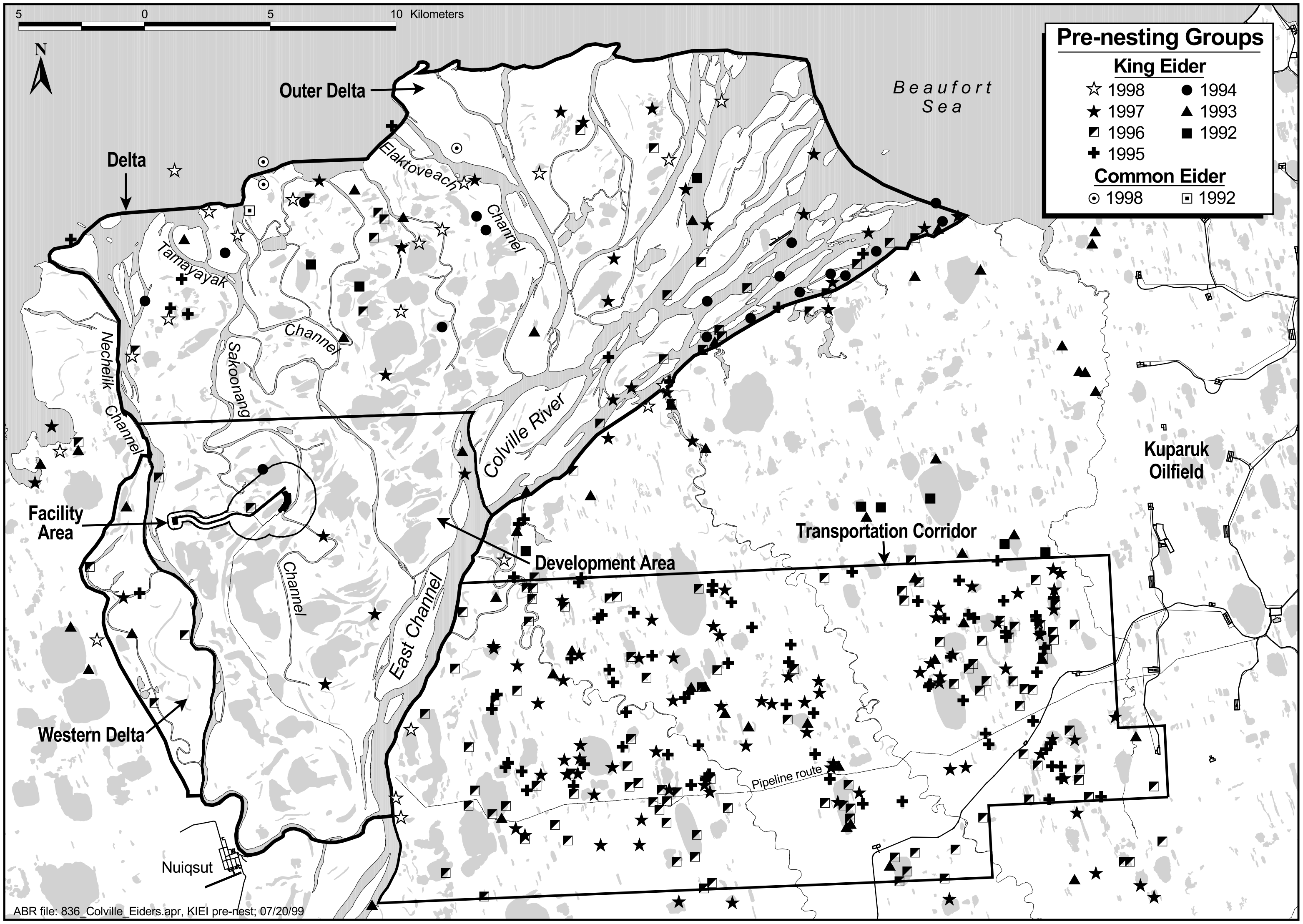

Figure 4. Distribution of King and Common eider groups observed during pre-nesting surveys in the Delta survey area, Colville River, Alaska, 1992–1998. The Transportation Corridor was surveyed in 1993 and 1995-1997. Locations are from Smith et al. (1993, 1994), Johnson et al. (1998), and this study.

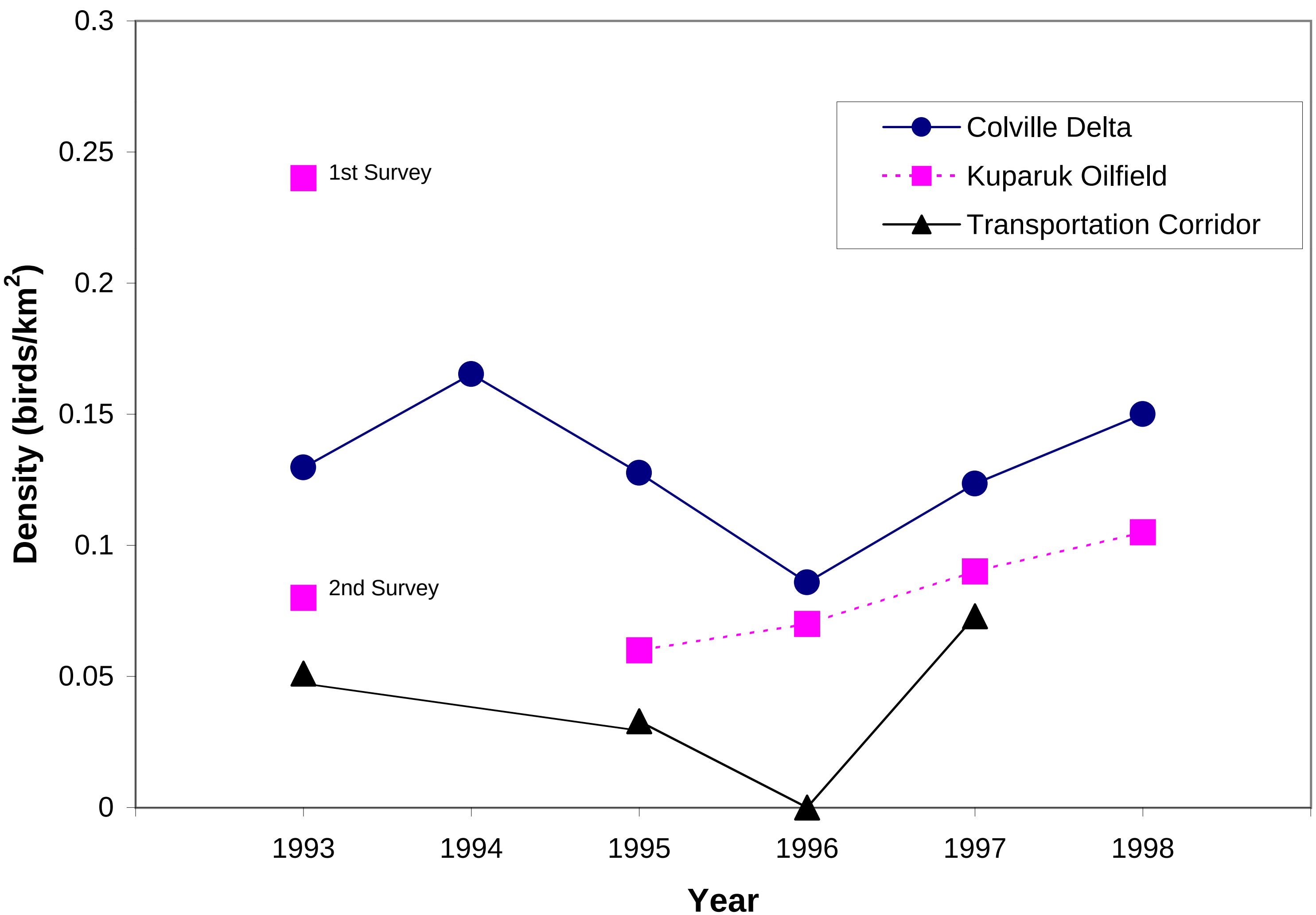

Figure 5. Trends in densities of Spectacled Eiders counted on aerial surveys during pre-nesting on the Colville River Delta, in the Transportation Corridor, and in the Kuparuk Oilfield, Alaska, 1993–1998. Data are from Anderson et al. (1999) and this study.

Table 4. Numbers and densities (uncorrected for sightability) of eiders seen during aerial surveys (100% coverage) of the Delta survey area (523 km²), Colville River, Alaska, 10–11 June 1998.

	Numbers of Eiders					Density (birds or pairs/km²)		
	Observed			Indicated			Indicated	
Species	Males	Females	Total	Total[a]	Pairs[b]	Observed Total	Total[a]	Pairs[b]
NON-FLYING BIRDS								
Spectacled Eider	35	25	60	70	35	0.11	0.13	0.07
King Eider	9	8	17	18	9	0.03	0.03	0.02
Common Eider	1	1	2	2	1	<0.01	<0.01	<0.01
FLYING BIRDS								
Spectacled Eider	11	0	11	16	11	0.02	0.03	0.02
King Eider	22	18	40	44	22	0.08	0.08	0.04
Common Eider	1	0	1	2	1	<0.01	<0.01	<0.01
NON-FLYING + FLYING BIRDS								
Spectacled Eider	46	25	71	86	46	0.14	0.16	0.09
King Eider	31	26	57	62	31	0.11	0.12	0.06
Common Eider	2	1	3	4	2	0.01	0	<0.01

[a] Total indicated = (number of males not in groups × 2) + number of birds in groups (see USFWS 1987b).
[b] Pairs indicated = number of males.

Johnson et al. 1996). Recalculating these densities for an area surveyed in 1994 (478 km²) that was common to all six years of study resulted in an estimated density of 0.15 birds/km² in 1998, slightly lower than the peak density measured in 1994 (Table 5). The lowest density on the delta (0.09 birds/km²) was observed in 1996, but that year's survey was affected by the relatively early departure of males from the breeding grounds (Johnson et al. 1997). Densities on the delta were higher than densities observed in the nearby Kuparuk Oilfield from 1993 to 1998 and Transportation Corridor (the pipeline route between Kuparuk Oilfield and the delta) from 1993–1997, with the exception of 1993, when an unusually high density was recorded on the first of two surveys in the Kuparuk Oilfield.

The density of King Eiders in 1998 (0.12 birds/km²) in the common survey area (478 km²) was the second highest observed since 1993 (Table 5). As with Spectacled Eiders, no annual trend was apparent on the delta, but densities on the delta have been dramatically below those in the Transportation Corridor and Kuparuk Oilfield in all years (1993–1997) but 1993 (Figure 6).

Within the Delta survey area, neither the Development Area nor the Facility Area appears to be important to breeding eiders (Figures 3 and 4). During the pre-nesting survey in 1998, we saw no eiders in the Development Area or the Facility Area. In 1997, we saw four Spectacled Eiders and eight King Eiders in the Development Area (Table 5). On aerial surveys in previous years, no more than four Spectacled Eiders and five King Eiders were seen in the Development Area. Only one pair of Spectacled Eiders (in 1993) and one pair of King Eiders have been seen in the Facility Area on pre-nesting aerial surveys in previous years.

Of all the areas surveyed on the delta, the Outer Delta consistently contained the highest density of Spectacled and King eiders (Table 5). In 1998, the density of Spectacled Eiders in this area (0.20 birds/km²) was the highest since 1994. The density of King Eiders in 1998 (0.16 birds/km²) was equal to previous high values.

Overall, the distribution of eiders on the delta was consistent annually. Except for a decline in King Eiders from 1994 to 1995, annual changes in abundance were relatively minor, however, with survey timing (relative to arrival and nest initiation) contributing to the variation.

Nesting

The northern portion of the delta, where eiders tended to concentrate during pre-nesting

Table 5. Numbers and densities of eiders during pre-nesting in the Delta and Transportation Corridor survey areas, Colville River, Alaska, 1993–1998. Counts were made from fixed-wing aircraft in early June (Johnson et al. 1998, this study). Survey areas varied in size among years but are adjusted here to the area common to all six years; therefore, numbers and densities may differ from those reported for the original survey areas. See Figure 1 for survey areas.

		1998		1997		1996		1995		1994		1993[a]	
Area	Species	No.	Birds /km^2	No.	Birds /km^2	No.	Birds /km^2	No.	Birds /km^2	No.	Birds /km^2	No.	Birds /km^2
Delta (478 km^2)[b]													
	Spectacled Eider	71	0.15	59	0.12	41	0.09	61	0.13	79	0.17	31	0.13
	King Eider	57	0.12	49	0.10	53	0.11	30	0.06	58	0.12	34	0.14
	Common Eider	3	0.01	0	0	0	0	0	0	0	0	0	0
	Unid. Eider	0	0	1	<0.01	4	0.01	15	0.03	4	0.01	3	0.01
Development Area (126 km^2)													
	Spectacled Eider	0	0	4	0.03	0	0	2	0.02	4	0.03	4	0.06
	King Eider	0	0	8	0.06	4	0.03	0	0	1	0.01	5	0.08
	Unid. Eider	0	0	0	0	0	0	2	0.02	0	0	1	0.02
Facility Area (9 km^2)													
	Spectacled Eider	0	0	0	0	0	0	0	0	0	0	2	0.43
	King Eider	0	0	0	0	2	0.22	0	0	0	0	0	0.00
Outer Delta (352 km^2)													
	Spectacled Eider	69	0.20	55	0.16	41	0.12	59	0.17	75	0.21	27	0.15
	King Eider	57	0.16	39	0.11	49	0.14	30	0.09	57	0.16	29	0.16
	Common Eider	3	0.01	0	0	0	0	0	0	0	0	0	0
	Unid. Eider	0	0	0	0	4	0.01	13	0.04	4	0.01	2	0.01
Western Delta (31 km^2)													
	Spectacled Eider	2	0.06	0	0	0	0.00	0	0.00	-	-	0	0.00
	King Eider	0	0	2	0.07	6	0.20	4	0.13	-	-	5	0.32
Transportation Corridor (274 km^2)[d]													
	Spectacled Eider	-	-	20	0.07	0	0	9	0.03	-	-	7	0.05
	King Eider	-	-	212	0.77	162	0.59	240	0.88	-	-	31	0.23
	Unid. Eider	-	-	0	0	1	<0.01	0	0	-	-	1	0.01

[a] Coverage of survey areas in 1993 was 50% of that in 1994–1998.
[b] Although the delta encompassed 551 km^2, only 478 km^2 were common to 6 years of surveys.
[c] The Transportation Corridor was not surveyed in 1998.

(Figures 3 and 4), also is where eiders appear to nest most commonly. We have not found any documented nest locations that were farther than 13 km from the coast (Figures 7 and 8), although we must emphasize that coverage during nest searching has never been complete on the delta. In four consecutive years (1995–1998), we searched near the Facility Area and found only one Spectacled Eider nest (in 1998) and only one probable King Eider nest (in 1996; identification based on color patterns of contour feathers in the nest; Anderson and Cooper 1994). Both eider nests were on the east side of the Sakoonang Channel, more than 1 km from the Alpine airstrip; however, the Spectacled Eider nest was within 1 km of the Pad 1 footprint. In 1996, we also searched eight areas on the Outer Delta that had supported Spectacled Eider nests in the past and found three Spectacled Eider nests (one identified by contour feathers) and two unidentified eider nests. Nest searches in some of those areas in 1994 produced 17 Spectacled Eider nests, 3 King Eider nests, and 1 Common Eider nest (Johnson 1995). Smith et al. (1994) found seven Spectacled Eider nests (5 identified by contour feathers), and one unidentified eider nest in 1993. 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 Spectacled Eider nest was found, which was 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,

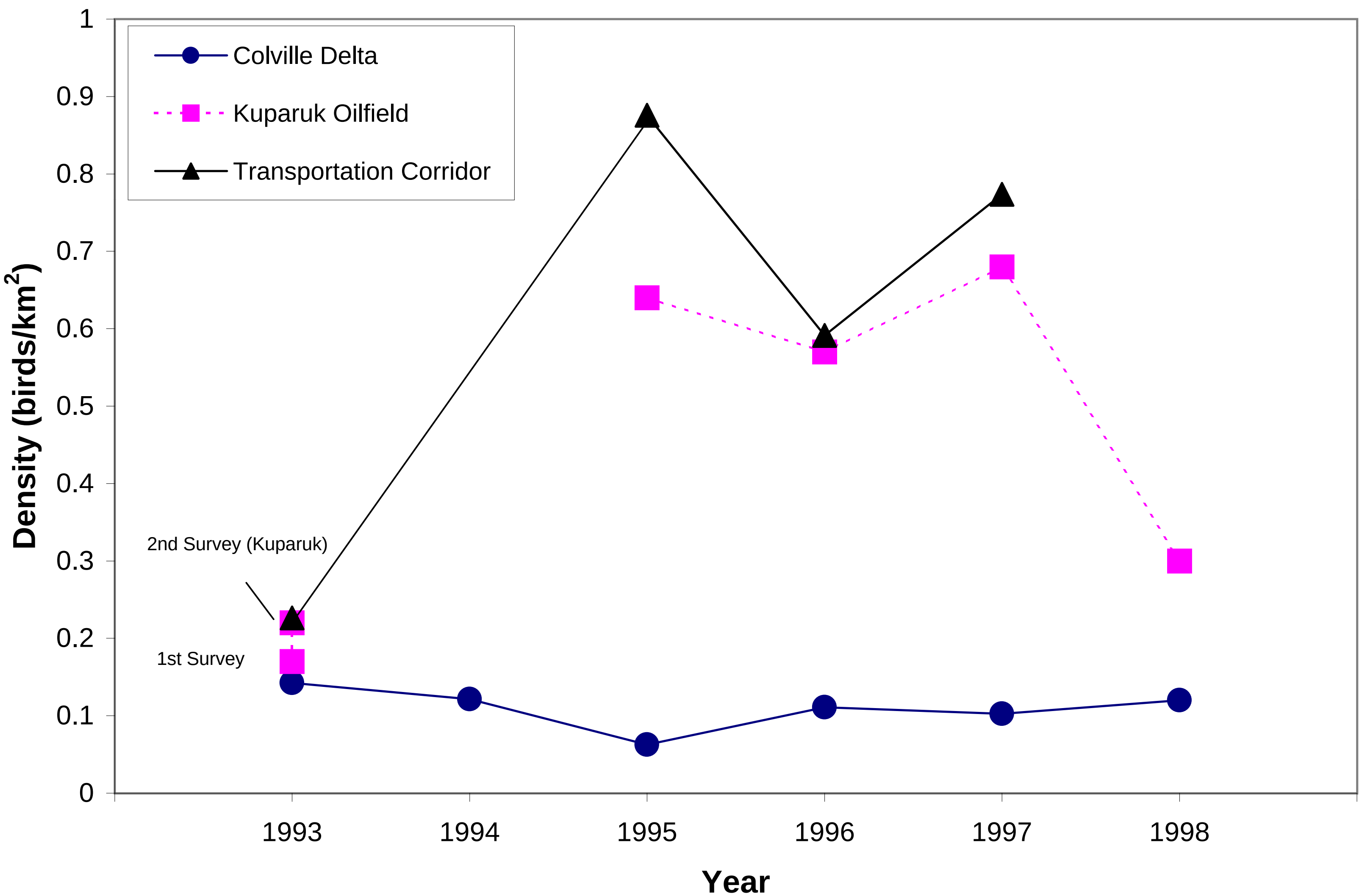

Figure 6. Trends in densities of King Eiders counted on aerial surveys during pre-nesting on the Colville River Delta, in the Transportation Corridor, and in the Kuparuk Oilfield, Alaska, 1993–1998. Data are from Anderson et al. (1999) and this study.

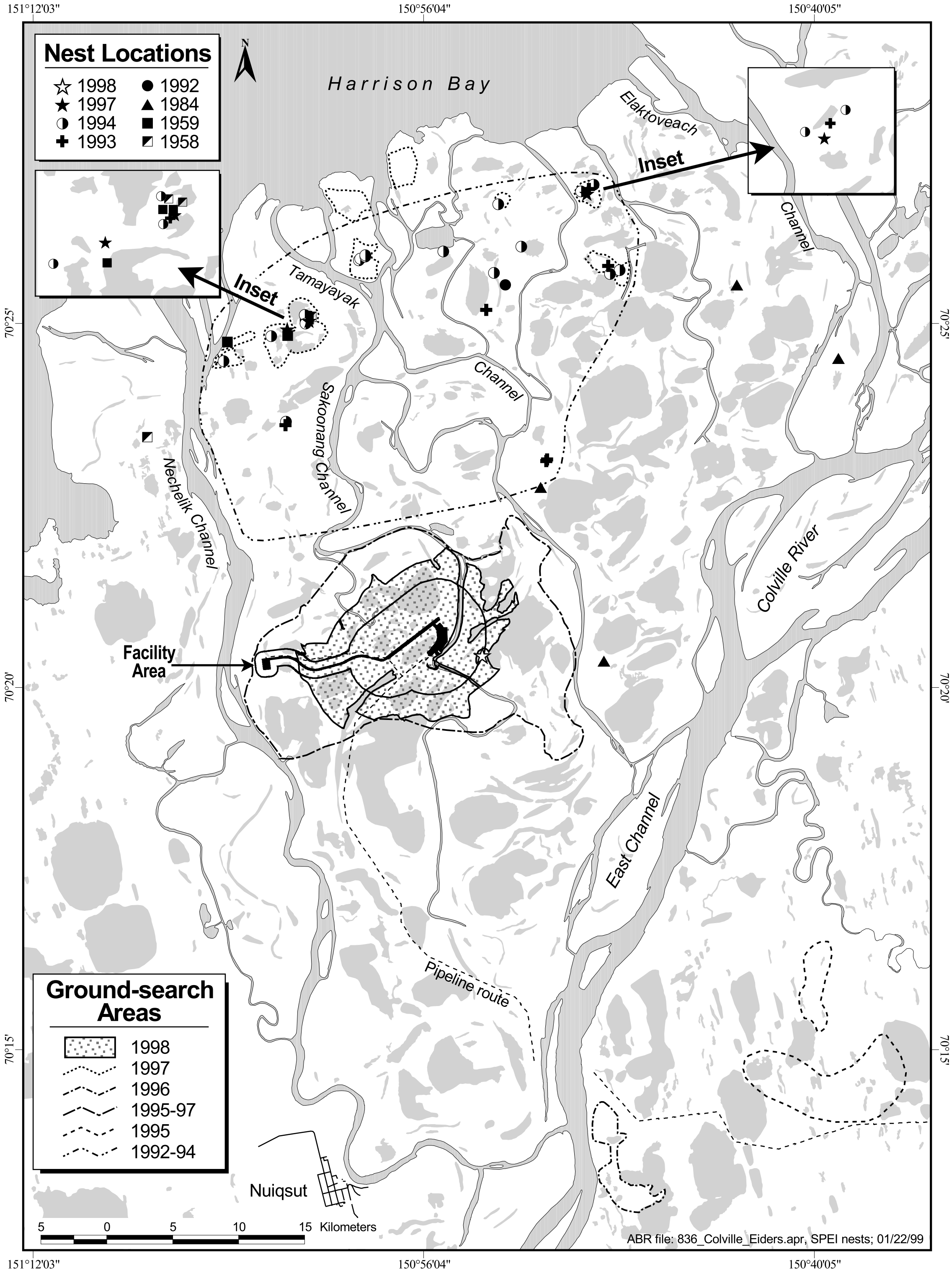

Figure 7. Distribution of Spectacled Eider nests located during ground searches in the Delta survey area, Colville River, Alaska, 1958, 1959, 1984, and 1992–1998. Locations are from T. Myres (1958, 1959, unpubl. data), M. North (1984, unpubl. data), Smith et al. (1993, 1994), Johnson et al. (1998), and this study. Nest locations and search areas do not represent all nesting areas for eiders.

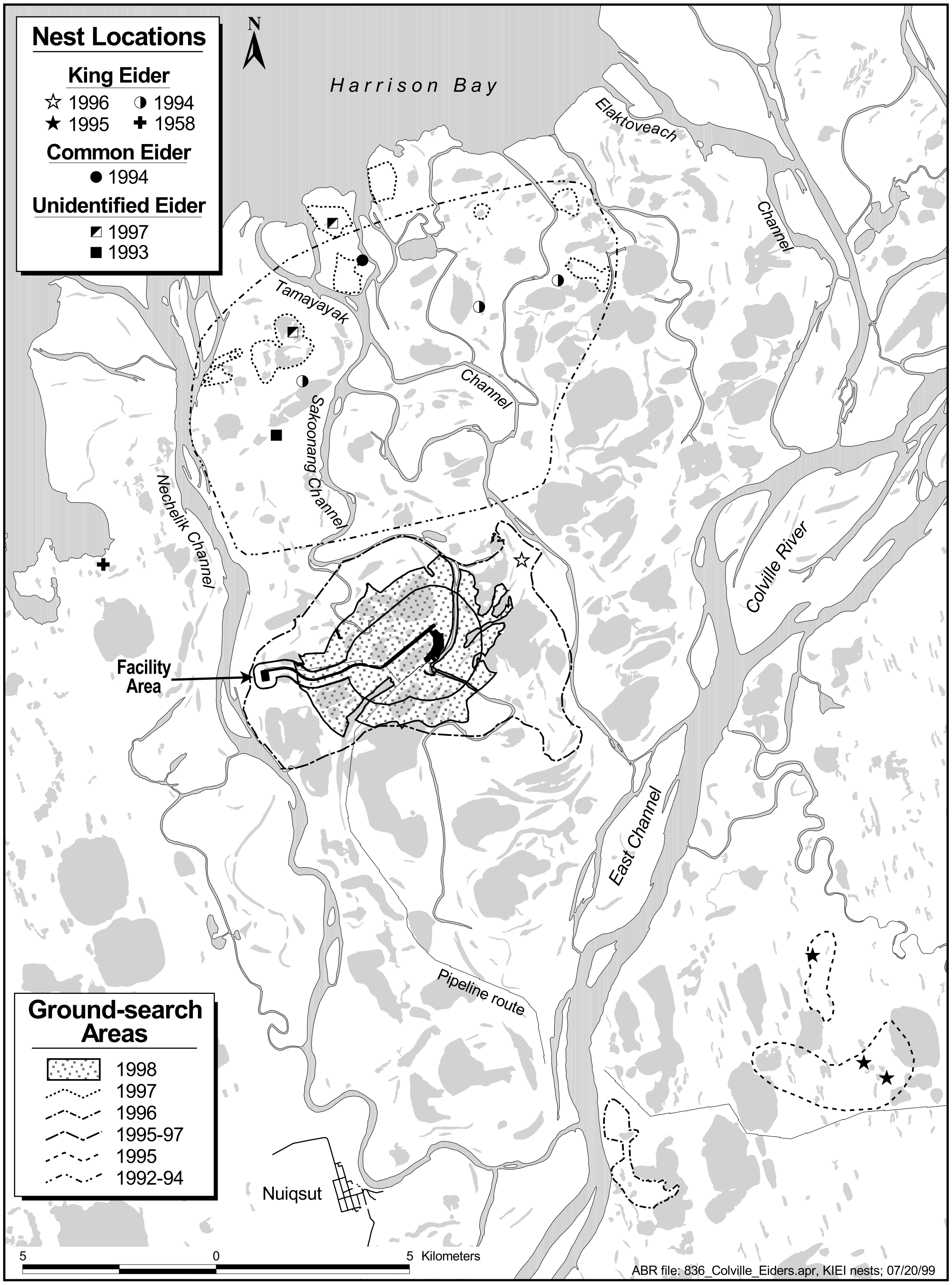

Figure 8. Distribution of King, Common, and unidentified eider nests located during ground searches in the Delta survey area, Colville River, Alaska, 1958, and 1992–1998. Locations are from T. Myres (1958, unpubl. data), Smith et al. (1993, 1994), Johnson et al. (1998), and this study. Nest locations and search areas do not represent all nesting areas for eiders.

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 of the nests found in 1993 and 1994 were on the same lakes as the nests from these earliest records (Figure 7).

Possibly because we have focused the nest searches on Spectacled Eiders, we have found few nests of other eider species on the delta. More probable, however, is that the delta does not support much nesting by other eider species. Similar search techniques were used in the Kuparuk Oilfield and 53% of the 178 nests found in six years belonged to King Eiders (Anderson et al. 1999). In seven years of nest searching on the delta, only 22% of 37 nests belonged to species other than Spectacled Eiders: one Common Eider nest, and four King Eider nests (2 identified by contour feathers). An additional three nests (8% of 37) belonged to unidentified eiders.

Brood-rearing

The distribution of broods seen on the delta opportunistically and during eider surveys was similar to the distribution of eiders during pre-nesting and nesting surveys (Figures 3–4, and 7– 9); no broods were observed >13 km from the coast. From 1996 to 1998, we saw no broods of Spectacled or King eiders during helicopter or foot surveys of the Facility Area; during those years, no other areas were searched specifically for eider broods on the delta. One brood of unidentified eiders was seen at the northern border of the Development Area during an aerial survey for loon broods in 1997 (Figure 9). In 1995, only one Spectacled Eider brood and one King Eider brood were seen during a systematic helicopter survey of the entire delta, and no eider broods were seen in the Development Area. The density of Spectacled Eider broods in 1995 was 0.004 and 0.006 broods/km^2 on the Delta and Outer Delta survey areas, respectively. 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). The number of broods undoubtedly is undercounted in aerial surveys, because the cryptic coloration and furtive behavior of female eiders and their young effectively prevents their detection. During ground 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.

HABITAT SELECTION

Both Spectacled and King eiders showed strong preferences for waterbodies during all portions of the breeding season. On the delta, pre-nesting Spectacled Eiders preferred habitats that occurred near the coast, whereas King Eiders preferred river and stream areas. During the nesting and brood-rearing seasons, the two species appear to use similar habitats.

Pre-nesting

Based on six years (1993-1998) of aerial surveys on the delta, pre-nesting Spectacled Eiders preferred (i.e., use was significantly greater than availability) 5 of 23 habitats that were available, and King Eiders preferred only 1 habitat (Tables 6 and 7). Measures of habitat selection for Spectacled and King eiders in 1998 are reported in Appendix C1, and previous years were presented in Johnson et al. (1996, 1997, 1998). On the delta, Spectacled Eiders preferred Brackish Water, Salt Marsh, Salt-killed Tundra, Shallow Open Water with Islands or Polygonized Margins, and Aquatic Sedge with Deep Polygons (Table 6). All 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 rarity on the delta (0.1% of the area). Aquatic Grass Marsh also was used by only two groups. On the delta, this rare habitat (0.2% of the area) of emergent vegetation had been significantly preferred in 1997, but no eiders used it in 1998, so it dropped from the 98th percentile of use in 1997 to the 97th percentile (97.5 is the cutpoint for significant preference in the two-tailed test).

For Spectacled Eiders, the greatest use (in terms of number of groups) during pre-nesting was of

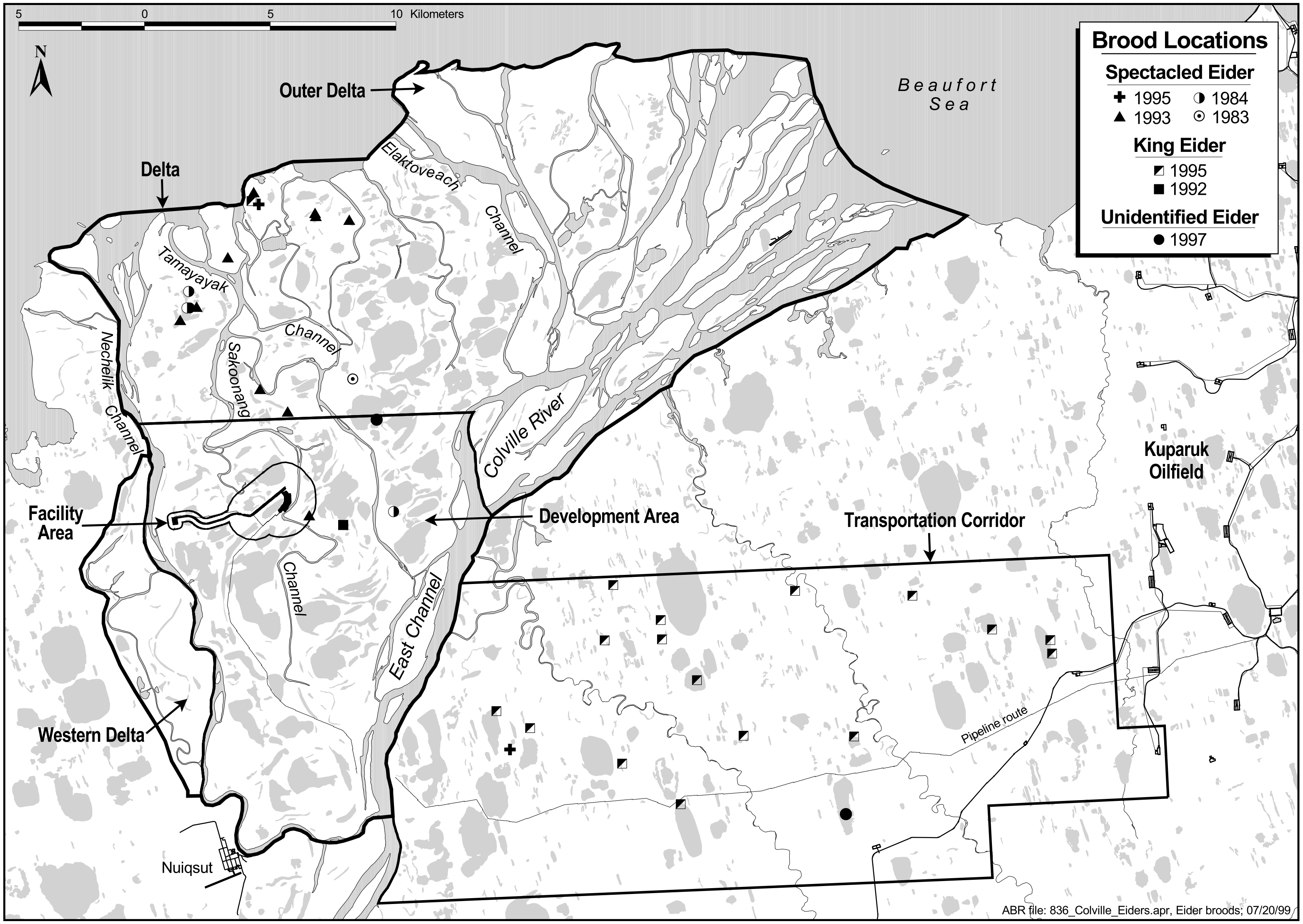

Figure 9. Distribution of Spectacled, King, and unidentified eider broods observed during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River, Alaska, 1983, 1984, 1992, 1993, 1995, and 1997. No broods were seen in 1998. Locations are from M. North (1983, 1984, unpubl. data), Smith et al. (1993, 1994), and Johnson et al. (1998).

Table 6. Habitat selection (pooled among years) by Spectacled Eiders during pre-nesting in the Delta survey area, Colville River, Alaska, 1993–1998 (from Johnson et al. 1998, this study). See Appendix C1 for 1998 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	1.7	-1.00	ns
Brackish Water	41	17	13.8	1.3	0.83	prefer
Tapped Lake w/ Low-water Connection	22	9	7.3	4.1	0.28	ns
Tapped Lake w/ High-water Connection	8	5	4.1	3.8	0.03	ns
Salt Marsh	21	10	8.1	3.2	0.43	prefer
Tidal Flat	0	0	0	8.8	-1.00	avoid
Salt-killed Tundra	22	12	9.8	4.9	0.32	prefer
Deep Open Water w/o Islands	6	4	3.3	4.3	-0.14	ns
Deep Open Water w/ Islands or Polygonized Margins	5	3	2.4	1.0	0.43	ns
Shallow Open Water w/o Islands	2	1	0.8	0.4	0.29	ns
Shallow Open Water w/ Islands or Polygonized Margins	2	2	1.6	0.1	0.88	prefer
River or Stream	7	4	3.3	14.7	-0.64	avoid
Aquatic Sedge Marsh	-	-	-	0	-	
Aquatic Sedge w/ Deep Polygons	56	30	24.4	2.6	0.80	prefer
Aquatic Grass Marsh	2	2	1.6	0.2	0.73	ns
Young Basin Wetland Complex	0	0	0	0.0	-1.00	ns
Old Basin Wetland Complex	0	0	0	0.0	-1.00	ns
Nonpatterned Wet Meadow	29	13	10.6	7.9	0.14	ns
Wet Sedge–Willow Meadow	27	10	8.1	18.5	-0.40	avoid
Moist Sedge–Shrub Meadow	0	0	0	2.4	-1.00	ns
Moist Tussock Tundra	0	0	0	0.5	-1.00	ns
Riverine or Upland Shrub	0	0	0	4.8	-1.00	avoid
Barrens (riverine, eolian, lacustrine)	2	1	0.8	14.8	-0.90	avoid
Artificial (water, fill, peat road)	0	0	0	0.0	-1.00	ns
Total	252	123	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Aquatic Sedge with Deep Polygons (30 groups), Brackish Water (17 groups), and Salt-killed Tundra (12 groups). Five habitats were avoided (i.e., use was significantly less than availability), but among these habitats, only Tidal Flat and Riverine or Upland Shrub were not used by Spectacled Eiders (Table 6). Among the unused habitats, only the most abundant types were classified as significantly avoided. In addition, the most abundant habitat on the delta, Wet Sedge–Willow Meadow, was used by 10 groups (8.1% of the total) of Spectacled Eiders, yet was avoided because its abundance (18% of the area) was so much greater than its use.

Elsewhere, studies have emphasized the importance of emergent vegetation for eiders using waterbodies. 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 Oilfield, most of the pre-nesting Spectacled Eiders were found in aquatic grass (*Arctophila)* and aquatic sedge (*Carex*) habitats (Anderson et al. 1999). 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 Aquatic Grass

Table 7. Habitat selection (pooled among years) by King Eiders during pre-nesting in the Delta survey area, Colville River, Alaska, 1993–1998 (Johnson et al. 1998, this study). See Appendix C1 for 1998 results.

Habitat	No. of Adults	No. of Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10	2	3.2	1.7	0.30	ns
Brackish Water	3	2	3.2	1.3	0.44	ns
Tapped Lake w/ Low-water Connection	9	4	6.5	4.1	0.22	ns
Tapped Lake w/ High-water Connection	4	2	3.2	3.8	-0.08	ns
Salt Marsh	0	0	0.0	3.2	-1.00	ns
Tidal Flat	2	1	1.6	8.8	-0.69	avoid
Salt-killed Tundra	7	4	6.5	4.9	0.14	ns
Deep Open Water w/o Islands	0	0	0	4.3	-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	117	35	56.5	14.7	0.59	prefer
Aquatic Sedge Marsh	-	-	-	0	-	-
Aquatic Sedge w/Deep Polygons	4	2	3.2	2.6	0.11	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	7	2	3.2	7.9	-0.42	avoid
Wet Sedge–Willow Meadow	10	6	9.7	18.5	-0.31	ns
Moist Sedge–Shrub Meadow	0	0	0	2.4	-1.00	ns
Moist Tussock Tundra	0	0	0	0.5	-1.00	ns
Riverine or Upland Shrub	2	1	1.6	4.8	-0.50	ns
Barrens (riverine, eolian, lacustrine)	1	1	1.6	14.8	-0.80	avoid
Artificial (water, fill, peat road)	0	0	0	<0.1	-1.00	ns
Total	176	62	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated from groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Marsh are probably analogous to the *Carex* and *Arctophila* ponds described elsewhere. Both these habitats were significantly preferred by Spectacled Eiders on the delta in 1997, but, of the two, only Aquatic Sedge with Deep Polygons was preferred in 1998 (Table 6).

King Eiders used 12 of 23 available habitats on the delta during pre-nesting, but only one habitat was used by large numbers of birds (Table 7). River or Stream was the only preferred habitat, used by 35 groups (56% of the total) containing 117 King Eiders. Three relatively abundant habitats on the delta were significantly avoided despite each being used by ≥1 group of King Eiders: Tidal Flat, Nonpatterned Wet Meadow, and Barrens. The high use of River and Stream, low use of typical nesting habitat (i.e., lakes and wet meadows), and the prevalence of flocks rather than pairs (see Distribution and Abundance) suggested that King Eiders had not yet dispersed into breeding areas during the pre-nesting survey. Furthermore, the low number of nests found later on nest searches indicates that the Colville River Delta may be more important as a stopover for King Eiders breeding elsewhere than as a nesting area. 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).

Nesting

We conducted nesting surveys on the ground because of the difficulty in finding eider nests during aerial surveys. Consequently, complete surveys of extensive 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 (1993, 1994, and 1997) or that included proposed development sites (1995–1998). 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 1998, 8 (28%) of 29 nests (total includes 6 nests identified by contour feathers) on the delta were found in Aquatic Sedge with Deep Polygons (Table 8). Other important nesting habitats were Brackish Water, Nonpatterned Wet Meadow, and Salt-killed Tundra, which together contained 52% of all nests. Obviously, we did not find eiders nesting on water, but nests on islands could be classified as in a waterbody type at the scale of our digital mapping (i.e., small islands and islands ≤5 m from shore were not mapped). Spectacled Eider nests were strongly associated with waterbodies in all habitats in which they occurred, averaging 1.0 m (range = 0.1-10 m, n = 29) from permanent water (Smith et al. 1994, Johnson et al. 1998). Brackish Water was the nearest waterbody to 45% of the nests, and Deep Open Water without Islands was the nearest to 21% of the nests (Table 8). We found no Spectacled Eider nests in 1995 or 1996, when the search was concentrated near the Facility Area (Figure 8).

Similar habitat associations were reported for other locations. Nests on the Yukon-Kuskokwim Delta averaged 2.1 m from water (Dau 1974). Annual mean distances of Spectacled Eider nests to water in the Kuparuk Oilfield ranged from 1.0 to 15 m over 6 years, and the waterbodies closest to

Table 8. Habitat use by Spectacled Eiders during nesting in the Delta survey area, Colville River, Alaska, 1992–1994, 1997, and 1998 (Johnson et al. 1998, this study). Nests were found during ground searches of selected portions of the study area. No nests were found in 1995 or 1996.

Habitat	No. of Nests	Use (%)
HABITAT USED		
Brackish Water	5	17.2
Tapped Lake w/ High-water Connection	1	3.4
Salt Marsh	1	3.4
Salt-killed Tundra	4	13.8
Deep Open Water w/o Islands	1	3.4
Shallow Open Water w/o Islands	1	3.4
Aquatic Sedge w/ Deep Polygons	8	27.6
Nonpatterned Wet Meadow	6	20.7
Wet Sedge–Willow Meadow	2	6.9
Total	29	100
NEAREST WATERBODY HABITAT [a]		
Brackish Water	13	44.8
Tapped Lake w/ High-water Connection	5	17.2
Deep Open Water w/o Islands	6	20.7
Deep Open Water w/ Islands or Polygonized Margins	2	6.9
Shallow Open Water w/o Islands	1	3.4
Shallow Open Water w/ Islands or Polygonized Margins	2	6.9
Total	29	100

[a] Nearest waterbody (≥0.25 ha in size) was measured from the digital map.

nests were primarily basin wetland complexes, shallow and deep open lakes, and water with emergents (both *Carex* and *Arctophila*) (Anderson et al. 1999). 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. 1999). 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 seven years of nest searches on the delta. Three of these nests were in Aquatic Sedge with Deep Polygons, and the other was in Salt-killed Tundra. 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. (1999) 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).

Brood-rearing

We did not conduct aerial surveys for eider broods in any year but 1995; however, one unidentified eider brood was seen in Deep Open Water without Islands in 1997 during a loon survey. Ground surveys were conducted for eider broods in the Facility Area from 1995 to 1998 and in various areas in 1992 and 1993. Only 11 Spectacled Eider broods have been seen since 1993 (Table 9), and only one was seen during a systematic survey. Most broods were found in 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).

Only two King Eider broods have been seen on the delta since studies began in 1992. One King Eider brood was seen in 1995 in Aquatic Sedge with Deep Polygons approximately 0.02 km from Brackish Water. The other King Eider brood was found in 1992 in Wet Sedge–Willow Meadow approximately 0.07 km from Deep Open Water without Islands.

TUNDRA SWANS

BACKGROUND

Tundra Swans arrive on the Colville Delta in mid- to late May (Simpson et al. 1982, Hawkins 1983). Swans occupy breeding territories and initiate nests soon after arrival, although they can be delayed by late snowmelt (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 territories and often use the same nest mounds in successive years (Palmer 1976, Monda et al. 1994, Anderson et al. 1999). 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 1976, 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). Freezing temperatures and snow in early autumn can hasten their departure and cause mortality of young swans (Lensink 1973, Monda and Ratti 1990).

Table 9. Habitat use by Spectacled Eiders and distance to nearest waterbody during brood-rearing in the Delta survey area, Colville River, Alaska, 1993 and 1995 (Johnson et al. 1996). Broods were located during both aerial and ground surveys.

Habitat	No. of Brood-rearing 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-rearing groups.
[b] Distance was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

DISTRIBUTION AND ABUNDANCE

Nesting

With minor exceptions, the distribution of Tundra Swan nests on the delta has been relatively consistent within areas and among years (Figure 10, Table 10). We counted 714 swans and 31 nests during standardized aerial surveys of the delta in 1998. An additional two nests were found during ground searches. These numbers are similar to those recorded in 1997, when we counted 749 swans and 32 nests on the delta (Tables 10 and 11). In 1995 and 1996, more nests were located during aerial surveys, but fewer swans were present. Factors that could account for the higher counts of swans in 1997 and 1998 include the occupation of the delta by flocks of failed breeders from the delta and surrounding region and the return of non-breeding sub-adults from previously successful breeding seasons. During the aerial survey on 19 June, 282 swans were seen in flocks of ≥10 individuals; the following day, 207 swans were seen in similar flocks. As a result of the large number of non-breeders present, only 7% of the total number of swans were associated with nests in 1998 (Table 11). Similarly, in the adjacent Kuparuk Oilfield, the 557 swans counted during nesting surveys in 1998 was the highest number of swans recorded there since surveys began in 1989 (Anderson et al. 1999). In contrast with the Colville Delta, however, nesting effort in the Kuparuk field dramatically rebounded from that in 1997: 107 nests were counted in 1998, versus only 73 nests in 1997.

In 1998, nest density (0.06 nests/km^2) determined from aerial survey remained within the range of values we have observed over the previous five years of surveys (0.03–0.08 nests/km^2). Higher densities of nests have been found on the delta during intensive ground searches, however. In 1982, 48 nests (~0.11 nests/km^2) were found on the northern 80% of the delta (Simpson et al. 1982). Nest densities determined from aerial surveys of other areas on the coastal plain were similar to those for the Colville Delta: 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 (Anderson et al. 1999).

In 1998, nest density within the Development Area (0.08 nests/km^2) was slightly greater than that

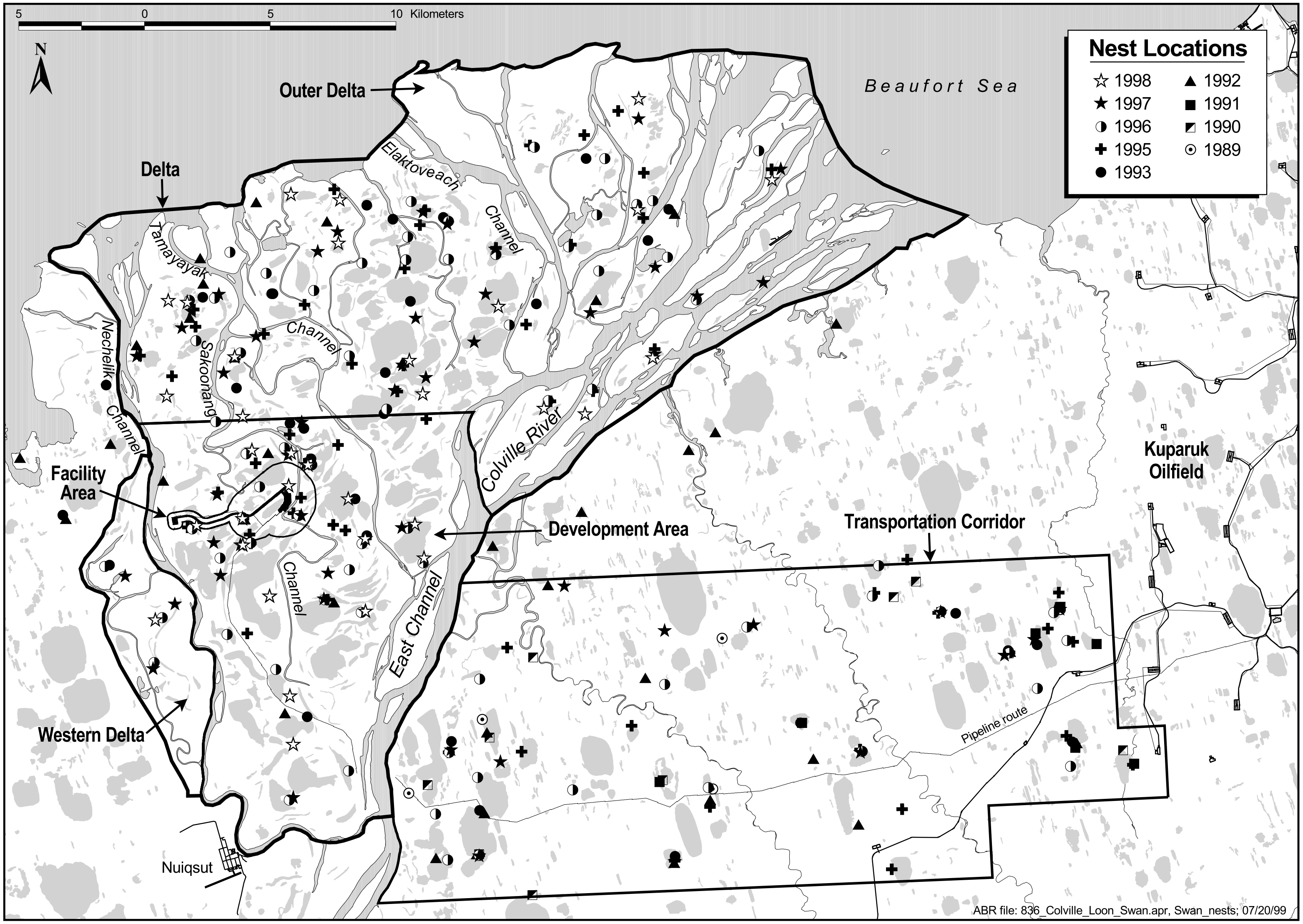

Figure 10. Distribution of Tundra Swan nests observed during aerial and ground surveys in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998. The Transportation Corridor was surveyed in 1989-1993 and 1995-1997. Locations are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), Smith et al. (1993, 1994), Johnson et al. (1998), and this study.

Table 10. Numbers and densities of Tundra Swan nests and broods counted on aerial surveys in the Delta and Transportation Corridor survey areas, Colville River, Alaska, 1989–1993 and 1995–1998 (Johnson et al. 1998, this study). The Transportation Corridor was not surveyed in 1998.

Area	Year	Nests		Broods		Mean Brood Size
		No.	No./km^2	No.	No./km^2	
Delta (551 km^2)	1998	31	0.06	22	0.04	2.4
	1997	32	0.06	24	0.04	2.5
	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)	1998	13	0.08	6	0.04	2.5
	1997	10	0.06	8	0.05	2.4
	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)	1998	3	0.33	1	0.11	3.0
	1997	1	0.11	1	0.11	3.0
	1996	1	0.12	3	0.33	3.7
	1995	3	0.33	0	0	0
	1993	0	0	0	0	0
	1992	1	0.12	1	0.12	1.0
Outer Delta (352 km^2)	1998	17	0.05	14	0.04	2.4
	1997	19	0.05	15	0.04	2.6
	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)	1998	1	0.03	2	0.06	2.0
	1997	3	0.10	1	0.03	3.0
	1996	3	0.10	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)	1997	11	0.03	11	0.03	2.4
	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

Table 11. Numbers of Tundra Swans counted on aerial surveys in the Delta and Transportation Corridor survey areas, Colville River, Alaska, 1989–1993 and 1995–1998 (Johnson et al. 1998, this study). The Transportation Corridor was not surveyed in 1998.

		Nesting		Brood-rearing					Fall Staging
Area	Year	Total Swans	Swans with Nests (%)	Total Swans	No. of Adults	No. of Young	Adults with Broods (%)	Young (%)	Total Swans
Delta									
	1998	714	7	440	338	52	12	12	411
	1997	749	7	348	287	61	14	18	286
	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	16	295
	1992	249	7	297	259	38	13	13	0
Transportation Corridor									
	1997	37	49	107	81	26	21	24	0
	1996	52	67	105	57	48	53	46	no data
	1995	87	40	93	66	27	30	29	5
	1993	50	32	83	60	23	33	28	no data
	1992	46	48	105	72	33	43	31	no data
	1991	40	25	84	67	17	18	20	no data
	1990	33	52	101	56	45	50	45	no data
	1989	38	24	69	63	6	6	8	no data

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

estimated for the entire Delta survey area (Table 10). Thirteen (42%) of the 31 nests located during aerial surveys on the delta occurred in the Development Area. Ground observers found another two nests, resulting in a combined count of 15 nests for the Development Area (0.09 nests/km^2). In previous years, we found 5-17 nests during aerial surveys in the Development Area, resulting in nest densities similar to that for the entire delta.

In the Facility Area in 1998, we found three swan nests during the standardized aerial survey (Figure 10). In previous years, we have found 0–3 swan nests on aerial surveys of the Facility Area (Table 10). We conducted a combination of aerial and ground surveys in 1995–1998. In 1998, we found six swan nests (0.4 nests/km^2) in the ground-survey area (14.8 km^2) around the Facility Area. Four of those nests were located by both aerial and ground surveys and two nests were found only by ground searchers. Thus, we suspect we undercount swan nest during aerial surveys. In the nearby Kuparuk Oilfield, Stickney et al. (1992) estimated that 27% of the swan nests were missed on the standard nesting aerial survey based on an intensive aerial survey designed to measure sightability of nests. Using a similar sightability comparison on the northern portion of the Alaska Peninsula, Wilk (1988) estimated that standard aerial surveys missed ~31% of the swan nests present.

On the Outer Delta, we located 17 swan nests during aerial surveys in 1998 (Table 10). The number and density of nests were similar in 1997, but less than in 1995 and 1996. On the Western Delta in 1998, we located one swan nest during aerial surveys (Figure 10, Table 10). Three nests were found there in 1997 and 1996, but no more than one nest was found in any other year.

Brood-rearing

Tundra Swan broods were distributed throughout the Colville Delta (Figure 11). Brood counts on the delta in mid-August 1998 indicated that approximately 71% of the 31 nests seen on aerial surveys were successful (Table 10). Similar nesting success rates were estimated from nest and brood surveys in 1997 (75%) and 1996 (73%), 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

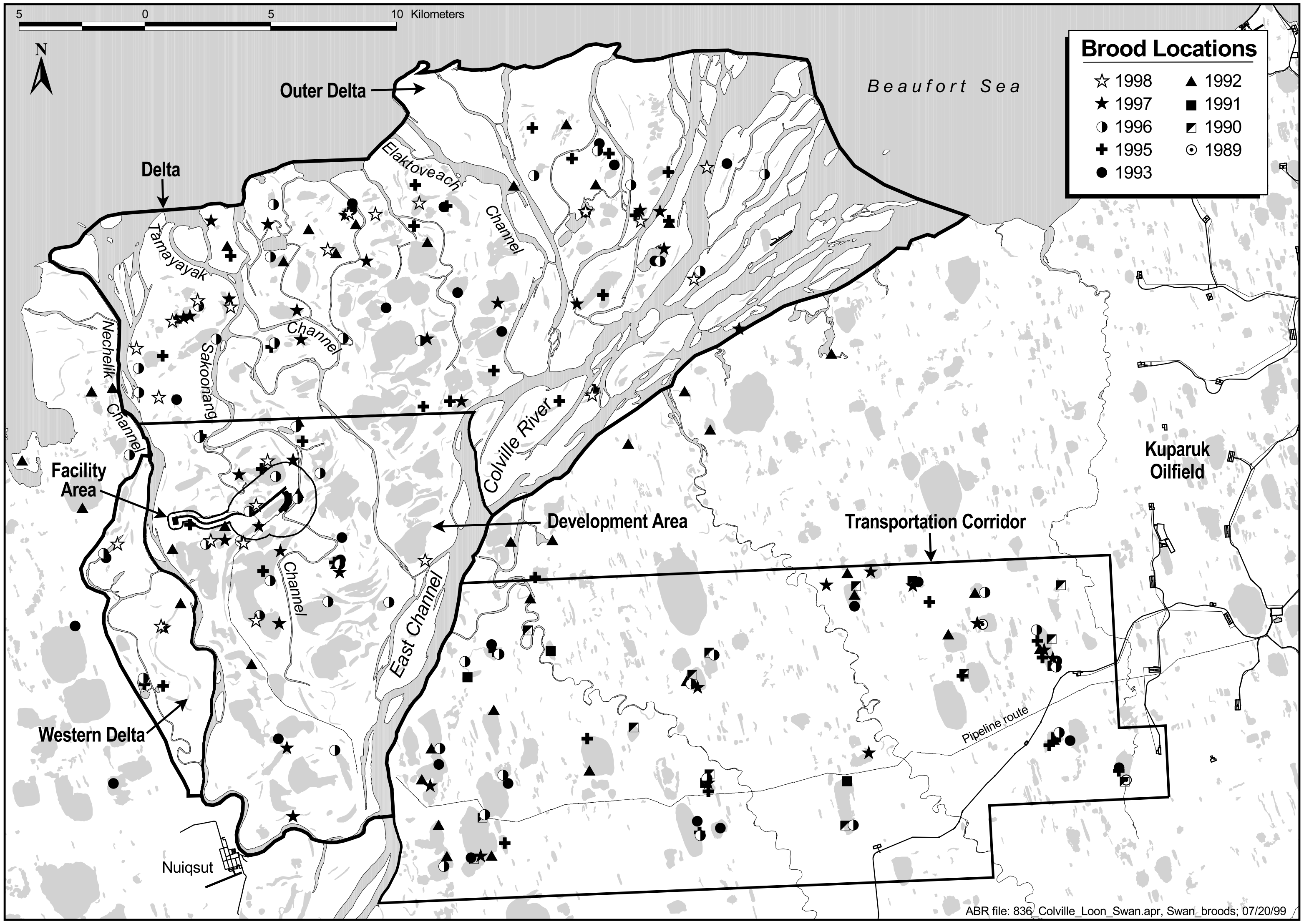

Figure 11. Distribution of Tundra Swan broods observed during aerial and ground surveys in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998. The Transportation Corridor was surveyed in 1989-1993 and 1995-1997. Locations are from Ritchie et al. (1990, 1991), Stickney et al. (1992, 1993), Smith et al. (1993, 1994), Johnson et al. (1998), and this study.

in 1992. Mean annual nesting success (calculated from standard aerial survey results only) on the delta was 78.2% (n = 6 years). In 1998, the brood density was 0.04 broods/km^2 and mean brood size was 2.4 young/brood (range = 1–4), the lowest mean brood size since 1992. The 68% nesting success of swans and mean brood size of 2.3 young (n = 73) in the Kuparuk Oilfield in 1998 were some of the lowest estimates on record there since 1988 (Anderson et al. 1999). Two earlier studies on the delta, both employing intensive ground 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 mean brood size in mid-August was 2.5 young/brood (Simpson et al. 1982). In a three-year study (1988-1990) of swans nesting on the Canning and Kongakut river deltas, the overall nesting success was 76% (n = 110 nests) (Monda et al. 1994).

Productivity (as indicated by nesting success, brood density, and mean brood size) on the delta during the six 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, 1995–1998) recorded mean brood sizes of 2.1–2.8 young/brood and densities of 0.02–0.04 broods/km^2 (Anderson et al. 1999). Platte and Brackney (1987) estimated 63–85% nesting success, 0.04 broods/km^2, and 2.5 young/brood on portions of the Arctic national Wildlife Refuge (ANWR) during 1982–1985.

The high number of adults found on the delta in 1998 resulted in young swans representing only 12% of all swans present in August, the smallest proportion of young we have recorded in six years of surveys (12–35%; Table 11). The number of adult swans counted on the delta during the brood-rearing survey was greater than in any of the previous years of this study. In 1982, the percentage of young swans on the delta was 26% (Simpson et al. 1982). In the adjacent Kuparuk Oilfield, the percentage of young swans has ranged from 21 to 34% since 1988 (Anderson et al. 1999).

In the Development Area, we found six broods during the aerial survey in 1998, continuing an apparent downward trend since the high point in 1996. (Table 10). However, we have recorded six broods in the Development Area in three of our six years of study. The apparently low nesting success (50%) in the Development Area in 1998 did not translate into a reduced brood density when compared with past years; the brood density in 1998 was about the same as the six-years average (0.04 broods/km^2). We found one brood in the Facility Area in 1998 (Figure 11).

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 1996, when densities of broods and nests were greater in the Development Area. On the Outer Delta, we found 14 broods (0.04 broods/km^2) on the aerial survey in 1998, similar to the count in 1997 (Table 10). Brood density on the Outer Delta has remained in the range of 0.03–0.05 broods/km^2 over the six years of aerial surveys.

Fall Staging

Tundra Swans have been widely distributed on the delta during our fall-staging surveys. However, most swans generally occur in several large flocks that occupy river channels on the Outer Delta (Figure 12). Wetlands immediately to the east of the delta, lying between the Miluveach River and Kalubik Creek, have had the largest aggregations of Tundra Swans on the Arctic Coastal Plain of Alaska during fall staging (Seaman et al. 1981), and we have observed large numbers there as well (Figure 12). In 1998, we flew one fall-staging survey on 14 September and counted the greatest number (411) of swans staging on the delta since we began this study (Table 11). In 1996, we counted 335 swans on the delta and 415 on several lakes just east of the delta (Figure 12). The distribution of swans in 1998 was slightly different from that in other years in that few swans were seen in the wetlands between Kalubik Creek and the Miluveach River; rather, swans were found primarily in the East Channel of the Colville Delta (e.g., near the mouth of the Miluveach River). We expanded our fall-staging survey area in 1998, flying over the wetlands at the mouths of the Tingmeachsiovik River and Fish Creek, west of the mouth of the Nechelik Channel. We counted 229 swans there, most within a single group. We have not surveyed this area during previous

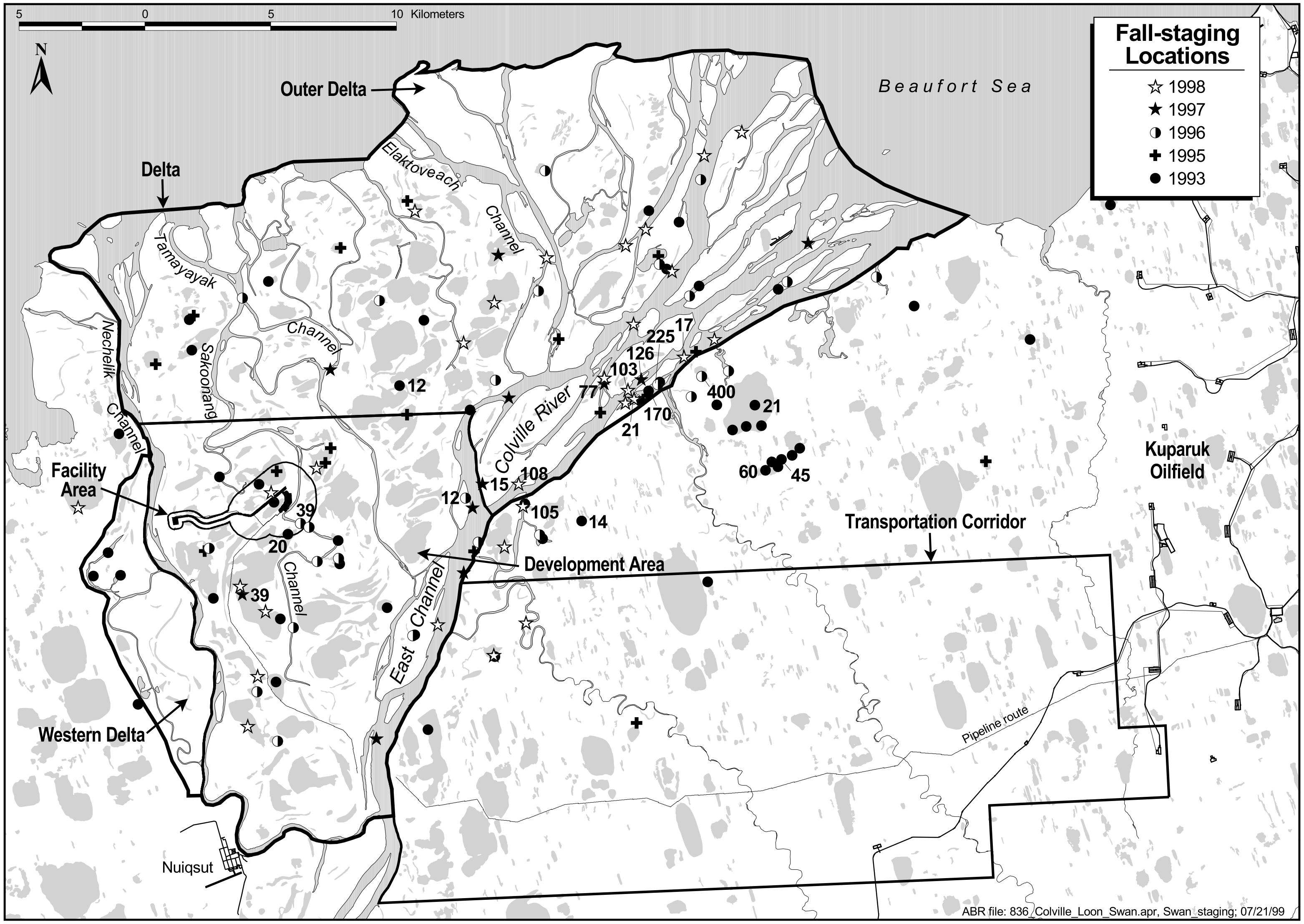

Figure 12. Distribution of Tundra Swan fall-staging groups observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River, Alaska, 1993 and 1995–1998. Numbers indicate size of groups >10. Locations are from Smith et al. (1994), Johnson et al. (1998), and this study.

years, so we do not know whether it is regularly used during fall staging.

We recorded varying departure times from the delta by swans beginning fall migration. For example, on 19 September 1995, we counted only 64 swans, most of which were in discrete family groups, distributed throughout the delta. Although weather at that time was exceptionally mild, three days of subzero temperatures two weeks earlier had caused lakes to freeze (J. Helmricks, Golden Plover, Prudhoe Bay, AK, pers. comm.) and may have induced most swans to leave. Similarly, in 1992, subzero temperatures after 8 September caused an early freeze, and swans vacated the delta by the time of our fall-staging survey (17 September; Smith et al. 1993). In contrast, temperatures in 1993 remained above freezing until after a staging survey on 15 September when we saw 295 swans (Table 11). In 1996, we also saw large numbers of swans (355) on the staging survey, but because the survey was conducted on 6 September before the first freezing temperatures of the month, we have no data on when the swans departed. These few observations suggest that the departure of most swans from the delta can be triggered before the middle of the September by cold temperatures and freeze-up of waterbodies, but large numbers of swans can remain on the delta later when temperatures remain above freezing. Surveys in four of the six years considered here documented large numbers of swans staging on or near the Colville Delta prior to migration (Table 11), an event also reported by Campell et al. (1988).

Although the Colville Delta and nearby wetlands have been identified as important fall-staging areas 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 (Anderson et al. 1999). Although swans from surrounding nesting areas may be staging on the delta, our counts of swans during staging surveys have not indicated an increase over the counts during the brood-rearing period (Table 11). To understand more clearly the importance of the delta and adjacent wetlands for swan staging, information on swan residency time there and the origin of swans seen there during fall is needed. That information would require marking swans from other areas on the Arctic Coastal Plain and locating them on multiple surveys throughout the fall-staging period.

HABITAT SELECTION

Nesting

Tundra Swans on the Colville Delta used a wide range of habitats for nesting. During six years of surveys on the delta, swan nests were located in 15 of 23 available habitats (Table 12). Six habitat types were preferred, and five were avoided. We found 147 nests (82% of the total) in preferred habitats; together these habitats covered 37% of the Delta survey area. Annual measurements of habitat selection for previous years can be found in Johnson et al. (1996, 1997, 1998); habitat selection for 1998 is presented in Appendix C2.

Most nests (72; 40% of the total) were located in Wet Sedge–Willow Meadow, a preferred habitat that also was the most available habitat (19% of the delta) in the Delta survey area (Table 12). The second-highest number of nests (23) occurred in Nonpatterned Wet Meadow, another preferred habitat. No other habitat type in the Delta survey area contained >20 nests. Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Moist Sedge–Shrub also were preferred. Swans avoided nesting in Tapped Lake with Low-water Connection, Tidal Flat, River or Stream, Riverine or Upland Shrub, and Barrens, which together composed 48% of the Delta survey area.

Swans on the delta appeared to be attracted to nest sites near lakes and ponds. The mean distance of swan nests to the nearest waterbody was 0.1 km (Table 13). In decreasing order of use, swan nests were most closely associated with three waterbody types on the delta: Deep Open Water without Islands, Tapped Lake with Low-water Connection, and Brackish Water.

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 the habitats differed in availability from those on the Colville Delta, the habitat use reported by Monda et al. (1994) was not directly comparable with our findings. Monda et al. (1994) found that

Table 12. Habitat selection (pooled among years) by nesting Tundra Swans in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998 (Johnson et al. 1998, this study). See Appendix C2 for 1998 results.

Habitat	Area (km^2)	No. of Nests	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.28	0	0	1.9	-1.00	ns
Brackish Water	6.50	0	0	1.2	-1.00	ns
Tapped Lake w/ Low-water Connection	21.40	2	1.1	3.9	-0.56	avoid
Tapped Lake w/ High-water Connection	20.40	4	2.2	3.7	-0.25	ns
Salt Marsh	16.36	8	4.5	3.0	0.20	ns
Tidal Flat	55.99	3	1.7	10.2	-0.72	avoid
Salt-killed Tundra	25.62	19	10.6	4.6	0.39	prefer
Deep Open Water w/o Islands	23.32	4	2.2	4.2	-0.31	ns
Deep Open Water w/ Islands or Polygonized Margins	5.15	7	3.9	0.9	0.61	prefer
Shallow Open Water w/o Islands	2.30	0	0	0.4	-1.00	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.54	0	0	0.1	-1.00	ns
River or Stream	81.88	0	0	14.8	-1.00	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.59	13	7.3	2.5	0.49	prefer
Aquatic Grass Marsh	1.37	2	1.1	0.2	0.64	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	41.92	23	12.9	7.6	0.26	prefer
Wet Sedge–Willow Meadow	102.37	72	40.0	18.6	0.37	prefer
Moist Sedge–Shrub Meadow	13.40	13	7.3	2.4	0.50	prefer
Moist Tussock Tundra	2.53	2	1.1	0.5	0.42	ns
Riverine or Upland Shrub	27.42	2	1.1	5.0	-0.63	avoid
Barrens (riverine, eolian, lacustrine)	79.03	6	3.4	14.3	-0.62	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	ns
Total	551.42	180	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated from nests.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

nesting habitat preferences differed 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 Aquatic 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

As during nesting, Tundra Swans with broods used most habitats on the delta; broods occurred in 18 of 23 available habitats (Table 14). Five habitats were preferred and four were avoided. Fifty-six broods were in preferred habitats and 14 broods were in avoided habitats.

Brood-rearing swans used waterbodies for foraging and escape habitat preferring them to terrestrial habitats. Swan broods preferred Brackish Water, Tapped Lake with Low-water Connection, Salt Marsh, and both Deep Open Water types, all of which together occupied 13% of the delta (Table 14). Most broods (17% of the total) were in Wet Sedge–Willow Meadow, but it was not preferred because it occupies the most area (19%) on the delta. Broods avoided Tidal Flat, River or Stream, Riverine or

Table 13. Distance to the nearest waterbody of Tundra Swan nests detected on aerial and ground surveys in the Delta survey area, Colville River, Alaska, 1989–1993 and 1995–1998 (Johnson et al. 1998, this study).

Nearest Waterbody Habitat	No. of Nests	Use (%)	Mean Distance[a] (km)
Brackish Water	29	14.3	0.11
Tapped Lake w/ Low-water Connection	31	15.3	0.10
Tapped Lake w/ High-water Connection	20	9.9	0.08
Deep Open Water w/o Islands	55	27.1	0.10
Deep Open Water w/ Islands or Polygonized Margins	17	8.4	0.04
Shallow Open Water w/o Islands	17	8.4	0.14
Shallow Open Water w/ Islands or Polygonized Margins	2	1.0	0.04
River or Stream	19	9.4	0.14
Aquatic Sedge Marsh	0	0	-
Aquatic Grass Marsh	13	6.4	0.07
Young Basin Wetland Complex	0	0	-
Old Basin Wetland Complex	0	0	-
Total	203	100	0.10

[a] Distance to nearest waterbody was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

Upland Shrub, and Barrens, which together compose 44% of the delta.

The preference for salt-affected habitats (Brackish Water, Salt Marsh, and Tapped Lake with Low-water Connection) by brood-rearing swans may reflect a seasonal change in distribution or habitat preference, in that 35% of all swan broods on the delta were in salt-affected habitats, compared with only 18% of all nests. Swan broods were found only slightly closer ($\bar{x}$ = 7 km; *n* = 133 broods) to the coast than nests ($\bar{x}$ = 7.2 km; *n* = 180 nests) suggesting that swans select different habitats between nesting and brood-rearing without moving closer to the coast.

All swan broods were found near (and often swimming in) waterbodies, and most were associated with saline waterbodies (Table 15). The mean distance of broods to a waterbody was 0.03 km (*n* = 142). Most broods were found in or near Tapped Lake with Low-water Connection (22% of 142 broods) and Brackish Water (22%). Deep Open Water without Islands, Tapped Lakes with High-water Connection, and Rivers or Streams were, in descending order of use, the three habitats most frequently occupied by the remaining broods.

Swan broods in northeast Alaska used different habitats as the brood-rearing season progressed (Monda et al. 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 methods may be related to nutritive quality of different plants or the increasing 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 submergent pondweed in late August and September in brackish water environments of river deltas in the Kobuk-Selawik Lowlands. On the Colville Delta, swans also favored pond weed during the brood-rearing and molting periods (Johnson and Herter 1989). Wilk (1988) describes spring-staging swans feeding on abundant pondweeds in tidally influenced habitat in the Naknek River. Monda et al. (1994) also found that pondweeds were an important component of the diet of swans on the Kongakut and Canning river deltas; pondweeds, along with another important food, alkali grass (*Puccinellia phryganodes*), grow well in salt-affected environments. Although we did not collect data on the feeding habits of swans, the use of salt-affected and aquatic marsh habitats by broods and

Table 14. Habitat selection (pooled among years) by Tundra Swans during brood-rearing in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998 (Johnson et al. 1998, this study). See Appendix C2 for 1998 results.

Habitat	Area (km^2)	No. of Broods	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.28	0	0	1.9	-1.00	ns
Brackish Water	6.50	9	6.8	1.2	0.70	prefer
Tapped Lake w/ Low-water Connection	21.40	18	13.5	3.9	0.55	prefer
Tapped Lake w/ High-water Connection	20.40	9	6.8	3.7	0.29	ns
Salt Marsh	16.36	9	6.8	3.0	0.39	prefer
Tidal Flat	55.99	1	0.8	10.2	-0.86	avoid
Salt-killed Tundra	25.62	11	8.3	4.6	0.28	ns
Deep Open Water w/o Islands	23.32	12	9.0	4.2	0.36	prefer
Deep Open Water w/ Islands or Polygonized Margins	5.15	8	6.0	0.9	0.73	prefer
Shallow Open Water w/o Islands	2.30	2	1.5	0.4	0.57	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.54	1	0.8	0.1	0.77	ns
River or Stream	81.88	5	3.8	14.8	-0.60	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.59	5	3.8	2.5	0.21	ns
Aquatic Grass Marsh	1.37	2	1.5	0.2	0.72	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	41.92	9	6.8	7.6	-0.06	ns
Wet Sedge–Willow Meadow	102.37	22	16.5	18.6	-0.06	ns
Moist Sedge–Shrub Meadow	13.40	2	1.5	2.4	-0.24	ns
Moist Tussock Tundra	2.53	0	0	0.5	-1.00	ns
Riverine or Upland Shrub	27.42	2	1.5	5.0	-0.54	avoid
Barrens (riverine, eolian, lacustrine)	79.03	6	4.5	14.3	-0.52	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	ns
Total	551.42	133	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated from broods.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than. availability, avoid = significantly less use than availability.

fall staging flocks on the Colville Delta suggests that some of the same plants are being sought on the Colville Delta.

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 also is an important nesting area for Yellow-billed Loons (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

The distribution of Yellow-billed Loons on the Colville Delta in 1998 was similar to that recorded on aerial surveys in 1993 and 1995–1997 (Smith et al. 1994; Johnson et al. 1998), and during ground studies in 1981, 1983, and 1984 (Rothe et al. 1983, North 1986). In all years, birds and their nests were concentrated in the central part of the delta, between

Table 15. Mean distance to the nearest waterbody of Tundra Swan broods detected on aerial and ground surveys in the Delta survey area, Colville River, Alaska, 1989–1993 and 1995–1998 (Johnson et al. 1998, this study).

	Delta		
Nearest Waterbody Habitat	No. of Broods	Use (%)	Mean Distance[a] (km)
Brackish Water	32	22.5	0.03
Tapped Lake w/ Low-water Connection	32	22.5	0.02
Tapped Lake w/ High-water Connection	19	13.4	0.04
Deep Open Water w/o Islands	25	17.6	0.02
Deep Open Water w/ Islands or Polygonized Margins	9	6.3	0
Shallow Open Water w/o Islands	5	3.5	0.03
Shallow Open Water w/ Islands or Polygonized Margins	1	0.7	0
River or Stream	16	11.3	0.08
Aquatic Sedge Marsh	0	0	-
Aquatic Grass Marsh	3	2.1	0.04
Young Basin Wetland Complex	0	0	-
Old Basin Wetland Complex	0	0	-
Total	142	100	0.03

[a] Distance to nearest waterbody was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

the Elaktoveach and Sakoonang channels (Figure 13). In 1998, we counted 36 Yellow-billed Loons during the aerial nesting survey, 23 of which were associated with 17 nests. The number of loons was lower in 1998 than counts made in 1993 or 1995–1997, but the number of nests found was the highest recorded in any year (Table 16). Densities of Yellow-billed loons in the Delta survey area ranged from 0.10 to 0.15 birds/km^2 during our six years of study. Similar densities have been reported for other Yellow-billed Loon nesting areas on the Arctic Coastal Plain of Alaska: Square Lake in the NPR–A (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 1996–1998, we revisited lakes where we had seen Yellow-billed Loon pairs but did not find nests during the initial aerial survey. During these second visits, we found an additional six nests in 1998, an additional four nests in 1997, and an additional five nests in 1996 that either had been missed or were initiated after the first survey (Table 16). With the additional nests found during revisit surveys in 1998, our total count of 23 Yellow-billed Loon nests for the delta survey area resulted in a density of 0.07 nests/km^2 and the highest count of nests recorded for the Colville Delta. During intensive ground surveys of the delta in 1983 and 1984, North (1986) found 19 and 20 nests, respectively.

In the Development Area in 1998, we counted 20 Yellow-billed Loons and 10 nests during the aerial nesting survey. The density of loonsin the Development Area (0.12 birds/km^2) was the lowest recorded since we began surveys in 1992, but the density of nests (0.06 nests/km^2) was higher than in any previous survey year (Table 16). With the addition of four nests found during revisit surveys, nest density was 0.08 nests/km^2. In 1998, nests were distributed throughout the central and eastern portions of the Development Area, unlike previous years when they were concentrated mostly in the eastern half (Figure 13). We found two nests in 1998 on lakes that had no previous nesting record from aerial or ground surveys and one nest on a lake where nesting had not been documented since 1984 (North et al. 1984a, Johnson et al. 1998).

During the aerial nesting survey in 1998, we found three Yellow-billed Loons in the Facility Area, two of which were a pair associated with a nest (Figure 13). In previous years in which the Facility Area was surveyed, we counted a similar number of loons and nests (Table 16). The lake where we found

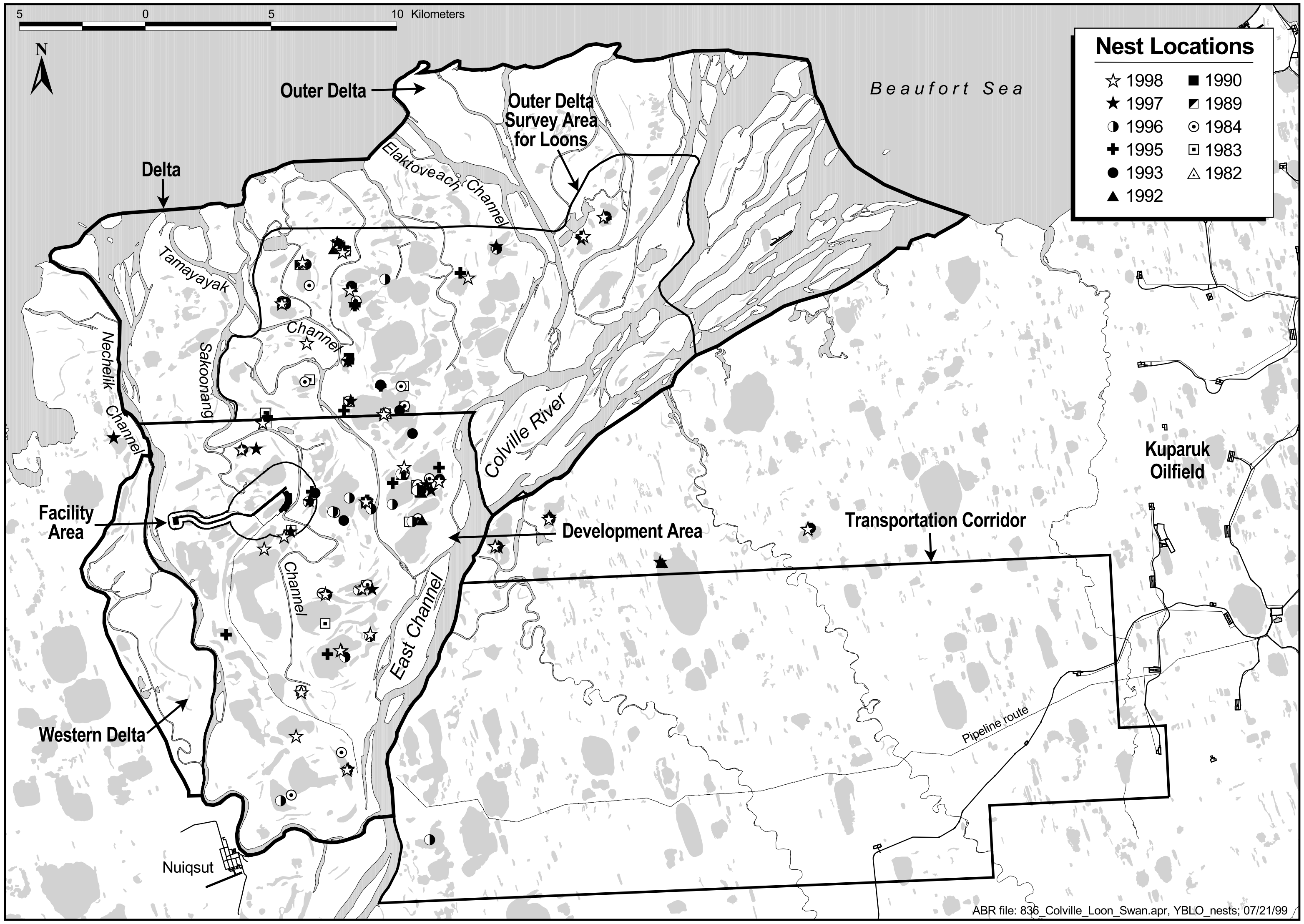

Figure 13. Distribution of Yellow-billed Loon nests observed during aerial and ground surveys in the Delta survey area, Colville River, Alaska, 1982–1984, 1989, 1990, 1992, 1993, and 1995–1998. The Transportation Corridor was surveyed in 1992, 1993 and 1995-1997. Locations are from M. North (1982–1984, 1989, 1990, unpubl. data), Smith et al. (1993, 1994), S. Earnst (1995–1997, unpubl. data), Johnson et al. (1998), and this study.

Table 16. Numbers and densities of loons and their nests counted on aerial surveys in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998 (Johnson et al. 1998, this study).

		Yellow-billed Loons				Pacific Loons[a]		Red-throated Loons[a]	
		Number		Density (no./km^2)		Number		Number	
Area	Year	Birds	Nests	Birds	Nests	Birds	Nests	Birds	Nests
Delta (323 km^2)									
	1998	36	17 (23)[b]	0.11	0.05 (0.07)[b]	71	13	3	0
	1997	48	10 (14)[b]	0.15	0.03 (0.04)[b]	103	26	6	1
	1996	45	12 (17)[b]	0.14	0.04 (0.05)[b]	74	18	4	2
	1995	39	11	0.12	0.03	62	10	11	0
	1993	49	11	0.15	0.03	130	24	44	0
	1992[c]	12	2	0.10	0.02	5	3	2	0
Development Area (169 km^2)									
	1998	20	10 (14)[b]	0.12	0.06 (0.08)[b]	40	7	3	0
	1997	29	6 (8)[b]	0.17	0.04 (0.05)[b]	61	14	0	0
	1996	30	8 (11)[b]	0.18	0.05 (0.07)[b]	59	13	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 km^2)									
	1998	3	1	0.34	0.11	1	0	0	0
	1997	2	0 (1)[b]	0.23	0 (0.11)[b]	1	0	0	0
	1996	3	1	0.34	0.11	5	1	0	0
	1995	2	1	0.23	0.11	0	0	0	0
	1993	2	1	0.23	0.11	8	0	0	0
	1992[c]	-	-	-	-	-	-	-	-
Outer Delta[d] (155 km^2)									
	1998	16	7 (9)[b]	0.10	0.05 (0.06)[b]	31	6	0	0
	1997	19	4 (6)[b]	0.12	0.03 (0.04)[b]	42	12	6	1
	1996	15	4 (6)[b]	0.10	0.03 (0.04)[b]	15	5	3	2
	1995	15	6	0.10	0.04	29	6	3	0
	1993	21	4	0.14	0.03	49	7	32	0
	1992[c]	8	1	0.09	0.01	5	3	2	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 km^2 were surveyed on the Delta, 93 km^2 were surveyed on the Outer Delta, 26 km^2 were surveyed in the Development Area, and the Facility Area was not surveyed.
[d] Portion of the Outer Delta described as the Loon Outer Delta survey area in Figure 13.

the 1998 nest also was used in 1983, 1996 (use assumed from presence of a brood), and 1997 (North et al. 1983, Johnson et al. 1998). In 1993, 1995, and 1996 we found a nest within the Facility Area on a lake east of the Sakoonang Channel. During the intensive aerial survey of the Facility Area in 1998, we found a nest just outside of the Facility Area on a lake bisected by its boundary. Yellow-billed Loon nests had not been observed on this lake previously.

The distribution of Yellow-billed Loons and nests on the Outer Delta (i.e., Loon Outer Delta survey area, Figure 13) was similar among years. We found most loons and nests confined to the area between the Tamayayak and Elaktoveach channels. In 1993, 1995, and 1998, we also found birds nesting east of the Elaktoveach Channel. Densities of Yellow-billed Loons on the Outer Delta ranged from 0.09 to 0.14 birds/km^2 for all years of study

(Table 16). Nest density was higher in 1998 (0.06 nests/km^2, including nests found during revisit surveys) than the four previous survey years when it was similar among those years. In 1992, only one nest was found in one of the two survey plots on the Outer Delta.

Our loon surveys focused on Yellow-billed Loons, which tend to nest on large lakes (>10 ha). 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 14, Table 16). Therefore, we have not calculated densities for these two species.

Pacific and Red-throated loons are more difficult to detect from aircraft than are Yellow-billed Loons because their smaller size and use of lakes with emergent vegetation decrease their detectability from aircraft. We flew the lake-to-lake survey pattern during the nesting season at a higher intensity (i.e., smaller lakes also were surveyed) in 1993 than in 1995–1998. This difference in survey intensity is reflected in the higher counts of Pacific and Red-throated loons in 1993 (Table 16). Although our counts are not adjusted for differences in detectability among loon species, Pacific Loons were the most abundant loon on the delta during each year of study and nesting was most common in the western and central part of the delta (Figure 14). Summarizing ground surveys on the delta, Rothe et al. (1983) reported similar findings and suggested that Pacific and Red-throated loon densities on the Colville Delta were comparable to other areas in the Arctic Coastal Plain. Density estimates from sample plots in 1981 were 1.5 birds/km^2 for Pacific Loons and 0.6 birds/km^2 for Red-throated Loon (Rothe et al. 1983). At Storkersen Point, 70 km east of the Colville Delta, Bergman and Derksen (1977) found similar Pacific Loon densities (1.6 birds/km^2) but higher Red-throated Loon densities (1.2–1.6 birds/km^2) during five years of study.

During the aerial survey for nests in 1998, we recorded one Pacific and no Red-throated loons in the Facility Area. In previous years, counts of Pacific Loons ranged from zero to eight birds and a nest was found in 1996 (Table 16). We found no Red-throated Loons during surveys in 1993 and 1995–1997. During the intensive helicopter survey for loons in the Facility Area in 1998, we recorded 10 Pacific Loons and 2 nests. We found the same number of birds and nests on the 1997 intensive loon survey and counted six Pacific Loons and one nest on the 1996 intensive loon survey. For Red-throated Loons, we saw two birds during the 1998 intensive loon survey and no birds on the 1996 or 1997 surveys.

Brood-rearing

The distribution of brood-rearing Yellow-billed Loons on the Colville Delta in 1998 was similar to that during nesting and also similar to the distribution of nesting and brood-rearing Yellow-billed loons in previous survey years (Figure 15). We counted 54 adult Yellow-billed Loons and 12 broods during the 1998 brood-rearing survey; all broods were associated with nesting lakes located during the nesting survey. Most nesting lakes where we did not find broods were still occupied by Yellow-billed Loon pairs. Adults with young remain on or near the nest lake during brood-rearing (North and Ryan 1989), while non-nesting and failed breeders maintain their territories throughout the summer (North and Ryan 1988). The density of Yellow-billed Loons on the delta during brood-rearing in 1995–1998 was nearly twice that in 1992 or 1993 (Table 17). In 1995–1998, we conducted surveys using a helicopter, rather than a fixed-wing aircraft, as the survey platform; this difference probably contributed to the higher bird count in those years.

Our count of 12 Yellow-billed Loon broods and 15 young on the delta in 1998 was the highest number of broods recorded during our six years of surveys (Table 17). The only other survey year that had a similar number of broods was 1995, when we counted 11 broods and 15 young. In all other years, we counted between one and seven broods. In 1984, North (1986, derived from Table 10) found 12 broods and 16 young during intensive ground surveys of the delta. Brood density on the delta during our six years of surveys ranged from 0.01 to 0.04 broods/km^2. In 1995, 1997, and 1998, we observed broods of >1 young. At the time of our

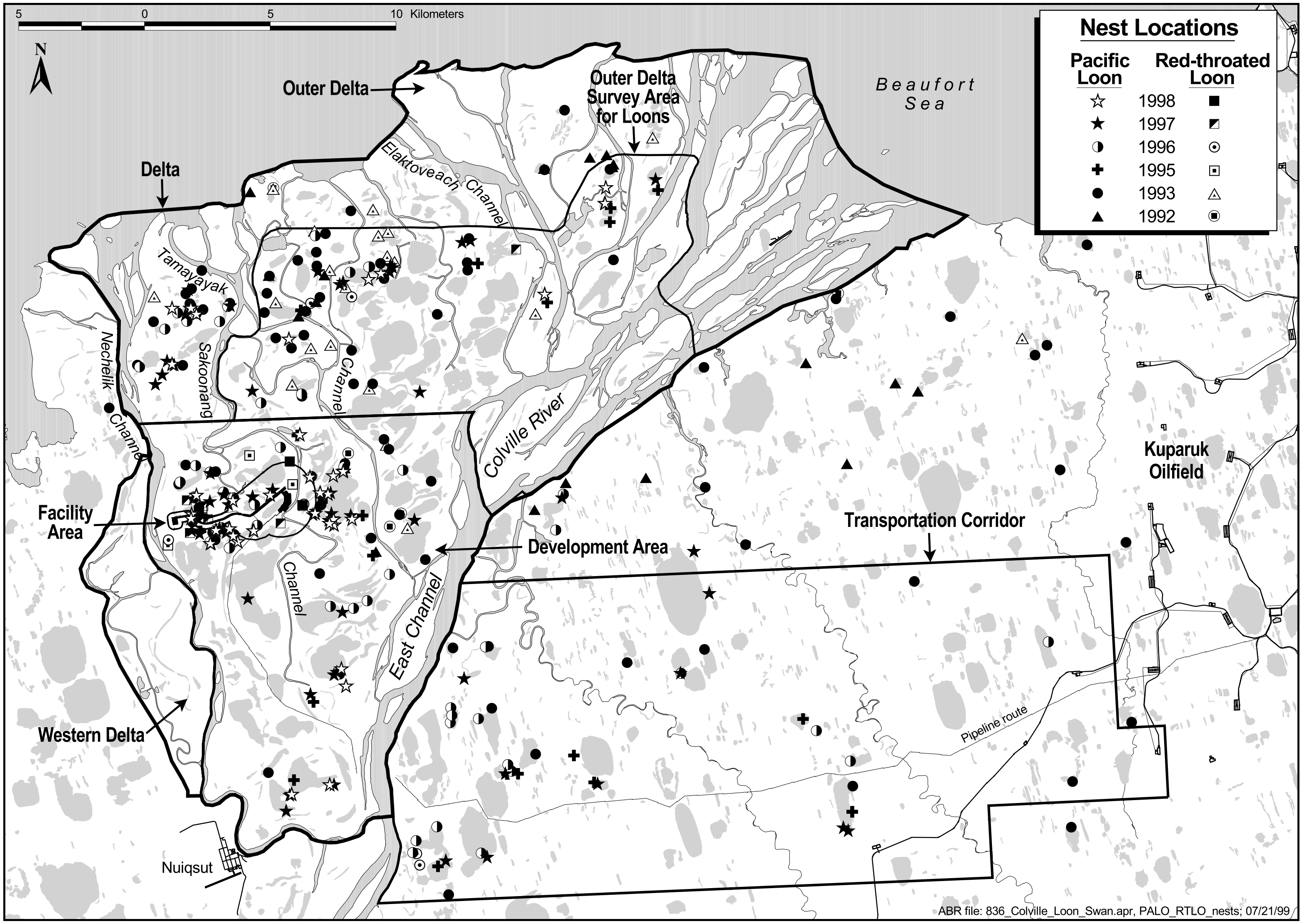

Figure 14. Distribution of Pacific and Red-throated loon nests observed during aerial and ground surveys in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998. The Transportation Corridor was surveyed in all the same years except 1998. Locations are from Smith et al. (1993, 1994), Johnson et al. (1998), and this study.

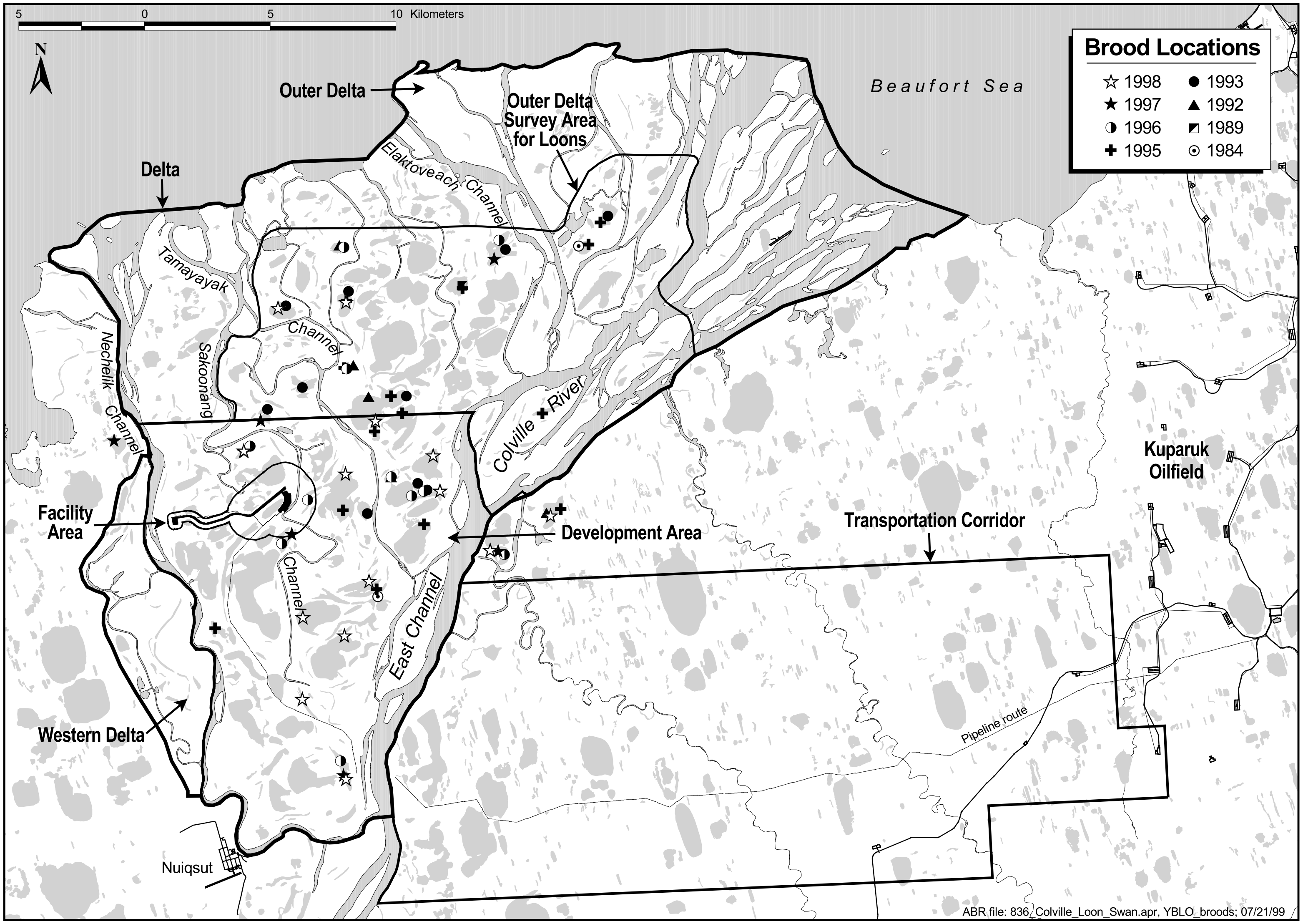

Figure 15. Distribution of Yellow-billed Loon broods observed during aerial and ground surveys in the Delta survey area, Colville River, Alaska, 1984, 1989, 1992, 1993, and 1995–1998. The Transportation Corridor was surveyed in 1992, 1993 and 1995-1997. Locations are from M. North (1984, 1989, unpubl. data), Smith et al. (1993, 1994), S. Earnst (1996, unpubl. data), Johnson et al. (1998), and this study.

Table 17. 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 1995–1998, in the Delta survey area, Colville River, Alaska (Johnson et al. 1998, this study).

		Yellow-billed Loons					Pacific Loons[a]			Red-throated Loons[a]		
		Number			Density (no./km^2)		Number			Number		
Area	Year	Adults	Broods	Young	Birds	Broods	Adults	Broods	Young	Adults	Broods	Young
Delta (323 km^2)												
	1998	54	12	15	0.17	0.04	129	31	34	15	8	11
	1997	65	5	8	0.20	0.02	153	15	17	24	5	6
	1996	62	6	6	0.19	0.02	89	25	30	19	6	9
	1995	49	11	15	0.15	0.03	182	34	40	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 km^2)												
	1998	31	10	13	0.18	0.06	100	23	26	12	6	9
	1997	38	4	7	0.23	0.02	91	12	14	19	5	6
	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 km^2)												
	1998	2	0	0	0.23	0	6	1	1	0	0	0
	1997	4	1	2	0.46	0.11	0	0	0	3	1	2
	1996	0	0	0	0	0	8	2	3	1	0	0
	1995	0	0	0	0	0	3	1	2	0	0	0
	1993	0	0	0	0	0	0	0	0	0	0	0
	1992[b]	-	-	-	-	-	-	-	-	-	-	-
Outer Delta[c] (155 km^2)												
	1998	23	2	2	0.15	0.01	29	8	8	3	2	2
	1997	27	1	1	0.17	0.01	62	3	3	5	0	0
	1996	32	3	3	0.21	0.02	20	4	4	6	1	1
	1995	24	7	9	0.16	0.05	92	22	26	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

[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 km^2 were surveyed on the Delta, 93 km^2 were surveyed on the Outer Delta, 26 km^2 were surveyed in the Development Area, and the Facility Area was not surveyed.
[c] Portion of the Outer Delta described as the Loon Outer Delta survey area in Figure 15.

brood-rearing surveys, chicks were about 2 to 6 weeks of age, based on estimated hatch dates from 11 to 28 July (North and Ryan 1988).

In the Development Area, we counted 31 adult Yellow-billed Loons and 10 broods during the 1998 brood-rearing survey (Figure 15). The number of loons recorded in 1998 was within the range of the number of birds found during surveys in 1995–1997, when a helicopter also was used as the survey platform (Table 17). We found more than twice the number of broods in the Development Area in 1998 than in any other survey year. Brood density in 1998 was 0.06 broods/km^2 compared to 0.02 broods/km^2 in 1993 and 1995–1997.

In the Facility Area, we found two Yellow-billed Loons and no broods during the aerial brood-rearing survey in 1998. On the same survey, we saw a pair of loons with a brood of two young on a large lake just east of the Facility Area (Figure 15). In 1997, we found two pairs of adult loons in the Facility Area, one of which had a brood with two young. In 1993, 1995, and 1996, we saw no Yellow-billed Loons or broods in the Facility Area during the brood-rearing survey.

We counted 23 Yellow-billed Loons and found 2 broods on the Outer Delta during brood-rearing in 1998 (Figure 15). The density of adults in 1998 was similar to that in 1995–1997 (Table 17). In 1993, when we surveyed the Outer Delta by fixed-wing aircraft, the density of adults was about half that in 1995–1998, and in 1992, when we surveyed sample plots, the density was about one-sixth that in 1995–1998. Brood densities varied from 0.01 to 0.05 broods/km^2 during our 6 years of study, regardless of the survey method. The highest number of broods recorded for the Outer Delta was in 1995, when seven broods were seen.

In 1998, we found Pacific and Red-throated loons and their broods throughout the Delta survey area (Figure 16). The numbers of birds and broods for both species were higher in the Development Area than on the Outer Delta in 1996–1998 (Table 17). These numbers, 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; thus, because our survey did not include all waterbodies, some broods were missed. Moreover, 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 1998, we counted six adult Pacific Loons and one brood during the aerial brood-rearing survey. The highest count of Pacific Loons and broods in the Facility Area occurred in 1996 when we recorded eight adults and two broods (Table 17). In 1993 and 1997, we recorded no Pacific Loons or broods. We saw Red-throated Loons in the Facility Area in only two survey years; in 1996, we recorded one adult and in 1997, we found three adults and one brood.

HABITAT SELECTION

Nesting

During five years of aerial surveys on the delta (1993, 1995–1998), 74 Yellow-billed Loon nests were found in 7 of 19 available habitats (Table 18). Habitat selection values for 1998 are reported in Appendix C3, and annual values for previous years were reported by Johnson et al. (1996, 1997, 1998). Three preferred habitats accounted for 48 (65%) of the 74 nests: Deep Open Water with Islands or Polygonized Margins, Aquatic Sedge with Deep Polygons, and Wet Sedge–Willow Meadow. Nests were built on peninsulas, shorelines, islands, or in emergent vegetation; the latter two types could be classified as part of a waterbody at the scale of our habitat map. Wet Sedge–Willow Meadow was the habitat most frequently used for nesting (42% of all nests), and it was the most abundant habitat on the delta (25% of total area). A larger sample of nests (combined from aerial and ground surveys) confirmed the importance of Wet Sedge–Willow Meadow; it was used 4× as frequently (47% of all nests) as any other habitat (Table 19). Nesting Yellow-billed Loons significantly avoided four habitats—Tapped Lake with Low-water Connection, River or Stream, Riverine or Upland Shrub, and Barrens—that were unused and occupied a large portion of the delta (41% of the total).

Because Yellow-billed Loons usually raise broods on the lakes where 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. Nests found during our study occurred most commonly near Deep Open Water without Islands (52% of all nests), Tapped Lake with High-water Connection (25%), and Deep Open Water with Islands or Polygonized Margins (20%) (Table 19). Measurements of the distance from the nest to the nearest waterbody were not recorded during aerial surveys, but all nests were close (≤1m) to water. During ground surveys in the Facility Area in 1996–1998, we found Yellow-billed Loon nests (n = 5) within 1 m of permanent water. Other ground-based studies of nesting Yellow-billed Loons on the Arctic Coastal Plain found nests occurring within 2 m of water (Sage 1971, Sjolander and Agren 1976, North and Ryan 1989).

North (1986) found that similar waterbody types were used by nesting Yellow-billed Loons on the Colville Delta in 1983 and 1984. Forty-eight percent of 23 nests occurred on Deep-*Arctophila* lakes, 39% were on Deep-Open lakes, and <1% were on ponds <0.5 ha in size, ponds 0.5–1.0 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

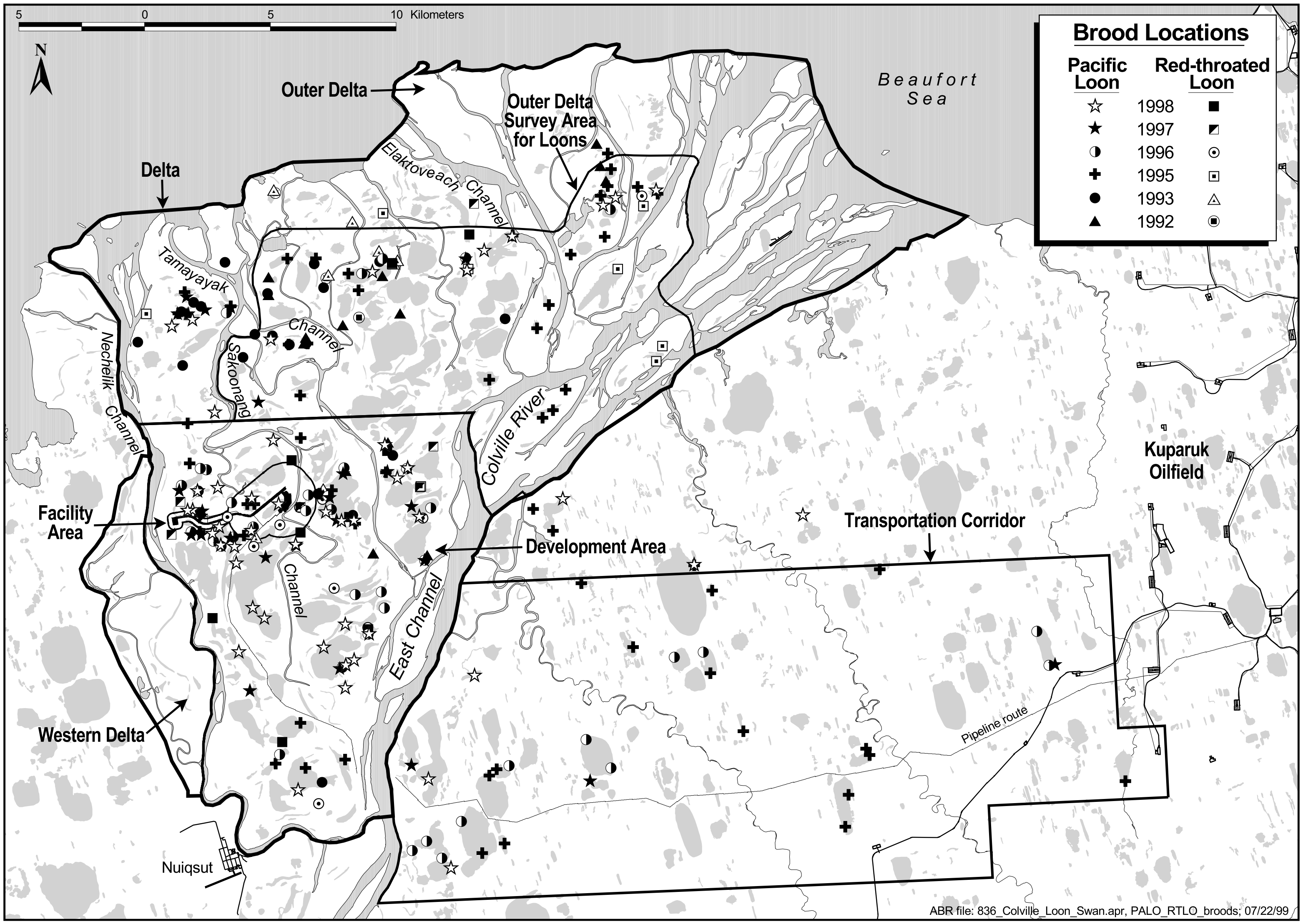

Figure 16. Distribution of Pacific and Red-throated loon broods observed during aerial and ground surveys in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998. The Transportation Corridor was surveyed in all the same years except 1998. Locations are from Smith et al. (1993, 1994), Johnson et al. (1998), and this study.

Table 18. Habitat selection (pooled among years) by nesting Yellow-billed Loons in the Delta survey area, Colville River, Alaska, 1993, and 1995–1998 (Johnson et al. 1998, this study). See Appendix C3 for 1998 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	avoid
Tapped Lake w/ High-water Connection	19.57	9	12.2	6.1	0.34	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	8	10.8	6.5	0.25	ns
Deep Open Water w/ Islands or Polygonized Margins	3.58	9	12.2	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	avoid
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	10.00	8	10.8	3.1	0.56	prefer
Aquatic Grass Marsh	1.20	1	1.4	0.4	0.57	ns
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	8	10.8	9.2	0.08	ns
Wet Sedge–Willow Meadow	80.84	31	41.9	25.0	0.25	prefer
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	avoid
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	avoid
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	74	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated from nests.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

Connections that we have described. Although North and Ryan (1988) reported that Yellow-billed Loons did not nest on tapped lakes, they did not discriminate 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 our 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.

Brood-rearing

During aerial surveys in 1995–1998, we found 34 Yellow-billed Loon broods in three habitats on the delta (Tapped Lake with High-water Connection and both types of Deep Open Water), all of which were preferred (Table 20). Deep Open Water without Islands was used by most broods (65%), followed by Tapped Lake with High-water Connection (23%) and Deep Open Water with Islands or Polygonized Margins (12%). No shallow-water habitats were used during brood-rearing. River or Stream, Wet Sedge–Willow Meadow, and Barrens, the three most abundant habitats in the survey area, were the only habitats avoided by loons during brood-rearing on the delta. The concurrence of habitats preferred

Table 19. Habitat use by nesting Yellow-billed Loons from aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River, Alaska, 1992, 1993, 1995–1998 (S. Earnst 1995–1997, unpubl. data; Johnson et al. 1998; this study).

Habitat	No. of Nests	Use (%)
HABITAT USED		
Tapped Lake w/ High-water Connection	11	10
Deep Open Water w/o Islands	9	8
Deep Open Water w/ Islands or Polygonized Margins	12	11
Aquatic Sedge w/ Deep Polygons	11	10
Aquatic Grass Marsh	1	1
Nonpatterned Wet Meadow	11	10
Wet Sedge–Willow Meadow	50	47
Moist Sedge–Shrub Meadow	1	1
Total	106	100
NEAREST WATERBODY HABITAT		
Tapped Lake w/ High-water Connection	27	25
Deep Open Water w/o Islands	55	52
Deep Open Water w/ Islands or Polygonized Margins	21	20
Shallow Open Water w/o Islands	2	2
Aquatic Grass Marsh	1	1
Total	106	100

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 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 (>1,100; USFWS, unpubl. data) on the delta are located within a colony or group of colonies (hereafter, the Anachlik Colony-complex) consisting of at least nine islands centered around Anachlik Island near 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 (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 other islands. Additional nesting locations for Brant are scattered across the delta, primarily in the northern half (Smith et al. 1993, 1994; Johnson et al. 1996, 1997).

After eggs hatch in early July, most brood-rearing groups of Brant move from nesting areas to salt marshes along the coast. A large percentage (>50%; J. Helmericks, pers. comm.) of brood-rearing groups from the Anachlik Colony-complex moves northeast towards Oliktok and Milne points (Stickney et al. 1994, Anderson et al. 1997). Some remain on Anachlik Island, and others move to the area northwest of the East Channel (J. Helmericks, pers. comm.). Brant from the smaller colonies probably use salt marshes from the Elaktoveach Channel west to 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- to late August (Johnson and Herter 1989), and major river deltas,

Table 20. Habitat selection (pooled among years) by Yellow-billed Loons during brood-rearing in the Delta survey area, Colville River, Alaska, 1995–1998 (Johnson et al. 1998, this study). See Appendix C3 for 1998 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	8	23.6	6.1	0.59	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	22	64.7	6.5	0.82	prefer
Deep Open Water w/ Islands or Polygonized Margins	3.58	4	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	avoid
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	avoid
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	34	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated from broods.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

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

During aerial surveys of the Delta survey area in 1998, we counted 91 Brant nests at 21 locations, excluding the Anachlik Colony-complex (Figure 17). We saw 285 Brant on the delta during the aerial survey. Our count of nests was similar to that in 1997, and more than twice that counted in 1995 and 1996. However, Brant numbers were almost half those in 1997, but were more than 60% greater than those in 1995 and 1996 (Table 21). In 1998, Brant occupied 17 of 27 nesting locations (consisting of ≥1 nest each) previously identified on the delta (excluding the Anachlik Colony-complex) and four new nesting locations. Some of the new nesting locations may represent a shifting of birds from previous nearby locations. The increase in the total number of nesting colonies in 1998 probably represents normal annual variation in nesting activity by Brant.

The Brant observed during nesting in 1998 were associated mainly with colonies; only one location with 15 birds may have been a flock of failed or non-breeders as no nests were seen. In 1997, a few large (≥80 birds) groups of non-breeders were observed; these may have been from the Kuparuk

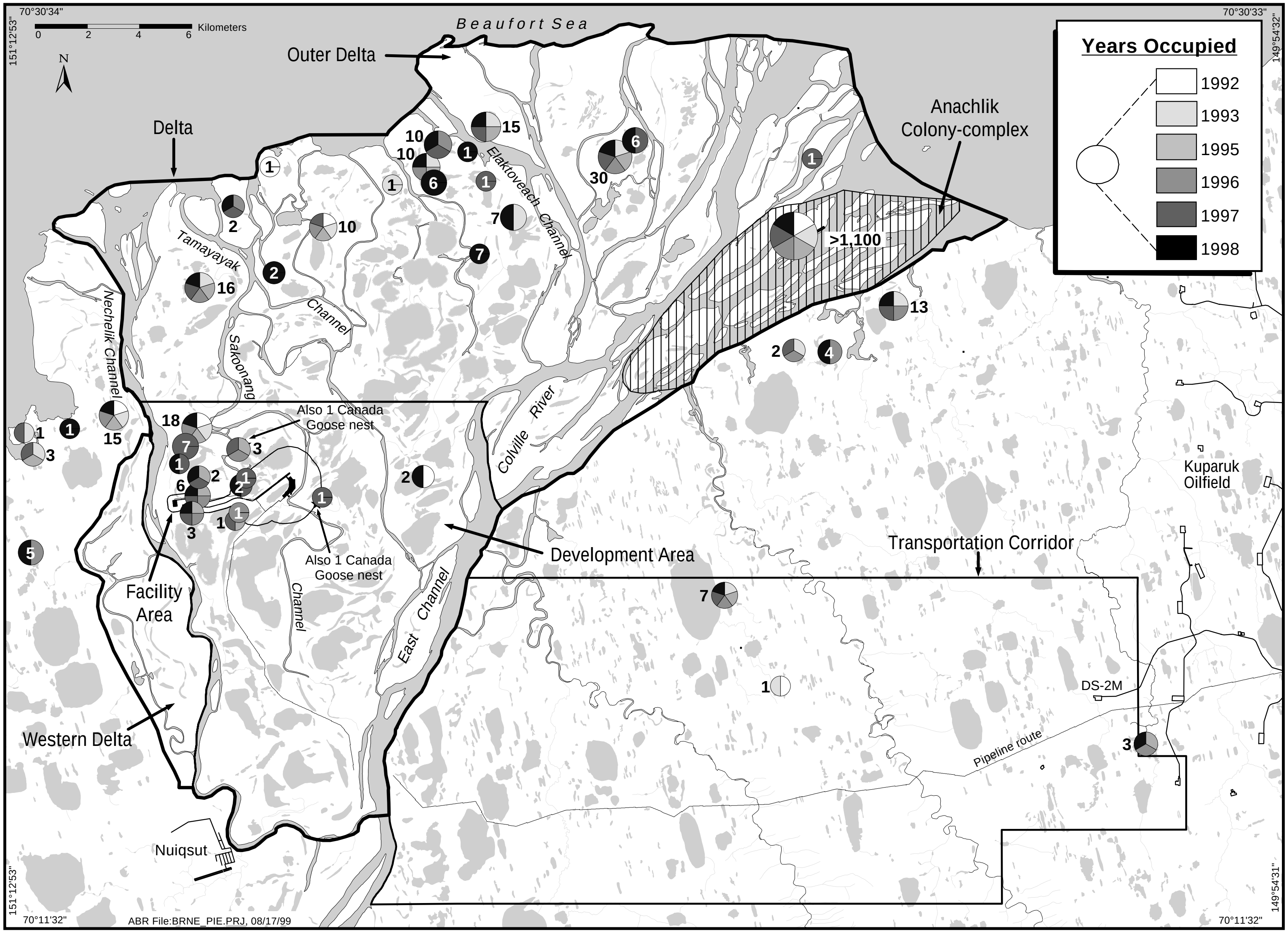

Figure 17. Distribution and nest counts of Brant colonies during aerial and ground surveys in the Delta and Transportation Corridor survey areas, Colville River, Alaska, 1992, 1993, and 1995–1998. Canada goose nests are reported for 1998 only. Locations are from Smith et al. (1993, 1994), Johnson et al. (1998), and this study. The number near each circle represents the maximal number of nests counted during the six years of study.

Table 21. Distribution and abundance of Brant, nesting locations, nests, and adults counted during aerial surveys on the Colville River Delta, Alaska, 1992, 1993, 1995–1998 (Johnson et al. 1998, this study).

Survey Area	Year	No. of Locations	No. of Nests	No. of Adults
Delta	1998	22	91	285
	1997	14	87	547
	1996	9	34	95
	1995	6	19	72
	1993	6	52	202
	1992	2	8	297
Development Area	1998	8	19	39
	1997	5	12	4
	1996	3	20	38
	1995	1	7	18
	1993	1	10	20
	1992	1	5	10
Facility Area[a]	1998	1	2	2
	1997	3	3	4
	1996	1	1	1
	1995	1	1	1
	1993	0	0	0
	1992	0	0	0
Outer Delta	1998	14	72	246
	1997	9	75	543
	1996	6	14	57
	1995	5	12	54
	1993	5	42	182
	1992	1	3	287

[a] The Facility Area includes observations from both aerial and ground surveys (see Johnson et al. 1998, 1999).

Oilfield or Howe Island in the Sagavanirktok River Delta. This latter colony was disrupted by bear preying on nests early during incubation (Lynn Noel, LGL Alaska Research Associates, pers. comm.). In 1998, the large Anachlik Colony-complex experienced predation by both bears and Golden Eagles, but this predation apparently occurred after our nesting survey.

We recorded eight Brant nesting locations in the Development Area during aerial surveys in 1998 (Figure 17), less than the 10 locations recorded in 1997, but greater than the 1–5 colonies counted in previous years (Johnson et al. 1998). We found one Brant nesting location (two nests) in the Facility Area in 1998, and four locations (1–3 nests each) just outside its boundary (Figure 18). In 1997, three nesting locations (of one nest each) were found within the Facility area, but in both 1995 and 1996, only one nest was found in the same area.

In 1998, more than half (13) of the Brant nesting locations, excluding the Anachlik Colony-complex, occurred on the Outer Delta (Figure 17). In previous years, we found Brant at 2–9 colonies in this area. The distributional patterns that we have observed in all years on the delta were consistent with longer-term studies conducted between the Colville and Kuparuk rivers that found that most (≥75%) Brant nest within 5 km of the coast (Stickney et al. 1994); the percentage on the Colville Delta is >90% because of the size of the Anachlik Colony-complex.

Brood-rearing

Data from both a multi-year banding study in the neighboring oilfields and our surveys indicate

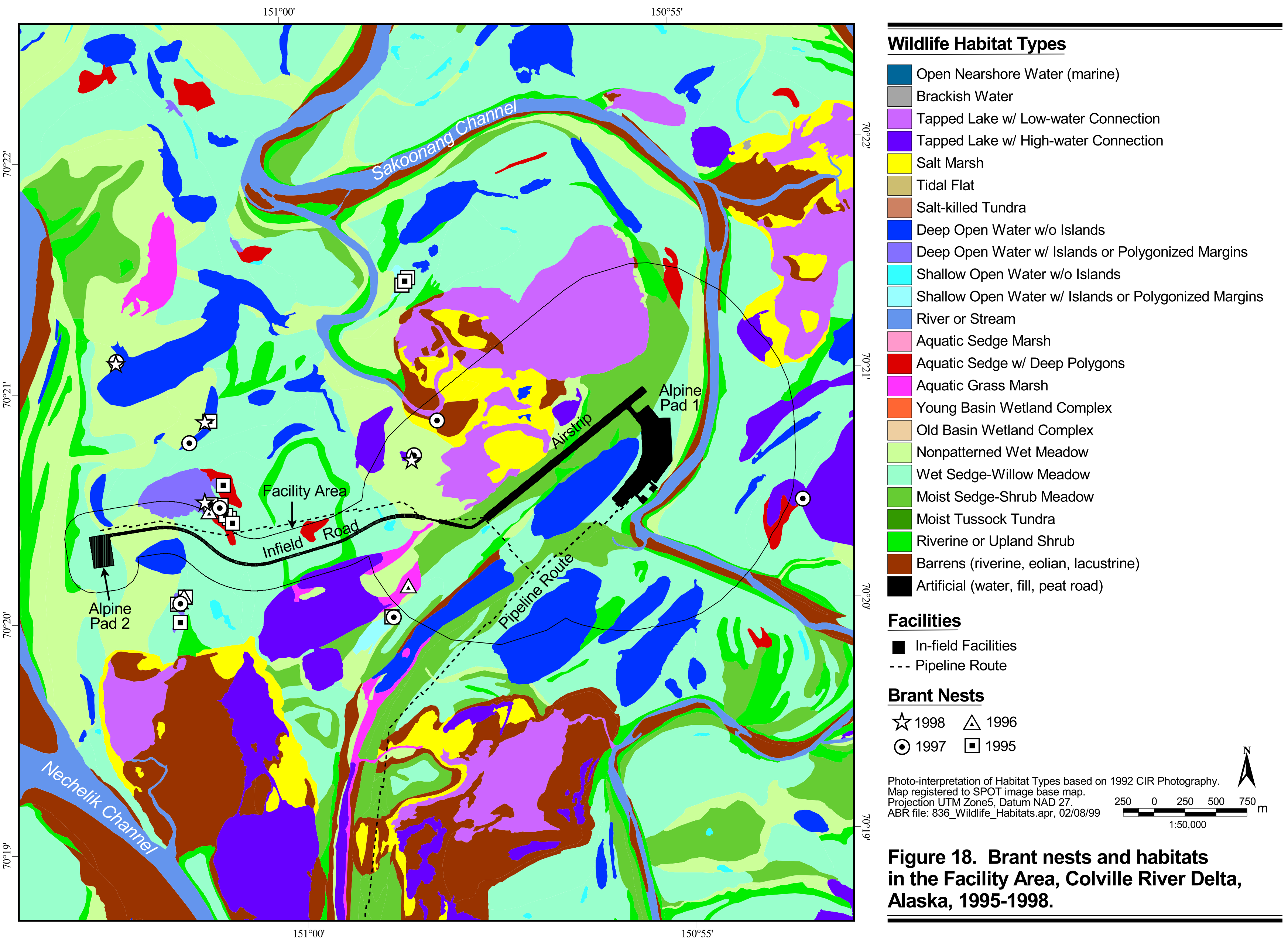

Figure 18. Brant nests and habitats in the Facility Area, Colville River Delta, Alaska, 1995-1998.

that brood-rearing groups of Brant from the Colville Delta disperse as far east as the Kuparuk River delta (Anderson et al. 1996, Martin and Nelson 1996, Martin et al. 1997), and as far west as the Tingmeachsiovik River (Smith et al. 1994). On the delta in 1998, we counted 1,974 Brant (836 adults/subadults and 1,138 goslings) at 13 locations during a systematic survey for geese (Figure 19, Table 22). The size of Brant flocks during brood-rearing ranged from 36 to 280 birds, and the mean percentage of goslings was 62% (range = 48–78%, n = 13 groups), compared to 48–52% goslings in previous years.

The number of Brant observed on the delta during brood-rearing in 1998 was the highest count since surveys were started by USFWS in 1988 (Table 22). The high number probably reflected moderate productivity at the still-growing Anachlik Colony-complex despite the predation that occurred on some of the outer islands (USFWS, unpubl. data), and a shift in distribution of brood-rearing groups. The number of Brant observed between the Elaktoveach and Nechelik channels was the largest ever recorded, while aerial surveys in the Kuparuk Oilfield indicated that only moderate numbers (701) had moved from the Anachlik Colony-complex to brood-rearing areas between Oliktok and Milne points, usually a primary destination for brood-rearing groups from that colony (ABR, unpubl. data). The second largest count of adults and goslings on the delta during brood-rearing occurred in 1995, when 1,480 birds were seen, and the lowest count occurred in 1992, when only 45 adults and no goslings were seen. The absence of goslings in 1992 was due, in part, to predation of nests in the Anachlik Colony-complex by a bear (J. Helmericks, pers. comm.).

Unlike 1997, when a small brood-rearing group was observed during ground surveys in the Development Area, we saw no Brant in this area in 1998. The predominant pattern for most Brant is to rear their broods along the coast (Stickney and Ritchie 1996). A study in the adjacent Kuparuk Oilfield found four of six radio-tagged Brant that nested inland reared their broods on inland lakes (Stickney 1997), but these Brant were in small brood-rearing groups (<10 broods) and represented only a small percentage of all brood-rearing Brant in the oilfield.

Fall Staging

During fall staging in 1998, we saw 293 Brant in 11 locations on the delta (Figure 20), and group sizes ranged from 6 to 80 birds ($\bar{x}$ = 27 birds). The number of Brant counted on the delta during this coastal survey in 1998 was lower than in 1996 (1,327 birds), 1995 (469 birds), and 1993 (355 birds), but was higher than in 1992 (200 birds) and 1997 (227 birds). A systematic, delta-wide survey (50% coverage) for staging geese conducted one day prior to the coastal survey in 1998 recorded 339 Brant at 15 locations, similar to the systematic

Table 22. Abundance, distribution, and percentage of goslings in brood-rearing groups of Brant on the Colville River Delta, Alaska, during late July–early August. Data for years prior to 1992 are from Bayha et al. (1992); data for 1992, 1993, and 1995–1998 are from ABR (unpubl. data) and this study.

Year	East Channel to Elaktoveach Channel	Elaktoveach Channel to Nechelik Channel	Total Birds	No. of Groups	Percent Goslings
1998	1,040	934	1,974	13	62
1997	242	180	422	8	40
1996	490	503	993	7	52
1995	1,175	305	1,480	6	48
1993	590	130	720	5	52
1992	0	45	45	2	0
1991[a]	410	100	510	no data	no data
1990[a]	433	195	628	no data	no data
1988[a]	70	103	173	no data	no data

[a] Counts were a mean of two surveys, except in 1991, when one survey was conducted between the Elaktoveach and Nechelik channels.

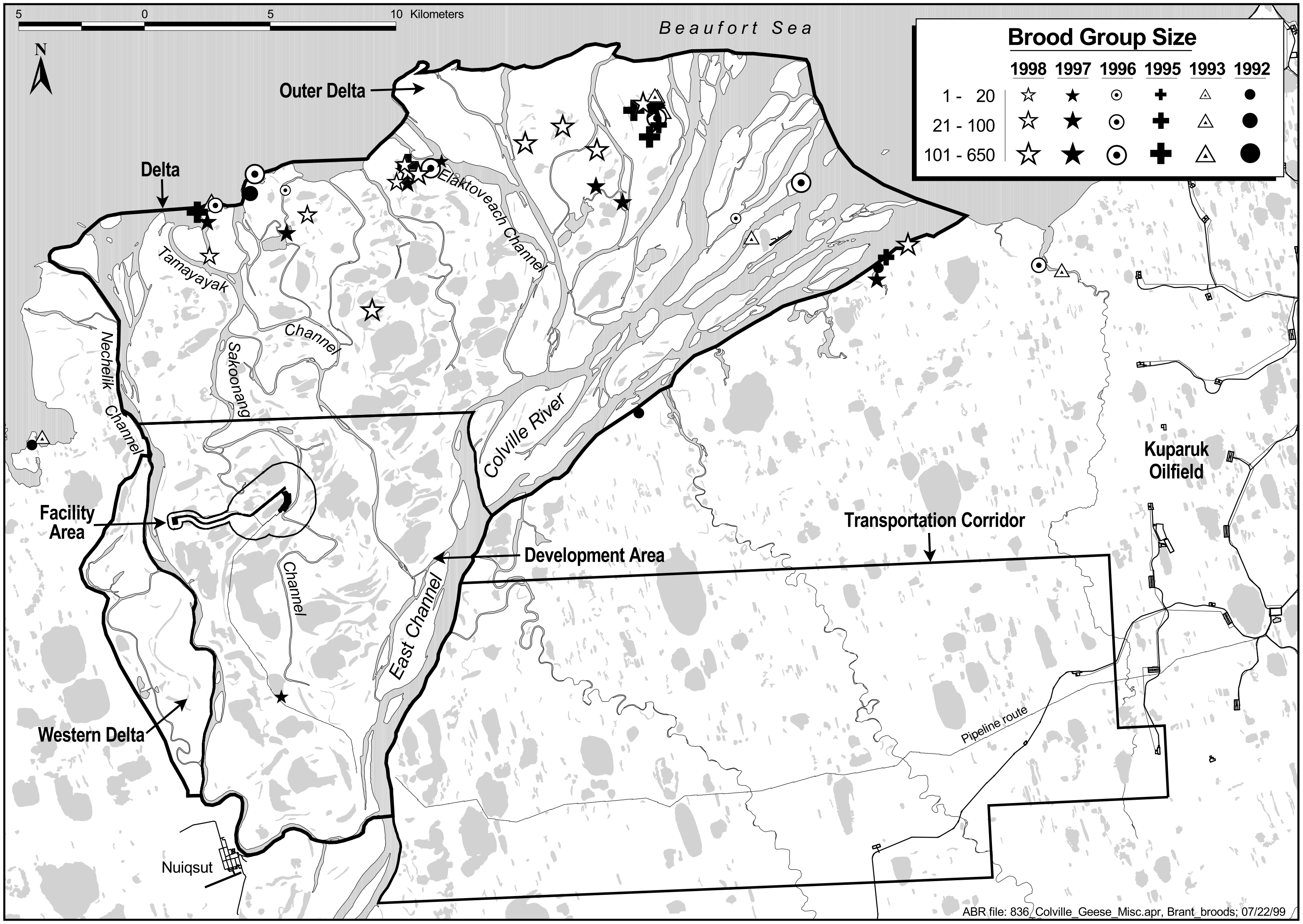

Figure 19. Distribution and size of Brant brood-rearing groups observed during aerial surveys in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998. Locations are from Smith et al. (1993, 1994), Johnson et al. (1998), and this study.

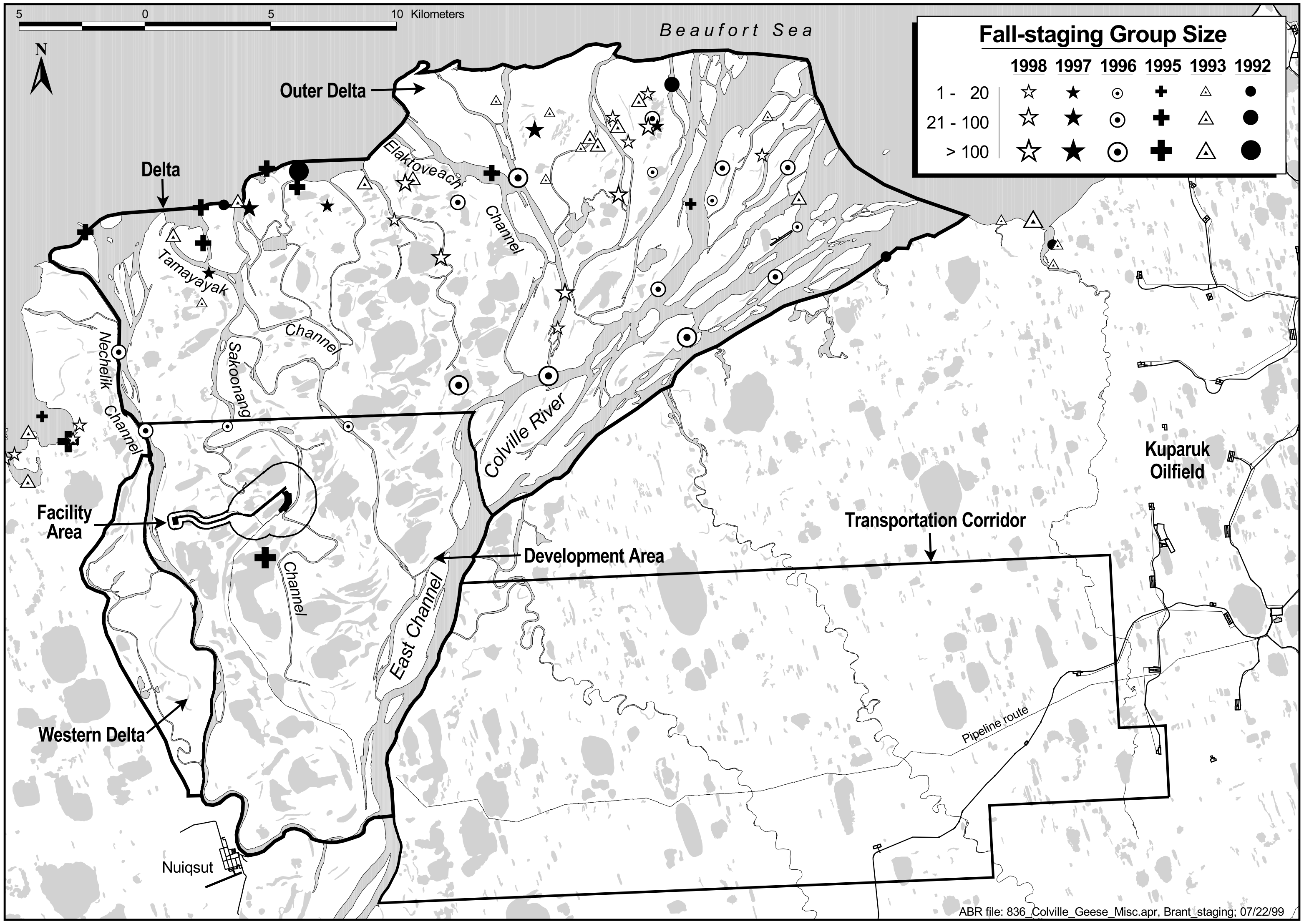

Figure 20. Distribution and size of Brant fall-staging groups observed during aerial surveys in the Delta survey area, Colville River, Alaska, 1992, 1993, and 1995–1998. Locations are from Smith et al. (1993, 1994), Johnson et al. (1998), and this study.

survey in 1997 (387 birds at 15 locations). The difference in numbers between survey types probably reflects differences in methodology, but also may indicate daily variations in use (i.e., some groups seen during the systematic survey had departed the delta prior to the coastal survey).

We saw no Brant either in the Facility Area or Development Area during the coastal survey for fall staging in 1998 (Figure 20), but we did record one group of 20 within the Development Area during the systematic survey. In 1996, we saw three groups in the Development Area, and we saw one group just south of the Facility Area in 1995.

HABITAT SELECTION

Brant primarily use coastal areas during nesting, brood-rearing, and fall staging (Figures 17, 19, and 20). 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, and 1995–1998; the brood-rearing analysis included 1992, 1993, 1995, 1996, and 1998 (in 1997, we did not conduct a comparable coastal survey).

Nesting

Seventeen colonies (excluding the Anachlik Colony-complex) comprising 114 nests (maximal estimate among all years) have been used by nesting Brant in that part of the Outer Delta that was surveyed consistently among years (Table 23). At those colonies, nesting Brant used 6 of 21 available habitats, and 2 of those habitats—Salt-killed Tundra and Aquatic Sedge with Deep Polygons—were preferred. These two habitats contained the most

Table 23. Habitat selection by nesting Brant (based on the cumulative locations of colonies) in the Outer Delta survey area, Colville River, Alaska, 1993, and 1995–1998 (Johnson et al. 1998, this study).

Habitat	Area (km^2)	Max. 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	0	0	4.2	-1.00	ns
Brackish Water	6.41	8	2	11.8	2.6	0.64	ns
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	21	3	17.7	5.2	0.54	ns
Tidal Flat	55.89	0	0	0	22.3	-1.00	avoid
Salt-killed Tundra	23.25	41	6	35.3	9.3	0.58	prefer
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	0	0	0	1.1	-1.00	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	avoid
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	7.62	13	4	23.5	3.0	0.77	prefer
Aquatic Grass Marsh	0.37	0	0	0	0.1	-1.00	ns
Young Basin Wetland Complex	0	-	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	-	0	-	-
Nonpatterned Wet Meadow	15.33	16	1	5.9	6.1	-0.02	ns
Wet Sedge–Willow Meadow	16.55	15	1	5.9	6.6	0.06	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	ns
Total	250.25	114	17	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated for number of colony locations only.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

colonies (6 and 4 colonies, respectively), and Salt-killed Tundra contained more nests (41) than all other habitats. Tidal Flats and River or Stream were the only habitats avoided. Basin Wetland Complexes, which typically are favored by Brant elsewhere on the Arctic Coastal Plain (Stickney and Ritchie 1996), were not available in the Outer Delta survey area.

The islands in the Anachlik Colony-complex, which contain nearly 1,200 nests, consist of large areas 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 waters (Table 24). No quantitative information is available on the location of nests in these habitats, so they were not included in our selection analysis. Several islands that supported colonies (e.g., Plover, Swan, and Turnstone islands) contain large proportions of Barrens, but only on Brant Island and Salt Grass Dunes, where only Barrens and Tidal Flat occur, are Brant known to nest almost exclusively in Barrens. An unknown proportion of the Brant on Char Island also nest in Barrens, but more nests in this colony are located in the adjacent Salt Marsh. The use of Barrens by Brant in the Anachlik Colony-complex is notable because Brant did not nest in this habitat elsewhere on the delta (Table 23).

Surveys of nesting Brant from Prudhoe Bay to as far west as Kasegaluk Lagoon indicate that islands at the mouths 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, which provides some protection from terrestrial predators such as arctic foxes, and that feature may be more important to nesting Brant than the specific habitats occupying the islands. Isolated barrier islands also are used by Brant nesting in Kasegaluk Lagoon in northwestern Alaska (Divoky 1978, Lehnhausen and Quinlan 1981, Ritchie 1996) and those nesting off the coast of the oilfields on the Niakuk Islands and other areas of the arctic coast (Johnson and Herter 1989; Ritchie et al. 1990; ABR, unpubl. data). These islands usually are composed of sand or gravel, with minimal vegetation, similar to the Barrens habitat used by Brant in the Anachlik Colony-complex.

We collected detailed information on the habitat of 25 individual nests located during ground searches in the Development Area in 1995–1998 (Table 25). Over 80% of the nests were in Deep Open Water with Islands or Polygonized Margins (10 nests), Aquatic Sedge with Deep Polygons (5 nests) and Non-patterned Wet meadow (5 nests). Additional nests were in Shallow Open Water with Islands or Polygonized Margins, Salt Marsh, and Tapped Lake with High-water Connection. The largest colony located during ground 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 except one were located <1 m from permanent water. The nests were near lake habitats, which included Deep Open Water (both types; 64% of nests), Shallow Open Water with Islands or Polygonized Margins (20%), and Tapped Lakes (both types; 16%).

Brood-rearing

During brood-rearing in 1993, 1995, 1996, and 1998, we saw 45 groups of Brant in 11 different habitats, with salt-affected habitats receiving the greatest use (Table 26). Habitat use in 1998 is presented in Appendix C4. Over all years, Brackish Water was used by the most Brant brood groups (33%) and was the only preferred habitat on the delta. The other salt-affected habitats used included Open Nearshore Water, Salt Marsh, Salt-killed Tundra, Tidal Flat, and Tapped Lake with Low-water Connection. Tidal Flat was the only habitat that was used significantly less than its availability (i.e., avoided). Brood-rearing groups frequently moved into nearby water when disturbed by our survey aircraft, so the high use of waterbodies probably is the result of some broods moving from adjacent foraging habitat (most likely Salt Marsh) as our aircraft approached. Brood-rearing groups tended to be close to five types of waterbody habitats: Brackish Water (58% of 48 groups), River or Stream (25%), Open Nearshore Water (12%), Tapped Lake

Table 24. Habitat availability (%) for islands in the Anachlik Colony-complex, Colville River Delta, Alaska. Brant nests were counted during ground searches in 1998 (USFWS, unpubl. data). The colony at Snow Goose Lake was not in an area classified for habitat.

	Availability by Island (%)										
Habitat	Anachlik (391 nests)	Brant (221 nests)	Char (204 nests)	Dune (2 nests)	Eskimo (156 nests)	Plover (34 nests)	Salt-Grass Dunes (7 nests)	Seal (0 nests[a])	Swan (89 nests)	Turnstone (77 nests)	White-front (4 nests)
Open Nearshore Water (marine)	0	0	0	0	0	0	0	0	0	0	0
Brackish Water	0	0.7	0	0	0	0	0	0	0.5	0	0
Tapped Lake w/ Low-water Connection	0	0	0	0	0	0	0	0	0	0	0
Tapped Lake w/ High-water Connection	0	0	0	0	0	0	0	0	0	0	6.4
Salt Marsh	0.3	0	3.7	0	0	11.9	0	3.0	8.3	1.5	0
Tidal Flat	14.5	96.1	89.3	0	0	0	97.9	0	0	0	0
Salt-killed Tundra	2.0	0	0	3.7	30.7	0	0	0	0	0	3.4
Deep Open Water w/o Islands	0	0	0	4.3	0	0	0	0.8	1.0	0	0.1
Deep Open Water w/ Islands or Polygonized Margins	7.0	0	0	6.7	0	0	0	3.1	0	0	0.6
Shallow Open Water w/o Islands	1.1	0	0	0.7	0	0	0	0.8	0	0.2	0.2
Shallow Open Water w/ Islands or Polygonized Margins	1.3	0	0	0.8	0	0	0	0	0	0	0.9
River or Stream	0	0	0	0	0	0	0	0	0	0	0
Aquatic Sedge Marsh	0	0	0	0	0	0	0	0	0	0	0
Aquatic Sedge w/ Deep Polygons	6.1	0	0	8.8	0	0	0	5.1	0	0	7.1
Aquatic Grass Marsh	0	0	0	0	0	0	0	0	0	0	1.8
Young Basin Wetland Complex	0	0	0	0	0	0	0	0	0	0	0
Old Basin Wetland Complex	0	0	0	0	0	0	0	0	0	0	0
Nonpatterned Wet Meadow	32.3	0	0	14.4	0	0	0	15.8	7.8	0	9.8
Wet Sedge–Willow Meadow	20.4	0	0	32.4	0	0	0	20.7	0	0	52.7
Moist Sedge–Shrub Meadow	3.4	0	0	0	29.3	0	0	6.7	10.6	0	0
Moist Tussock Tundra	0	0	0	0	0	0	0	0	0	0	0
Riverine or Upland Shrub	1.0	0	0	2.3	0	3.3	0	1.4	0	0.9	0.1
Barrens (riverine, eolian, lacustrine)	10.1	3.2	7.0	25.9	40.0	84.8	2.1	42.8	71.8	97.4	16.9
Artificial (water, fill, peat road)	0.6	0	0	0	0	0	0	0	0	0	0
Total	100	100	100	100	100	100	100	100	100	100	100
Total area (km^2)	4.0	2.4	1.1	4.4	0.5	0.9	0.8	1.8	1.4	1.2	3.0

[a] A brown bear destroyed all nests before the nest census began.

Table 25. Habitat use and nearest waterbody habitat of individual Brant nests located during ground searches in the Development Area, Colville River Delta, Alaska, 1995–1998 (Johnson et al. 1998, this study).

Habitat	No. of Nests	Use (%)
HABITAT USED		
Tapped Lake w/ High-water Connection	2	8.0
Salt Marsh	1	4.0
Deep Open Water w/ Islands or Polygonized Margins	10	40.0
Shallow Open Water w/ Islands or Polygonized Margins	2	8.0
Aquatic Sedge w/ Deep Polygons	5	20.0
Nonpatterned Wet Meadow	5	20.0
Total	25	100
NEAREST WATERBODY HABITAT[a]		
Tapped Lake w/ Low-water Connection	1	4.0
Tapped Lake w/ High-water Connection	3	12.0
Deep Open Water w/o Islands	2	8.0
Deep Open Water w/ Islands or Polygonized Margins	14	56.0
Shallow Open Water w/ Islands or Polygons	5	20.0
Total	25	100

[a] Nearest waterbody (≥0.25 ha in size) was measured from the digital map.

Table 26. Habitat selection (pooled among years) by Brant brood-rearing groups in the Outer Delta survey area, Colville River, Alaska, 1993, 1995, 1996, and 1998 (Johnson et al. 1997, this study).

Habitat	Area (km^2)	No. of Brood-rearing Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Monte Carlo Results[b]
Open Nearshore Water (marine)	10.46	5	11.1	4.8	0.40	ns
Brackish Water	6.29	15	33.3	2.9	0.84	prefer
Tapped Lake w/ Low-water Connection	5.17	1	2.2	2.4	-0.03	ns
Tapped Lake w/ High-water Connection	2.06	0	0	0.9	-1.00	ns
Salt Marsh	12.61	4	8.9	5.8	0.21	ns
Tidal Flat	55.89	4	8.9	25.5	-0.48	avoid
Salt-killed Tundra	22.22	5	11.1	10.1	0.05	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	1	2.2	0.2	0.80	ns
Shallow Open Water w/ Islands or Polygonized Margins	0.20	0	0	0.1	-1.00	ns
River or Stream	43.15	5	11.1	19.7	-0.28	ns
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	6.40	1	2.2	2.9	-0.14	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	2.2	4.3	-0.31	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	0.81	0	0	0.4	-1.00	ns
Barrens (riverine, eolian, lacustrine)	28.08	3	6.7	12.8	-0.32	ns
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	ns
Total	219.06	45	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated for brood-rearing groups.

[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

with Low-water Connection (2%) and Shallow Open without Islands (2%) (Table 27). The mean distance of brood-rearing groups to the nearest waterbody was 0.02 km.

In addition to the brood-rearing groups seen on coastal surveys in previous years in the Delta survey area, we saw some groups just outside the survey boundaries and some groups during surveys for other species (Figure 19). The habitats used by these additional groups (Table 27) were not appreciably different than those used by Brant seen on the coastal surveys in the Delta survey area (Table 26), and reaffirmed the importance of salt-affected habitats and the coastal zone to Brant during the brood-rearing season.

GREATER WHITE-FRONTED GOOSE

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 were among the highest densities recorded for these geese and their nests on the Arctic Coastal Plain of Alaska (Simpson and Pogson 1982, Rothe et al. 1983, Simpson 1983). Since then, higher nest densities (3.8 nests/km^2) have been found on the delta in an area searched intensively for goose nests (Johnson et. al. 1999).

Table 27. Habitat use by Brant and distance to nearest waterbody during brood-rearing in the Delta survey area, Colville River, Alaska, 1992, 1993, 1996, and 1998 (Johnson et al. 1997, 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-rearing Groups	Use (%)	Mean Distance to Waterbody [a] (km)
HABITAT USED			
Open Nearshore Water (marine)	6	12.5	-
Brackish Water	16	33.3	-
Tapped Lake w/ Low-water Connection	1	2.1	
Salt Marsh	4	8.3	-
Tidal Flat	4	8.3	-
Salt-killed Tundra	5	10.4	-
Shallow Open w/o Islands	1	2.1	
River or Stream	6	12.5	-
Aquatic Sedge w/ Deep Polygons	1	2.1	-
Wet Sedge–Willow Meadow	1	2.1	-
Barrens (riverine, eolian, lacustrine)	3	6.3	-
Total	48	100	
NEAREST WATERBODY HABITAT			
Open Nearshore Water (marine)	6	12.5	0.01
Brackish Water	28	58.3	0.01
Tapped Lake w/ Low-water Connection	1	2.1	0.00
Shallow Open Water w/o Islands	1	2.1	0.00
River or Stream	12	25.0	0.02
Total	48	100	0.02

[a] Distance to nearest waterbody was measured to waterbodies ≥0.25 ha in size on the digital map and may not be as accurate as measurements on the ground.

DISTRIBUTION AND ABUNDANCE

Brood-rearing

In 1998, we conducted a systematic aerial survey (50% coverage) to collect information on the distribution and group sizes of brood-rearing and molting White-fronted Geese (Table 2). In 1996, we conducted the first systematic survey (25% coverage), whereas in previous years, brood-rearing information for White-fronted Geese was collected opportunistically during aerial surveys conducted for Brant and eiders. In 1998, we saw 2,389 White-fronted Geese in 49 groups on the delta, the greatest number seen in any year (Figure 21). In 1997, we saw 2,126 White-fronted Geese, 543 in 1996 (25% coverage), and 1,265 in 1995 (during the Brant survey). Group sizes in 1998 ranged between 8 and 190 individuals ($\bar{x}$ = 48.8). These groups generally were distributed throughout the study area and typically occurred in or near water, including Brackish Water, Salt Marsh, Tide Flat, Salt-killed Tundra, Barrens, Tapped Lakes (both types), Deep Open Water (both types), and River or Stream. Most groups (34 of 49 groups, 69%) were in Brackish Water, Tapped Lake with Low-water Connection, or both types of Deep Open Water. Goslings composed ~50% of the total number of birds (1,206 of 2,389) seen during the aerial survey in 1998. This percentage of goslings was greater than that seen in 1997 (35%), but similar to 1996 (55%). The early snowmelt in 1998 probably facilitated early nest initiation. Nests that are initiated earlier without subsequent loss to predation or bad weather, also hatch earlier and produce goslings that grow more rapidly and have better survival than goslings from late-hatching nests (Sedinger and Flint 1991, Lindholm et al. 1994).

During the systematic surveys for geese in 1998, we observed 647 White-fronted Geese in 12 groups in the Development Area; none occurred in the Facility Area. During other surveys around the Facility Area, however, we did record additional groups of these geese (see Johnson et al. 1999). In previous years, we counted 484 White-fronted Geese in the Development Area in 1997, and 145 geese in 1996.

During the aerial survey on the Outer Delta in 1998, we recorded 1,742 White-fronted Geese in 37 groups, compared to 1,642 in 1997, and only 177 in 1996 (25% coverage). We saw no geese on the Western Delta in either 1998 or 1997, but we did see 50–60 geese there in both 1995 and 1996.

Fall Staging

During fall staging in 1998, large numbers of White-fronted Geese, in groups that averaged <30 birds, were distributed throughout the delta in a variety of aquatic and terrestrial habitats (Figure 22). This pattern of staging distribution was similar to that seen in 1997, but different from 1996, when geese were concentrated around river channels and large lakes in fewer, but larger groups. White-fronted Geese did not concentrate near the coast, as did Brant, but were distributed relatively evenly between the Outer Delta and the Development Area. On the systematic survey (50% coverage) for fall-staging geese, we counted 1,656 birds in 57 groups on the delta in 1998, which was similar to 1997 (1,732 birds). In contrast, we recorded 1,356 birds on a similar survey, but with only 25% coverage, in 1996. Prior to 1996, we made observations opportunistically during surveys for focal species. Hence, the level of effort devoted to sampling White-fronted Geese varied among years. Counts of fall-staging White-fronted Geese seen on the delta during 1991, 1992, and 1995, were 555, 2,250, and 491 geese, respectively (Johnson et al. 1998). 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.

Approximately half (825) of all staging White-fronted Geese in 1998 were seen in the Development Area (Figure 22); the mean group size was 52 birds. These numbers and mean group size were similar to what was recorded for this area in 1997 (758 birds in 12 groups) and in 1996 (737 birds in 10 groups). In 1991, 1992, and 1995, we opportunistically counted 194, 20, and 130 birds, respectively, in the Development Area (see Johnson et al. 1998: Figure 27).

In 1998, we counted 788 White-fronted Geese in 36 groups on the Outer Delta during the systematic fall-staging survey (Figure 22); mean group size was 22 birds. In previous years, we saw 909 White-fronted Geese in 1997, 564 geese in 1996, and 361 geese in 1995. The largest numbers were seen in 1992, when we counted 1,787 and 2,250 White-

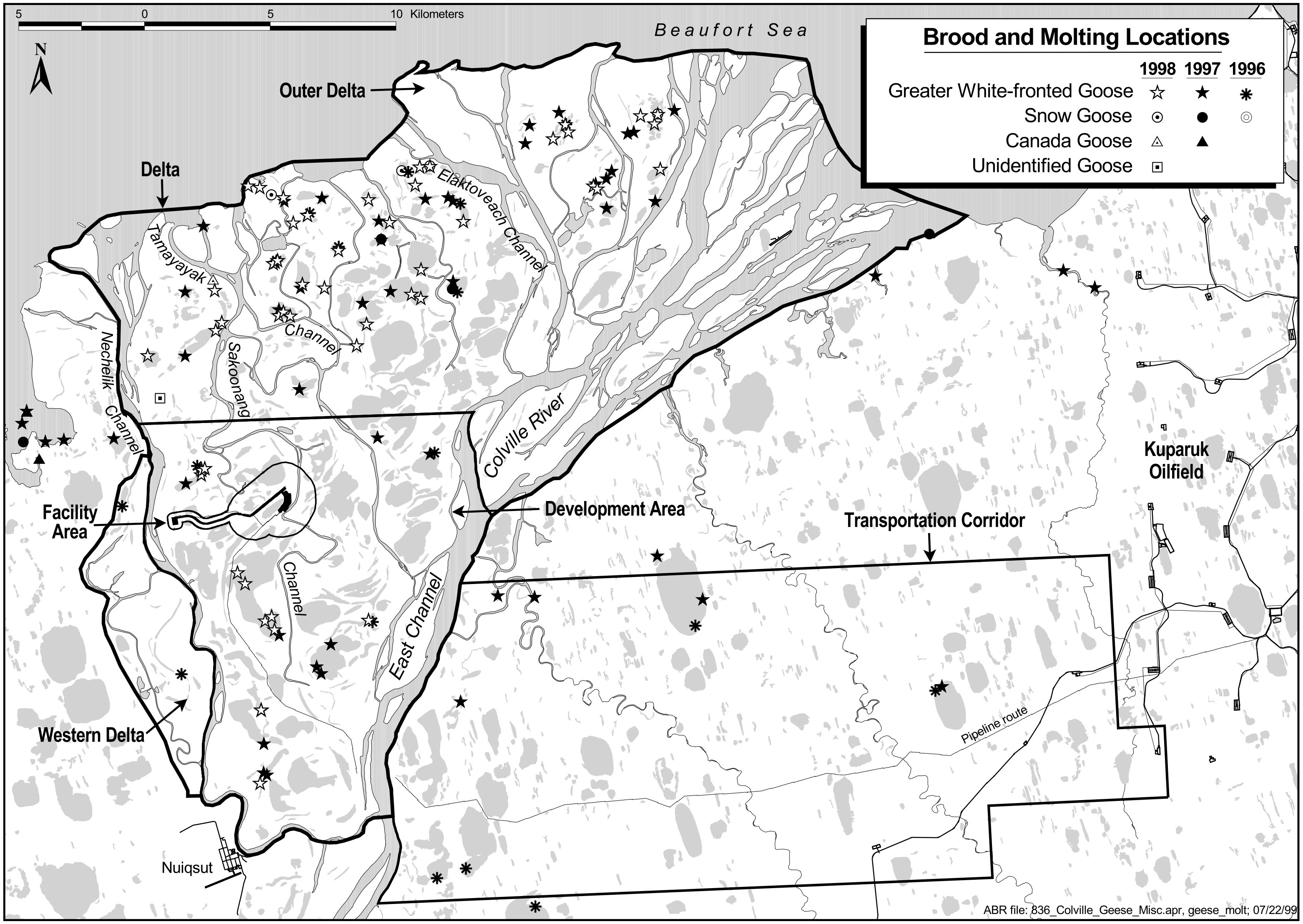

Figure 21. Distribution of brood-rearing and molting groups of Greater White-fronted, Snow, and Canada geese observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River, Alaska, July 1996–1998. The Transportation Corridor was not surveyed in 1998. Locations are from Johnson et al. (1998) and this study. Survey coverage was 25% in 1996 and 50% in 1997 and 1998.

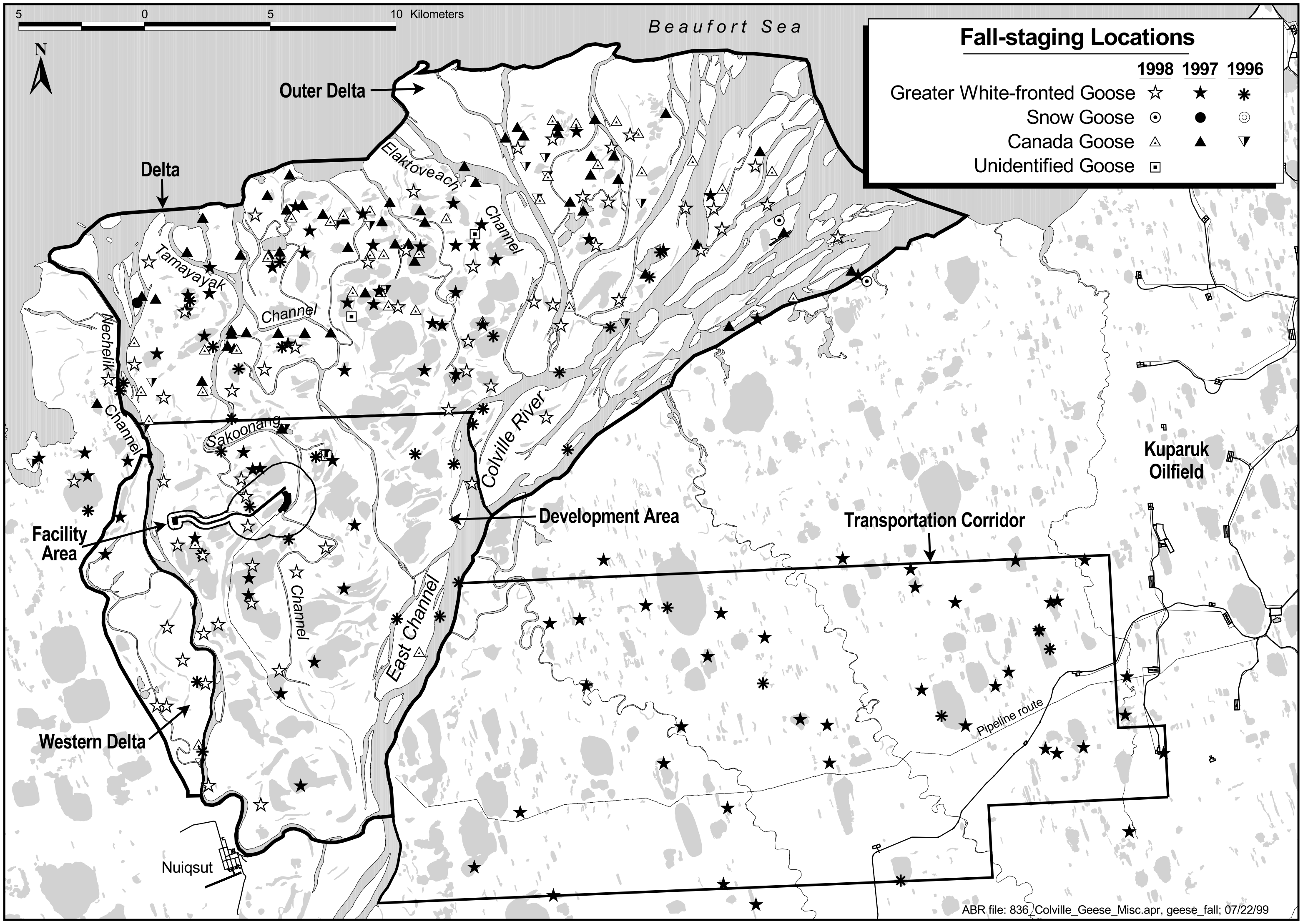

Figure 22. Distribution of fall-staging groups of Greater White-fronted, Snow, and Canada geese observed during aerial surveys in the Delta and Transportation Corridor survey areas, Colville River, Alaska, August 1996–1998. The Transportation Corridor was not surveyed in 1998. Locations are from Johnson et al. (1997) and this study. Survey coverage was 25% in 1996 and was 50% in 1997and 1998.

fronted Geese incidentally on other surveys. In 1991, we saw 343 geese on the Outer Delta during a swan survey (ABR, unpubl. data).

SNOW GOOSE

BACKGROUND

Early in this century, Snow Geese may have nested commonly and gathered for molting and brood-rearing in widespread portions of the Arctic Coastal Plain (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.). Today, three small 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 between the Kuparuk Oilfield and Kasegaluk Lagoon (King 1970; Ritchie and Burgess 1993; ABR, unpubl. data). Currently in Alaska, large numbers of Snow Geese only occur during fall staging in the Arctic National Wildlife Refuge (Johnson and Herter 1989).

DISTRIBUTION AND ABUNDANCE

Nesting

Few nests of Snow Geese have been found on the Colville Delta in any year. In 1998, we found no Snow Goose nests opportunistically during any of our aerial surveys, and no ground surveys were conducted on the Outer Delta where nests occurred in previous years. Nests were observed in 1997 and 1995 on aerial surveys, and in both 1993 and 1994, two nests were found each year during ground searches (Johnson et al. 1998). We found no Snow Goose nests on the Colville Delta in 1996, although we saw a few scattered nests just west of the delta, near the mouth of Fish Creek. All nests were <5 km from the coast in the Outer Delta survey area.

Brood-rearing

Small groups of Snow Geese have been seen in most years during brood-rearing surveys for Greater White-fronted Geese and Brant and all these groups were seen on the Outer Delta. In 1998, we recorded four groups of brood-rearing Snow Geese totaling 75 birds (32 adults and 43 goslings) during the systematic survey for geese, and four groups totaling 97 birds (36 adults and 61 goslings) during the coastal survey the following day, the largest number of birds seen so far during our studies on the delta (Figure 21). The number of Snow Geese seen on the former survey was ~3× greater than the number seen on the comparable survey in 1997, the previous high count. In both 1995 and 1996, we saw only one group of Snow Geese during the aerial surveys for brood-rearing geese (see Johnson et al. 1998: Figure 28); the group seen in 1995 was without goslings. No Snow Geese were recorded during surveys in 1992 or 1993, however.

Fall Staging

During late August 1998, we saw one group of 30 Snow Geese on the systematic survey for geese, compared to one group (6 birds) of Snow Geese during the systematic goose survey and four groups (37 birds) during the coastal survey in 1997 (Figure 22). We saw three Snow Geese in one group in late August 1996, and 20 in 2 groups in 1995 (Johnson et al. 1998: Figure 27). Similar to brood-rearing, all groups were seen on the Outer Delta. No Snow Geese were seen during staging surveys in 1992 or 1993.

CANADA GOOSE

BACKGROUND

Several hundred Canada Geese nest along the banks and bluffs of the upper Colville River (Kessel and Cade 1958). Prior to 1996, Canada Geese were not reported nesting either on the Colville Delta or in NPR–A, although local residents have observed Canada Geese nesting in the NPR–A at least since the 1980s (J. Helmericks, pers. comm.). Canada Geese nest in scattered locations on the Arctic Coastal Plain east of the Colville River (Ritchie et al. 1991; ABR, unpubl. data) 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 Colville Delta 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 and feed (Johnson and Richardson 1981, Garner and Reynolds 1986).

DISTRIBUTION AND ABUNDANCE

Nesting

In 1998, we did not find any Canada Goose nests during aerial surveys, although we did find two nests during ground surveys in the vicinity of the Facility Area (see Johnson et al. 1999). In 1997, we found one Canada Goose nest on the Outer Delta near the Nechelik Channel and two nests just west of the delta in NPR–A during aerial surveys. At one of these locations in NPR–A, we saw 10 Canada Goose nests in 1996, the first documented record of them nesting close to the delta or in the NPR–A (Johnson et al. 1997). The nest found on the Outer Delta was the first record we have of a Canada Goose nest on the delta.

Brood-rearing

In 1998, we observed one brood-rearing group of Canada Geese (8 adults and 16 goslings) during the systematic survey for geese, the first record of these geese during either this survey or the coastal Brant survey, and only the third record of these geese on the delta during the brood-rearing/molting period (Figure 21). This brood-rearing group was observed on the Outer Delta. In 1997, we observed two Canada Geese (adults or subadults) in the Development Area during a ground survey in mid-July. The only other year when Canada Geese were seen on the delta was 1993, when a group of 30 was seen during a ground survey on the Outer Delta.

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 1998, we observed 1,276 Canada Geese in 36 groups during the systematic survey (50% coverage) for geese (Figure 22). In 1997, we recorded 2,101 Canada Geese during the systematic survey (50% coverage) for geese, but one day later, we recorded 1,932 Canada Geese during the coastal Brant survey. The greatest numbers of Canada Geese were recorded in 1992, when we counted 10,950 Canada Geese (Johnson et al. 1998: Figure 27). In 1996, the only other year a systematic survey (25% coverage) was conducted, we recorded 1,486 Canada Geese on the delta. In other years, the numbers seen incidentally were less: 923 birds in 1995, 825 birds in 1993, and 310 birds in 1991. What influences the variability in numbers of Canada Geese and their use of the delta during fall staging is unclear, but some of this variability probably is an artifact of the intensity and timing of aerial surveys.

In 1998, we saw 2 groups totalling 84 birds in the Development Area during the staging survey (Figure 22), but we saw additional groups during surveys that covered lakes in and around the Facility Area (Johnson et al. 1999). In 1997, we saw 1 group of 12 Canada Geese in the Development Area (Figure 26) during the aerial survey and 2 groups of 195 birds during a ground survey. In 1996, we saw 3 groups containing 426 geese in the Development Area and in 1995, 1 group of 75 birds (Johnson et al. 1998: Figure 27). 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 (ABR, unpubl. data).

On the Outer Delta in 1998, we saw 1,182 Canada Geese in 33 groups (Figure 22). In previous years, we recorded 2,089 Canada Geese in 1997, 1,050 geese in 1996, and 245 geese in 1991. One group of Canada Geese (10 birds) was seen in the Western Delta survey area during fall staging in 1998. Use of this area was limited and variable among years. No Canada Geese were seen in the Western Delta survey area during fall staging in 1997, although 10 were seen there in 1996 (Figure 22).

ARCTIC AND RED FOXES

BACKGROUND

Both arctic and red foxes occur in northern Alaska on the Arctic Coastal Plain. Arctic foxes are common on the coastal plain. Red foxes are common in the foothills and mountains of the Brooks Range, but are restricted largely to major drainages (such as the Colville and Sagavanirktok rivers) on the coastal plain, where they are much less common than the arctic fox (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 late March or April, and pups are born in late May or June after a gestation period of ~52 days (Chesemore 1975). Pups first emerge from dens at 3–4 weeks of age (Garrott et al. 1984), and dens are occupied from late spring until pups disperse in mid-August (Chesemore 1975). Throughout their circumpolar range, arctic fox litters average 4–8 pups but can range up to 15 pups (Chesemore 1975, Follmann and Fay 1981, Strand et al. 1995).

Survival of arctic fox pups to weaning is highest in years when small mammals (primarily lemmings) are abundant (Macpherson 1969). Causes of pup mortality include predation, starvation, and sibling aggression (Macpherson 1969, Garrott and Eberhardt 1982, Burgess et al. 1993). For both arctic and red foxes, lemmings and voles are the most important year-round prey, supplemented by carcasses of caribou and marine mammals and, in summer, by arctic ground squirrels and nesting birds and their eggs; 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). Before our surveys in recent years (Smith et al. 1993, 1994; Johnson et al. 1996, 1997, 1998), 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 region in the late 1970s.

DEN NUMBERS, DISTRIBUTION, AND OCCUPANCY

In six years of surveys and contacts with other observers, we have located 54 fox dens between the western edge of the Colville Delta and the western edge of the Kuparuk Oilfield (Figure 23). In 1998, 49 of these dens were classified as arctic fox dens and 5 were occupied by red foxes; one of the red fox dens was used formerly by arctic foxes. We have been unsuccessful in locating 4 other dens on the Colville Delta reported to us by other researchers (M. North, unpubl. data; S. Earnst, pers. comm.). Our sample of confirmed dens has increased in each year of study, from 6 dens in 1992 to 54 dens in 1998. Three arctic fox dens were added to the database in 1998: two in the Transportation Corridor and one on the Colville Delta. No new sites were found during our systematic search of most of the Outer Delta on 28 June 1998. We suspect additional dens are present in other areas of the Outer Delta not yet searched thoroughly, particularly because of the abundance of arctic ground squirrel burrows in dune habitats on the delta, which make it difficult to distinguish fox dens.

Of the 54 confirmed dens, all 5 red fox dens and 15 arctic fox dens are on the Colville Delta, 20 arctic fox dens are in the Transportation Corridor, and the remaining 14 arctic fox dens are located north and south of the corridor (Table 28). The density of red fox dens on the delta was 1 den/110 km^2; few comparative data are available for this species from other arctic tundra areas. The overall density of arctic fox dens (active and inactive) in the combined Delta (551 km^2) and Transportation Corridor (343 km^2) survey areas is 1 den/26 km^2. The density on the Delta (1 den/37 km^2) is lower than in the Transportation Corridor (1 den/17 km^2; Table 29), probably due to the more limited availability of suitable denning habitat on the Outer Delta. The overall density is higher than the 1 den/34 km^2 reported by Eberhardt et al. (1983) for their Colville study area (which extended farther east–west than ours, but not as far inland). The overall density we report for arctic foxes is 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 is slightly higher than the mean densities reported for large areas of tundra in the Northwest Territories (1 den/36 km^2; Macpherson 1969) and Siberia (1 den/32 km^2; Boitzov 1937, as cited in MacPherson 1969) (Table 29).

Based on brief visits at 46 arctic fox dens and longer observations at 11 of those dens between 26 June and 13 July, we confirmed that pups were present at 7 natal dens and suspected that pups were present at 4 other (active) dens (Table 30). Thus, the number of natal dens with pups was in the range of 7–11 (15–23%) of the 46 arctic fox dens checked; the remaining (inactive) dens showed signs of occasional use by adults only or were completely inactive (Table 30). Arctic fox pups were known or suspected to be present only at dens on the Colville

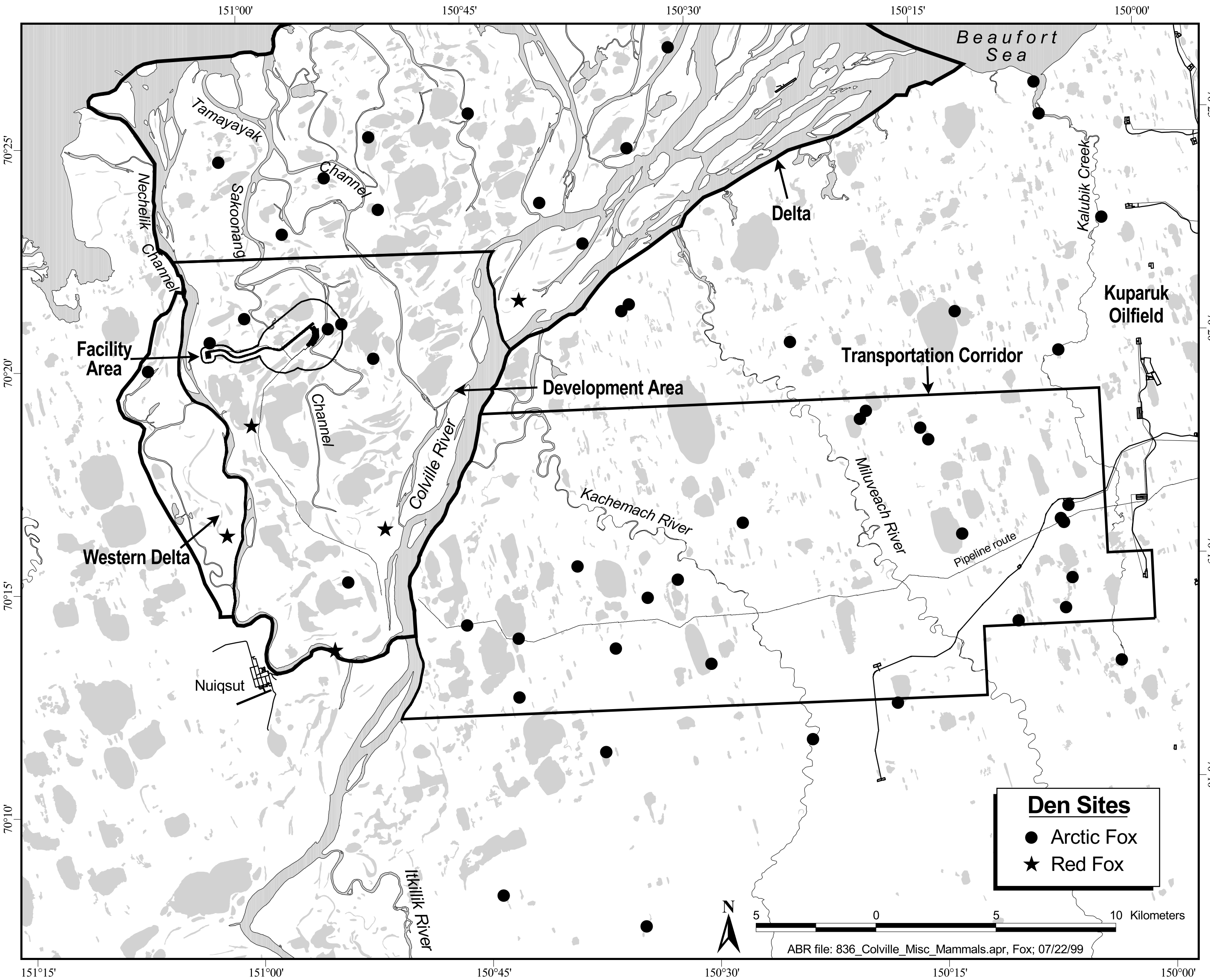

Figure 23. Distribution of arctic and red fox dens found during aerial and ground surveys on the Colville River Delta and adjacent areas, Alaska, in 1992, 1993, and 1995–1998 Survey coverage was not uniform over the entire area portrayed.

Table 28. Landforms, activity status, and numbers of pups seen at arctic and red fox dens on the Colville River Delta and adjacent coastal plain, Alaska, during the 1995–1998 seasons.

Location/Species/Landform	1998 Status [a]	No. of Pups[b] (1998)	Status[c] 1997	1996	1995
DELTA					
Arctic Fox					
old dune	natal	3	inactive	natal	inactive
old dune	inactive	–	inactive?	inactive	natal
dune/lake bank	inactive	–	inactive?	natal	inactive
lake bank	natal?	0?	natal?	natal	inactive
dune/lake bank	inactive	–	inactive	natal	natal
dune/lake bank	active	0?	natal	natal	secondary?
dune ridge	natal	2	inactive?	natal	natal
dune mound	inactive	–	inactive?	inactive	inactive
dune/riverbank	natal	1	natal	natal	secondary
dune/lake bank	nd	–	nd	inactive	inactive
low ridge	natal	3	active	secondary?	secondary?
low dune ridge	inactive	–	natal	secondary	–
sand dune	inactive	–	inactive	nd	–
low mound	natal?	0?	inactive	–	–
sand dune	inactive	–	–	–	–
Red Fox					
dune/lake bank	active	0?	inactive?	inactive	inactive
sand dune	active	0?	inactive	inactive	natal
sand dune	natal	2	active	natal	secondary?
dune/riverbank	natal?	0?	inactive	natal	natal
sand dune	natal	6	active?	natal	natal
TRANSPORTATION CORRIDOR					
Arctic Fox					
pingo	inactive	–	inactive	natal	secondary
pingo	inactive	–	inactive	natal	natal
stream bank	inactive?	–	inactive?	natal	natal
drained-lake bank	inactive	–	inactive	inactive	inactive
pingo	inactive	–	inactive	inactive	inactive
lake bank	inactive	–	inactive?	natal	natal
lake bank	inactive	–	inactive	natal	inactive?
low ridge	nd	–	inactive	inactive	inactive
low ridge	nd	–	inactive	inactive	inactive
drained-lake bank	inactive	–	active	inactive	inactive
lake bank	inactive	–	inactive?	natal	–
terrace bank	inactive	–	active	secondary	–
low mound	inactive	–	active	natal	–
terrace bank	inactive	–	inactive	natal	–
lake bank	inactive	–	inactive	natal	–
drained-lake bank	inactive	–	inactive?	active	–
low mound	inactive	–	active	–	–
drained-lake island	inactive	–	inactive	–	–
pingo ridge	inactive	–	–	–	–
drained-lake bank	inactive	–	–	–	–
NORTH OR SOUTH OF TRANSPORTATION CORRIDOR					
Arctic Fox					
pingo	inactive	–	natal	inactive	inactive
pingo	natal	3	inactive	natal	secondary
pingo	inactive	–	natal	inactive	inactive
stream bank	inactive	–	natal	inactive	natal
drained-lake bank	inactive	–	inactive	inactive	inactive
drained-lake bank	natal	5	natal	inactive?	secondary
old gravel pad	inactive	–	inactive	inactive	inactive
lake bank	natal	4	natal?	inactive?	–
stream bank	inactive	–	inactive	natal	–
stream bank	inactive	–	inactive	inactive	–
stream bank	active	–	natal	inactive	–
drained-lake bank	inactive	–	natal	natal	–
drained-lake bank	inactive	–	natal?	–	–
drained-lake bank	inactive	–	secondary	–	–

[a] Based on observations between 26 June and 13 July (26–28 June and 10–13 July for most dens); question mark indicates uncertainty regarding status ("active" means natal vs. secondary status could not be determined); nd = no data (site not checked).
[b] Number of different pups counted; question mark indicates count suspected to be incomplete; dashes indicate no data (site not observed).
[c] Sources: 1997—Johnson et al. (1998); 1996—Johnson et al. (1997); 1995—Johnson et al. (1996).

Table 29. Densities of arctic fox dens in the Delta and Transportation Corridor survey areas, Colville River, Alaska, compared with data from other tundra areas. Table was modified from Burgess et al. (1993: Table 3).

Location	Den Density[a] (1 den/*x* km^2)	Source[b]
COLVILLE WILDLIFE STUDY		
Delta survey area	37	This study
Transportation Corridor survey area	17	This study
OTHER STUDIES		
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–Kuskokwim Delta, Alaska	1	Anthony et al. 1985
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
Taymyr 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/37 km^2 in the Colville Delta survey area.
[b] Russian sources from Macpherson (1969) and Garrott (1980); size of study area is unknown for some references.

Table 30. Occupancy and activity status of arctic fox dens on the Colville River Delta and adjacent coastal plain, Alaska, during the 1993 and 1995–1998 denning seasons.

	1998		1997[c]		1996[c]		1995[c]		1993[c]	
Den Status	No.	%	No.	%	No.	%	No.	%	No.	%
Natal	7	15	4	9	22	51	9	26	5	22
Secondary	–	–	–	–	3	7	2	6	7	30
Active [a]	4	8	7	17	4	9	2	6	–	–
Inactive [b]	35	76	33	74	14	33	21	62	11	48
Total	46		44		43		34		23	

[a] Dens showing heavy use, but for which natal vs. secondary status, could not be determined.
[b] Dens showing no signs of activity or dens showing limited use by adults, but not pups.
[c] Sources: 1997—Johnson et al. (1998); 1996—Johnson et al. (1997); 1995—Johnson et al. (1996); 1993—Smith et al. 1994

Delta or north and south of the Transportation Corridor; for the first time in this study, pups were not observed at any of the dens in the corridor.

At 23%, den (natal, secondary, and active categories combined) occupancy by litters was relatively low in 1998, similar to 1997 (26% of 44 dens; Table 30). In contrast, den occupancy in 1996 was the highest on record for the Colville area (67% of 43 dens). In 1995, litters were present at 38% of 34 arctic fox dens examined, and in 1993, 52% of 23 dens were occupied by litters. Low-intensity survey coverage late in the 1992 season resulted in a sample that was too small to calculate meaningful percentages. In their Colville study area, Eberhardt et al. (1983) reported that the percentage of dens containing pups 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).

In any year, estimates of pup production must be considered minimal because pups often remain underground for extended periods, making it difficult to obtain reliable counts. During 10–13 July 1998, we expended 68 person hours observing 11 arctic fox dens and all 5 red fox dens, and were able to obtain complete litter counts at 7 arctic fox dens and 2 red fox dens. We counted 21 pups at the 7 arctic fox dens, a mean litter size of 3 pups (Table 28). Observations at dens in 1996–1997 were most successful for obtaining pup counts during early morning and evening, when foxes were more active than during midday. Several 1998 litters were successfully counted even in midday, however. Although all 5 red fox dens were active, we were able to count pups at only 2 dens (2 and 6 pups, a mean of 4 per litter). Red fox dens are more difficult to observe than arctic fox dens because they tend to be located in sand dunes having high topographic relief and tall shrubs that obscure the dens.

In some years (such as 1996), 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. We were aware of no such movements in 1998, but we conducted our observations relatively early in the season.

The mean litter size (3.0) for arctic foxes in 1998 was nearly identical with the 1993 and 1995 means of 3.1 pups (Smith et al. 1994, Johnson et al. 1996), and was half the mean of 6.1 pups from the high-production year of 1996 (Johnson et al. 1997). These Figures were identical to those reported by Garrott (1980) for low and high years of pup production in his Colville study area. In 1978, when small mammals were 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). 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 complete litter count.

The low occupancy rate and small number of arctic fox litters in 1998 led us to infer that, as in 1997, the density of small mammals in our study area was low, although we have no population sampling data on which to base this conclusion. Our observers saw few lemmings or lemming predators (e.g., snowy owls and jaegers) while searching for bird nests in the study area. Den occupancy can vary substantially among years and regions in relation to population level and food abundance (Macpherson 1969, Chesemore 1975, Garrott 1980, Eberhardt et al. 1983). Therefore, the relatively low occupancy rate of dens and numbers of pups produced in 1997–1998 are strong circumstantial evidence of low abundance of small mammals, contrasting starkly with 1996, when den occupancy and litter size were high and small mammals were abundant.

SELECTION OF DENNING HABITAT

The presence of permafrost in arctic tundra forces foxes to dig dens in locations that have relatively deep seasonal thaw layers. Foxes locate dens on raised landforms with well-drained soil; typical locations on the Arctic Coastal Plain include ridges, dunes, lake and stream shorelines, pingos, and low mounds (Chesemore 1969, Eberhardt et al. 1983, Burgess et al. 1993).

Delta Area

Because both arctic and red foxes have similar denning requirements and will use the same den sites in different years, we included dens used by both species in our analysis of habitat selection. Fifteen arctic fox dens and five red fox dens constituted our habitat selection sample for the Delta survey area. Dens were located in 4 of the 13 available habitats (Table 31). Fifteen dens (75% of the total) were in the Riverine or Upland Shrub type (all were in the upland shrub subtype, rather than riverine shrub), the only denning habitat that was preferred. The other habitats used by denning foxes on the delta were Wet Sedge–Willow Meadow (three dens), Moist Sedge–Shrub Meadow (one den), and Nonpatterned Wet Meadow (one den). Foxes avoided the extensive river bars and mudflats (Barrens) on the delta.

Transportation Corridor

We included all 20 arctic fox dens in the Transportation Corridor in our analysis (Table 32). To date, we have found no red fox dens in the corridor, although red foxes have been seen near the Kalubik Creek drainage in the northeastern portion of the corridor. Dens were located in 4 of the 10 available habitats. As on the delta, Riverine or Upland

Table 31. Habitat selection by arctic and red foxes denning in the Delta survey area, Colville River, Alaska. The sample analyzed included all active and inactive dens of arctic foxes (*n* = 15 dens) and red foxes (*n* = 5 dens) confirmed during 1992–1998, 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)	0	-	-	0	-	-
Brackish Water	0	-	-	0	-	-
Tapped Lake w/ Low-water Connection	0	-	-	0	-	-
Tapped Lake w/ High-water Connection	0	-	-	0	-	-
Salt Marsh	16.36	0	0	4.3	–1.00	ns
Tidal Flat	55.99	0	0	14.8	–1.00	ns
Salt-killed Tundra	25.62	0	0	6.8	–1.00	ns
Deep Open Water w/o Islands	0	-	-	0	-	-
Deep Open Water w/ Islands or Polygonized Margins	0	-	-	0	-	-
Shallow Open Water w/o Islands	0	-	-	0	-	-
Shallow Open Water w/ Islands or Polygonized Margins	0	-	-	0	-	-
River or Stream	0	-	-	0	-	-
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.59	0	0	3.6	–1.00	ns
Aquatic Grass Marsh	0	-	-	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	41.92	1	5.0	11.1	–0.38	ns
Wet Sedge–Willow Meadow	102.37	3	15.0	27.1	–0.29	ns
Moist Sedge–Shrub Meadow	13.40	1	5.0	3.5	0.17	ns
Moist Tussock Tundra	2.53	0	0	0.7	–1.00	ns
Riverine or Upland Shrub	27.42	15	75.0	7.2	0.82	prefer
Barrens (riverine, eolian, lacustrine)	79.03	0	0	20.9	–1.00	avoid
Artificial (water, fill, peat road)	0.02	0	0	<0.1	–1.00	ns
Total	378.28	20	100	100		

[a] Aquatic habitats were assigned zero availability for fox dens.
[b] Ivlev's E = (use – availability)/(use + availability).
[c] Significance calculated from 1,000 simulations at $\alpha = 0.05$: ns = not significant; prefer = use significantly greater than availability; avoid = use significantly less than availability.

Table 32. Habitat selection by arctic foxes denning in the Transportation Corridor survey area, Colville River, Alaska. The sample analyzed included all active and inactive dens confirmed during 1992–1998.

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	-	-	0	-	-
Salt Marsh	0	-	-	0	-	-
Tidal Flat	0	-	-	0	-	-
Salt-killed Tundra	0	-	-	0	-	-
Deep Open Water w/o Islands	0	-	-	0	-	-
Deep Open Water w/ Islands or Polygonized Margins	0	-	-	0	-	-
Shallow Open Water w/o Islands	0	-	-	0	-	-
Shallow Open Water w/ Islands or Polygonized Margins	0	-	-	0	-	-
River or Stream	0	-	-	0	-	-
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	0.03	0	0	<0.1	–1.00	ns
Aquatic Grass Marsh	0	-	-	0	-	-
Young Basin Wetland Complex	14.23	0	0	5.0	–1.00	ns
Old Basin Wetland Complex	35.60	2	10.0	12.5	–0.11	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	84.67	10	50.0	29.9	0.25	ns
Moist Tussock Tundra	94.62	5	25.0	33.4	–0.14	ns
Riverine or Upland Shrub	7.74	3	15.0	2.7	0.69	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	283.64	20	100	100		

[a] Aquatic habitats were assigned zero availability for fox dens.
[b] Ivlev's E = (use – availability)/(use + availability); calculated from number of dens.
[c] Significance calculated from 1,000 simulations at $\alpha = 0.05$: ns = not significant; prefer = use significantly greater than availability; avoid = use significantly less than availability.

Shrub was the only preferred habitat; in the Transportation Corridor, this type constitutes only 2.7% of the area of terrestrial habitats. The most dens in a single type (10) were located in Moist Sedge–Shrub Meadow, the second most available habitat (29.9% of total area) in the corridor. Fewer dens were located in Moist Tussock Tundra (5 dens), Riverine or Upland Shrub (3 dens, all in upland shrub), and Old Basin Wetland Complex (2 dens). No habitats were significantly avoided by denning foxes in the Transportation Corridor.

In both the Delta and Transportation Corridor survey areas, foxes prefer Riverine or Upland Shrub for denning (Tables 31 and 32). Dens in other habitats actually are located in small patches of higher microrelief that are below our minimal mapping size of habitat areas. 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 28; Garrott 1980, Eberhardt et al. 1983). Those landforms are usually vegetated with upland shrubs and less commonly with riverine shrubs. Pingos are used commonly as den sites in the Prudhoe Bay area (Burgess et al. 1993), but account for only a small percentage of the 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). These observations all confirm that the primary requirement for denning habitat is well-drained soil with a texture conducive to burrowing, conditions that occur on elevated microsites within a variety of larger habitat types.

OTHER MAMMALS

Most sightings of other mammals in 1998 were made opportunistically or incidentally during surveys for birds, foxes, or caribou (the latter for the separate study by Lawhead 1999). We have not conducted specific surveys for mammals other than caribou and foxes during our 1992–1998 surveys, except for several aerial surveys of muskoxen in the Itkillik uplands to the south of the delta, and spotted seal haulouts along the main channel and northeastern delta. Previous reports (e.g., Johnson et al. 1998) provide more detailed background information on polar bears, grizzly (brown) bears, muskoxen, spotted seals, and several other species. The following species accounts provide updates for the 1998 season, with brief discussions of context and relevance.

POLAR BEAR

Information on the distribution of polar bear maternity dens in the Beaufort Sea region has accumulated slowly from reports over several decades (few systematic surveys have been conducted specifically to locate polar bear dens), and has been supplemented by tracking of marked females through telemetry. Of 90 dens occupied by pregnant female polar bears (tracked by telemetry) 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 has been increasing in recent years, probably as a result of population recovery following prohibition of sport hunting in 1972 (Stirling and Andriashek 1992, Amstrup and Gardner 1994). The Beaufort Sea population increased at a mean rate of 2.4% over the last two decades, and currently is thought to be increasing slightly or stabilizing near carrying capacity (USFWS 1995). The increasing population and the increasing proportion of terrestrial denning suggest that the number of females denning on land in the Colville Delta region may increase accordingly.

Records obtained from various sources (S. Amstrup, pers. comm.; S. Schliebe, pers. comm.; USFWS 1995) indicate a low frequency of occurrence of maternity dens in the vicinity of the Colville Delta (Figure 24). These records include locations of dens in the immediate vicinity of the delta (some dating from the 1920s, 1940s, and 1950s), as recorded in interviews with hunters from Nuiqsut (USFWS 1995: Appendix A). It should be noted that, because the locations mapped from the accumulated records over many years cover a wide range of accuracy, all locations should be considered approximate.

Polar bears den occasionally on the Colville Delta. For instance, a den was occupied in the winter of 1996–1997 in the northeastern Development Area (I. Helmericks, pers. comm. to USFWS); that den is the most recent one discovered in the study area. East of the delta, lower Kalubik Creek has been used repeatedly by denning females over the years, as indicated by three additional records (undated) from the USFWS database (Figure 24). Additional literature records of dens were reported by Seaman et al. (1981: Figure 7), who showed 12 locations of dens and females with cubs recently out of dens between the lower Itkillik River and Kalubik Creek, plus 5 locations in the Beaufort Sea within 30 km of the mouth of the Colville River. 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. All of the den locations reported by Seaman et al. (1981) and Lentfer and Hensel (1980) presumably are included in the USFWS database.

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. Therefore, dunes and bluffs along the Colville River channels and bluffs along Kalubik Creek and the Miluveach and Kachemach rivers provide the habitats most likely to be used by denning polar bears in the general study area.

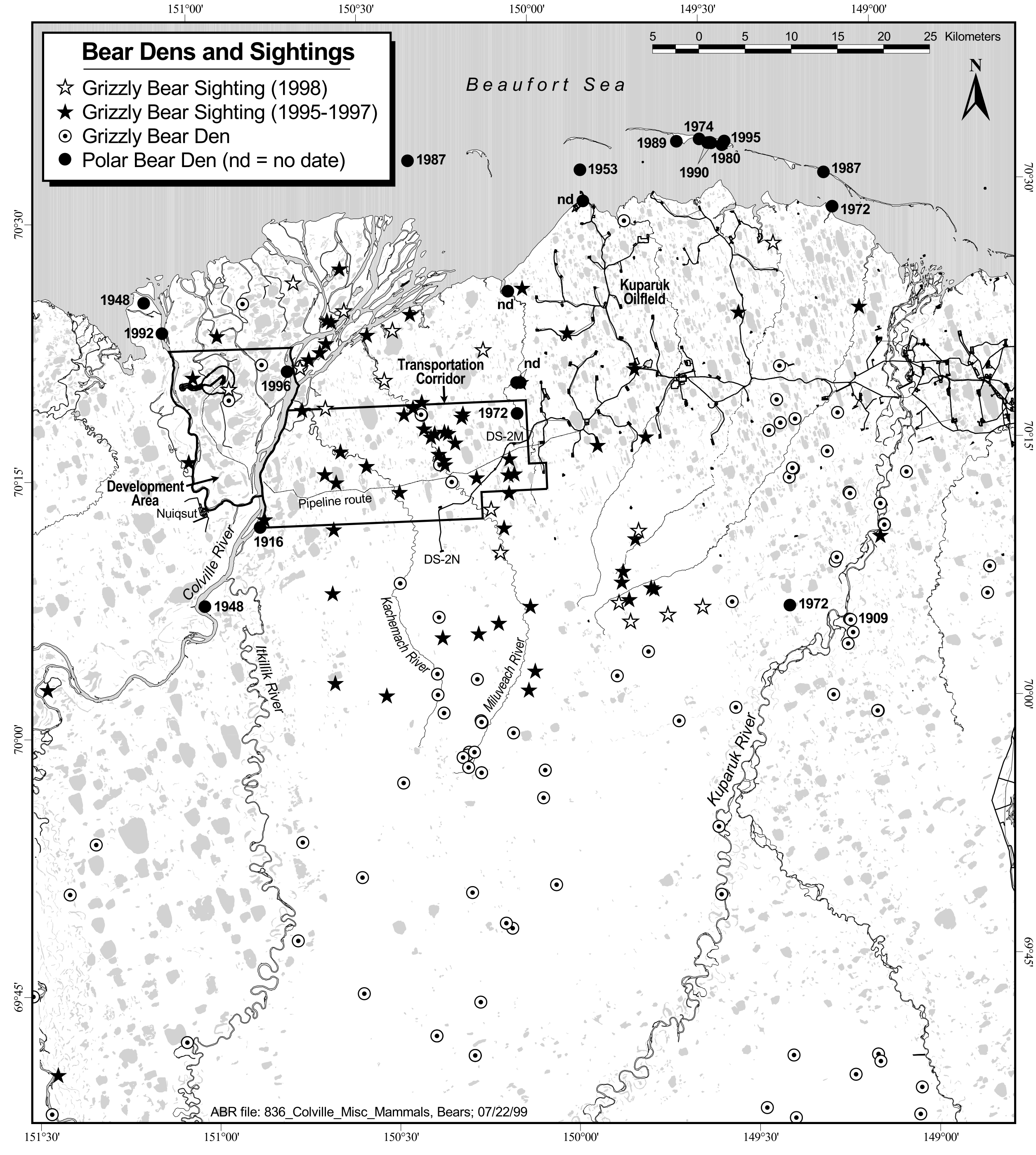

Figure 24. Distribution of winter dens of polar and grizzly bears (records from USFWS and ADFG databases) and incidental sightings of grizzly bears during aerial surveys near the Colville River Delta, Alaska, June–September 1995–1998. Observation effort was greatest in the Development Area and Transportation Corridor during June–August.

GRIZZLY BEAR

From June to August 1998, we observed grizzly bears on 18 occasions, totaling 21 animals, during our surveys for birds, foxes, and caribou (Figure 24). At least six different bears, including a female and her 2-year-old cub, were involved in these sightings. More bears probably were represented, however, because we often were unable to distinguish ear tags of individuals marked by the Alaska Department of Fish and Game (ADFG) in their ongoing study in the oilfield region. As in previous years, we saw several grizzly bears (at least five different individuals) during the first half of June on the caribou calving grounds south of the Kuparuk Oilfield (see Lawhead 1999 for survey details). Most of our later sightings occurred west of the Kuparuk Oilfield because we frequently flew over that area, and because that area includes favorable riverine habitat along the Miluveach and Kachemach rivers that has been used consistently in past years. In 1998, at least one bear spent much of the summer on the eastern portion of the Colville Delta. Over the years of our study, we have seen grizzly bears more commonly in the Transportation Corridor and the uplands south of it than on the delta (Figure 24). Our sightings have increased over time in concert with our increased observation effort from 1992 to 1996–1998. 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.

Since 1991, ADFG has captured and marked approximately 60 bears on the central Arctic Coastal Plain between the Colville and Canning rivers (at least 26 were radio-collared as of winter 1998–1999) in an ongoing study of use of the oilfields by bears. Additional unmarked bears also occur in the region, although most bears now appear to have been tagged. Most of the bears collared and tracked 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.), and additional dens used in the past by unmarked bears also have been located by ADFG. 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.).

Approximately 60 of the grizzly bear dens found by ADFG were located between the Kuparuk Oilfield and the Colville River, south to 69º 40' N (Figure 24). At least 42 dens are known to have been used by 17 different marked bears from the 1991–1992 to the 1998–1999 denning seasons; the other dens were older or were used by unmarked bears. Marked bears have denned on the Colville Delta four times since marked bears first denned there in winter 1996–1997. One den, containing two subadult males in 1996–1997, was located along the Sakoonang Channel approximately 1.5 km south of the Facility Area. One of these two males also denned on the delta in the winters of 1997–1998 and 1998–1999. The fourth den, occupied by a pregnant female that gave birth to a litter of three cubs in the 1996–1997 season, was located in a large sand dune on Ptarmigan Island in the East Channel in the northeast corner of the Development Area. In the Transportation Corridor, four different dens have been occupied by marked bears along the Miluveach River in recent years: two dens during winter 1997–1998, and one each in 1995–1996 and 1996–1997. One marked bear denned in 1998–1999 about 5 km southwest of the southernmost Tarn drill site (DS-2N). Most grizzly bear dens in the Colville–Kuparuk 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.

MUSKOX

The muskoxen population inhabiting the area between the Sagavanirktok and Colville rivers is thought to have originated through dispersal from the reintroduced population in ANWR. On 9 April 1998, ADFG conducted a winter survey of muskoxen west of the Sagavanirktok river (Game Management Unit [GMU] 26B ‘West’). ADFG located 79 muskoxen on that survey, all in the Itkillik uplands (G. Carroll, pers. comm.), where we have found the largest numbers in our surveys during late May and early June (see below). At the same time, USFWS found 153 muskoxen between the Sagavanirktok and Canning rivers (GMU 26B ‘East’), for a total of 232 in GMU 26B (Hicks 1998). More muskoxen had been seen in GMU 26B on the first regional muskoxen survey in the previous year. On 16 April

1997, ADFG located 92 muskoxen in GMU 26B West, nearly all of which were in the Itkillik uplands (a few muskoxen also were found in the White Hills). The total number counted in GMU 26B (West and East combined) in 1997 was 279 muskoxen (Hicks 1997).

During the summers of 1992–1993 and 1995–1998, we saw most muskoxen south and east of the Colville Delta, although a few (mostly lone bulls) have been seen on the delta (Figure 25). We first found relatively large numbers of muskoxen (24 animals in 2 groups) in the uplands east of the Itkillik River, 40–50 km south of the Transportation Corridor, during a caribou calving survey in late May 1993. We have returned in early June each year since then (except 1994) because the largest numbers of muskoxen we have seen occurred consistently in that general location and at that time of year. The number there increased each year from 1993 through 1997, indicating an expanding population.

In 1998, however, we located only one group of 25 muskoxen (including 4 calves) in the general area of concentration in preceding years. In contrast, we found 99 muskoxen (including 19 calves) in the same area of the Itkillik uplands on 4 June 1997, 84 muskoxen (including 22 calves) on 5 June 1996, and 61 muskoxen (including 7 calves) on 5 June 1995. The calf numbers in these counts probably were lower than the actual numbers produced each year because calving continues after early June (Reynolds et al. 1986). Although we have not conducted systematic surveys of this species in the lower Colville and Itkillik drainages, the similarity of the numbers we observed in June 1997 with those found by ADFG in April 1997 indicates that we were monitoring the majority of the population west of the Sagavanirktok River in the last few years. As of 1998, we were no longer confident that was the case. We are unable to explain the low numbers seen in the Itkillik uplands in June 1998, but predation by bears (three collared bears were found on muskoxen carcasses on an ADFG telemetry survey on 23 May 1998) and dispersal to other areas because of early snowmelt and/or human activity on the ground (intensive 3D seismic exploration) in the area just north of the wintering area may have been contributing factors.

We observed several groups of muskoxen repeatedly during July–September 1998 in the vicinity of the Colville Delta and Transportation Corridor. The largest group consisted of 23–24 muskoxen, including 2 calves, along the east bank of the East Channel near the pipeline crossing, between mid-August and mid-September. A group of 8 muskoxen was found on 7 August on the lower Kachemach River. A group of 17 muskoxen, including 5 calves, was seen moving rapidly northeast, paralleling the Tarn road and crossing the Miluveach River, on 12 July. Earlier, this group had been near the Tarn road north of DS-2N (J. Dell, Maritime Helicopters, pers. comm.). From mid-June to at least early July, a group of 7 adults and 4 calves consistently used the area along the coast east of the Milne Point Oilfield, and inland to the Cascade drill site in the Milne Point field. Three mixed sex groups were seen along the Kuparuk River south of the Kuparuk sales oil pipeline, ranging from 18 animals (including 4 calves) on 16 June, to 8 animals on 11 August.

These observations of muskoxen groups scattered between the Colville and Kuparuk rivers are generally similar to those from past years, although we saw none in July 1998 along the lower Kachemach River, where muskoxen occurred consistently in July 1996–1997. In July 1997, a mixed-sex group of 24 muskoxen, including 3 calves, consistently used riverine shrub habitat along the lower Kachemach River, and muskoxen were observed repeatedly in the area between the Itkillik and Kachemach river mouths during July–September (Johnson et al. 1998). In July 1996, a mixed-sex group of 20–21 muskoxen, including 7 calves, moved down the Kachemach River, then south toward the Itkillik River (Johnson et al. 1997). Mixed-sex groups containing calves were seen each summer in 1992, 1993, and 1995 near the mouth of the Itkillik River and along the eastern side of the Colville River north of there (Smith et al. 1993, 1994; Johnson et al. 1996). Sightings of muskoxen on the delta have been less common, and have generally involved few animals. A single cow with a calf was seen on an island in the East Channel in 1997, and several lone bulls were seen on the delta in previous years.

Research in ANWR has shown that muskox home ranges are larger, and activity and movement rates are much higher, during summer than winter (Reynolds et al. 1986). Long-distance movements from winter to summer range are common in mid-

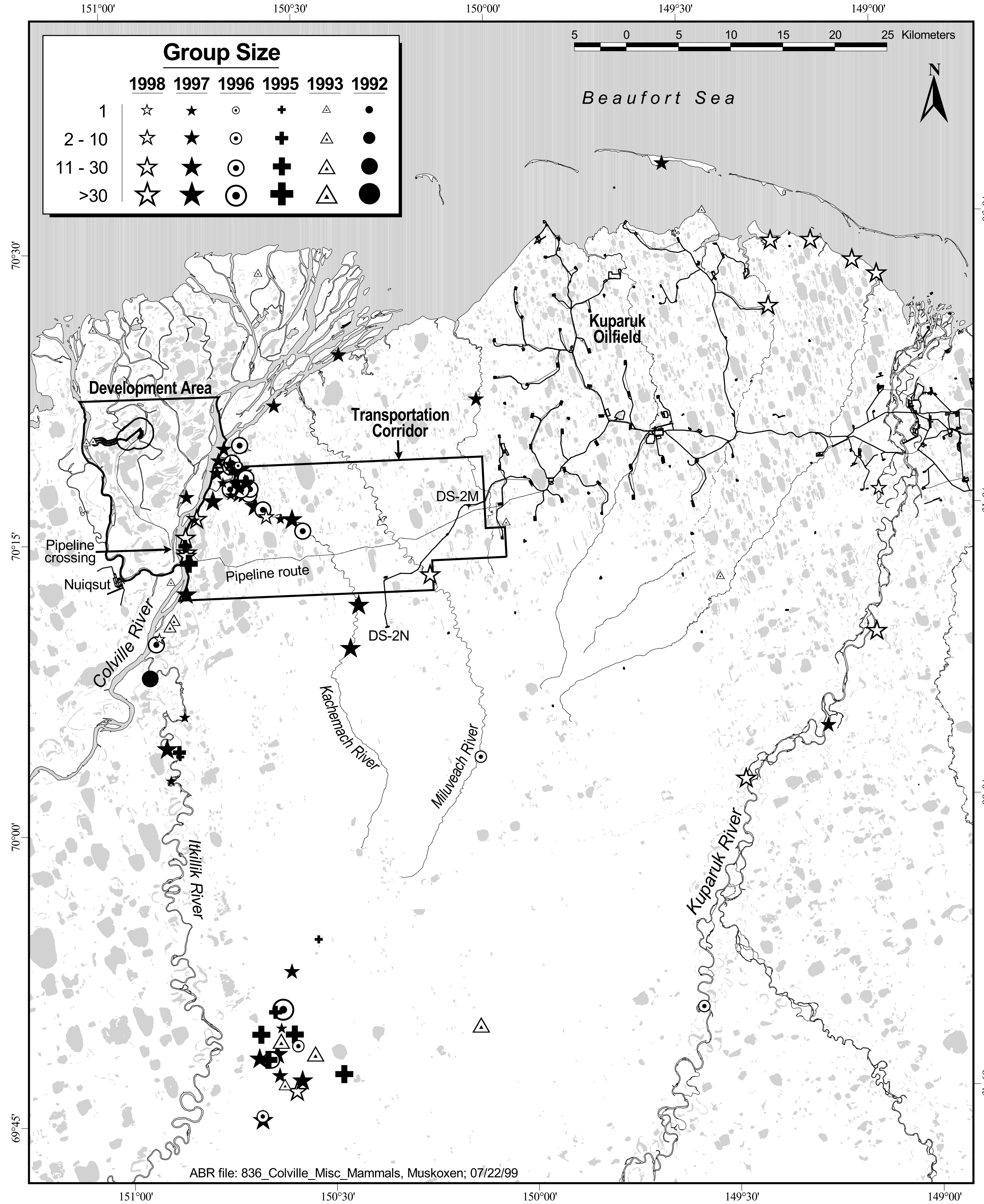

Figure 25. Distribution of muskoxen seen during aerial surveys near the Colville River Delta, Alaska, May–September 1992–1993, and 1995–1998. Observation effort was greatest in the Development Area and Transportation Corridor during June–August.

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 contained 10–30 animals in summer (Reynolds et al. 1986, Reynolds 1992b). Our observations indicate that the muskox population residing in the Itkillik–Colville region follows a similar pattern of seasonal movements and group dynamics. Muskoxen winter in the uplands east of the Itkillik River, then disperse during summer into smaller groups, some of which move northward along the Itkillik and Kachemach rivers to the Colville Delta vicinity, especially the riverine habitats bordering the East Channel, and move southward again later in the summer and fall.

SPOTTED SEAL

In the Chukchi and Beaufort seas, spotted seals haul out on land from mid-July through late October (Seaman et al. 1981; Frost et al. 1993; ABR, Inc., unpubl. data). Favored haul-out sites are small islands, sand spits, and shoals adjacent to deep water (Seaman et al. 1981, Frost et al. 1993, ABR, Inc., unpubl. data). Although the distribution and abundance of spotted seals from Pt. Barrow eastward along the Beaufort Sea coast is poorly documented, the Colville Delta is known to be used by seals in summer and autumn. Seaman et al. (1981) reported an estimate from J. Helmericks of 150–200 seals using the Colville Delta from late July through autumn. Satellite tracking of spotted seals outfitted with transmitters has revealed that movements of individuals from Kasegaluk Lagoon (on the Chukchi Sea coast in northwestern Alaska) to the Colville Delta may begin as late as August (Frost et al. 1993).

We did not conduct specific surveys for spotted seals in 1998, but checked on known haulouts opportunistically during aerial surveys for other species. About 16 seals were hauled out on a small island in the East Channel off the mouth of the Kachemach River, on 25 August 1998 (Figure 26). On 14 September, four seals were hauled out at a consistently used site at the southwest end of Anachlik Island. During eight aerial surveys in 1997, we saw small groups of spotted seals on four occasions, hauled out on sand spits or in adjacent shoals in these same two locations (Johnson et al. 1998). Seals were not seen elsewhere on the delta, nor were any seen on or around the Jones Islands or Pingok Island in 1997. Seaman et al. (1981) speculated that adequate haulout sites on the delta are limited in number. The two locations where we observed seals in 1998 probably represent traditionally used sites.

MOOSE

We spotted a female moose in the Development Area on 10–11 June 1998, and again on 11 July, in the area between Nanuk Lake and the Sakoonang Channel. Moose are rare on the delta, and occur at much higher densities upstream along the Colville River (Coady 1979). At least two female moose were seen on 16 and 20 July 1997 near the East Channel and Pikonik Mound, north of the Transportation Corridor. Our observers saw no moose on the delta during 1992–1996, although we found two sets of tracks one year. USFWS biologists saw 1–4 moose per year during summer field work on the delta in the early 1980s (Simpson et al. 1982, Renken et al. 1983, Rothe et al. 1983).

BELUKHA

We spotted a pod of 10 belukha whales on 4 July 1998 in the nearshore waters within a half-mile of the coast west of Oliktok Point. Sightings of this species are unusual during midsummer, especially that close to shore. Belukhas typically pass much farther offshore on spring and fall migrations between the Bering Sea and eastern Beaufort Sea off the Mackenzie River delta (Hazard 1988).

WOLVERINE

A single adult wolverine (with unusual blond coloration over its the entire back) was seen near the mouth of the Kachemach River on 11 June 1998. Wolverines are rare to uncommon on the outer coastal plain. Another wolverine was reportedly seen near the pipeline crossing of the East Channel in winter 1997–1998, and a very dark individual was seen in fall 1998 (R. Griffeth, pers. comm.). We have seen only one other during our studies, on the Outer Delta in July 1993 (Smith et al. 1994).

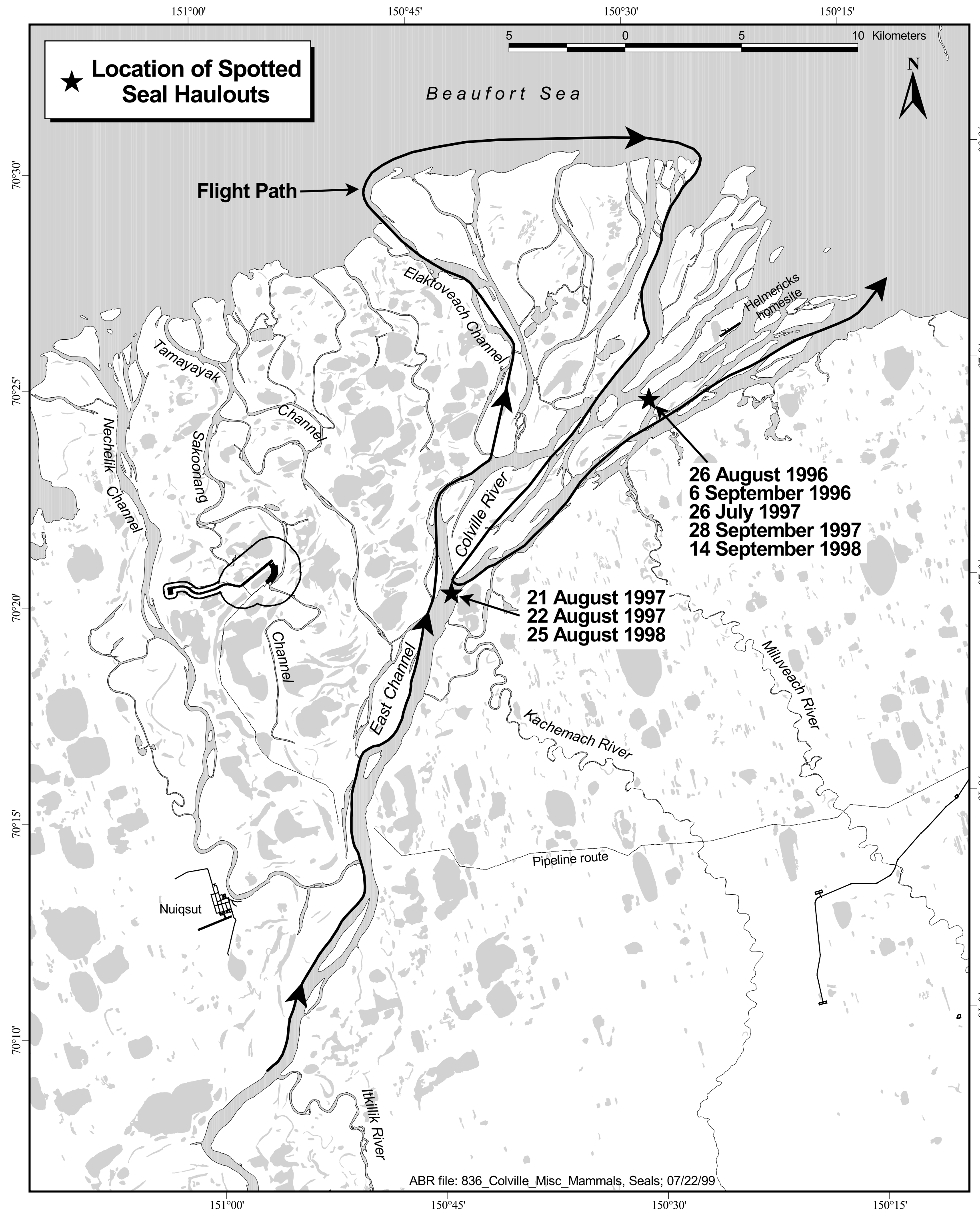

Figure 26. Locations and dates of Spotted Seal observations on the Colville River, Alaska, 1996, 1997, and 1998. The flight path was not followed in 1998; observations in that year were made opportunistically during other surveys.

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Appendix A. Common and scientific names of birds and mammals seen during the Colville River Deltaildlife Study, May–October 1992–1998.

BIRDS

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

MAMMALS

Snowshoe Hare	*Lepus americanus*
Arctic Ground Squirrel	*Spermophilus parryii*
Brown Lemming	*Lemmus sibiricus*
Collared Lemming	*Dicrostonyx rubricatus*
Gray Wolf	*Canis lupus*
Arctic Fox	*Alopex lagopus*
Red Fox	*Vulpes vulpes*
Grizzly Bear	*Ursus arctos*
Ermine	*Mustela erminea*
Wolverine	*Gulo gulo*
Spotted Seal	*Phoca largha*
Moose	*Alces alces*
Caribou	*Rangifer tarandus*
Muskox	*Ovibos moschatus*

Appendix B. Descriptions of wildlife habitat types found in the Delta and Transportation Corridor survey areas, Colville River, Alaska, 1998.

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 lake 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 C*arex 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.

Appendix B. (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.

Appendix B. (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 (S*alix 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.

Appendix B. (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 C1. Habitat selection by Spectacled Eiders and King Eiders during pre-nesting on the Delta survey area, Colville River, Alaska, 1998.

Species/Habitat	Area (km^2)	No. of Groups	No. of Adults	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection[b]
SPECTACLED EIDER							
Open Nearshore Water (marine)	8.32	0	0	0	1.6	-1.00	11
Brackish Water	6.42	5	10	16.7	1.2	0.86	1
Tapped Lake w/ Low-water Connection	21.42	4	8	13.3	4.1	0.53	4
Tapped Lake w/ High-water Connection	20.29	0	0	0	3.9	-1.00	11
Salt Marsh	16.68	2	5	6.7	3.2	0.35	5
Tidal Flat	37.37	0	0	0	7.1	-1.00	11
Salt-killed Tundra	25.63	2	4	6.7	4.9	0.15	8
Deep Open Water w/o Islands	23.31	2	3	6.7	4.5	0.20	7
Deep Open Water w/ Islands or Polygonized Margins	5.15	1	1	3.3	1.0	0.54	3
Shallow Open Water w/o Islands	2.30	0	0	0	0.4	-1.00	11
Shallow Open Water w/ Islands or Polygonized Margins	0.55	0	0	0	0.1	-1.00	11
River or Stream	75.43	1	1	3.3	14.4	-0.62	9
Aquatic Sedge Marsh	0	-	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.60	6	13	20.0	2.6	0.77	2
Aquatic Grass Marsh	1.37	0	0	0	0.3	-1.00	11
Young Basin Wetland Complex	<0.01	0	0	0	<0.1	-1.00	11
Old Basin Wetland Complex	0.01	0	0	0	<0.1	-1.00	11
Nonpatterned Wet Meadow	41.92	4	13	13.3	8.0	0.25	6
Wet Sedge–Willow Meadow	101.83	1	2	3.3	19.5	-0.71	10
Moist Sedge–Shrub Meadow	13.10	0	0	0	2.5	-1.00	11
Moist Tussock Tundra	2.49	0	0	0	0.5	-1.00	11
Riverine or Upland Shrub	27.10	0	0	0	5.2	-1.00	11
Barrens (riverine, eolian, lacustrine)	78.67	0	0	0	15.0	-1.00	11
Artificial (water, fill, peat road)	0.02	0	0	0	<0.1	-1.00	11
Total	522.97	30	60	100	100		
KING EIDER							
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	3	16.7	4.1	0.61	2
Tapped Lake w/ High-water Connection	20.29	0	0	0	3.9	-1.00	6
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	1	2	16.7	4.9	0.55	3
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	2	4	33.3	14.4	0.40	4
Aquatic Sedge Marsh	0	0	0	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.60	1	2	16.7	2.6	0.73	1
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	1	6	16.7	8.0	0.35	5
Wet Sedge–Willow Meadow	101.83	0	0	0	19.5	-1.00	6
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	6	17	100	100		

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

Appendix C2. Habitat selection by Tundra Swans during nesting and brood-rearing in the Delta survey area, Colville River, Alaska, 1998.

Season/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)	10.28	0	0	1.9	-1.00	12
Brackish Water	6.50	0	0	1.2	-1.00	12
Tapped Lake w/ Low-water Connection	21.40	0	0	3.9	-1.00	12
Tapped Lake w/ High-water Connection	20.40	1	3.2	3.7	-0.05	10
Salt Marsh	16.36	1	3.2	3.0	0.06	9
Tidal Flat	55.99	1	3.2	10.2	-0.51	12
Salt-killed Tundra	25.62	3	9.7	4.6	0.37	7
Deep Open Water w/o Islands	23.32	0	0	4.2	-1.00	12
Deep Open Water w/ Islands or Polygonized Margins	5.15	4	12.9	0.9	0.87	4
Shallow Open Water w/o Islands	2.30	0	0	0.4	-1.00	12
Shallow Open Water w/ Islands or Polygonized Margins	0.54	0	0	0.1	-1.00	12
River or Stream	81.88	0	0	14.8	-1.00	12
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.59	3	9.7	2.5	0.60	5
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	1
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	12
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	12
Nonpatterned Wet Meadow	41.92	2	6.5	7.6	-0.07	8
Wet Sedge–Willow Meadow	102.37	11	35.5	18.6	0.28	6
Moist Sedge–Shrub Meadow	13.40	2	6.5	2.4	0.47	3
Moist Tussock Tundra	2.53	1	3.2	0.5	0.76	2
Riverine or Upland Shrub	27.42	1	3.2	5.0	-0.20	12
Barrens (riverine, eolian, lacustrine)	79.03	1	3.2	14.3	-0.62	11
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	12
Total	551.42	31	100	100		
BROOD-REARING						
Open Nearshore Water (marine)	10.28	0	0	1.9	-1.00	11
Brackish Water	6.50	1	4.5	1.2	0.59	11
Tapped Lake w/ Low-water Connection	21.40	2	9.1	3.9	0.40	2
Tapped Lake w/ High-water Connection	20.40	2	9.1	3.7	0.42	11
Salt Marsh	16.36	2	9.1	3.0	0.51	7
Tidal Flat	55.99	0	0	10.2	-1.00	11
Salt-killed Tundra	25.62	2	9.1	4.6	0.32	5
Deep Open Water w/o Islands	23.32	1	4.5	4.2	0.04	3
Deep Open Water w/ Islands or Polygonized Margins	5.15	3	13.6	0.9	0.87	1
Shallow Open Water w/o Islands	2.30	0	0	0.4	-1.00	11
Shallow Open Water w/ Islands or Polygonized Margins	0.54	0	0	0.1	-1.00	11
River or Stream	81.88	0	0	14.8	-1.00	10
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	13.59	1	4.5	2.5	0.30	4
Aquatic Grass Marsh	1.37	0	0	0.2	-1.00	11
Young Basin Wetland Complex	<0.01	0	0	<0.1	-1.00	11
Old Basin Wetland Complex	0.01	0	0	<0.1	-1.00	11
Nonpatterned Wet Meadow	41.92	2	9.1	7.6	0.09	9
Wet Sedge–Willow Meadow	102.37	4	18.2	18.6	-0.01	8
Moist Sedge–Shrub Meadow	13.40	1	4.5	2.4	0.30	6
Moist Tussock Tundra	2.53	0	0	0.5	-1.00	11
Riverine or Upland Shrub	27.42	0	0	5.0	-1.00	11
Barrens (riverine, eolian, lacustrine)	79.03	1	4.5	14.3	-0.52	11
Artificial (water, fill, peat road)	0.02	0	0	<0.1	-1.00	11
Total	551.42	22	100	100		

[a] Ivlev's E = (use – availability/use + availability); calculated from numbers of nests or broods.
[b] Lower numbers indicate higher preference.

Appendix C3. Habitat selection by Yellow-billed Loons during nesting and brood-rearing in the Delta survey area, Colville River, Alaska, 1998.

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	7
Tapped Lake w/ Low-water Connection	19.38	0	0	6.0	-1.00	7
Tapped Lake w/ High-water Connection	19.57	1	4.5	6.1	-0.14	5
Salt Marsh	5.64	0	0	1.7	-1.00	7
Tide Flat	0.06	0	0	<0.1	-1.00	7
Salt-killed Tundra	7.48	0	0	2.3	-1.00	7
Deep Open Water w/o Islands	21.09	1	4.5	6.5	-0.18	6
Deep Open Water w/ Islands or Polygonized Margins	3.58	3	13.6	1.1	0.85	1
Shallow Open Water w/o Islands	1.87	0	0	0.6	-1.00	7
Shallow Open Water w/ Islands or Polygonized Margins	0.40	0	0	0.1	-1.00	7
River or Stream	38.33	0	0	11.9	-1.00	7
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	10.00	3	13.6	3.1	0.63	2
Aquatic Grass Marsh	1.20	0	0	0.4	-1.00	7
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	29.78	3	13.6	9.2	0.19	4
Wet Sedge–Willow Meadow	80.84	11	50.0	25.0	0.33	3
Moist Sedge–Shrub Meadow	9.10	0	0	2.8	-1.00	7
Moist Tussock Tundra	0.01	0	0	<0.1	-1.00	7
Riverine or Upland Shrub	22.61	0	0	7.0	-1.00	7
Barrens (riverine, eolian, lacustrine)	51.27	0	0	15.9	-1.00	7
Artificial (water, fill, peat road)	0	-	-	0	-	-
Total	323.42	22	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	4	33.3	6.1	0.69	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	6	50.0	6.5	0.77	2
Deep Open Water w/ Islands or Polygonized Margins	3.58	2	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	12	100	100		

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

Appendix C4. Habitat selection by Brant brood-rearing groups in the Outer Delta survey area, Colville River, Alaska, 1998.

Habitat	Area (km^2)	No. of Brood-rearing Groups	Use (%)	Availability (%)	Selection Index (Ivlev's E)[a]	Rank Order of Selection
Open Nearshore Water (marine)	10.46	0	0	4.8	-1.00	7
Brackish Water	6.29	7	53.9	2.9	0.90	2
Tapped Lake w/ Low-water Connection	5.17	1	7.7	2.4	0.53	3
Tapped Lake w/ High-water Connection	2.06	0	0	0.9	-1.00	7
Salt Marsh	12.61	1	7.7	5.8	0.14	4
Tidal Flat	55.89	0	0	25.5	-1.00	7
Salt-killed Tundra	22.22	1	7.7	10.1	-0.14	6
Deep Open Water w/o Islands	0.69	0	0	0.3	-1.00	7
Deep Open Water w/ Islands or Polygonized Margins	1.78	0	0	0.8	-1.00	7
Shallow Open Water w/o Islands	0.53	1	7.7	0.1	0.94	1
Shallow Open Water w/ Islands or Polygonized Margins	0.20	0	0	0.1	-1.00	7
River or Stream	43.15	2	15.4	19.7	-0.12	5
Aquatic Sedge Marsh	0	-	-	0	-	-
Aquatic Sedge w/ Deep Polygons	6.40	0	0	2.9	-1.00	7
Aquatic Grass Marsh	0.19	0	0	0.1	-1.00	7
Young Basin Wetland Complex	0	-	-	0	-	-
Old Basin Wetland Complex	0	-	-	0	-	-
Nonpatterned Wet Meadow	9.76	0	0	4.5	-1.00	7
Wet Sedge–Willow Meadow	9.33	0	0	4.3	-1.00	7
Moist Sedge–Shrub Meadow	1.73	0	0	0.8	-1.00	7
Moist Tussock Tundra	1.68	0	0	0.8	-1.00	7
Riverine or Upland Shrub	0.81	0	0	0.4	-1.00	7
Barrens (riverine, eolian, lacustrine)	28.08	0	0	12.8	-1.00	7
Artificial (water, fill, peat road)	0.02	0	0	0	-1.00	7
Total	219.06	13	100	100		

[a] Ivlev's E = (use – availability)/(use + availability); calculated for brood-rearing groups.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.