SIXTH ANNUAL REPORT

AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2008

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EXECUTIVE SUMMARY

Avian aerial surveys were conducted in the Colville Delta and in the northeastern National Petroleum Reserve–Alaska (NPRA) in 2008 in support of the Alpine Satellite Development Project (ASDP) for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation. The surveys continued long-term data acquisition begun in 1992 on the Colville Delta and in 1999 in the NPRA. Surveys focused on the abundance, distribution, and habitat use of 5 focal species: Spectacled Eider, King Eider, Tundra Swan, Yellow-billed Loon, and Brant. These five species were selected because of 1) threatened or sensitive status, 2) indications of declining populations, 3) restricted breeding range, or 4) concern of regulatory agencies for development impacts. Monitoring a collection of focal species with differing habitat requirements provides both in-depth data on species trends and responses to a changing environment and a general view of ecosystem health. Aerial surveys for eiders, swans, and Brant were conducted from fixed-wing airplanes. Surveys for loons were conducted from a helicopter. In 2008, the ASDP comprised 6 satellite drill sites (2 completed, 4 proposed) that would send oil for processing to the existing Alpine Facility on the Colville Delta.

The Colville Delta study area (552 km²) encompassed the entire delta from the East Channel of the Colville River to the westernmost distributary of the Niġliq Channel. The Alpine Facility began oil production on the Colville Delta in 2000. Two ASDP satellite drill sites were built in the winter of 2005: CD-3 was built as a roadless drill site to reduce its gravel footprint in eider breeding habitat on the outer delta, and CD-4 was connected by a road on the south side of the Alpine Facility. The CD-3 site began producing oil in August 2006, and CD-4 began producing in November 2006. The NE NPRA study area (1,571 km²) abutted the western edge of the Colville Delta and encompassed 5 proposed development sites that are part of the ASDP: drill sites CD-5, CD-6, CD-7, and Fiord West, and the Clover A gravel mine site.

Each spring, open houses were held in Nuiqsut to allow residents to visit with CPAI biologists and other scientists to discuss information on and concerns for resources in the Colville Delta and NPRA areas. In March 2008, biologists attended a science fair at the school during the day, followed by an open community meeting in the evening where they presented findings of recent research. During the summer field season, CPAI posted weekly updates on public bulletin boards in Nuiqsut and with local government offices. The updates reported on surveys (for example, type of aircraft used, altitude of aircraft, and species enumerated) conducted the previous week and the schedule of surveys for the upcoming week. The open house meetings and weekly updates served to keep local residents informed on the progress and results of studies conducted by CPAI in the area near Nuiqsut.

Results of aerial surveys for focal bird species indicated that 2008 was a relatively good year for large birds in the Colville Delta and NPRA study areas. Numbers of birds, nests, and broods were generally at or above long-term averages and in several cases were records or near records. Spring conditions were relatively warm in 2008. Mean monthly temperatures for May and June in Kuparuk were 2° C warmer than the 20-year mean temperatures for those months. Mean May and June temperatures were similarly warmer than average at Colville Village on the outer Colville Delta. Snow disappeared from the tundra by the 1st week of June, ice disappeared from deep lakes by 25 June, and mosquitoes were fully emerged by 23 June, all early dates for these seasonal events.

Spectacled Eiders were more numerous (80 eiders) on the Colville Delta during the pre-nesting aerial survey in 2008 than during all 15 years of similar surveys. As in previous years, Spectacled Eiders were found primarily in the CD North subarea. Spectacled Eiders in the NPRA occurred at about one third the density of the Colville Delta, with most occurring in the Fish Creek West and Development subareas.

King Eiders were less than half as numerous as Spectacled Eiders on the Colville Delta during the pre-nesting aerial survey in 2008, and most of the King Eiders were in the Northeast Delta subarea. The density of King Eiders on the Colville Delta study area in 2008 was just above the long-term average. King Eiders were much more abundant in NPRA than on the Colville Delta; their

density in NPRA in 2008 was about twice the long-term average.

Yellow-billed Loons had one of their most productive years since surveys on the Colville Delta began in 1993. We found the highest number of Yellow-billed Loon nests (38) and the highest number of Yellow-billed Loon broods (27) recorded in 14 years of aerial surveys in the Colville Delta study area. In the NPRA study area, we counted 29 Yellow-billed Loon nests and 19 broods. We have not surveyed the same portion of NPRA in the past, so we cannot compare 2008 results with previous years' totals. Apparent nesting success for Yellow-billed loons on the Colville Delta in 2008 was the same as in 2007, which was higher than during the previous 2 years that we conducted weekly nest monitoring. Overall, 27 of 38 nests of Yellow-billed Loons in the Colville Delta study area in 2008 hatched for an apparent nesting success of 71%. In NPRA, 19 of 29 nests hatched for 65% apparent nesting success. Hatch began between nest visits on 2 and 7 July and the final nest hatched by 4 August. Five of the 27 broods in the Colville Delta and 7 of 19 broods in NPRA were lost before the brood-rearing aerial survey (18-19 August). The presence of numerous (≥20) eggshell fragments indicated hatch occurred at 3 nests for which broods were never observed in both study areas.

Most successful Yellow-billed Loon nests (16) on the Colville Delta hatched 2 chicks. Nine pairs either hatched only 1 egg or lost 1 of their chicks sometime between hatching and the next weekly survey. Two pairs hatched an unknown number of young. By the final brood monitoring survey on the Colville Delta on 16 September, 52% of the 27 pairs at successful nests still retained ≥1 chick, 22% had no chicks, and the status of 26% could not be determined due to poor survey conditions. Only 4 pairs retained 2 young through the final survey. Loon chicks were approximately 7–10 weeks old during the last survey and none were observed flying by that time. Broods were not monitored weekly in NPRA.

Fourteen Yellow-billed Loon nests on the Colville Delta were monitored with time-lapse cameras. Camera monitoring had little negative effect on nesting loons. Thirteen loons left nests during camera installation and 1 loon was off its nest before researchers arrived. No loons were observed to leave nesting lakes during camera installations. All loons returned to their nests after cameras were installed (mean = 64 min off nest) and no predation attempts were made on nests while loons were disturbed by camera installations. Apparent nesting success for camera monitored nests was 79%, slightly higher than for all Yellow-billed Loon nests on the Colville Delta. Loons at both hatched and failed nests exhibited high nest attendance, spending 97.1% (n = 9) and 98.0% (n = 3) of monitored time on nests, respectively. All but 2 cameras documented the day of hatch or failure; one camera became fogged with moisture and the other was knocked off its aim, possibly by a caribou. No predation events were observed on camera images. At 1 nest, predation occurred after the camera was knocked out of aim, and at 2 nests, images during those events were obscured by a combination of fog, low magnification of the lens, and large distance from camera to the nest.

Twenty-six nests and 23 broods of Pacific Loons were counted opportunistically during Yellow-billed Loon surveys in the Colville Delta study area in 2008. One nest of Red-throated Loons but no broods were seen during the same aerial surveys. In the NPRA study area, Pacific Loons were counted with 54 nests and 50 broods. No nests or broods were tallied for Red-throated Loons in the NPRA study area although 3 adults were seen on the nesting survey.

Thirty-six Tundra Swan nests were found in the Colville Delta study area in 2008, which is near the average from 15 years of aerial surveys. The brood count of 23 swan broods in the Colville Delta study area was just below the long-term average. Apparent nesting success was 64%. The mean brood size of 2.5 young in 2008 was average, but the 58 swan young counted on the delta was below the long-term average of 65 young produced on the Delta.

In NPRA during 2008, we counted 69 nests and 34 broods of Tundra Swans. The density of swan nests and broods in NPRA was about half that on the Colville Delta. Apparent nesting success was a relatively low 49% in NPRA. The average brood size was 2.6 young, similar to that on the Colville Delta.

Brant and Snow Geese were numerous in the Colville Delta and NPRA study areas in 2008.

Most geese were seen in the coastal areas of the CD North and Fish Creek Delta subareas. The total count for Brant on the Colville Delta during brood-rearing was the second highest recorded (3,637), and the gosling count (1,798) was the highest ever recorded along the same survey route. In the NPRA, we counted a total of 4,012 Brant which included 1,395 young. On the same survey in 2008, a record 1,967 Snow Geese including 1,133 goslings were counted in the Colville Delta study area. In the NPRA, 234 Snow Geese were tallied, of which 127 were goslings. Numbers of Snow Geese have been increasing in recent years.

During the fall-staging survey in 2008, we counted 200 Brant in the Colville Delta study area and 692 Brant in the NPRA study area. A total of 96 Snow Geese were counted on the Colville Delta, all of which were located in the CD North subarea. Only 1 group of 54 Snow Geese was seen in the NPRA study area during the fall-staging survey.

Greater White-Fronted Geese were the most frequently encountered goose during the fall-staging survey. A total of 773 White-Fronted Geese were recorded in the Colville Delta. We also counted 246 White-Fronted Geese in 22 groups in the NPRA study area. White-Fronted Geese increased in abundance inland from the coast over the areas we surveyed. Canada Geese were the least abundant goose in the survey areas. Fifty-five Canada Geese were recorded on the Colville Delta, and 122 birds were recorded in the NPRA study area, chiefly in the Fish Creek Delta.

Forty-nine Glaucous Gull nests and at least 25 broods were counted incidentally on loon aerial surveys in the Colville Delta study area in 2008. This was the highest count of Glaucous Gull nests in the Colville Delta study area in 9 years of surveys, with the majority of nests occurring in the CD South subarea. In the NPRA, we found 40 Glaucous Gull nests and 5 broods in 2008. The largest number of nests was in the Alpine West subarea. Smaller but notable numbers of Sabine's Gulls were recorded incidentally. Two colonies of Sabine's Gulls containing 15 nests were observed on the Colville Delta during the aerial survey for nesting loons in 2008. In the NPRA study area, we located 53 Sabine's Gull nests, of which 51 were in 6 colonies.

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INTRODUCTION

During 2008, ABR, Inc., conducted wildlife surveys for selected birds and mammals in the Colville River Delta and Northeast Planning Area of the National Petroleum Reserve–Alaska (NPRA) in support of the Alpine Satellite Development Project (ASDP) of ConocoPhillips Alaska, Inc. (CPAI). The wildlife studies in 2008 were a continuation of work initiated by CPAI's predecessors, ARCO Alaska, Inc., and Phillips Alaska, Inc., in the Colville River Delta in 1992 (Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 1999b, 2000a, 2000b, 2001, 2002, 2003a, 2003b, 2004, 2005, 2006a, 2006b, 2007a, 2007b, 2008b; Burgess et al. 2000, 2002a, 2003a) and in the NPRA in 1999 (Anderson and Johnson 1999; Murphy and Stickney 2000; Johnson and Stickney 2001; Burgess et al. 2002b, 2003b; Johnson et al. 2004, 2005, 2006b, 2007b). Avian surveys in the NPRA were resumed in 2008 after being discontinued in 2007 due to delays in permitting for the CD-5 drill site. The ASDP studies augment long-term wildlife monitoring programs that have been conducted by CPAI (and its predecessors) across large areas of the central Arctic Coastal Plain since the early 1980s (see Murphy and Anderson 1993, Stickney et al. 1993, Anderson et al. 2008, Lawhead et al. 2008).

The primary goal of wildlife investigations in the region since 1992 has been to describe the distribution and abundance of selected species before, during, and after construction of oil development projects. We report here the results of avian surveys in 2008 that were conducted in the Colville River Delta and northeastern NPRA. CPAI began producing oil on the Colville River Delta in 2000 with the Alpine Development's CD-1 and CD-2 drill sites, and augmented oil production in 2006 with the CD-3 and CD-4 drill sites. CPAI plans additional oil and gas development sites in NE NPRA as part of the Alpine Satellite Development Project (BLM 2004): CD-5 (Alpine West), CD-6 (Lookout), and CD-7 (Spark), and a newly proposed site named Fiord West (Figure 1). Readers are directed to prior reports for wildlife information from previous years.

Surveys in 2008 were designed to provide data on the distribution, abundance, and habitat use of 5 focal taxa (common names followed by Iñupiaq names): Spectacled Eider (Qavaasuk), King Eider (Qiŋalik), Tundra Swan (Qugruk), geese (Niġliq), and Yellow-billed Loon (Tuullik) (scientific names and Iñupiaq names listed in Appendix A). These 5 taxa were selected in consultation with resource agencies because of 1) threatened or sensitive status, 2) indications of declining populations, 3) restricted breeding range, 4) importance to subsistence hunting, or 5) concern by regulatory agencies for development impacts. Monitoring a collection of focal species provides both in-depth data on individual species trends and responses to a changing environment, as well as a general overview of ecosystem health. Data collection for a suite of indicator species with diverse life histories and habitat needs is an efficient way to monitor a multi-species system, obviating the need to study all species that breed in the study area. Ground-based surveys for nesting birds were not conducted in 2008. Required state and federal permits were obtained for authorized survey activities, including a Scientific or Educational Permit (Permit No. 08-013) from the State of Alaska and a Federal Fish and Wildlife Permit—Threatened and Endangered Species [Permit No. TE012155-3 issued under Section 10(a)(1)(A) of the Endangered Species Act (58 FR 27474-27480)]. Similar avian species were monitored in the Kuparuk Oilfield on the eastern border of the Colville River Delta in 2008 (Anderson et al. 2009). Aerial surveys for Steller's Eiders (Igniqauqtuq) near Barrow (Obritschkewitsch 2008), Alaska and banding of snow geese (Kaŋuq) on the Colville River Delta (Ritchie et al. 2008) also were supported by CPAI. Studies of caribou (Tuttu) and other large mammals in the ASDP area in 2008 are reported in Lawhead and Prichard (2009). Additional studies on the use of the ASDP area by grizzly bears (Akłaq) were conducted by the Alaska Department of Fish and Game (ADFG) with support from CPAI in 2002–2008. CPAI also supported the Polar Bear (Nanuq) Conservation Program lead by the U.S. Geological Survey's Alaska Science Center, in its efforts to capture, mark, and monitor polar bears in the central Beaufort Sea.

Wildlife study objectives were developed and study progress was reported through a series of agency and community scoping and planning meetings, beginning in 2001. Annual informational meetings are held each spring in Nuiqsut to allow residents to visit with CPAI biologists and other scientists to share information and discuss concerns for resources in the Colville Delta and NPRA areas. On 20 March 2008, biologists attended a science fair at the school during the day, followed by an open community meeting in the evening where they presented findings of recent research. In 2007, a meeting was scheduled with the Kuukpik Subsistence Oversight Panel and slide shows were presented on current studies at an open house on 19 June 2007. The open house was attended by approximately 40 people from the village of Nuiqsut. During the summer field season in 2008, CPAI posted weekly updates on bulletin boards in the post office, store, and community center in Nuiqsut. Updates were also emailed to key representatives of the Kuukpik Subsistence Oversight Panel (KSOP), Kuukpik Corporation, and the Department of Wildlife of the North Slope Borough. The updates reported on surveys (for example, type of aircraft used, altitude of aircraft, and species enumerated) conducted the previous week and the schedule of surveys for the upcoming week. The open house meetings and weekly updates served to keep local residents informed on the progress and results of studies conducted by CPAI in the area near Nuiqsut.

STUDY AREA

The place names used throughout this report are those depicted on U.S. Geological Survey (USGS) 1:63,360-scale topographic maps, because they are the most widely available published maps of the region. The corresponding local Iñupiaq names for drainages (and wildlife species) are provided in parentheses at the first usage in text and on the study area map (Figure 1). Iñupiaq names are presented out of respect for local residents, to facilitate clear communication with Iñupiaq speakers, and because they pre-date the English names used on USGS maps. We acknowledge that the Iñupiaq names presented are not comprehensive, and we understand that the published USGS names for some streams (notably the Ublutuoch and Tingmeachsiovik rivers) do not correctly reflect local usage. The Iñupiaq names we use for Fish and Judy creeks in northeastern NPRA are taken from the *Iñupiat–English Map of the North Slope Borough* (NSB Planning Department, Barrow, Alaska, May 1997). Additional information was supplied to CPAI in recent years by Nuiqsut elders. Even in cases where USGS attempted to use the correct Iñupiaq names, the anglicized spellings are outdated and so have been corrected to the modern Iñupiaq spellings through consultation with Emily Ipalook Wilson and Dr. Lawrence Kaplan of the Alaska Native Language Center (ANLC) at the University of Alaska Fairbanks. Marjorie Kasak Ahnupkanna and Archie Ahkiviana were consulted to confirm the names of other channels on the Colville River Delta (E. Wilson, ANLC, pers. comm.).

COLVILLE DELTA

The Colville River Delta (henceforth, Colville 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. Two permanent human settlements occur on the Colville Delta—the Iñupiat village of Nuiqsut (population ~400) established in 1973 and Helmericks' family homesite established in the 1950's, also known as "Colville Village".

Oil development on the Colville Delta began in 1998 with construction of the Alpine Facility (a full-production facility including a processing plant, camp, airstrip, and the CD-1 and CD-2 drill sites) (Figure 1). In 2005, construction began on 2 satellite drill sites, whose oil is also processed at Alpine. The CD-3 satellite is a roadless drill site accessible by aircraft during the summer and fall and by ice roads during winter (Figure 1). Due to this remoteness, drilling at this satellite is only conducted during the winter months when ice roads are used for access. The CD-4 satellite is connected to Alpine by an all-season road. Both the CD-3 and CD-4 drill sites began producing oil in 2006.

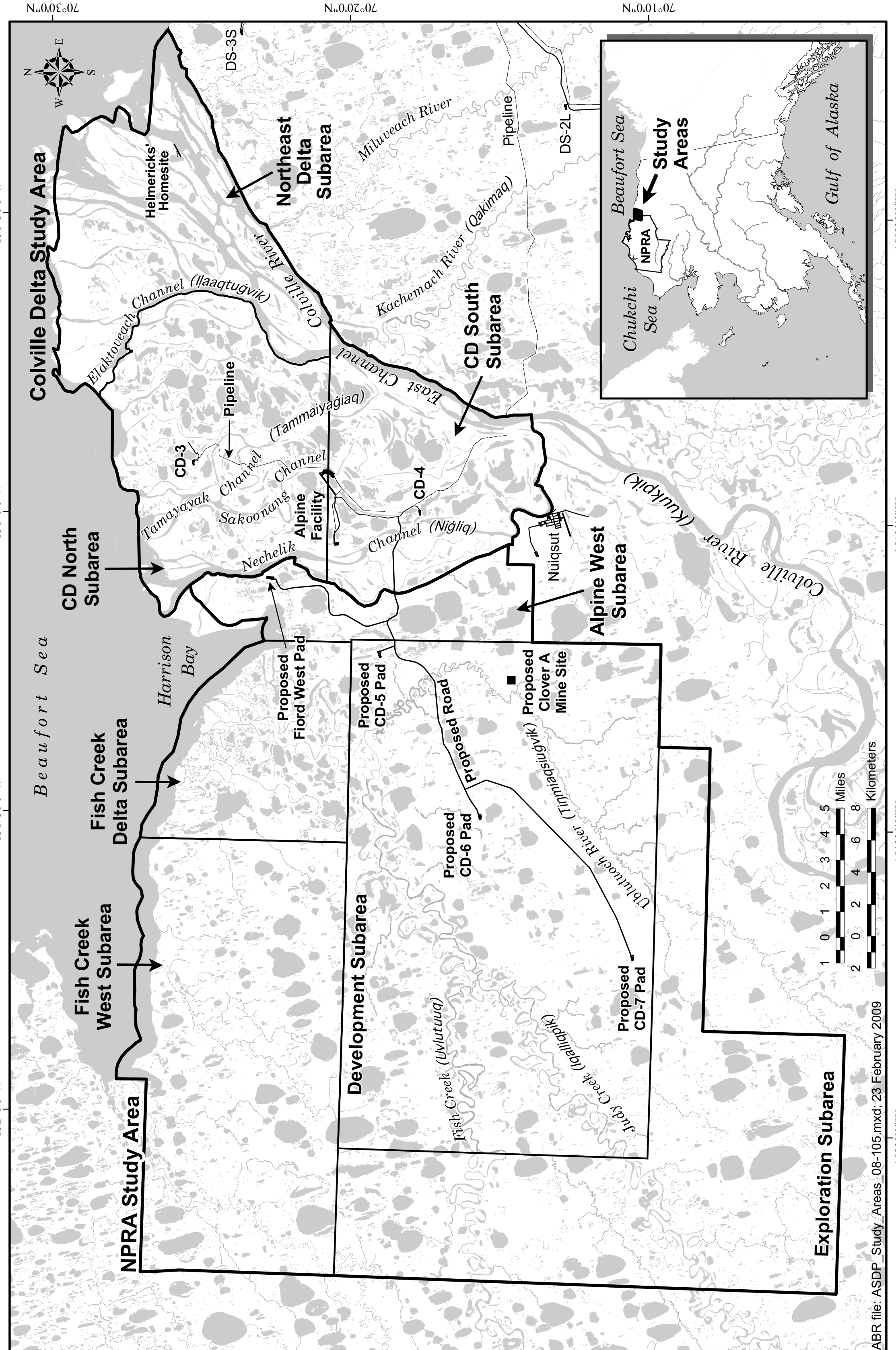

Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2008.

Landforms, vegetation, and wildlife habitats in the Colville Delta were described in the Ecological Land Survey (Jorgenson et al. 1997), and the resulting habitat map was updated in 2004 to unify it with similar mapping of the surrounding Coastal Plain (Figure 2).

Coastal and riverine landforms dominate the delta. Fluvial processes predominate, although eolian and ice-aggradation processes are important to landscape development, as are lacustrine and basin-drainage processes. Of the 26 wildlife habitat types identified on the delta, 4 habitats are clearly dominant (Figure 2, Table 1): Patterned Wet Meadow (19% of the entire delta), River or Stream (15%), Barrens (14%), and Tidal Flat Barrens (11%). No other habitats comprise more than 8% of the delta. Aquatic habitats are a major component of the delta, comprising 32% of the total delta. Coastal salt-affected habitats—Tidal Flat Barrens, Salt-killed Tundra, Salt Marsh, Moist Halophytic Dwarf Shrub, Open Nearshore Water, and Brackish Water—together comprise 21% of the total area and contribute greatly to avian biodiversity. Tapped lakes (Tapped Lake with Low-water Connection and Tapped Lake with High-water Connection) are unique to the delta environment and also are important to the physical and biological diversity of the delta, although they occupy slightly less than 8% of the total area. Other important habitats for birds are those that contain emergent aquatic vegetation (Deep Polygon Complex, Grass Marsh, and Sedge Marsh) and waterbodies with islands and polygonized margins (Deep Open Water with Islands or Polygonized Margins and Shallow Open Water with Islands or Polygonized Margins), which account for a combined total of <5% of the delta. The definition and composition of each habitat are provided in Appendix B. A strong north–south gradient occurs across the delta in the distribution of many of these habitats, with coastal habitats, Tapped Lakes with Low-water Connections, Deep Polygon Complex, and Nonpatterned Wet Meadow decrease in abundance with increasing distance from the coast, whereas Tapped Lakes with High-water Connections, Sedge Marsh, Grass Marsh, Patterned Wet Meadow, Moist Sedge–Shrub Meadow, and the non-halophytic shrub types are more prevalent away from the coast. These patterns of habitat distribution have strong effects on the distribution and abundance of various wildlife species in the delta.

As mentioned above, lakes and ponds are dominant physical features of the Colville Delta. The most abundant waterbodies on the delta are polygon ponds, which generally are shallow (i.e., ≤2 m deep), freeze to the bottom during winter, and thaw by June. Deep ponds and lakes (>2 m deep) with steep, vertical sides are more common on the delta than in adjacent areas of the Arctic Coastal Plain. Lakes >5 ha in size cover 16% of the delta's surface (Walker 1978) and some of these lakes are deep (to 10 m), freezing only in the upper 2 m during winter and retaining floating ice until the first half of July (Walker 1978). Several other types of lakes occur on the delta, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, thaw lakes, and tapped lakes (Walker 1983). Tapped lakes are connected to the river by narrow channels that result from thermokarst of ice wedges and by the migration of river channels (Walker 1978). Channel connections allow water levels in tapped lakes to fluctuate with changes in coastal water level resulting in barren or partially vegetated and often salt-affected shorelines. 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).

As used in this report, the Colville Delta study area (552 km²) comprises the CD North, CD South, and the Northeast Delta subareas (Figure 1). These subareas are useful in describing the distribution of birds on the delta, and together they encompass the entire delta from the eastern bank of the East Channel of the Colville River to the west bank of the westernmost distributary of the Nechelik (Niġliq) Channel and inland to the juncture of these channels.

NPRA

The NPRA study area (1,571 km²) abuts the western edge of the Colville Delta and comprises 5 subareas: the Development, Exploration, Alpine West, Fish Creek Delta, and Fish Creek West subareas (Figure 1). The NPRA study area is located in the northeastern section of the NPRA,

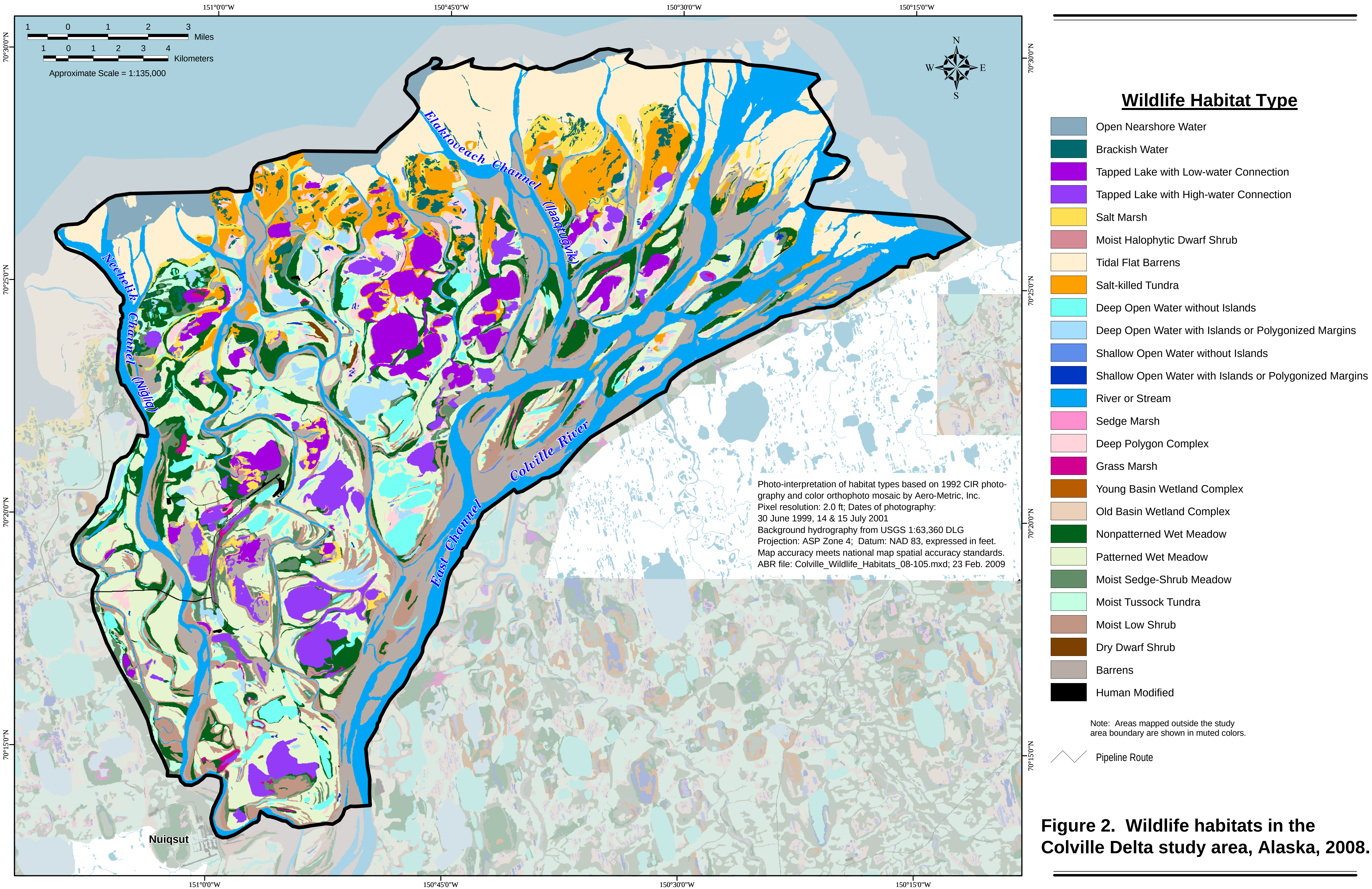

Figure 2. Wildlife habitats in the Colville Delta study area, Alaska, 2008.

Table 1. Habitat availability in the Colville Delta and the NPRA study areas, Alaska, 2008.

	Colville Delta		NPRA	
Habitat	Area (km²)	Availability (%)	Area (km²)	Availability (%)
Open Nearshore Water	10.12	1.8	22.32	2.7
Brackish Water	6.55	1.2	9.46	1.1
Tapped Lake with Low-water Connection	21.73	3.9	8.47	1.0
Tapped Lake with High-water Connection	20.77	3.8	2.55	0.3
Salt Marsh	16.31	3.0	16.51	2.0
Moist Halophytic Dwarf Shrub	0.14	<0.1	0.44	0.1
Dry Halophytic Meadow	0	0	0.21	<0.1
Tidal Flat Barrens	58.42	10.6	16.63	2.0
Salt-killed Tundra	25.63	4.6	6.49	0.8
Deep Open Water without Islands	20.72	3.8	50.59	6.1
Deep Open Water with Islands or Polygonized Margins	7.78	1.4	42.13	5.1
Shallow Open Water without Islands	2.01	0.4	7.76	0.9
Shallow Open Water with Islands or Polygonized Margins	0.56	0.1	13.24	1.6
River or Stream	82.79	15.0	10.28	1.2
Sedge Marsh	0.13	<0.1	13.52	1.6
Deep Polygon Complex	13.17	2.4	0.35	<0.1
Grass Marsh	1.44	0.3	2.47	0.3
Young Basin Wetland Complex	<0.01	<0.1	2.66	0.3
Old Basin Wetland Complex	0.14	<0.1	63.90	7.7
Riverine Complex	0	0	2.81	0.3
Dune Complex	0	0	8.07	1.0
Nonpatterned Wet Meadow	41.50	7.5	24.21	2.9
Patterned Wet Meadow	102.45	18.6	90.09	10.9
Moist Sedge–Shrub Meadow	12.25	2.2	172.93	20.9
Moist Tussock Tundra	3.24	0.6	203.83	24.7
Moist Tall Shrub	0	0	1.02	0.1
Moist Low Shrub	27.10	4.9	10.68	1.3
Moist Dwarf Shrub	0	0	4.77	0.6
Dry Tall Shrub	0	0	1.71	0.2
Dry Dwarf Shrub	0.47	0.1	7.25	0.9
Barrens	76.11	13.8	8.66	1.0
Human Modified	0.65	0.1	0	0
Subtotal (total mapped area)	552.19	100	826.03	100.0
Unknown (unmapped areas)	0		744.68	
Total	552.19		1,570.72	

6–39 km west of the village of Nuiqsut and 1–43 km west of the Alpine Facility. The NPRA study area encompasses 5 proposed development sites that are part of the ASDP: CD-5, CD-6, CD-7, Fiord West, and the Clover A gravel mine site (Figure 1). A proposed road connects the 4 well pads and also connects the CD-5 pad to the Alpine Facility at CD-4.

Three major streams flow through the NPRA study area (Figure 1). On USGS topographic maps (Harrison Bay 1:63,360 series, 1955) these drainages are labeled as Fish Creek, Judy Creek, and the Ublutuoch River, but they are commonly known by other names among Iñupiat residents: Fish Creek is called Uvlutuuq, Judy Creek is Iqalliqpik, and the Ublutuoch River is Tiŋmiaqsiuġvik (Figure 1).

Landforms, vegetation, and wildlife habitats in the northeastern NPRA were described in the Environmental Impact Statement for the lease area (BLM 1998) and in the Ecological Land Survey (ELS; Jorgenson et al. 2003, 2004). Coastal plain and riverine landforms dominate the northeastern section of the NPRA. Coastal landforms also are present but limited to the northeast corner of the study area (i.e., the Fish Creek Delta; Figure 1). On the coastal plain, lacustrine processes, basin drainage, and ice aggradation are the primary geomorphic factors that modify the landscape. In riverine areas along Fish and Judy creeks, fluvial processes predominate, although eolian and ice-aggradation processes also contribute to ecological development (Jorgenson et al. 2003).

Six of the 31 wildlife habitats identified in the NPRA study area are not present on the Colville Delta study area (Figure 3, Table 1). Three habitats dominate the NPRA landscape: Moist Tussock Tundra (25% of area), Moist Sedge–Shrub Meadow (21%), and Patterned Wet Meadow (11%; Table 1). Aquatic habitats comprise 23% of the study area. Although the NPRA study area includes some coastal habitats in the Fish Creek Delta, they are much less abundant than in the adjacent Colville Delta (Table 1). Riparian habitats also are much less common in the NPRA than they are on the Colville Delta.

Like the Colville Delta, the northeastern NPRA is an important area for wildlife and for subsistence harvest. The northeastern NPRA supports a wide array of wildlife, providing breeding habitat for geese, swans, passerines, shorebirds, gulls, and predatory birds, such as jaegers and owls. The Fish Creek and Judy Creek drainages in the NPRA study area are a regionally important nesting area for Yellow-billed Loons, annually supporting a larger number of nesting pairs than does the Colville Delta (Burgess et al. 2003b, Johnson 2004). The NPRA study area is used by caribou from 2 adjacent herds: the Teshekpuk Herd, primarily, and the Central Arctic Herd, secondarily (BLM 1998, Prichard et al. 2001, Arthur and Del Vecchio 2003).

METHODS

Aerial surveys are the primary means for collecting data on bird species using the Colville Delta and NPRA because of the large size of the study areas and the short periods of time that each species is at the optimal stage for data collection. A total of 5 aerial surveys were conducted using fixed-wing aircraft for Spectacled Eiders, Tundra Swans, and geese. Each of these surveys was scheduled specifically (see Table 2 for survey details) for the period when the species was most easily detected (for example, when Spectacled Eider males in breeding plumage were present) or when the species was at an important stage of its breeding cycle (nesting or raising broods). Thirteen aerial surveys (1 per week) were conducted from a helicopter for loons targeting specific lakes suitable to Yellow-billed Loons. Concerns about disturbance to local residents and wildlife from survey flights have dictated that we conduct the fewest survey flights necessary and at the highest altitudes possible. Flight altitudes were set at the maximum level at which the target species could be adequately detected and counted. Survey flights specifically avoid the areas around the village of Nuiqsut and the Helmericks' homesite. All survey flights are reported to local residents the week before and after in weekly updates posted in Nuiqsut.

Bird locations from all surveys were recorded on 1:64,000 or larger scale photomosaics of 1-ft pixel imagery taken in 2004 (eastern Colville Delta, by Aeromap U.S.) or 2006 (western Colville Delta and NPRA, by Aero-metric, Inc.). Bird locations were reviewed in the field and later in the office before they were digitized into a GIS database. See Data Management, below, for data management protocols.

EIDER SURVEYS

Regional abundance and distribution of Spectacled and King eiders (other eider species are seen infrequently), were evaluated with data collected on 1 aerial survey flown during the pre-nesting period (Table 2), when male eiders (the more visible of the 2 sexes in breeding plumage) were still present on the breeding grounds. The pre-nesting survey in 2008 (Figure 4) covered the same areas surveyed in 2007 in the Colville Delta study area and in 2006 in the NPRA study area (Figure 4). The pre-nesting survey was conducted 9–13 June using the same methods that were used

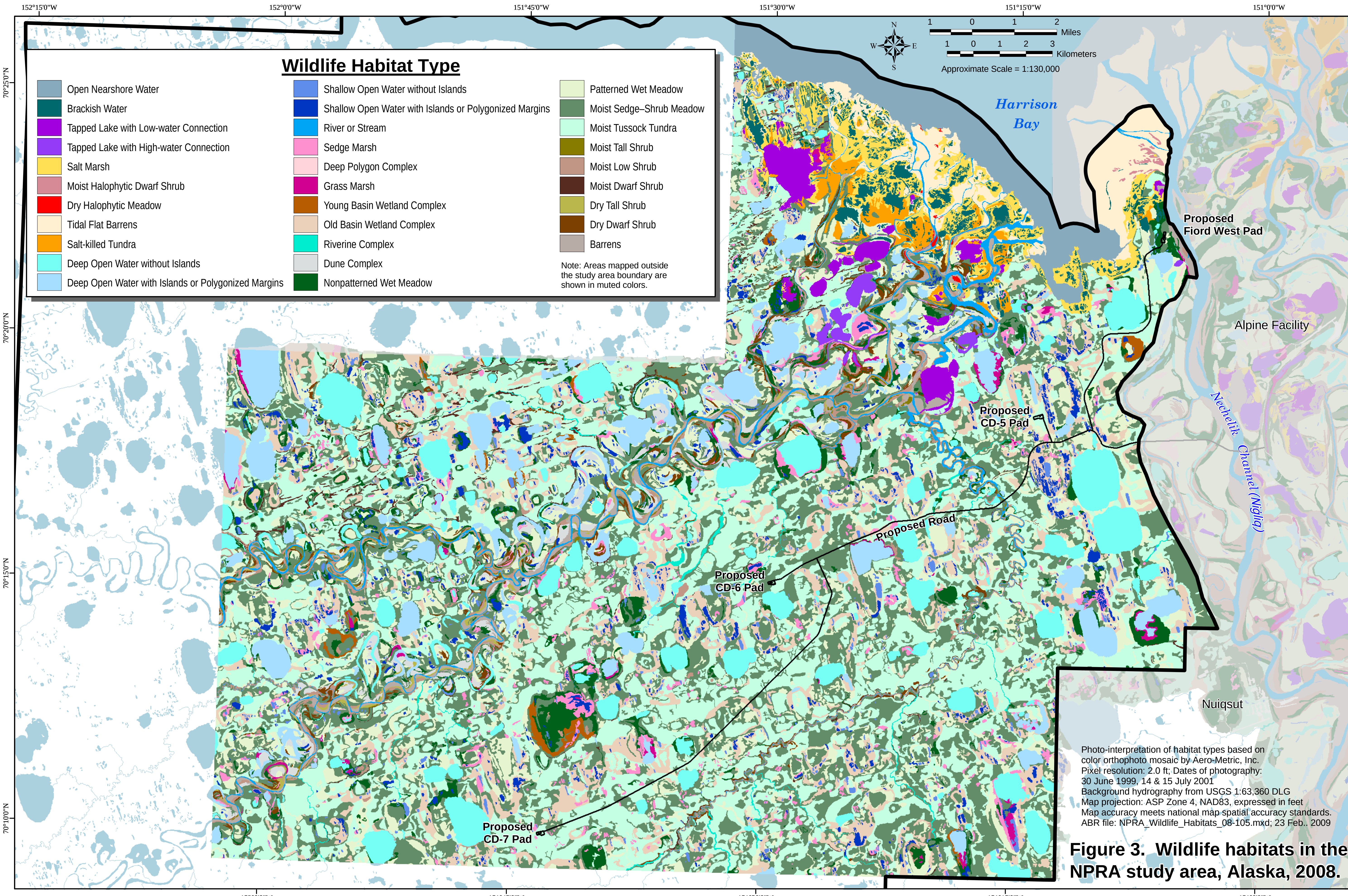

Figure 3. Wildlife habitats in the NPRA study area, Alaska, 2008.

Table 2. Avian surveys conducted in the Colville Delta and NPRA study areas, Alaska, 2008.

Survey Type / Season / Survey Area [a]	Number of Surveys	Survey Dates	Aircraft [b]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
Eider survey							
Pre-nesting							
Colville Delta	1	11–12 June	C185	0.4	0.4	30–35	100% coverage
NPRA	1	9–13 June	C185	0.4	0.8	30–35	50% coverage
Yellow-billed Loon surveys[c]							
Nesting	1	23–26 June	206L	–	–	60	All lakes ≥5 ha and adjacent lakes
Nest monitoring	5 (1/week)	2 July–4 Aug.	206L	–	–	60	Lakes with active nests
Brood-rearing	1	18–19 Aug.	206L	–	–	60	All lakes ≥5 ha
Brood monitoring[d]	11 (1/week)	14 July–16 Sept.	206L	–	–	60–90	Lakes with broods
Tundra Swan surveys							
Nesting	1	22–26 June	C185	1.6	1.6	150	100% coverage
Brood-rearing	1	17–20 Aug.	C185	1.6	1.6	150	100% coverage
Goose surveys							
Brood-rearing	1	29 July	PA-18	–	–	75–150	Coastal and lake-to- lake pattern
Fall-staging[e]	1	20 Aug.	C185	0.8	1.6	150	50% coverage

[a] Study areas included the Colville Delta and NPRA (Figure 1) unless otherwise noted
[b] C185 = Cessna 185 fixed-wing airplane; C206 = Cessna 206 fixed-wing airplane; PA-18 = Piper PA-18 "Super Cub" fixed-wing airplane; 206L = Bell "Long Ranger" helicopter
[c] Pacific and Red-throated loons, Glaucous Gull nests, and colonies of Sabine's Gulls were recorded incidentally
[d] Colville Delta only
[e] Western Colville Delta and Fish Creek Delta only

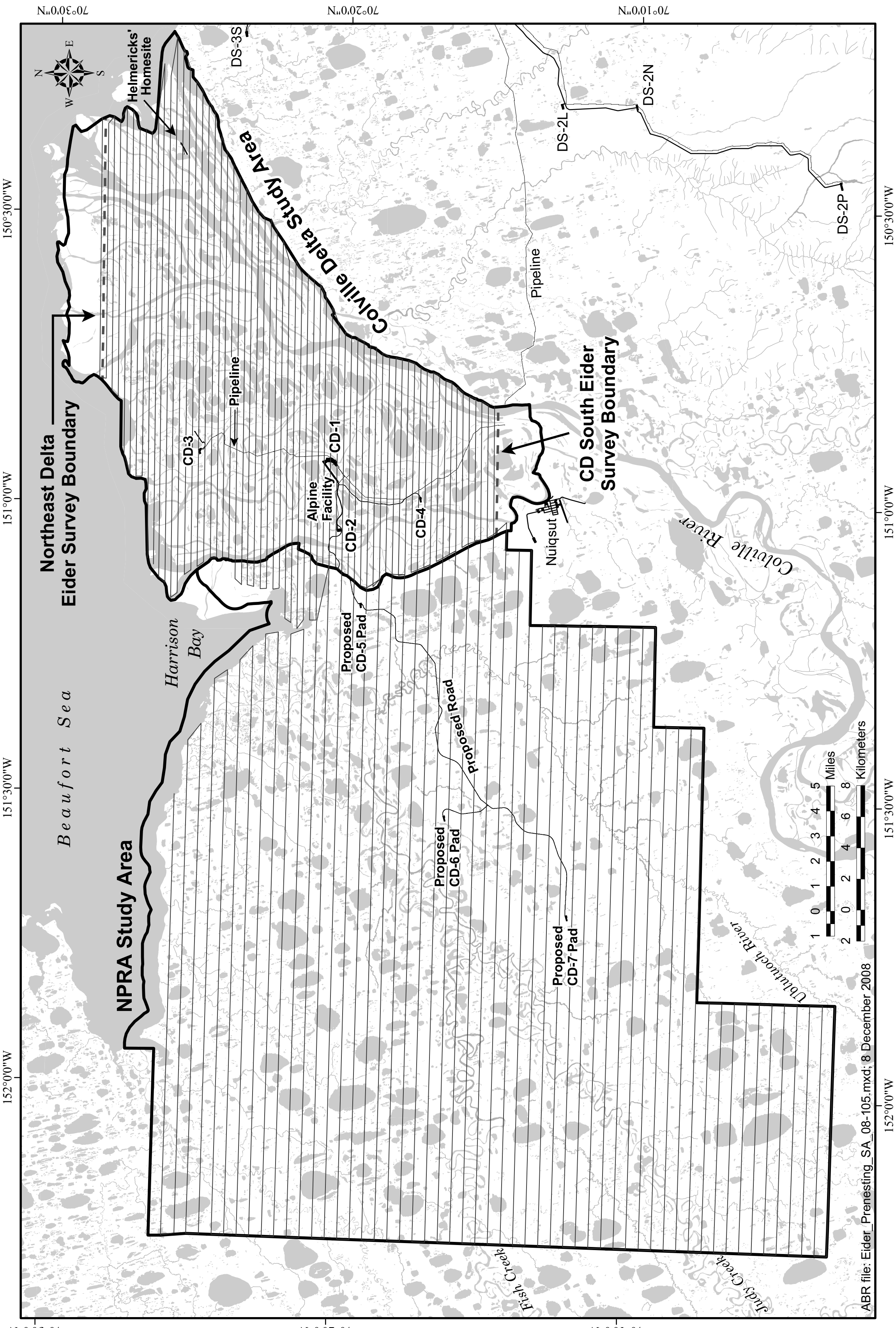

Figure 4. Transect lines and survey areas for aerial surveys of pre-nesting eiders, Colville Delta and NPRA study areas, Alaska, 2008.

on the Colville Delta in 1993–1998 and 2000–2007 and in the NPRA study area in 1999–2006, although the survey areas and survey coverage differed among years (see Anderson and Johnson 1999; Murphy and Stickney 2000; Johnson and Stickney 2001; Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 2000a, 2002, 2003b, 2004, 2005, 2006b, 2007b; Burgess et al. 2000, 2002a, 2003a). The survey was flown in a Cessna 185 airplane at 30–35 m above ground level (agl) and approximately 145 km/h. A Global Positioning System (GPS) receiver was used to navigate pre-determined east–west transect lines that were spaced 800 m apart (50% coverage) in the NPRA study area and 400 m apart (100% coverage) over the Colville Delta study area (Figure 4). An observer on each side of the airplane (in addition to the pilot) counted eiders in a 200-m-wide transect (delimited by tape on windows and wing struts, see Pennycuick and Western 1972). Three areas were not surveyed on the Colville Delta: the extensive tidal flats and marine waters on the northernmost delta were not included because eiders rarely use those habitats, a 2.4-km radius circle around the Helmericks' home site was avoided to reduce disturbance to its residents, and similarly, the extreme southern delta was avoided to limit disturbance to Nuiqsut residents (Figure 4). Eider locations were recorded on color photomosaic maps (1:63,360-scale) and tape recorders were used to record species, number of identifiable pairs and individuals of each sex, and activity (flying or on the ground).

We recorded the observed number of birds and pairs and calculated the "indicated" number of birds and densities (number/km²). Following the USFWS (1987a) protocol, the total indicated number of birds excludes flying birds and is twice the number of males not in groups (groups are defined as >3 birds of mixed sex that cannot be separated into singles or pairs) plus the number of birds in groups (see USFWS 1987a for exceptions to the rule).

LOON SURVEYS

Aerial surveys to search for nesting Yellow-billed Loons were conducted once on 23–26 June 2008 and once for brood-rearing loons on 18–19 August 2008 (Table 2). The surveys were flown in the CD North and CD South subareas of the Colville Delta study area, which have been surveyed consistently since 1993 (Figure 5). Five large lakes in the Northeast Delta subarea were included in the survey in 2008 that have been surveyed occasionally in past years. In the NPRA study area, loon surveys were conducted in the Alpine West (surveyed 2002–2006), Fish Creek Delta (surveyed in 2005–2006), and Fish and Judy Creek subareas (surveyed in 2001–2004 as part of the Development and Exploration subareas). The Fish and Judy Creek subarea is a new subarea for 2008, comprising the series of lakes that have been used by Yellow-billed Loons in previous years (2001–2004) along the stream corridors in the Development and Exploration subareas. Nine lakes outside the Fish and Judy Creek subarea were also surveyed because these lakes had Yellow-billed Loon activity in previous years (Figure 5). The remainder of the Development and Exploration subareas were excised from the loon survey to reduce helicopter costs. Both nesting and brood-rearing surveys were conducted in a helicopter flying at ~60 m agl in a lake-to-lake pattern searching most lakes ≥5 ha in size and immediately adjacent smaller lakes and aquatic habitats that are typical breeding habitats for nesting Yellow-billed Loons (Sjölander and Ågren 1976, North and Ryan 1989). We targeted lakes 5 ha and larger for nest surveys to increase survey efficiency, and we included adjacent smaller lakes to ensure we searched most if not all of the potential nesting habitat. North and Ryan (1989) found only 3 nests on lakes <2 ha, and all were within 70 m of larger lakes used for rearing broods. The smallest brood-rearing lake was 13 ha (North and Ryan 1989). Tapped Lakes with Low-water Connections (lakes whose levels fluctuate with river levels) were excluded from surveys because Yellow-billed Loons do not use such lakes for nesting (North 1986, Johnson et al. 2003b). Observations of Pacific (Malġi) and Red-throated loons (Qaqsrauq) were recorded incidentally. All locations of loons and their nests were recorded on color photomosaics (~1:1,500 or 1:30,000 scale) and later digitized into a GIS database.

The total numbers of adults, nests, broods, and young counted on aerial surveys were summarized for each species of loon. Densities of adults, nests,

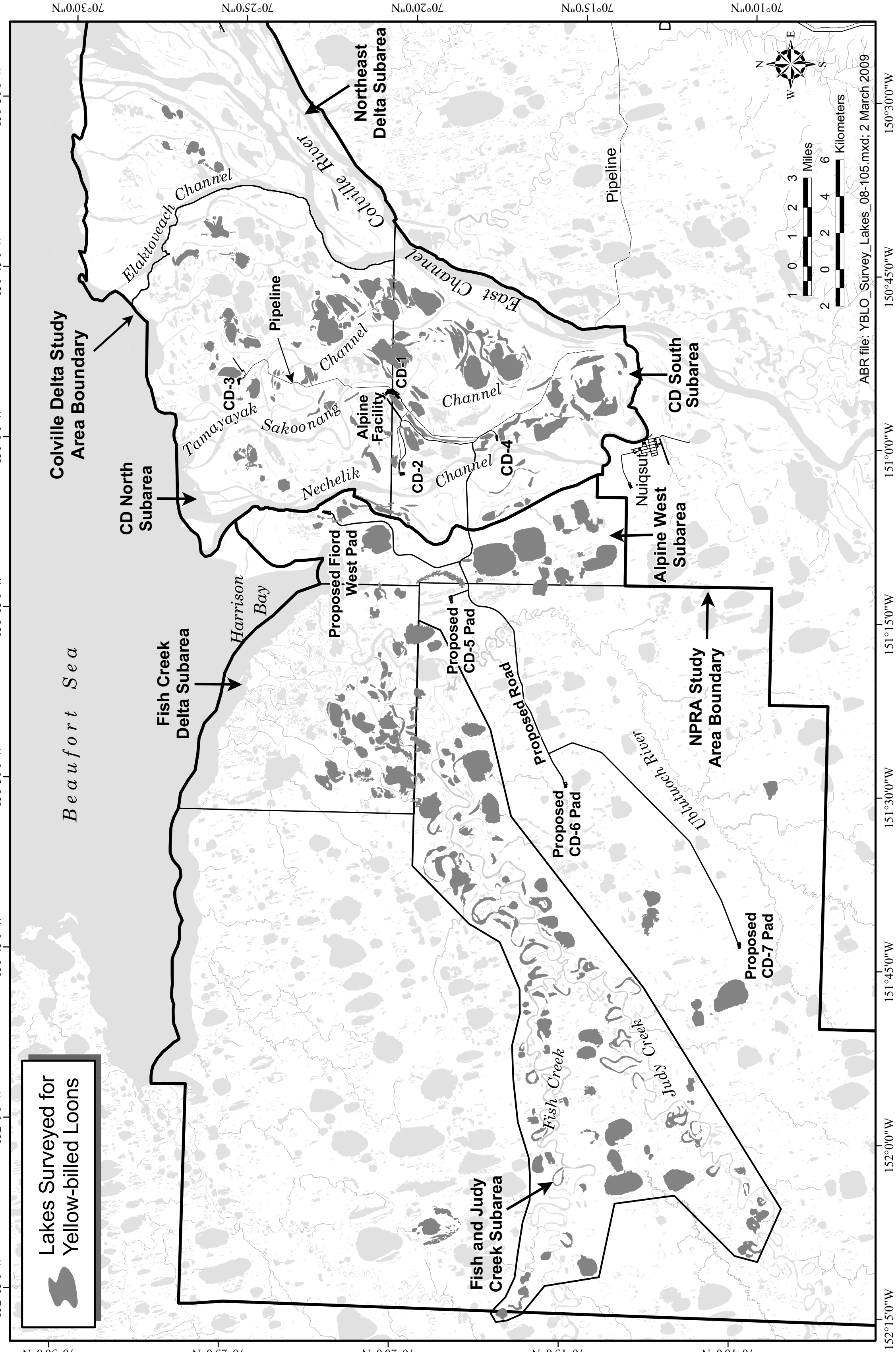

Figure 5. Lakes included in aerial surveys for nesting Yellow-billed Loons, Colville Delta and NPRA study areas, Alaska, 2008.

and broods were calculated only for Yellow-billed Loons because smaller lakes that frequently are used by Pacific and Red-throated loons were not included in the survey.

NEST MONITORING AND NEST FATE

In addition to the nesting and brood-rearing surveys described above, weekly surveys were conducted to monitor the status of confirmed Yellow-billed Loon nests in the Colville Delta and NPRA study areas. Traditional nest lakes without an active nest during the nesting survey were revisited to search for nests for 2 weeks after the nesting survey. After 2 weeks, the monitoring surveys visited only confirmed nests and no attempt was made to search for additional nests.

Each nest was surveyed weekly from a helicopter until the nest was noted as inactive. Active nests had an incubating adult or eggs were present. Inactive nests were either failed or hatched. Nests were assumed failed when adults were not incubating, eggs were not present, a brood was not seen, and, upon nest inspection, the nest contained fewer than 20 egg fragments and egg membranes were absent, or eggshells had signs of predation (holes, albumen, yolk, or blood) (Parrett et al. 2008). Nests were assumed successful if a brood was present, separate egg membranes were found, or if the nest contained >20 egg fragments. Egg remains were used in addition to the presence of broods to classify nest fate because some broods may not survive the period between hatch and the following aerial survey. When a nest appeared inactive, the nesting lake was immediately searched for young by flying along the shoreline and scanning across the lake. Adjacent lakes known from previous surveys to be brood-rearing locations also were surveyed. Inactive nests were visited on the ground to inspect their contents. The nest and the surrounding area within 5 m, including the water around the nest, were examined for the presence of egg fragments and egg membranes. Loons may reuse nests from previous years, so only the current year's layer of loose vegetation on top of the nest was inspected, to avoid recording evidence from previous years. If egg fragments were found, they were counted and, based on the length of their longest side, placed into 7 approximate size categories in 5-mm increments from ≤5 mm to >30 mm. Egg membranes or pieces of membranes also were counted and measured.

BROOD MONITORING

In the Colville Delta study area, weekly brood monitoring surveys were conducted after hatch to estimate chick survival and document juvenile recruitment of Yellow-billed Loons. Brood-monitoring surveys were flown in a manner similar to the brood-rearing survey described above. We surveyed traditional brood-rearing lakes for each territory by flying the shoreline and scanning for loons. Lakes were circled at least twice, and if no young were seen, a transect was flown down the center of the lake. If young still were not seen, the territory was revisited at the end of the survey. We considered a brood failed if no young were observed during 2 consecutive weekly surveys. Brood locations were hand-mapped and the number of adults and young was recorded.

The age of each brood was estimated by subtracting the date the first chick was initially observed from the date the last chick was finally observed. To account for the unknown number of days the chick was alive before that period, we added the midpoint of the survey interval between the last date incubation was observed and the date the chick was first observed. In the same manner, we accounted for the days alive between the date a live chick was last observed and the date of the next survey when the brood was absent or unknown. For example, on the first survey a chick was seen it was assumed to be 4 days old (midpoint of the 7-day interval between incubation and chick observation), and on the date the last chick was no longer observed, it was assumed to be 4 days older than when last observed (mid-point of 7-day interval between last alive and loss dates).

TIME-LAPSE CAMERAS

In the Colville Delta study area, we deployed time-lapse cameras at 14 Yellow-billed Loon nests primarily to test their efficacy in monitoring nest survival and, secondarily, to summarize nest attendance patterns and identify causes of nest failures. We used 12 Silent Image® Professional (model PM35, 640-x-480 pixel; Reconyx, Lacrosse, WI) digital time-lapse cameras customized with 8× zoom lenses and 2 of the same model cameras with standard lenses. We randomly selected nests to monitor from those that were found during the June nesting survey. Cameras were installed within 1 day of nest discovery. The cameras were mounted on tripods that were tied down to stakes to stabilize them against the wind. All cameras were equipped with 2-GB compact flash memory cards. Cameras were run on alkaline C-cell batteries and programmed to take 1 picture every 65 seconds. At these settings, cameras could run for ~30 d without requiring maintenance (e.g., battery or memory changes). Cameras were not revisited until nests were no longer active.

We reviewed digital images on personal computers with Irfanview software (version 4.1.0). Loon activity was classified into 4 major classes of activity: incubation, break, incubation exchange, and recess. Incubation included sitting postures of normal incubation, assumed incubation (bird could not be seen, but did not leave the nest), alert incubation (head up in a rigid, attentive posture), concealed incubation (head and body down and flattened in vegetation), preening on the nest, and gathering nest material while on the nest. Break activities included brief standing activities at the nest: settling, sitting or standing beside the nest, changing positions, standing over the nest, rolling eggs, and standing while preening. Recess activities were absences from the nest and those activities immediately preceding and following the recess: egg moving, swimming beside the nest, flying, and gone from view. Predators in camera views were identified to species and classified by distance from the nest and activity.

Nests were monitored from the day of camera set-up through nest failure or when the loons and their young were observed leaving the nest. Day of hatch was defined as occurring when the first chick was seen at the nest. The day of nest failure occurred when adults quit attending the nest and chicks were not seen.

The number of days or minutes of monitoring were calculated after excluding the day of camera set-up, hatch, or failure, as well as periods of poor visibility and researcher disturbance. Periods of poor visibility (e.g., heavy fog, moisture on the lens, or too little or too much light for correct photographic exposure) were excluded from calculations when we could not judge whether a loon was incubating or off the nest. Incubation constancy was calculated as the percentage of time the bird was observed incubating out of the number of minutes monitored. Mean daily number of recesses was calculated as the sum of the number of recesses divided by number of days monitored.

TUNDRA SWAN SURVEYS

One aerial survey for nesting and 1 aerial survey for brood-rearing Tundra Swans were flown during 23–26 June and 17–20 August 2008, respectively (Table 2). Each aerial survey covered the entire Colville Delta and NPRA study areas (Figure 6). The surveys were conducted in accordance with USFWS protocols (USFWS 1987b, 1991). East–west transects spaced 1.6 km apart were flown in a Cessna 206 fixed-wing airplane that was navigated with the aid of a GPS receiver. Flight speed was 145 km/h and altitude was 150 m agl. Two observers each searched 800-m-wide transects on opposite sides of the airplane while the pilot navigated and scanned for swans ahead of the airplane, providing 100% coverage of the surveyed area. Locations and counts of swans and their nests were recorded on color photomosaics (1:63,360-scale). Each nest on the Colville Delta was photographed with a 35-mm camera for site verification.

Numbers of swans, nests, and broods were summarized and densities calculated for each subarea. Apparent nesting success was estimated from the ratio of broods to nests counted during aerial surveys only. The accuracy of these estimates can be affected by differential detection, predation, and movements of broods; therefore, the calculated estimates of nesting success should be considered relative indices.

GOOSE SURVEYS

In 2008, 2 aerial surveys were flown for geese in the Colville Delta and NPRA study areas. A survey was flown on 29 July for brood-rearing and molting Brant and Snow Geese in the coastal zone of the Colville Delta and NPRA study areas (Table 2). That survey was flown in a Piper PA-18 “Super Cub” aircraft at 75–150 m agl and approximately 100–120 km/h along the coast and in a lake-to-lake pattern (Figure 7). One pilot and 1 observer searched appropriate habitats along the coast, rivers, channels, and lakes. The numbers of adults

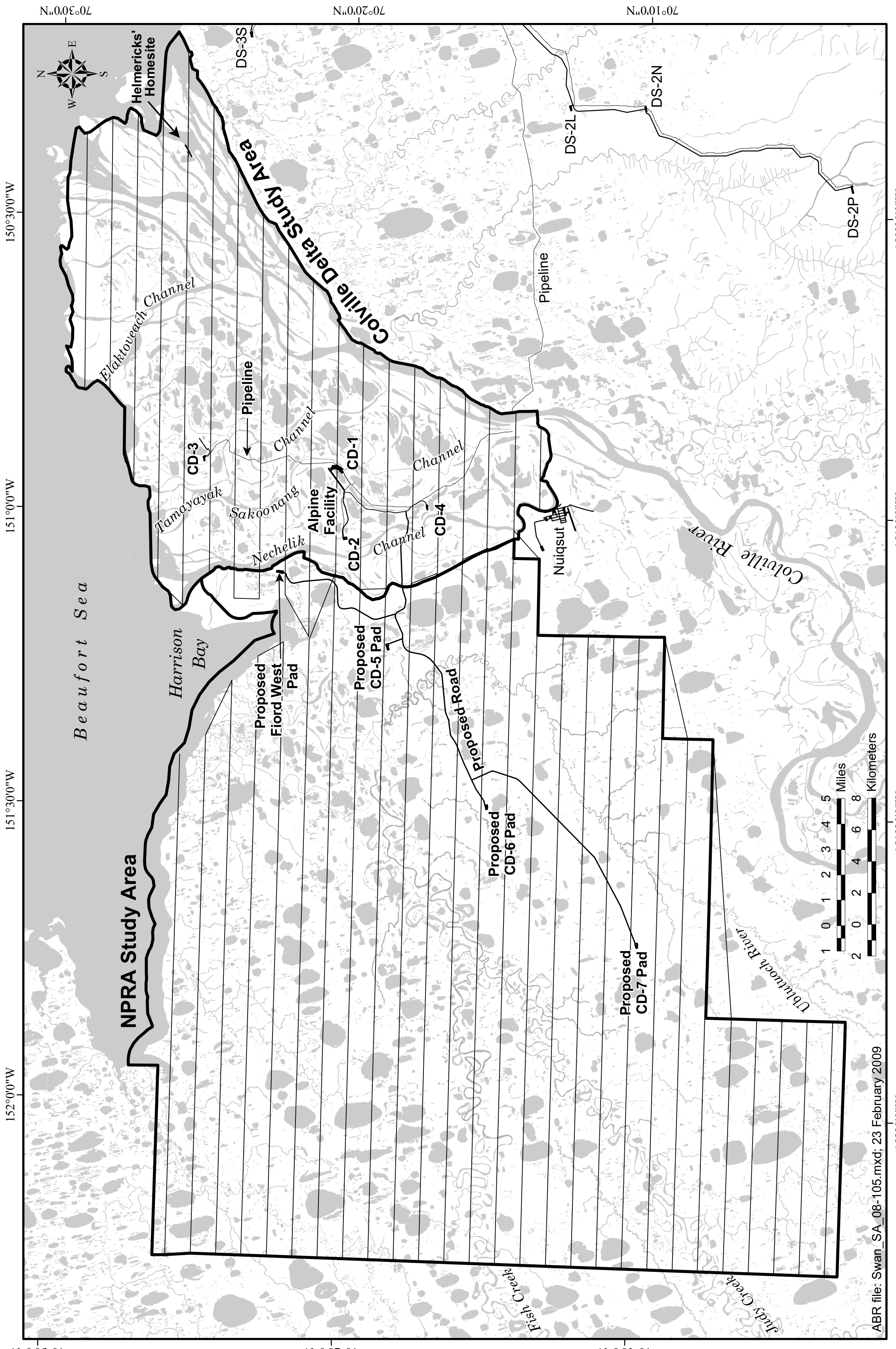

Figure 6. Transect lines and survey areas for aerial surveys of nesting and brood-rearing Tundra Swans, Colville Delta and NPRA study areas, Alaska, 2008.

and young Brant and Snow Geese were recorded and their locations were saved on a GPS receiver. Geese in small groups (<50) were counted visually from the airplane, whereas larger groups were counted on photographs taken with a Canon EOS 20D digital SLR camera (8.2 megapixel), and a 17–85 mm image-stabilizing lens.

Another aerial survey was flown on 20 August for fall-staging geese in the western portion of the Colville Delta study area and the eastern portion of the NPRA study area (Table 2, Figure 7). The survey was flown in a Cessna 206 aircraft at 90 m agl and approximately 145 km/h. A GPS receiver was used to navigate pre-determined east-west transect lines that were spaced 1.6 km apart. An observer on each side of the airplane counted all geese in a 400-m-wide transect, achieving 50% area coverage. Goose locations were recorded on color photomosaic maps (1:63,360-scale), and species, group size, and location (flying or on the ground) were recorded on the field maps. Goose locations were later digitized into a GIS database. In the Colville Delta study area, the fall-staging survey covered 102.1 km^2 of the CD North subarea (49.4% of the entire subarea) and 51.3 km^2 (32.9%) of the CD South subarea. In the NPRA study area, the staging survey covered 66.0 km^2 (50.5%) of the Fish Creek Delta subarea, 29.1 km^2 (36.6%) of the Alpine West subarea, and 43.8 km^2 (7.1%) of the Development subarea.

GULL SURVEYS

Glaucous Gulls nests and broods were recorded incidentally during the aerial surveys conducted for Yellow-billed Loons in the Colville Delta and NPRA study areas (see Loon Surveys, above, for methods). Colonies of Sabine's Gulls (Iqirgagiak) also were recorded opportunistically on the same survey. All nest and brood observations were recorded on color photomosaics (1:30,000 scale) and later digitized into a GIS database.

HABITAT MAPPING AND ANALYSIS

As described above, wildlife location data from the aerial surveys were plotted on the maps of wildlife habitats (Figures 2 and 3) using map coordinates, recorded either from GPS readings taken in the field, or by plotting locations on georeferenced maps or photomosaics and subsequently deriving coordinates. By this method, a wildlife habitat was assigned to each observation. For each species, habitat use (% of observations in each identified habitat type) was determined separately for various seasons (e.g., pre-nesting, nesting, and brood-rearing), as appropriate. For each species/season, we calculated 1) the number of adults, flocks, nests, young, or broods in each habitat, and 2) the percent of total observations in each habitat (habitat use). Habitat use was calculated from group locations for species or seasons when birds were in pairs, flocks, or broods, because we could not assume independence of location, habitat use, or habitat selection among individuals in these groups (i.e., a few large groups could bias results).

For a subset of species/surveys, a statistical evaluation of habitat selection was used to evaluate whether habitats were used in proportion to their availability. (Note that habitat availability [the percent availability of each habitat in the survey area] often differed among species, because survey areas often differed, as described below). When multiple years of survey data were available, all comparable data were used in statistical evaluation of habitat selection. For this purpose, annual surveys were considered comparable only when the survey areas were similar in habitat composition, because habitat availability was calculated by summing annual habitat availability over years.

Habitat selection was evaluated for the following species and seasons:

- pre-nesting Spectacled Eiders and King Eiders (aerial surveys, Colville Delta 1993–1998 and 2000–2008 and NPRA study area 2001–2006 and 2008)
- nesting and brood-rearing Tundra Swans (aerial surveys, Colville Delta 1992–1998 and 2000–2008 and NPRA study area 2001–2006 and 2008)
- nesting and brood-rearing Yellow-billed Loons (aerial surveys, Colville Delta 1993–1998 and 2000–2008 [nests] and 1995–1998 and 2000–2008 [broods]).

For other species, the number of observations from comparable annual surveys was inadequate for statistical analysis. Several habitats, based on similar composition or physiography and low areal

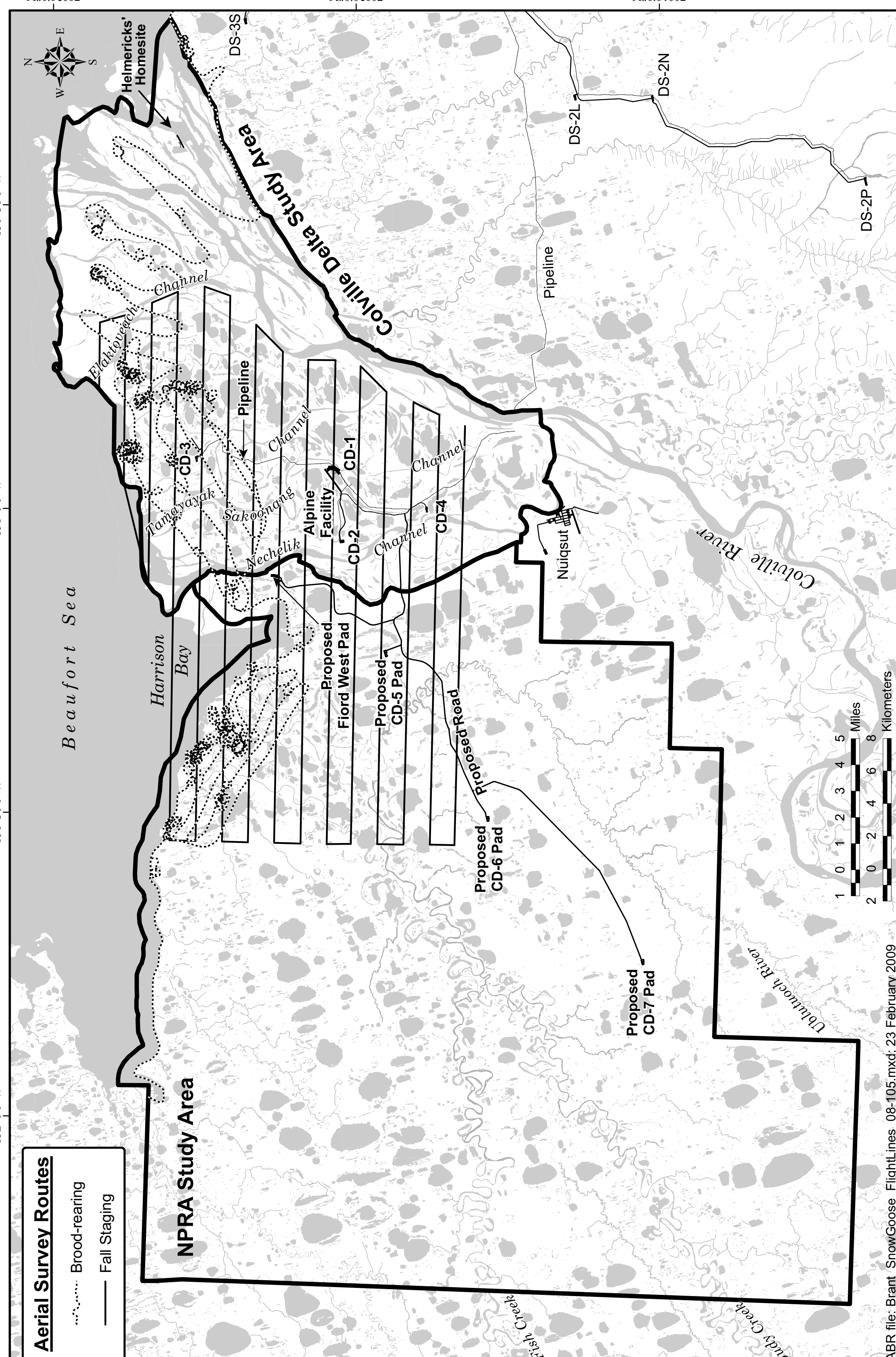

Figure 7. Flight lines for aerial surveys of brood-rearing and fall-staging geese, Colville Delta and NPRA study areas, Alaska, 2008.

coverage, were merged for the avian analyses to reduce the number of classes. For example, Moist Halophytic Dwarf Shrub (≤0.1% of both study areas; Table 1) was merged with Salt Marsh, Dry Halophytic Meadow (<0.1% of NPRA) was combined into Tidal Flat Barrens, and all non-halophytic shrub types (all but one occupied <1% of each study area) were combined into Tall, Low, or Dwarf Shrub.

Habitat selection was inferred from comparisons of observed habitat use with random habitat use. Random habitat use was based on the percent availability of each habitat. Monte Carlo simulations (1,000 iterations) were used to calculate a frequency distribution of random habitat use, with the sample sizes in each simulation equaling the number of observed nests or groups of birds in that season. The resulting distribution was used to compute 95% confidence intervals around the expected value of habitat use (Haefner 1996, Manly 1997). We defined habitat preference (i.e., use > availability) as observed habitat use greater than the 95% confidence interval of simulated random use, which represents an alpha level of 0.05 (2-tailed test). Conversely, we defined habitat avoidance (i.e., use < availability) as observed habitat use below the 95% confidence interval of simulated random use. The simulations and calculations of confidence intervals were conducted with Microsoft® Excel.

DATA MANAGEMENT

All data collected during surveys for CPAI were compiled into a centralized database following CPAI's GPS/GIS Data Management Protocols, North Slope, Alaska, Version 3.4 (CPAI 2007). Individual nest, bird, or bird group locations were recorded with decimal-degree coordinates in the WGS 84 map datum and later transferred into the NAD 83 map datum. Uniform attribute data were recorded for all observations and proofed after data collection and proofed again during data entry. Survey data were submitted in GIS-ready format with corresponding metadata. Historical data from long-term surveys also were submitted using the same protocol and standards as in 2007, to maintain consistency and make it possible to join multi-year datasets into a single archival database, maintained by CPAI.

RESULTS

CONDITIONS IN THE STUDY AREAS

Birds returning to the Colville Delta encountered warmer than average spring conditions in 2008. Mean monthly temperatures in the nearby Kuparuk Oilfield in 2008 were 2° C warmer for both May and June than the long-term (20-year) mean for those months (www.ncdc.noaa.gov/oa/ncdc.html). Temperatures for Colville Village (an island on the outer Colville Delta) in 2008 were 2° C warmer in May and 1° C warmer in June compared to the 12-year period for which data are available. Breakup on the Colville River in 2008 was average, both for date of peak discharge, and for surface elevation and discharge rate, and was considered a 2-year flood event. Flood waters reached the head of the delta on 26 May, and excepting some brief ice-jam events, most of the flood had passed through that area by 31 May (Michael Baker, Jr., Inc. 2008). During the period of waterfowl arrival and peak nest initiation (15 May–15 June), 107 cumulative thawing degree-days were recorded in the Kuparuk Oilfield, the fourth warmest in 20 years (range = 19–128 thawing degree-days; Figure 8). The high number of thawing degree-days recorded was driven by the warm temperatures in the end of May, when 34 thawing degree-days were recorded, as well as warm temperatures in early June. At Colville Village, 19 thawing degree-days were recorded in May, and the total of 65 thawing degree-days for the waterfowl arrival and peak nest initiation period was the third highest recorded for this area.

The outer Colville Delta contained little snow cover at the end of May and by 4–5 June none remained. Snow also had melted at the Kuparuk Airstrip by 30 May (Lawhead and Prichard 2009). Deep lakes on the Colville Delta retained 95% ice cover on 12 June, ~75% ice cover through 19 June, and were ice-free by 25 June. In most years, deep lakes on the Colville Delta are not ice free before the first or second weeks of July. Mosquitoes were abundant on the Colville Delta on 23 June and probably began emerging a few days previously, which is 1–2 weeks earlier than the most common emergence dates in past years. We do not have dates of first hatch for tundra birds in 2008 to

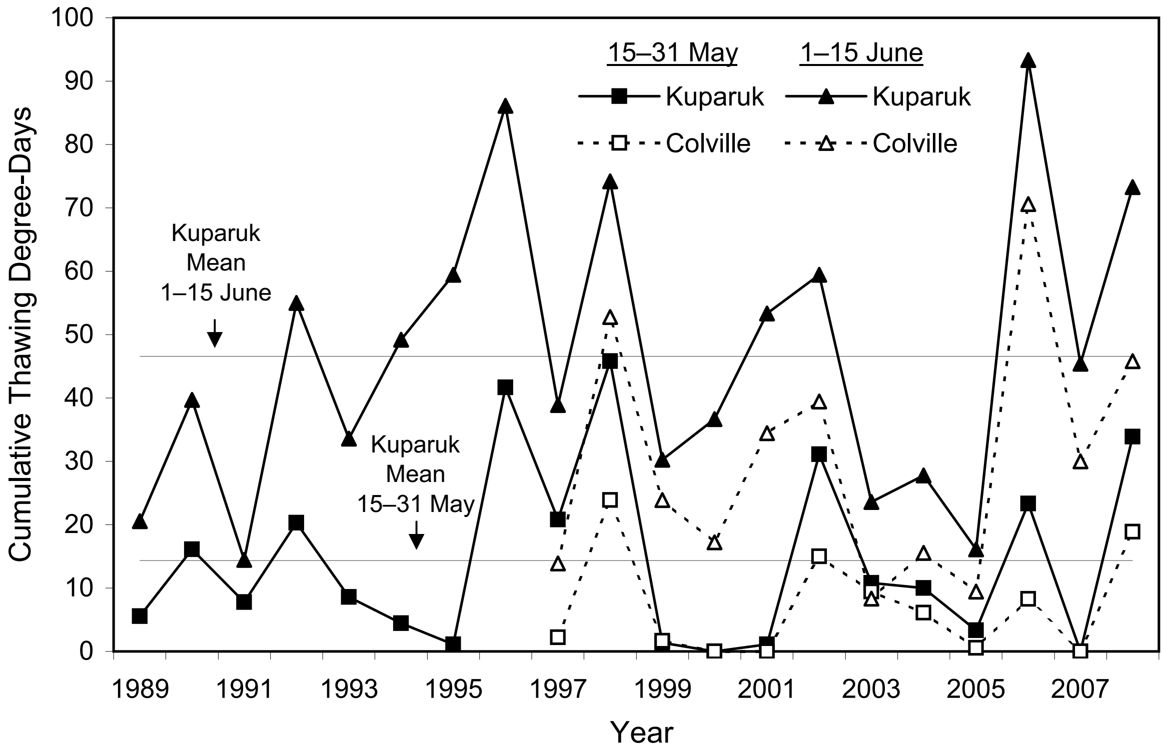

Figure 8. Cumulative and mean thawing degree-days at the Kuparuk Oilfield and Colville Village, Alaska, 15–31 May and 1–15 June, 1989–2008.

compare with past dates. Nonetheless, from temperature and snow conditions in 2008, we judge that the timing of the avian breeding season was advanced relative to typical years on the Colville Delta.

EIDERS

Of the 2 species of eiders that commonly occur in the Colville Delta and NPRA study areas, the Spectacled Eider has received the most attention because it was listed as “threatened” under the Endangered Species Act in 1993 (58 FR 27474-27480). The Spectacled Eider nests at low densities across the outer Colville Delta and nests in even lower numbers in inland parts of the delta and in scattered wetland basins in the NPRA study area (Burgess et al. 2003a, 2003b; Johnson et al. 2004, 2005). The King Eider is more widespread and generally more numerous than the Spectacled Eider, although their relative abundance varies geographically. Steller’s Eiders (also a threatened species, listed in 1997) and Common Eiders occur infrequently in the Colville Delta and NPRA study areas.

SPECTACLED EIDER

Colville Delta

Distribution and Abundance

The Spectacled Eider count during pre-nesting in 2008 was the highest in 15 years of surveys on the Colville Delta and continued an increasing trend that began in 2005 (Figure 9). We counted 80 Spectacled Eiders, of which 66 were observed on the ground and 14 were in flight (Table 3). All sightings of Spectacled Eiders in the Colville Delta study area during the pre-nesting survey in 2008 were in groups of 1–5 birds, and all but 7 Spectacled Eiders were found in the CD North subarea (Figure 10, Table 3). The density of observed birds in the CD North subarea was 0.35 birds/km² (on ground and in flight), and the density of indicated birds (USFWS 1987a) was 0.39

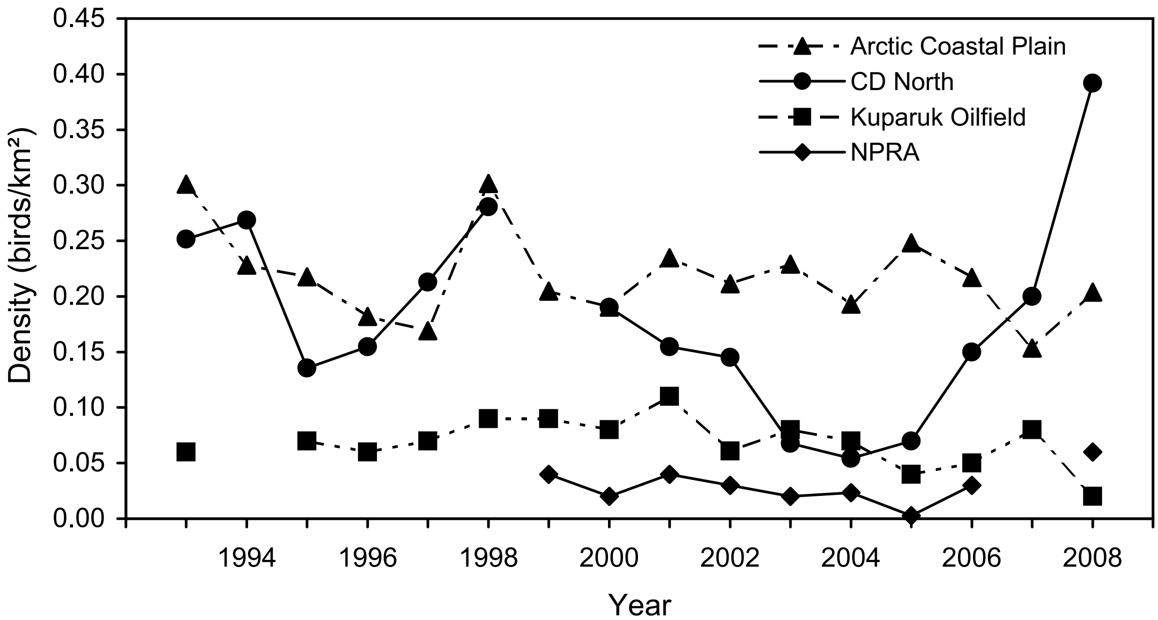

Figure 9. Density of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain of Alaska, 1993–2008. Arctic Coastal Plain data from Larned et al. 2009, Kuparuk data from Anderson et al. 2009, and CD North and NPRA data from this study.

birds/km². The density in the entire Colville Delta study area was 0.16 observed birds/km² and 0.18 indicated birds/km².

Habitat Use

Pre-nesting Spectacled Eiders used 17 of 24 available habitats during 15 years of aerial surveys on the Colville Delta study area. Seven habitats were preferred (i.e., use significantly greater than availability) by pre-nesting Spectacled Eiders: 3 salt-affected habitats (Brackish Water, Salt Marsh, and Salt-killed Tundra), 3 aquatic habitats (Grass Marsh and both Deep and Shallow Open Water with Islands or Polygonized Margins), and Deep Polygon Complex, a terrestrial habitat (Table 4). Patterned Wet Meadow had high use (15%, 41 groups of eiders) but was not preferred because of its higher availability (20%). All other habitats were avoided or used in proportion to their availabilities.

NE NPRA

Distribution and Abundance

In NPRA in 2008, Spectacled Eiders were most abundant in the Fish Creek West and Exploration subareas (Figure 10, Table 5). Over the entire NPRA study area, we counted 41 observed (on ground and in flight) and 46 indicated total Spectacled Eiders resulting in a density of 0.05 observed birds/km² and 0.06 indicated total birds/km², roughly 1/3 the density on the Colville Delta study area.

Habitat Use

Pre-nesting Spectacled Eiders used 12 of 26 available habitats in the NPRA study area over 7 years of aerial surveys. Spectacled Eiders preferred 3 habitats during pre-nesting in NPRA that also were preferred in the Colville Delta survey area: Brackish Water and both Deep and Shallow Open Water with Islands or Polygonized Margins (Table 6). Sample size is low (34 groups total), so the selection analysis is lacking power; we will likely find that additional habitats are preferred as the sample size in the selection analysis increases in the future.

OTHER EIDERS

Colville Delta

Distribution and Abundance

King Eiders (33 total birds) were less than half as numerous as Spectacled Eiders (80 total

Table 3. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2008.

SPECIES Subarea Location	Observed				Indicated Total[a]	Observed Density[b]	Indicated Density[a,b]
	Males	Females	Total	Pairs			
SPECTACLED EIDER							
CD North							
On ground	41	19	60	17	81	0.29	0.39
In flight	9	4	13	3	–	0.06	–
All birds	50	23	73	20	–	0.35	–
Northeast Delta							
On ground	4	2	6	2	8	0.04	0.05
In flight	1	0	1	0	–	0.01	–
All birds	5	2	7	2	–	0.04	–
CD South							
On ground	0	0	0	0	0	0	0.00
In flight	0	0	0	0	–	0	–
All birds	0	0	0	0	–	0	–
Total (subareas combined)							
On ground	45	21	66	19	89	0.13	0.18
In flight	10	4	14	3	–	0.03	–
All birds	55	25	80	22	–	0.16	–
KING EIDER							
CD North							
On ground	5	3	8	3	10	0.04	0.05
In flight	2	0	2	0	–	0.01	–
All birds	7	3	10	3	–	0.05	–
Northeast Delta							
On ground	14	3	17	1	28	0.11	0.18
In flight	2	1	3	1	–	0.02	–
All birds	16	4	20	2	–	0.13	–
CD South							
On ground	1	1	2	1	2	0.01	0.01
In flight	1	0	1	0	–	0.01	–
All birds	2	1	3	1	–	0.02	–
Total (subareas combined)							
On ground	20	7	27	5	40	0.05	0.08
In flight	5	1	6	1	–	0.01	–
All birds	25	8	33	6	–	0.07	–

[a] Total indicated birds was calculated according to standard USFWS protocol (USFWS 1987a)
[b] Density based on 100% coverage of subareas: CD North = 206.7 km², Northeast Delta = 157.6 km², CD South = 137.2 km², all subareas combined = 501.4 km²; numbers were not corrected for sightability

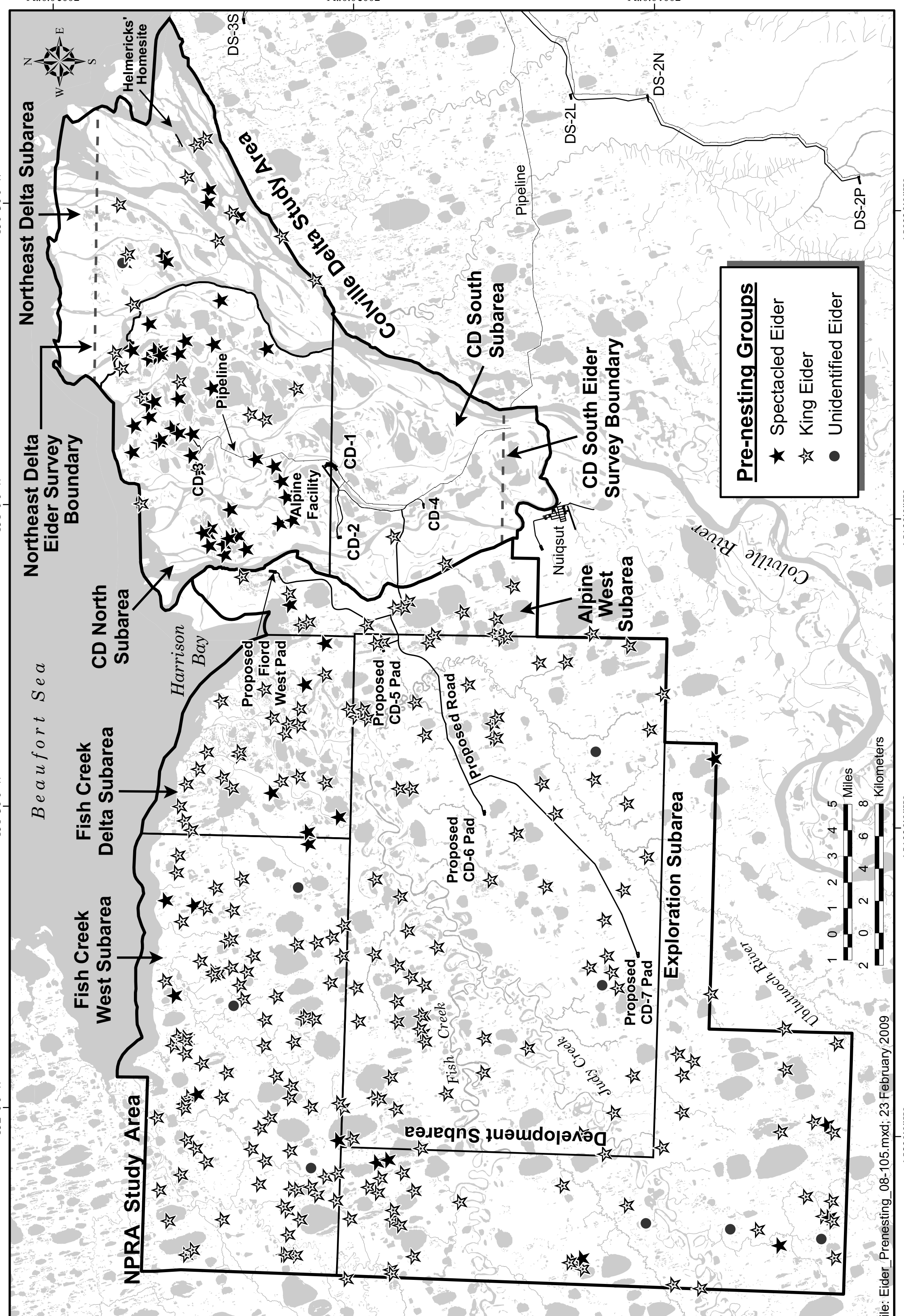

Figure 10. Spectacled and King eider groups during pre-nesting, Colville Delta and NPRA study areas, Alaska, 2008.

Table 4. Habitat selection by Spectacled and King eider groups during pre-nesting, Colville Delta, Alaska, 1993–1998 and 2000–2008.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
SPECTACLED EIDER						
Open Nearshore Water	0	0	0.0	1.6	avoid	low
Brackish Water	63	28	10.4	1.3	prefer	low
Tapped Lake with Low-water Connection	29	12	4.4	4.5	ns	
Tapped Lake with High-water Connection	12	7	2.6	3.8	ns	
Salt Marsh	39	21	7.8	3.2	prefer	
Tidal Flat Barrens	2	1	0.4	6.9	avoid	
Salt-killed Tundra	49	26	9.6	5.1	prefer	
Deep Open Water without Islands	19	12	4.4	4.0	ns	
Deep Open Water with Islands or Polygonized Margins	18	11	4.1	1.6	prefer	low
Shallow Open Water without Islands	5	3	1.1	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	5	4	1.5	0.1	prefer	low
River or Stream	18	9	3.3	14.3	avoid	
Sedge Marsh	0	0	0.0	0.0	ns	low
Deep Polygon Complex	116	65	24.1	2.7	prefer	
Grass Marsh	4	3	1.1	0.2	prefer	low
Young Basin Wetland Complex	0	0	0.0	0.0	ns	low
Old Basin Wetland Complex	0	0	0.0	0.0	ns	low
Nonpatterned Wet Meadow	50	25	9.3	8.2	ns	
Patterned Wet Meadow	81	41	15.2	19.5	ns	
Moist Sedge-Shrub Meadow	0	0	0.0	2.3	avoid	
Moist Tussock Tundra	1	1	0.4	0.6	ns	low
Tall, Low, or Dwarf Shrub	0	0	0.0	4.9	avoid	
Barrens	2	1	0.4	14.8	avoid	
Human Modified	0	0	0.0	0.1	ns	low
Total	513	270	100	100		
KING EIDER						
Open Nearshore Water	11	3	1.7	1.6	ns	low
Brackish Water	25	14	7.8	1.3	prefer	low
Tapped Lake with Low-water Connection	21	10	5.6	4.5	ns	
Tapped Lake with High-water Connection	8	3	1.7	3.8	ns	
Salt Marsh	14	6	3.3	3.2	ns	
Tidal Flat Barrens	4	2	1.1	6.9	avoid	
Salt-killed Tundra	33	17	9.4	5.1	prefer	
Deep Open Water without Islands	12	5	2.8	4.0	ns	
Deep Open Water with Islands or Polygonized Margins	9	4	2.2	1.6	ns	low
Shallow Open Water without Islands	0	0	0.0	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	1	0.6	0.1	ns	low
River or Stream	205	69	38.3	14.3	prefer	
Sedge Marsh	0	0	0.0	0.0	ns	low
Deep Polygon Complex	26	14	7.8	2.7	prefer	low
Grass Marsh	6	2	1.1	0.2	ns	low
Young Basin Wetland Complex	0	0	0.0	0.0	ns	low
Old Basin Wetland Complex	0	0	0.0	0.0	ns	low
Nonpatterned Wet Meadow	5	4	2.2	8.2	avoid	
Patterned Wet Meadow	32	19	10.6	19.5	avoid	
Moist Sedge-Shrub Meadow	2	1	0.6	2.3	ns	low
Moist Tussock Tundra	0	0	0.0	0.6	ns	low
Tall, Low, or Dwarf Shrub	2	1	0.6	4.9	avoid	
Barrens	13	5	2.8	14.8	avoid	
Human Modified	0	0	0.0	0.1	ns	low
Total	430	180	100	100		

[a] % use = (groups / total groups) x 100.

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

[c] Expected number < 5.

Table 5. Number and density (birds/km^2) of eiders during pre-nesting aerial surveys, NPRA study area, Alaska, 2008.

SPECIES Subarea Location	Observed Males	Observed Females	Observed Total	Observed Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a,b]
SPECTACLED EIDER							
Development							
On ground	1	1	2	1	2	0.01	0.01
In flight	0	0	0	0	–	0.00	–
All birds	1	1	2	1	–	0.01	–
Alpine West							
On ground	1	1	2	1	2	0.05	0.05
In flight	0	0	0	0	–	0.00	–
All birds	1	1	2	1	–	0.05	–
Fish Creek Delta							
On ground	4	1	5	1	8	0.09	0.14
In flight	1	1	2	1	–	0.03	–
All birds	5	2	7	2	–	0.12	–
Fish Creek West							
On ground	7	5	12	4	14	0.08	0.09
In flight	1	0	1	0	–	0.01	–
All birds	8	5	13	4	–	0.09	–
Exploration							
On ground	10	5	15	4	20	0.07	0.10
In flight	1	1	2	1	–	0.01	–
All birds	11	6	17	5	–	0.08	–
Total (subareas combined)							
On ground	23	13	36	11	46	0.05	0.06
In flight	3	2	5	2	–	0.01	–
All birds	26	15	41	13	–	0.05	–
KING EIDER							
Development							
On ground	75	53	128	36	150	0.42	0.49
In flight	12	5	17	4	–	0.06	–
All birds	87	58	145	40	–	0.48	–
Alpine West							
On ground	13	8	21	8	26	0.50	0.62
In flight	0	0	0	0	–	0.00	–
All birds	13	8	21	8	–	0.50	–
Fish Creek Delta							
On ground	28	18	46	14	54	0.80	0.94
In flight	4	2	6	1	–	0.10	–
All birds	32	20	52	15	–	0.91	–
Fish Creek West							
On ground	102	71	173	41	203	1.14	1.34
In flight	13	6	19	6	–	0.13	–
All birds	115	77	192	47	–	1.27	–
Exploration							
On ground	34	20	54	13	68	0.27	0.34
In flight	16	9	25	3	–	0.12	–
All birds	50	29	79	16	–	0.39	–
Total (subareas combined)							
On ground	252	170	422	112	501	0.56	0.66
In flight	45	22	67	14	–	0.09	–
All birds	297	192	489	126	–	0.65	–

[a] Total indicated birds was calculated according to standard USFWS protocol (USFWS 1987a)

[b] Surveys conducted at 50% coverage. Density based on area surveyed: Development subarea = 304.6 km² surveyed, Alpine West = 41.8 km², Fish Creek = 57.3 km², Fish Creek West = 151.2 km², Exploration = 200.2 km², all subareas combined = 755.1 km²; numbers not corrected for sightability

Table 6. Habitat selection by Spectacled and King eider groups during pre-nesting in the NPRA study area, Alaska, 2001–2006 and 2008.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
SPECTACLED EIDER						
Open Nearshore Water	0	0	0.0	0.4	ns	low
Brackish Water	8	4	11.8	0.9	prefer	low
Tapped Lake with Low-water Connection	0	0	0.0	0.8	ns	low
Tapped Lake with High-water Connection	0	0	0.0	0.2	ns	low
Salt Marsh	2	1	2.9	1.7	ns	low
Tidal Flat Barrens	0	0	0.0	0.9	ns	low
Salt-killed Tundra	0	0	0.0	0.6	ns	low
Deep Open Water without Islands	2	1	2.9	6.5	ns	low
Deep Open Water with Islands or Polygonized Margins	10	5	14.7	1.0	prefer	low
Shallow Open Water without Islands	5	4	11.8	5.6	ns	low
Shallow Open Water with Islands or Polygonized	15	7	20.6	1.7	prefer	low
River or Stream	1	1	2.9	1.1	ns	low
Sedge Marsh	1	1	2.9	1.7	ns	low
Deep Polygon Complex	0	0	0.0	0.0	ns	low
Grass Marsh	2	1	2.9	0.3	ns	low
Young Basin Wetland Complex	0	0	0.0	0.3	ns	low
Old Basin Wetland Complex	11	6	17.6	8.4	ns	low
Riverine Complex	0	0	0.0	0.3	ns	low
Dune Complex	0	0	0.0	1.1	ns	low
Nonpatterned Wet Meadow	2	1	2.9	3.2	ns	low
Patterned Wet Meadow	4	2	5.9	11.2	ns	low
Moist Sedge-Shrub Meadow	0	0	0.0	21.8	avoid	
Moist Tussock Tundra	0	0	0.0	25.9	avoid	
Tall, Low, or Dwarf Shrub	0	0	0.0	3.2	ns	low
Barrens	0	0	0.0	1.1	ns	low
Human Modified	0	0	0.0	0.0	ns	
Total	63	34	100	100		
KING EIDER						
Open Nearshore Water	4	2	0.6	0.4	ns	low
Brackish Water	28	14	4.1	0.9	prefer	low
Tapped Lake with Low-water Connection	29	8	2.3	0.8	prefer	low
Tapped Lake with High-water Connection	0	0	0.0	0.2	ns	low
Salt Marsh	42	19	5.6	1.7	prefer	
Tidal Flat Barrens	8	3	0.9	0.9	ns	low
Salt-killed Tundra	2	1	0.3	0.6	ns	low
Deep Open Water without Islands	100	34	10.0	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	85	32	9.4	1.0	prefer	low
Shallow Open Water without Islands	60	31	9.1	5.6	prefer	
Shallow Open Water with Islands or Polygonized	117	50	14.7	1.7	prefer	
River or Stream	59	24	7.0	1.1	prefer	low
Sedge Marsh	24	12	3.5	1.7	prefer	
Deep Polygon Complex	0	0	0.0	0.0	ns	low
Grass Marsh	15	4	1.2	0.3	prefer	low
Young Basin Wetland Complex	0	0	0.0	0.3	ns	low
Old Basin Wetland Complex	134	62	18.2	8.4	prefer	
Riverine Complex	2	1	0.3	0.3	ns	low
Dune Complex	0	0	0.0	1.1	ns	low
Nonpatterned Wet Meadow	18	10	2.9	3.2	ns	
Patterned Wet Meadow	39	23	6.7	11.2	avoid	
Moist Sedge-Shrub Meadow	14	6	1.8	21.8	avoid	
Moist Tussock Tundra	7	4	1.2	25.9	avoid	
Tall, Low, or Dwarf Shrub	1	1	0.3	3.2	avoid	
Barrens	0	0	0.0	1.1	avoid	low
Human Modified	0	0	0.0	0.0	ns	
Total	788	341	100	100		

[a] use = (groups / total groups) x 100.
[b] Significance calculated from 1,000 simulations at = 0.05; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.
[c] Expected number < 5.

birds) during the 2008 pre-nesting period in the Colville Delta study area (Table 3). The total density (0.08 birds/km²) was similar to the mean of the previous 14 years (0.07 birds/km²). Most King Eiders (61%) were seen in the Northeast Delta subarea (Figure 10). The Northeast Delta subarea is highly dissected by distributary channels and in past years has been used by large flocks of King Eiders, probably in transit to other breeding areas (Johnson et al. 2003b).

No Steller's or Common eiders were seen on the Colville Delta in 2008. Steller's Eiders rarely are seen in the vicinity of the Colville Delta. In 2007, a male Steller's Eider was seen flying on the Colville Delta. Single males or pairs have been seen in the Colville Delta and the northeast NPRA (Johnson and Stickney 2001) during 2001, and in the Kuparuk Oilfield during 1995, 2000, 2001, and 2007 (not all sightings in the Kuparuk Oilfield were confirmed; see Anderson et al. 2008).

Common Eiders are seen infrequently on the Colville Delta, but may be more common in the nearshore marine waters that are mostly outside the survey area. One pair of Common Eiders was observed in 2007 in the nearshore marine water just northwest of the study area boundary. Pairs have been recorded during pre-nesting in 1992, 1998, and 2001, and a nest was found near the coastline in 1994 (Johnson 1995).

Habitat Use

Steller's and Common eiders have not been numerous enough to enable evaluation of habitat preferences on the Colville Delta. Pre-nesting King Eiders used 18 of 24 available habitats in the Colville Delta study area over 15 years of aerial surveys. King Eiders preferred 3 of the same habitats preferred by Spectacled Eiders on the Colville Delta: Brackish Water, Salt-killed Tundra, and Deep Polygon Complex (Table 4). King Eiders also preferred River or Stream, where the largest percentage (38%) of the groups was found. The high use of River or Stream suggests that many King Eiders were in transit to breeding areas farther east, because River or Stream is not potential breeding habitat, and large numbers of these eiders are not using other open and available breeding habitats on the delta. Furthermore, King Eiders nest at very low densities on the Colville Delta in the several locations where intensive nest searches have been conducted (Burgess et al. 2003a, Johnson et al. 2003a, Johnson et al. 2008a), indicating that most of the pre-nesting King Eiders seen on the delta are stopping over during migration.

NE NPRA

King Eiders were the only eider species other than Spectacled Eiders seen on pre-nesting surveys of NPRA in 2008. King Eiders were approximately an order of magnitude more abundant in the NPRA study area than were Spectacled Eiders (Figure 10, Table 5). The Fish Creek West subarea contained the highest number (203 indicated total birds) and density (1.34 indicated total birds/km²) of King Eiders among the subareas in NPRA. The indicated total of King Eiders in the NPRA study area in 2008 was 501 birds and the indicated total density was 0.66 birds/km², an increase over the 332 King Eiders and 0.48 birds/km² tallied in 2006 (Johnson et al. 2007b).

Habitat Use

King Eiders used 20 of 26 available habitats and preferred 11 habitats over 7 years of pre-nesting surveys in the NPRA study area (Table 6). Old Basin Wetland Complex, Shallow Open Water with Islands or Polygonized Margins, and Deep Open Water without Islands were the most frequently used habitats and also were preferred. The remaining preferred habitats included Brackish Water, Tapped Lake with Low-water Connection, Salt Marsh, Deep Open Water with Islands or Polygonized Margins, Shallow Open Water without Islands, River or Stream, Sedge Marsh, and Grass Marsh.

LOONS

YELLOW-BILLED LOON

Colville Delta

Distribution and Abundance

On the Colville Delta in 2008, Yellow-billed Loons had one of their most productive years since surveys were initiated there in 1993. During the nesting survey in 2008, 69 Yellow-billed Loons and 38 nests were observed in the Colville Delta study area (Table 7, Figure 11), the largest numbers in 14 years of surveys (Burgess et al. 2003a; Johnson et al. 2003b, 2004, 2005, 2006b, 2007b, 2008b). As in previous years, Yellow-billed Loon nests in 2008 were concentrated in the central part of the delta (Figure 11), and most nests were on lakes where Yellow-billed Loons have nested previously (Rothe et al. 1983; North 1986; Burgess et al. 2003a; Johnson et al. 2003b, 2004, 2005, 2006b, 2007b, 2008b). Three nests found in 2008 were on lakes with no prior history of nesting by Yellow-billed Loons; however, 1 of those lakes was surveyed in only 1995, 1996, 2007, and 2008, and the other 2 lakes (one surveyed since 2002 and the other since 1993) were occupied in previous years by Pacific Loons. Five of the 38 nests were found only during the weekly monitoring surveys in July and it is likely that these 5 nests were inactive (not yet initiated) at the time of the nest survey. Two nests were found on lakes in the Northeast Delta subarea and were not included in density calculations (Table 7), in order to be consistent with data presentations from previous years.

During the brood-rearing survey in 2008, 27 Yellow-billed Loon broods were recorded in the Colville Delta study area, the largest number in 14 years (Figure 11, Table 7). Two of these broods were found in the Northeast Delta subarea, 3 broods were observed only during the weekly monitoring surveys in July, and 2 broods were determined by eggshell evidence that indicated nests hatched where no broods were observed on either the monitoring or brood-rearing surveys (see *Nest Fate*, below).

Habitat Use

During 14 years of nesting aerial surveys in the CD North and CD South subareas, which have been surveyed each year, 291 Yellow-billed Loon nests were found in 11 of 24 available habitats on the Colville Delta (Table 8). Three habitats were preferred for nesting (Patterned Wet Meadow, Deep Open Water with Islands or Polygonized Margins, and Sedge Marsh), altogether supporting 206 of 291 total nests. Within these areas, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. All nests were on shorelines of lakes, but only nests on islands or in emergent vegetation were assigned to aquatic habitat; otherwise nests were assigned to the terrestrial habitat on the lakeshore. Patterned Wet Meadow was the most frequently used habitat for nesting (39% of all nests), and it also was the most abundant habitat on the delta (25% of the loon survey area; Table 8). Nesting Yellow-billed Loons avoided 9 habitats, which in combination occupied 48% of the CD North and CD South study areas (Table 8).

One hundred forty-eight Yellow-billed Loon broods were found in 4 habitats, 3 of which were preferred: Deep Open Water without Islands, Deep Open Water with Islands or Polygonized Margins, and Tapped Lake with High-water Connection (Table 8). One brood was found in Brackish Water during the brood-rearing survey but was observed most often using Tapped Lake with High-water Connection during weekly monitoring surveys. No shallow-water habitats were used during brood-rearing. The selection analyses for nesting and brood-rearing reaffirms the importance of large, deep waterbodies to breeding Yellow-billed Loons.

Nest Fate

Nesting success of Yellow-billed Loons in 2008 was 71% (Table 9), which is the same as in 2007 and higher than in the 2 previous years (Johnson et al. 2006b, 2007b, 2008b). Overall, 27 of 38 nesting pairs of Yellow-billed Loons in the Colville Delta study area hatched at least 1 young. Two of the 27 pairs were determined to have hatched young based on eggshell evidence at the nest, but those broods did not survive the period between hatch and the following aerial survey. Of the 27 successful nests, 1 (4%) hatched between nest visits on 2 and 7 July; the majority of nests, 19 (70%), hatched between 7 and 14 July; 2 more nests (7%) hatched by 22 July; 4 more (16%) by 28 July; and the remaining nest hatched by 4 August (Table 9). This last nest to hatch was first found active on 7 July, a relatively late date. Five broods (3 observed on monitoring surveys and 2 determined by eggshell evidence) were lost by the time of the brood-rearing aerial survey (18 August).

Eleven of 38 Yellow-billed Loon nests on the Colville Delta failed to hatch (Table 9). Four of 11 nests (36%) failed during the week after the nest survey, by 2 July. Two more nests failed by 7 July, 3 failed by 14 July, and the remaining 2 failed by 22 July (Table 9). After that week, only 4 nests were active and all hatched.

Table 7. Number and density of loons and their nests, broods, and young during aerial surveys, Colville Delta and NPRA study areas, Alaska, 2008.

STUDY AREA / Subarea[b] / Survey Type	Yellow-billed Loons: Number – Adults	Yellow-billed Loons: Number – Nests/ Brood	Yellow-billed Loons: Number – Young	Yellow-billed Loons: Density (number/km²) – Adults	Yellow-billed Loons: Density (number/km²) – Nests/ Broods	Pacific Loons[a]: Number – Adults	Pacific Loons[a]: Number – Nests/ Broods	Pacific Loons[a]: Number – Young	Red-throated Loons[a]: Number – Adults	Red-throated Loons[a]: Number – Nests/ Broods	Red-throated Loons[a]: Number – Young
COLVILLE DELTA											
CD North											
Nesting	34	20	–	0.16	0.10	76	13	–	7	1	–
Brood-rearing	28	15	20	0.14	0.07	78	13	14	0	0	0
CD South											
Nesting	33	16	–	0.21	0.10	90	11	–	4	0	–
Brood-rearing	27	10	12	0.17	0.06	70	7	7	2	0	0
Northeast Delta[c]											
Nesting	2	2	–	–	–	16	2	–	0	0	–
Brood-rearing	2	2	2	–	–	6	3	3	0	0	0
Total (subareas combined)[d]											
Nesting	69	38 [e]	–	0.18	0.10	182	26	–	11	1	–
Brood-rearing	57	27 [f]	34	0.15	0.07	154	23	24	2	0	0
NPRA											
Alpine West											
Nesting	2	1	–	0.03	0.01	36	18	–	1	0	–
Brood-rearing	4	1	2	0.05	0.01	68	9	13	0	0	0
Fish Creek Delta											
Nesting	15	5	–	0.11	0.04	84	11	–	0	0	–
Brood-rearing	7	5	6	0.05	0.04	47	11	11	0	0	0
Fish and Judy Creek Corridor											
Nesting	61	21	–	0.24	0.08	155	18	–	2	0	–
Brood-rearing	54	11	15	0.21	0.04	192	23	24	0	0	0
Outside of Survey Subareas[c]											
Nesting	4	2	–	–	–	66	7	–	0	0	–
Brood-rearing	5	2	2	–	–	63	7	9	0	0	0
Total (subareas combined)[d]											
Nesting	82	29 [e]	–	0.17	0.06	341	54	–	3	0	–
Brood-rearing	70	19 [f]	25	0.14	0.04	370	50	57	0	0	0

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and surveys did not include smaller lakes (<10 ha) where those species commonly nest

[b] CD North = 206.7 km², CD South = 155.9 km², Alpine West = 79.7 km², Fish Creek Delta = 130.5 km², Fish and Judy Creek Corridor = 255.9 km²; see Figure 5

[c] Densities were not calculated for the Northeast Delta subarea and the survey area outside of the Alpine West, Fish Creek Delta, and Fish and Judy Creek Corridor subareas because the entire area was not surveyed

[d] Density includes CD North and CD South for Colville Delta (362.6 km² total) , and Alpine West, Fish Creek Delta, and Fish and Judy Creek Corridor for NPRA (466.1 km² total)

[e] Total number includes 5 nests found only during monitoring surveys in the Colville Delta study area and 6 nests in the NPRA study area

[f] Total number includes 3 broods and 5 young found only during monitoring surveys and 2 broods determined by eggshell evidence in the Colville Delta study area, and 6 broods and 10 young found only during monitoring surveys and 1 brood determined by eggshell evidence in the NPRA study area

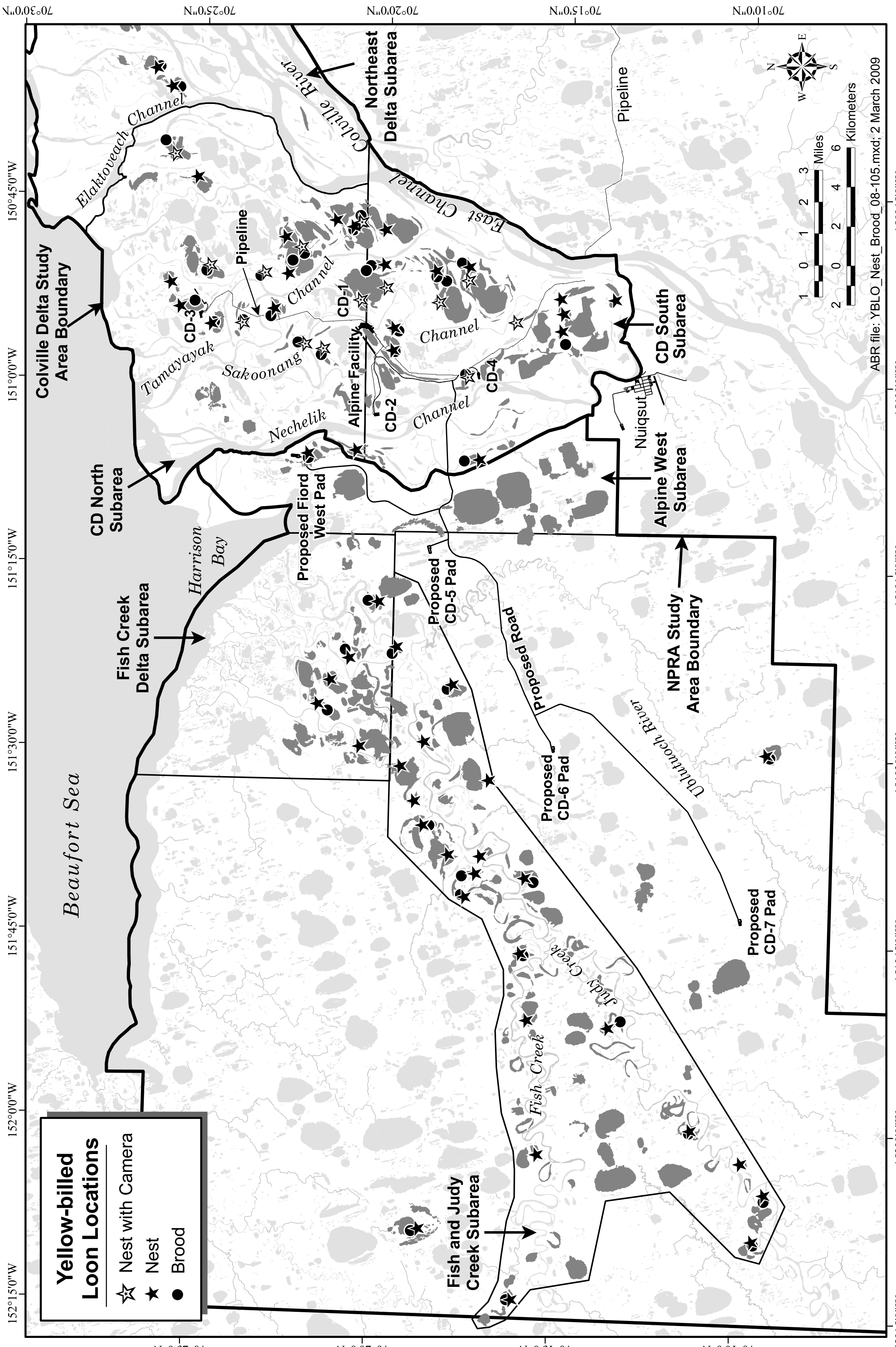

Figure 11. Yellow-billed Loon nests and broods, Colville Delta and NPRA study areas, Alaska, 2008.

Table 8. Habitat selection by nesting (1993–2008) and brood-rearing (1995–2008) Yellow-billed Loons in the Colville Delta study area, Alaska.

SEASON Habitat	No. of Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING				
Open Nearshore Water	0	0	2.0	avoid
Brackish Water	0	0	1.1	ns
Tapped Lake with Low-water Connection	0	0	5.4	avoid
Tapped Lake with High-water Connection	16	5.5	5.4	ns
Salt Marsh	0	0	2.6	avoid
Tidal Flat Barrens	0	0	3.5	avoid
Salt-killed Tundra	0	0	4.2	avoid
Deep Open Water without Islands	16	5.5	5.5	ns
Deep Open Water with Islands or Polygonized Margins	88	30.2	1.8	prefer
Shallow Open Water without Islands	0	0	0.3	ns
Shallow Open Water with Islands or Polygonized Margins	1	0.3	0.1	ns
River or Stream	0	0	8.8	avoid
Sedge Marsh	5	1.7	<0.1	prefer
Deep Polygon Complex	14	4.8	2.8	ns
Grass Marsh	2	0.7	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	31	10.7	8.7	ns
Patterned Wet Meadow	113	38.8	24.6	prefer
Moist Sedge–Shrub Meadow	3	1.0	3.2	avoid
Moist Tussock Tundra	0	0	0.9	ns
Tall, Low, or Dwarf Shrub	2	0.7	6.5	avoid
Barrens	0	0	12.1	avoid
Human Modified	0	0	0.1	ns
Total	291	100	100	
BROOD-REARING				
Open Nearshore Water	0	0	2.0	ns
Brackish Water	1	0.7	1.1	ns
Tapped Lake with Low-water Connection	0	0	5.4	avoid
Tapped Lake with High-water Connection	28	18.9	5.4	prefer
Salt Marsh	0	0	2.6	avoid
Tidal Flat Barrens	0	0	3.5	avoid
Salt-killed Tundra	0	0	4.2	avoid
Deep Open Water without Islands	67	45.3	5.5	prefer
Deep Open Water with Islands or Polygonized Margins	52	35.1	1.8	prefer
Shallow Open Water without Islands	0	0	0.3	ns
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns
River or Stream	0	0	8.8	avoid
Sedge Marsh	0	0	<0.1	ns
Deep Polygon Complex	0	0	2.8	avoid
Grass Marsh	0	0	0.3	ns
Young Basin Wetland Complex	0	0	<0.1	ns
Old Basin Wetland Complex	0	0	<0.1	ns
Nonpatterned Wet Meadow	0	0	8.7	avoid
Patterned Wet Meadow	0	0	24.6	avoid
Moist Sedge–Shrub Meadow	0	0	3.2	avoid
Moist Tussock Tundra	0	0	0.9	ns
Tall, Low, or Dwarf Shrub	0	0	6.5	avoid
Barrens	0	0	12.1	avoid
Human Modified	0	0	0.1	ns
Total	148	100	100	

[a] 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. % use = (nests / total nests) × 100 or (broods / total broods) × 100

Table 9. Weekly status and fate of Yellow-billed Loon nests in the Colville Delta study area, Alaska, 2008.

Territory No.	23 Jun	2 Jul	7 Jul	14 Jul	22 Jul	28 Jul	4 Aug	Fate/Total
1	Active	Active	Active	Inactive	–	–	–	Hatched
2	Active	Active	Active	Inactive	–	–	–	Hatched
3	Active	Active	Active	Inactive	–	–	–	Hatched
4	Active	Active	Active	Inactive	–	–	–	Failed
6	Active	Active	Active	Inactive	–	–	–	Hatched
7	Active	Active	Active	Active	Inactive	–	–	Hatched[a]
8	–	Active	Active	Active	Active	Inactive	–	Hatched
9	Active	Active	Active	Active	Inactive	–	–	Hatched
10	Active	Active	Active	Inactive	–	–	–	Hatched
11	Active	Active	Active	Inactive	–	–	–	Hatched
12	Active	Active	Active	Inactive	–	–	–	Hatched
13	Active	Active	Active	Inactive	–	–	–	Hatched
14	Active	Active	Active	Inactive	–	–	–	Hatched
15	Active	Active	Active	Inactive	–	–	–	Hatched
16	–	–	Active	Active	Active	Active	Inactive	Hatched
17	Active	Active	Active	Inactive	–	–	–	Hatched
18	Active	Active	Active	Inactive	–	–	–	Failed
20	Active	Active	Inactive	–	–	–	–	Failed
21	Active	Inactive	–	–	–	–	–	Failed
22	Active	Inactive	–	–	–	–	–	Failed
23	–	Active	Active	Active	Active	Inactive	–	Hatched
24	Active	Active	Active	Inactive	–	–	–	Hatched
25	Active	Active	Active	Inactive	–	–	–	Hatched
26	Active	Active	Active	Inactive	–	–	–	Hatched
27	Active	Active	Active	Inactive	–	–	–	Hatched
29	Active	Inactive	–	–	–	–	–	Failed
30	Active	Active	Active	Inactive	–	–	–	Hatched[a]
31	Active	Active	Active	Inactive	–	–	–	Hatched
32	Active	Active	Active	Active	Inactive	–	–	Failed
33	Active	Active	Inactive	–	–	–	–	Failed
34	–	–	Active	Active	Active	Inactive	–	Hatched
37	Active	Active	Inactive	–	–	–	–	Hatched
38	–	Active	Active	Active	Active	Inactive	–	Hatched
39	Active	Active	Active	Active	Inactive	–	–	Failed
42	Active	Active	Active	Inactive	–	–	–	Failed
43	Active	Inactive	–	–	–	–	–	Failed
44	Active	Active	Active	Inactive	–	–	–	Hatched
45	Active	Active	Active	Inactive	–	–	–	Hatched
No. Active	33	32	31	9	5	1	0	38
No. Hatched	0	0	1	19	2	4	1	27
No. Failed	0	4	2	3	2	0	0	11

[a] No brood was seen but nest classified as hatched based on eggshell remains

The contents of all 38 Yellow-billed Loon nests were examined after nests were no longer active. Twenty-seven nests were classified as successful and 11 failed based on egg remains at the nest. Successful nests contained between 35 and 90 eggshell fragments and broods were observed at all but 2 of these nests. Of >1,500 eggshell fragments found in successful nests, 73% were ≤10 mm in length. Twelve of 27 successful nests also contained pieces of thickened egg membrane. Membranes were whole at 3 nests while the remainder had pieces ranging from 5–70 mm in length. The majority of egg membranes and eggshell fragments were found in nest bowls, but a total of 255 fragments were found in the water or on shore adjacent to successful nests. Four of the 11 failed nests contained damaged eggs, such as eggs with holes in them or broken in half, and these damaged eggs were associated with 5–10 mm pieces of eggshell. One nest contained only a 15-mm piece of eggshell, whereas the remaining 6 nests were empty. Causes of nest failure were unknown.

Time-lapse Cameras

We monitored 14 of 38 Yellow-billed Loon nests with time-lapse cameras in 2008 (Table 10). Zoom cameras were placed 75–298 m from nests (mean = 127 m, n = 12), whereas the standard cameras were placed 27–30 m from nests (mean = 29 m, n = 2). Researchers were transported to and from nesting areas by helicopter for camera setup and were at nests an average of 49 min (range 38–62 min, n = 14 nests). Thirteen of 14 loons left their nests during camera setup: 6 swam away from nests as the helicopter landed and 7 did so as researchers approached the camera setup location. One loon was swimming next to its nest upon our arrival and was either on recess or swam away as the helicopter approached. We did not observe any loon fly away from its nest lake, although it was possible we missed that while installing cameras. Most of the loons swam away and stayed partially or totally hidden in the lake.

Table 10. Nest history and incubation activity of Yellow-billed loon nests monitored by time-lapse digital cameras in the Colville Delta study area, Alaska, 2008.

Territory	Nest initiation date[a]	Fate[b]	Date range[c]	No. days monitored[d]	Incubation constancy	Exchange frequency (no/d)	Recess frequency (no/d)	Recess length (min/recess)
3[e]	11 June	S	23 June–9 July	–	–	–	–	–
6	8 June	S	24 June–6 July	11.0	98.8	1.5	1.5	9.7
10	10 June	S	23 June–8 July	12.9	98.5	1.6	1.4	13.5
11[f]	–	S	23 June–27 June	3.8	94.3	1.1	2.4	32.9
13	9 June	S	23 June–7 July	12.3	98.3	1.1	1.5	14.0
14	15 June	S	24 June–13 July	17.5	96.7	1.0	2.5	17.1
17	10 June	S	24 June–8 July	12.6	99.2	1.4	1.0	8.5
18[f]	–	F	24 June–7 July	11.1	99.0	1.8	1.3	8.4
22	–	F	24 June–29 June	3.7	95.6	2.2	2.4	25.4
24	12 June	S	24 June–10 July	14.3	95.6	0.8	2.7	23.7
27	10 June	S	24 June–8 July	11.2	97.4	1.3	2.9	10.3
29	–	F	23 June–25 June	1.0	99.4	3.0	1.0	9.0
37	7 June	S	23 June–5 July	10.1	95.4	1.3	4.0	14.1

[a] Estimated by subtracting 28 d from the day of hatch
[b] S = successfully hatched, F = failed to hatch
[c] Date range includes the day of camera installation through the date of hatch, failure, or camera malfunction.
[d] Excludes day of instrumentation, hatch, brood departure or nest failure, and periods of time where photo images could not be interpreted due poor weather conditions
[e] Incubation parameters were not calculated because the camera was too far from the nest to adequately judge behavior
[f] Camera aim shifted during monitoring so that the nest was no longer in the field of view

All 14 loons returned to incubate after camera installation. Two returned while researchers were still in the area, whereas the remaining 12 returned an average of 23 min (range 3–55 min) after researchers departed in the helicopter. In total, loons were absent from nests for an average of 64 min (range 19–104 min, n = 13 nests). No nest predation was recorded on camera during these absences.

Cameras adequately recorded daily nest survival data and we were able to identify the day of hatch or failure from all but 2 camera-monitored nests. One of these 2 cameras collected moisture inside the camera lens and all but the first few hours of photos were blurred. The other camera collected data for ~4 d before it was bumped, possibly by caribou, and thereafter was aimed away from the nest. Both of these nests eventually hatched.

Of the 14 camera-monitored nests, 11 hatched and 3 failed for an apparent nesting success of 79%. The median hatch date for camera-monitored nests was 8 July (range 5–13 July, n = 10; Table 10). These dates agree with dates from monitoring surveys that indicated most nests hatched between visits on 7 and 14 July. Loons at both hatched and failed nests exhibited high nest attendance, spending 97.1% (n = 9) and 98.0% (n = 3) of monitored time on nests, respectively.

We were unable to identify causes of nest failure. Two nests failed during periods of fog, which prevented the camera from taking clear pictures. The remaining nest failed after something bumped the camera during a period of heavy fog. On retrieval, we noted that the cords that guyed that camera tripod were chewed and severed. Predators were difficult to identify near nests because of the combination of the large distance between nests and cameras, insufficient magnification by the camera lenses, and poor visibility in fog.

We conclude from this cursory evaluation that the camera monitoring had little negative effect on nesting loons because 1) apparent nesting success of nests monitored by cameras was slightly higher than unmonitored nests, 2) nesting loons returned to monitored nests and resumed normal incubation, and 3) no attempts at nest predation were observed during camera installation. We caution that Yellow-billed Loons unexposed to human activity may react differently than those on the Colville Delta. We advise using cameras with higher magnification and placing cameras nearer to nests (so that fog would have less of an effect) to improve identification of nest predators and detection of chicks in the nest. However, moving cameras nearer to nests may result in unintended disturbance of nesting loons, so this approach needs to be conducted cautiously as an experiment to determine whether it adversely affects incubation behavior.

Brood Fate

By the final weekly monitoring survey on 16 September, 14 (52%) of the 27 pairs at successful nests still retained ≥1 chick, 6 (22%) pairs had no chicks, and the status of 7 (26%) broods could not be determined due to poor survey conditions (Table 11). We classified the fate of these 7 broods as unknown.

Most successful nests hatched 2 chicks: 16 of 27 (59%) pairs were observed with 2 chicks. Nine pairs either hatched only 1 egg or lost 1 of their chicks sometime between hatching and the next weekly survey. Two pairs hatched an unknown number of young. Broods were not observed at these 2 nests but nests were determined successful based on egg remains. By 16 September, only 4 pairs were confirmed with 2 young (Table 11).

Of the 6 pairs that lost all their young, 2 failed within 1 week of hatch (territories 7 and 30) and the other 4 failed at 2, 4, 6, and 9 weeks after hatch (territories 14, 25, 37, and 17, respectively; Table 11). During the first weekly survey after hatching, 2 chicks were reported hatched at territory 14, but 1 chick was barely alive ~3 m from the nest while the other was swimming with both adults in a different part of the lake. The time-lapse camera at this nest showed that the adults left the nest ~2 hours prior to the nest fate visit. No young were found at this territory the following week. We observed only 1 chick at territory 25, and it disappeared in early August at age 21 d. The pair at territory 37 also lost 1 chick in early August at age 29.5 d and lost their remaining chick during the following week at age 34 d. Territory 17 only produced 1 chick and it was found dead floating on the water on 8 September at age 56 d.

Table 11. Number of Yellow-billed Loon chicks observed during weekly surveys, Colville Delta study area, Alaska, 2008.

	July				August				September			Age (d) when last	Brood
Territory	7	14	22	28	4	11	18	25	1	8	16[a]	seen	Fate[b]
1	Inc[c]	1	1	1	1	1	1	1	1	1	1	67.5	A
2	Inc	2	2	2	2	2	1	1	1	1	U	59.5	U
3	Inc	2	1	1	1	1	1	1	1	1	U	59.5	U
6	Inc	2	1	1	1	1	1	1	1	1	1	67.5	A
7	Inc	Inc	0[d]	0	–	–	–	–	–	–	–	4.0	F
8	Inc	Inc	Inc	2	2	2	2	2	2	1	1	53.0	A
9	Inc	Inc	2	1	1	1	1	1	1	1	1	52.0	A
10	Inc	2	2	2	1	1	1	1	1	1	U	59.5	U
11	Inc	2	2	2	2	2	2	2	1	0	U	52.5	U
12	Inc	2	2	2	2	2	2	2	2	1[e]	2	67.5	A
13	Inc	1	1	1	1	0[e]	1	1	1	1	U	59.5	U
14	Inc	2	0	0	–	–	–	–	–	–	–	7.5	F
15	Inc	1	1	1	1	1	1	1	1	1	1	67.5	A
16	Inc	Inc	Inc	Inc	U[f]	2	2	2	2	2	2	46.5	A
17	Inc	1	1	1	1	1	1	1	1	0[g]	–	56.0	F
23	Inc	Inc	Inc	2	2	2	2	2	2	2	2	53.0	A
24	Inc	1	1	1	1	1	1	1	1	1	1	67.5	A
25	Inc	U[f]	1	1	0	0	0	–	–	–	–	21.0	F
26	Inc	2	2	2	2	2	2	2	2	2	U	59.5	U
27	Inc	2	2	2	2	2	2	2	2	1[e]	2	67.5	A
30	Inc	0[d]	0	–	–	–		–	–	–	–	3.5	F
31	Inc	2	2	2	2	2	2	2	2	2	U	59.5	U
34	Inc	Inc	Inc	1	1	1	1	1	1	1	1	53.0	A
37	2	0[e]	2	2	1	0	0	–	–	–	–	34.0	F
38	Inc	Inc	Inc	U[f]	2	1	1	1	1	1	1	53.0	A
44	Inc	1	0[e]	1	1	1	1	1	1	1	1	67.5	A
45	Inc	1	1	0[e]	1	1	1	1	1	1	1	67.5	A
Totals													
Broods of 2	1	11	9	10	9	9	8	8	7	6	4	–	–
Broods of 1	0	7	10	12	13	13	14	14	15	14	10	–	–
Unknown	0	1	0	1	1	0	0	0	0	0	7	–	–
Chick loss	0	1–2[h]	3–5[h]	1	3	2	1	0	1	3	U	–	–

[a] Visibility was poor during this survey due to high winds, so we classified the number of young as "unknown" on territories where no young were detected
[b] A = active, young present until 16 September, U = unknown, fate of the brood could not be determined, F = failed
[c] "Inc" denotes loons that were incubating at the time of the survey
[d] Nest determined hatched based on egg remains
[e] Young likely present, but missed during this survey
[f] Adult brooding an unknown number of young
[g] Young found dead floating on the surface of the lake
[h] Range represents loss of brood that had unknown number of chicks (1 or 2)

Another goal of brood monitoring was to estimate juvenile recruitment, or how many chicks survived to fledging. The period from hatching to fledging is unknown in Yellow-billed Loons, but is assumed to be similar to Common Loons, which make their first flights at ~11 weeks (McIntyre and Barr 1997, North 1994). In this study, chicks greater than 7-weeks old were observed exercising their wings by wing stretching or flapping and by running across the water while wing-flapping. Our last survey was conducted on 16 September when most loon chicks were approximately 7–10 weeks old and none had been observed flying by that time (Table 11). Furthermore, we had poor survey conditions during this survey, which made the status of some broods difficult to determine.

NPRA

Distribution and Abundance

During the nesting survey in 2008, 82 Yellow-billed Loons and 29 nests were recorded in the NPRA study area (Figure 11, Table 7). Six of those nests were found only during the weekly monitoring surveys in July. All 6 nests were found on lakes included in the nesting survey and likely were not active or the adults were on incubation recess at the time of that survey. Most loons and nests were found in the Fish and Judy Creek subarea (0.24 birds/km^2; 0.08 nests/km^2), followed by the Fish Creek Delta subarea (0.11 birds/km^2; 0.04 nests/km^2), and Alpine West (0.03 birds/km^2; 0.01 nests/km^2). The density of Yellow-billed Loon adults in the NPRA study area during nesting (0.17 birds/km^2) was similar to that in the Colville Delta study area (0.18 birds/km^2) in 2008, but the density of nests was just over half that on the delta (0.06 nests/km^2 compared to 0.10 nests/km^2, respectively). Two of the 29 nests were found outside of the survey subareas but within the NPRA study area on lakes where Yellow-billed Loons were recorded in previous years and were not included in density calculations in order to be consistent with data presentations from previous years (Figure 11, Table 7). All Yellow-billed Loon nests found in NPRA in 2008 were on lakes where adults or nesting were recorded during surveys in previous years (Johnson et al. 2005, 2006b, 2007b).

During brood-rearing in 2008, 70 adult Yellow-billed Loons and 19 broods were observed in the NPRA study area (Figure 11, Table 7). Most broods (58%) were found in the Fish and Judy Creek subarea. Six of the 19 broods were observed only during weekly monitoring surveys in July and 1 brood was determined by eggshell evidence that indicated a nest hatched where no brood was observed on either the monitoring or brood-rearing surveys. The density of Yellow-billed Loon broods in the NPRA study area in 2008 was 0.04 broods/km^2, just over half the density of broods in the Colville Delta study area (0.07 broods/km^2). Two of the 19 broods were found outside of the survey subareas but within the NPRA study area and were not included in density calculations.

Habitat Use

During aerial surveys in 2008, a total of 24 Yellow-billed Loon nests were found in the part of the NPRA study area covered by the habitat map (Table 12). Nests occurred in 8 habitats, and the 3 habitats most frequently used for nesting were Deep Open Water with Islands or Polygonized Margins (38% of all nests), Patterned Wet Meadow (21%), and Tapped Lake with High-water Connection (12%). Habitat selection was not evaluated because of the small sample size in 2008 and because the change in annual survey areas prevented pooling other years together with 2008.

Yellow-billed Loon broods were observed in 2 habitat types in 2008: Deep Open Water with Islands or Polygonized Margins (11 broods) and Tapped Lake with High-water Connection (2 broods; Table 12). No shallow-water habitats were used during brood-rearing.

Nest Fate

Overall, 19 of 29 Yellow-billed Loon nests in the NPRA study area in 2008 hatched for an apparent nesting success of 65% (Table 13). At 1 nest, no young were seen on surveys, but that nest was determined successful based on eggshell remains. Of the 19 successful nests, the majority hatched by 15 July: 3 (16%) hatched between nest visits on 2 and 8 July and 12 (63%) hatched between 8 and 15 July. Three more nests (16%) hatched by 22 July. The remaining nest (5%) was first discovered on 2 July and it hatched by 29 July. Seven broods (6 observed on monitoring surveys and 1 determined by eggshell evidence) were lost by the time of the brood-rearing aerial survey (18–19 August).

Table 12. Habitat use by nesting and brood-rearing Yellow-billed Loons in the NPRA study area, Alaska, 2008.

Habitat	Nests Number	Nests Use (%)	Broods Number	Broods Use (%)
Tapped Lake with High-water Connection	3	12.5	2	15.4
Deep Open Water with Islands or Polygonized Margins	9	37.5	11	84.6
Shallow Open Water with Islands or Polygonized Margins	1	4.2	0	0
Sedge Marsh	2	8.3	0	0
Grass Marsh	1	4.2	0	0
Nonpatterned Wet Meadow	1	4.2	0	0
Patterned Wet Meadow	5	20.8	0	0
Moist Sedge–Shrub Meadow	2	8.3	0	0
Total	24[a]	100	13[b]	100

[a] Excludes 3 nests that occurred outside the area mapped for habitat and 2 nests outside the 2008 study area
[b] Excludes 3 broods that occurred outside the area mapped for habitat, 2 broods outside the 2008 study area, and 1 brood determined by eggshell evidence

Ten of 29 Yellow-billed Loon nests failed to hatch (Table 13). Three (30%) of 10 nests failed between nest visits on 25 and 2 July, whereas the majority, 6 (60%), failed during the following week, between nest visits on 2 and 8 July. The remaining nest (10%) failed by 15 July (Table 13).

The contents of all 29 Yellow-billed Loon nests were examined after nests were no longer active. Nineteen nests were classified as successful based on egg remains at the nest. These nests contained 20–85 small eggshell fragments inside the nest. Broods were observed at all but 1 of these nests. Of 1,100 eggshell fragments found in successful nests, 70% were ≤10 mm in length. Eleven of 19 successful nests also contained pieces of thickened egg membrane. Membranes were whole at 3 nests while the remainder had pieces ranging from 10–40 mm in length. The majority of egg membranes and eggshell fragments were found in nest bowls and only ~40 fragments were found in the water or on shore adjacent to successful nests. Of the 11 nests where broods were not seen, 10 were presumed failed and 1 was classified as successful based on 20 egg fragments in the nest. Five of the 10 failed nests were associated with damaged eggs. Egg halves or large pieces of eggshell were found within 2 m of 4 failed nests and 1 nest contained 2–10 mm pieces of eggshell cemented together with egg albumen. The remaining 5 nests were empty. Causes of nest failure were unknown.

PACIFIC AND RED-THROATED LOONS

Colville Delta

One hundred eighty-two adults and 26 nests of Pacific Loons were counted opportunistically in the Colville Delta study area during the Yellow-billed Loon nesting survey in 2008 (Figure 12, Table 7). Eleven Red-throated Loons and 1 nest were seen during that survey. During the brood-rearing survey in 2008, 154 adult Pacific Loons and 23 broods were observed in the Colville Delta study area (Figure 12, Table 7). Two Red-throated Loon adults but no broods were seen during that survey. Opportunistic counts of Pacific and Red-throated loons reflect their general distribution on the Colville Delta but are not indicative of the relative abundance of these species (due to differences in species detectability). Nests of Red-throated Loons are not easily detected from the air. Because the survey focused on lakes larger than those typically occupied by Pacific and Red-throated loons for nesting and brood-rearing, densities have not been calculated

Table 13. Weekly status and fate of Yellow-billed Loon nests in the NPRA study area, Alaska, 2008.

Territory No.	25 Jun	2 Jul	8 Jul	15 Jul	22 Jul	29 Jul	Fate/Total
51	Active	Active	Active	Inactive	–	–	Hatched
52	Active	Active	Active	Active	Inactive		Hatched
54	Active	Active	Active	Active	Inactive		Hatched
56	–	–	Active	Inactive	–	–	Failed
57		Active	Inactive	–	–	–	Failed
58	Active	Active	Inactive	–	–	–	Failed
61	–	Active	Inactive	–	–	–	Failed
62	Active	Active	Active	Inactive	–	–	Hatched
63	Active	Inactive	–	–	–	–	Failed
64	Active	Active	Inactive	–	–	–	Failed
65	Active	Active	Inactive	–	–	–	Hatched
66	–	Active	Unknown	Inactive	–	–	Hatched
68	Active	Active	Inactive	–	–	–	Hatched
73	–	Active	Active	Active	Active	Inactive	Hatched
75	Active	Active	Inactive	–	–	–	Failed
77	Active	Active	Active	Inactive	–	–	Hatched
80	Active	Inactive	–	–	–	–	Failed
81	Active	Active	Active	Inactive	–	–	Hatched
83	–	Active	Inactive	–	–	–	Failed
84	Active	Active	Active	Inactive	–	–	Hatched
85	Active	Active	Inactive	–	–	–	Hatched
86	Active	Active	Active	Inactive	–	–	Hatched
87	Active	Active	Active	Inactive	–	–	Hatched
88	Active	Active	Active	Inactive	–	–	Hatched
89	Active	Active	Active	Inactive	–	–	Hatched
91	Active	Inactive	–	–	–	–	Failed
92	Active	Active	Active	Inactive	–	–	Hatched
94	Active	Active	Active	Active	Inactive	–	Hatched[a]
95	Active	Active	Active	Inactive	–	–	Hatched
No. Active	23	25	16	4	1	0	29
No. Hatched	0	0	3	12	3	1	19
No. Failed	0	3	6	1	0	0	10
No. Unknown	0	0	1	0	0	0	0

[a] No brood was seen but nest classified as hatched based on eggshell remains

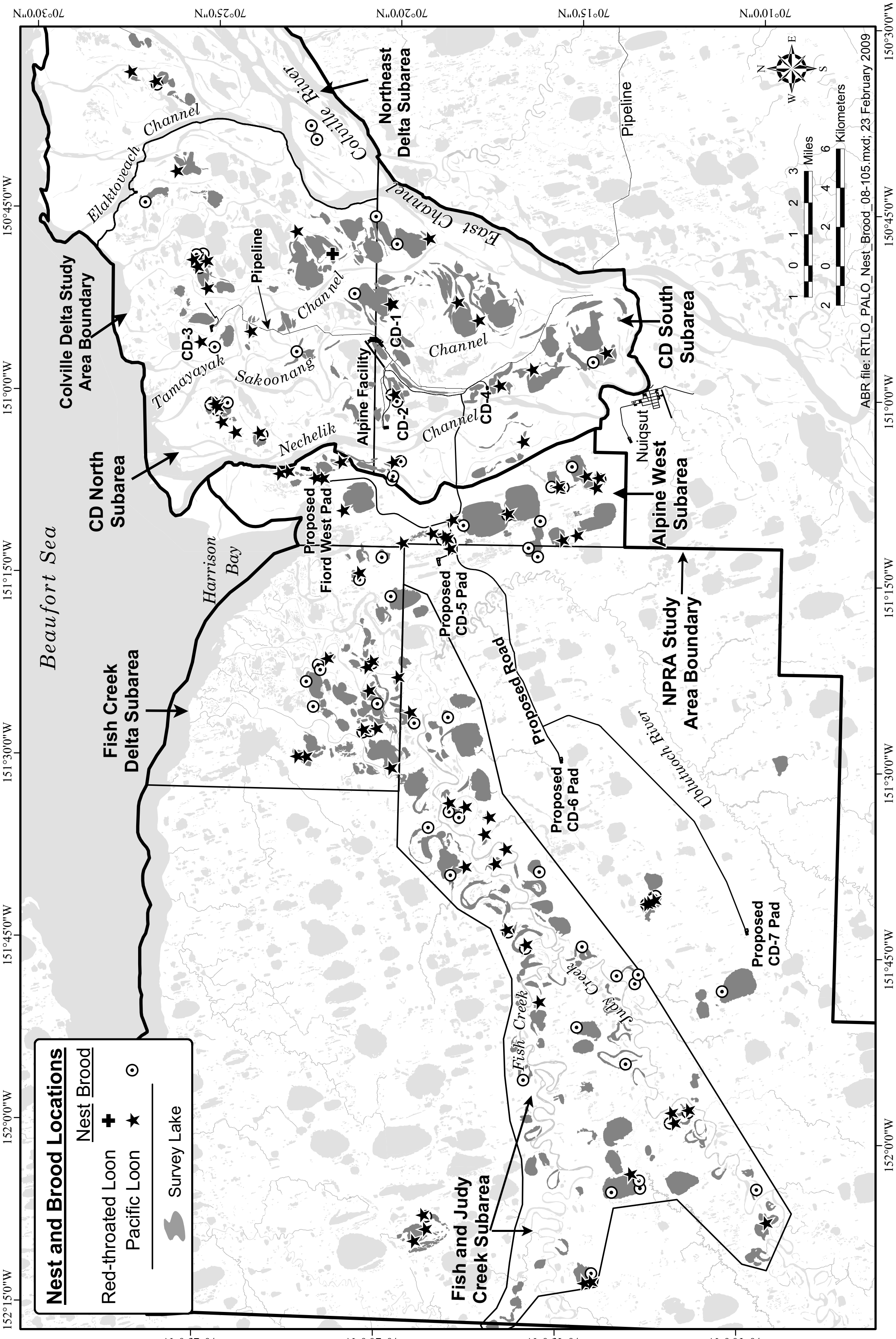

Figure 12. Pacific and Red-throated loon nests and broods, Colville Delta and NPRA study areas, Alaska, 2008.

for these 2 species. Nonetheless, Pacific Loons were clearly the most abundant loon on the delta in 2008 and in previous years.

NPRA

Pacific Loons also were the most abundant and widespread loon species breeding in the NPRA study area in 2008 (Figure 12, Table 7). On the loon nesting survey in 2008, 341 adult Pacific Loons and 54 nests were found (Table 7). Three Red-throated Loon adults but no nests were seen on that same survey. During the brood-rearing survey in 2008, 370 adult Pacific Loons (50 broods) and no Red-throated Loons were counted (Figure 12, Table 7).

TUNDRA SWAN

COLVILLE DELTA

Distribution and Abundance

During the 2008 nesting survey, 411 swans, including 90 pairs, were counted in the Colville Delta study area (Figure 13). The count of swans in 2008 was somewhat greater than the 15-year average count of 378 swans found in the study area. Thirty-six swan nests were found in the Colville Delta study area in 2008 (Table 14), about equal to the annual average of 35 nests. Fourteen nests were located in the CD North subarea, 7 were in the CD South subarea, and 15 were in the Northeast Delta subarea. Eighteen additional swan nests were discovered during helicopter-based loon surveys of portions of the Colville delta and are not included in the aerial swan survey total (Table 14); however, all swan nests are shown in Figure 13.

During the brood-rearing survey, 23 Tundra Swan broods were observed in the Colville Delta study area; slightly below the 15-year mean of 26 broods. Apparent overall nesting success was 64% (Table 14). The mean brood size of 2.5 young in 2008 was equal to the 15-year mean; however, the total of 58 young counted on the delta was below the 15-year mean of 65 young per year.

Habitat Use

Habitat selection was evaluated for 514 Tundra Swan nests recorded on the Colville Delta since 1992 (Table 15). Although some nest sites were used in multiple years (and thus not annually independent locations), 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 was used in all the years that surveys were conducted. Previous investigations have reported that 21–49% of swan nests are located on mounds used during the previous year (Hawkins 1983, Monda et al. 1994) and that nest sites reused from previous years were slightly more successful than new nest sites (Monda et al. 1994). Therefore, deletion of multi-year nest sites from selection analysis could bias the results towards habitats used by less experienced or less successful pairs. Instead, we have chosen to include all nest sites, while recognizing that all locations may not be annually independent.

Tundra Swans on the Colville Delta used a wide range of habitats for nesting. Over 15 years of surveys, Tundra Swans nested in 19 of 24 available habitats, of which 7 habitats were preferred and 7 were avoided (Table 15). Seventy-eight percent of the nests were found in the 7 preferred habitats: Salt Marsh, Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Deep Polygon Complex, Grass Marsh, Patterned Wet Meadow, and Moist Sedge–Shrub Meadow. Nests occurred most frequently in Patterned Wet Meadow (38% of all nests), Salt-killed Tundra (11%), and Nonpatterned Wet Meadow (10%).

Habitat selection was evaluated for 388 Tundra Swan broods recorded on the Colville Delta since 1992 (Table 15). Nine habitats were preferred: Brackish Water, both types of Tapped Lakes, both types of Deep Open Water, Salt Marsh, Salt-killed Tundra, Shallow Open Water without Islands, and Grass Marsh. Broods were seen most frequently in Tapped Lake with Low-water Connections (15% of all broods), and Patterned Wet Meadow (13%), and Tapped Lake with High-water Connections (10%).

The high use of salt-affected or coastal habitats (e.g., Brackish Water, Salt Marsh, Salt-killed Tundra, Tidal Flat Barrens, and Tapped Lake with Low-water Connection) by brood-rearing swans reflects an apparent seasonal change in distribution or habitat preference, in that 37% of all swan broods on the delta were in salt-affected habitats, compared with only 21% of all nests (Table 15). Similar patterns have been reported by

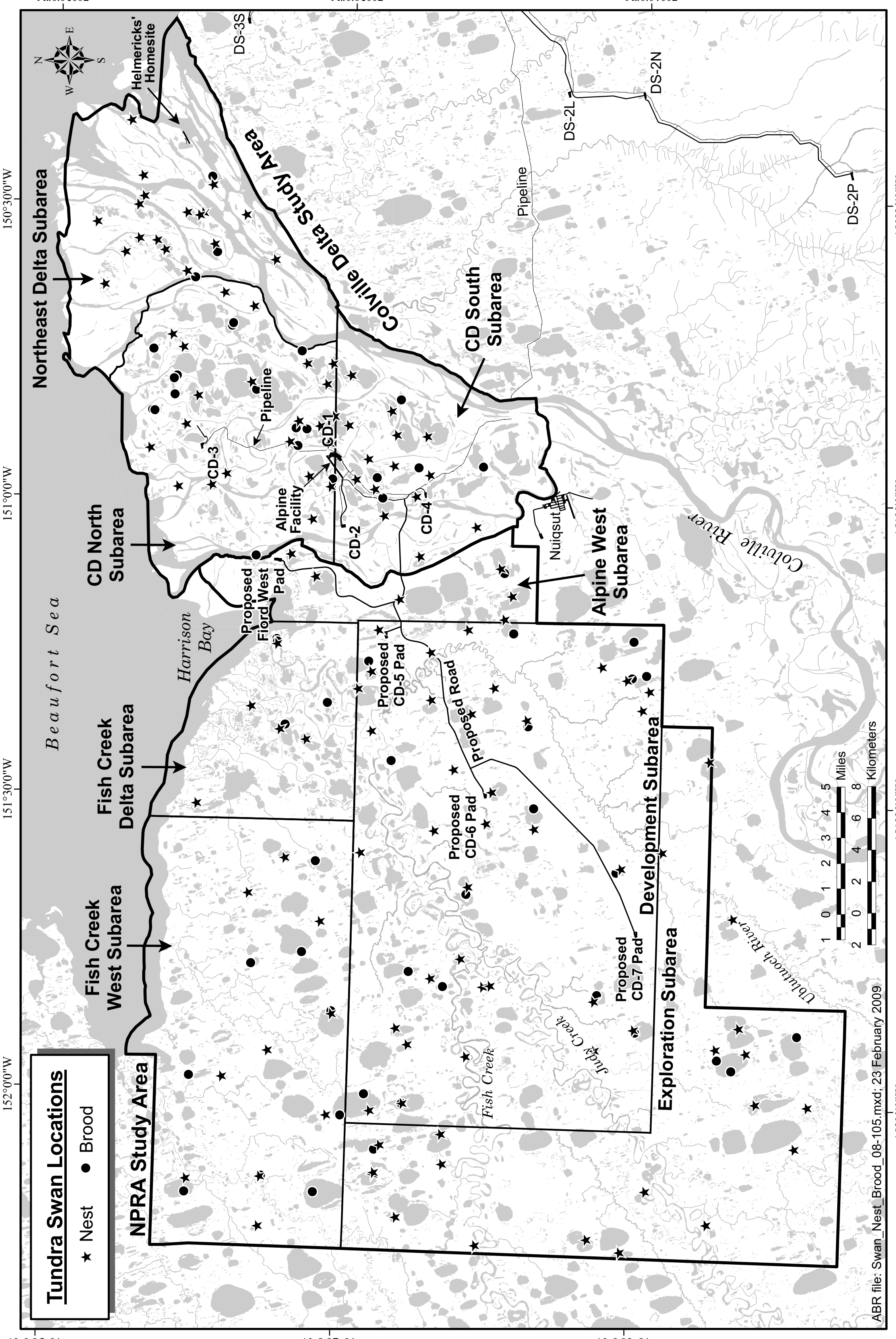

Figure 13. Tundra Swan nests and broods, Colville Delta and NPRA study areas, Alaska, 2008.

Table 14. Number and density of Tundra Swan nests and broods during aerial surveys, Colville Delta and NPRA study areas, Alaska, 2008.

STUDY AREA Subarea	Nests: Number	Nests: Density (nests/km²)	Apparent Nesting Success[a] (%)	Broods: Number	Broods: Density (broods/km²)	Mean Brood Size
COLVILLE DELTA[b]						
CD North	14	0.07	100	15	0.07	2.6
CD South	7	0.04	71	5	0.03	2.4
Northeast Delta	15	0.08	20	3	0.02	2.3
Total (subareas combined)	36	0.08	64	23	0.04	2.5
NPRA[c]						
Development	32	0.05	50	16	0.03	2.8
Alpine West	5	0.06	20	1	0.01	3.0
Fish Creek Delta	4	0.03	100	4	0.03	2.5
Fish Creek West	10	0.03	90	9	0.03	2.2
Exploration	18	0.04	22	4	0.01	2.8
Total (subareas combined)	69	0.04	49	34	0.02	2.6

[a] Apparent nesting success = (broods / nests) × 100
[b] CD North subarea = 206.7 km², CD South subarea = 155.9 km², Northeast Delta subarea = 189.6 km², and Colville Delta study area (subareas combined) = 552.2 km²
[c] Development subarea = 615.8 km², Alpine West subarea =79.7 km², Fish Creek Delta subarea = 130.5 km², Fish Creek West subarea =340.4 km², Exploration subarea = 404.7 km², NPRA study area (subareas combined) = 1,571.1 km²

previous investigations (Spindler and Hall 1991, Monda et al. 1994).

NPRA

Distribution and Abundance

During the 2008 nesting survey, 438 swans were counted in the NPRA study area. The total included 168 pairs, of which 69 pairs were nesting (Table 14). An additional 5 nests were discovered during the course of helicopter-based loon-nesting surveys of limited portions of the NPRA study area. Nests were distributed relatively unevenly throughout the 5 subareas, probably reflecting the differing quality of available nesting habitat in each (Figure 13, Table 14). Apparent nesting success among the subareas ranged from a low of 20% to a high of 100%. Over all subareas, apparent nesting success was only 49%, which is low relative to the 79% apparent success of the adjacent Colville Delta (Table 14).

Thirty-four swan broods were counted during the August brood-rearing survey, with an average of 2.6 young/brood; slightly greater than the 2.5 young /brood average found on the Colville Delta.

Habitat Use

Habitat selection was calculated for 300 Tundra Swan nests recorded in the NPRA study area since 2001 (Table 16). Tundra Swans nested in 21 of 25 available habitats, but preferred only 3 habitats—Shallow Open Water with Islands or Polygonized Margins, Grass Marsh, and Young Basin Wetland Complex—in which 29 nests were located.

Swan broods in NPRA were attracted to large, deep waterbodies, similar to where swan broods were found on the Colville Delta. Habitat selection was evaluated for 148 Tundra Swan broods recorded in the NPRA study area since 2001 (Table 16). Tundra Swan broods used 20 of 25 available habitats. Ninety-eight broods were located in the

Table 15. Habitat selection by nesting and brood-rearing Tundra Swans in the Colville Delta study area, Alaska, 1992–2008.

SEASON Habitat	No. of Nests or Broods	Use (%)	Availability (%)	Monte Carlo Results[a]
NESTING				
Open Nearshore Water	0	0.0	1.8	avoid
Brackish Water	6	1.2	1.2	ns
Tapped Lake with Low-water Connection	2	0.4	3.9	avoid
Tapped Lake with High-water Connection	4	0.8	3.8	avoid
Salt Marsh	34	6.6	3.0	prefer
Tidal Flat Barrens	5	1.0	10.6	avoid
Salt-killed Tundra	58	11.2	4.6	prefer
Deep Open Water without Islands	13	2.5	3.8	ns
Deep Open Water with Islands or Polygonized Margins	29	5.6	1.4	prefer
Shallow Open Water without Islands	2	0.4	0.4	ns
Shallow Open Water with Islands or Polygonized Margins	0	0.0	0.1	ns
River or Stream	0	0.0	15.0	avoid
Sedge Marsh	2	0.4	0.0	prefer
Deep Polygon Complex	70	13.6	2.4	prefer
Grass Marsh	10	1.9	0.3	prefer
Young Basin Wetland Complex	0	0.0	0.0	ns
Old Basin Wetland Complex	0	0.0	0.0	ns
Nonpatterned Wet Meadow	33	6.4	7.5	ns
Patterned Wet Meadow	192	37.2	18.6	prefer
Moist Sedge-Shrub Meadow	24	4.7	2.2	prefer
Moist Tussock Tundra	8	1.6	0.6	prefer
Tall, Low, or Dwarf Shrub	10	1.9	5.0	avoid
Barrens	13	2.5	13.8	avoid
Human Modified	1	0.2	0.1	ns
Total	516	100.0	100.0	
BROOD-REARING				
Open Nearshore Water	1	0.3	1.8	avoid
Brackish Water	25	6.4	1.2	prefer
Tapped Lake with Low-water Connection	57	14.7	3.9	prefer
Tapped Lake with High-water Connection	39	10.1	3.8	prefer
Salt Marsh	29	7.5	3.0	prefer
Tidal Flat Barrens	3	0.8	10.6	avoid
Salt-killed Tundra	30	7.7	4.6	prefer
Deep Open Water without Islands	34	8.8	3.8	prefer
Deep Open Water with Islands or Polygonized Margins	12	3.1	1.4	prefer
Shallow Open Water without Islands	6	1.5	0.4	prefer
Shallow Open Water with Islands or Polygonized Margins	2	0.5	0.1	ns
River or Stream	20	5.2	15.0	avoid
Sedge Marsh	0	0.0	0.0	ns
Deep Polygon Complex	10	2.6	2.4	ns
Grass Marsh	9	2.3	0.3	prefer
Young Basin Wetland Complex	0	0.0	0.0	ns
Old Basin Wetland Complex	0	0.0	0.0	ns
Nonpatterned Wet Meadow	21	5.4	7.5	ns
Patterned Wet Meadow	51	13.1	18.6	avoid
Moist Sedge-Shrub Meadow	6	1.5	2.2	ns
Moist Tussock Tundra	1	0.3	0.6	ns
Tall, Low, or Dwarf Shrub	7	1.8	5.0	avoid
Barrens	25	6.4	13.8	avoid
Human Modified	0	0.0	0.1	ns
Total	388	100.0	100.0	

[a] 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.

Table 16. Habitat selection by nesting and brood-rearing Tundra Swans in the NPRA study area, Alaska, 2001–2006 and 2008.

SEASON Habitat	No. of Nests or Broods	Use (%)	Availability (%)	MonteCarlo Results[a]
NESTING				
Open Nearshore Water	0	0.0	0.7	ns
Brackish Water	4	1.3	0.8	ns
Tapped Lake with Low-water Connection	1	0.3	0.7	ns
Tapped Lake with High-water Connection	1	0.3	0.2	ns
Salt Marsh	9	3.0	1.4	ns
Tidal Flat Barrens	1	0.3	1.0	ns
Salt-killed Tundra	2	0.7	0.5	ns
Deep Open Water without Islands	10	3.3	6.5	avoid
Deep Open Water with Islands or Polygonized Margins	22	7.3	5.2	ns
Shallow Open Water without Islands	3	1.0	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	17	5.7	1.6	prefer
River or Stream	0	0.0	1.1	ns
Sedge Marsh	8	2.7	1.7	ns
Deep Polygon Complex	0	0.0	0.0	ns
Grass Marsh	8	2.7	0.3	prefer
Young Basin Wetland Complex	4	1.3	0.3	prefer
Old Basin Wetland Complex	26	8.7	8.3	ns
Riverine Complex	1	0.3	0.4	ns
Dune Complex	2	0.7	1.1	ns
Nonpatterned Wet Meadow	12	4.0	3.0	ns
Patterned Wet Meadow	34	11.3	11.2	ns
Moist Sedge-Shrub Meadow	55	18.3	22.2	ns
Moist Tussock Tundra	77	25.7	26.3	ns
Tall, Low, or Dwarf Shrub	3	1.0	3.2	avoid
Barrens	0	0.0	1.0	ns
Total	300	100	100	
BROOD-REARING				
Open Nearshore Water	1	0.7	0.7	ns
Brackish Water	5	3.4	0.8	prefer
Tapped Lake with Low-water Connection	6	4.1	0.7	prefer
Tapped Lake with High-water Connection	0	0.0	0.2	ns
Salt Marsh	2	1.4	1.4	ns
Tidal Flat Barrens	0	0.0	1.0	ns
Salt-killed Tundra	0	0.0	0.5	ns
Deep Open Water without Islands	40	27.0	6.5	prefer
Deep Open Water with Islands or Polygonized Margins	29	19.6	5.2	prefer
Shallow Open Water without Islands	1	0.7	1.0	ns
Shallow Open Water with Islands or Polygonized Margins	3	2.0	1.6	ns
River or Stream	15	10.1	1.1	prefer
Sedge Marsh	4	2.7	1.7	ns
Deep Polygon Complex	0	0.0	0.0	ns
Grass Marsh	3	2.0	0.3	prefer
Young Basin Wetland Complex	1	0.7	0.3	ns
Old Basin Wetland Complex	4	2.7	8.3	avoid
Riverine Complex	1	0.7	0.4	ns
Dune Complex	0	0.0	1.1	ns
Nonpatterned Wet Meadow	7	4.7	3.0	ns
Patterned Wet Meadow	7	4.7	11.2	avoid
Moist Sedge-Shrub Meadow	10	6.8	22.2	avoid
Moist Tussock Tundra	5	3.4	26.3	avoid
Tall, Low, or Dwarf Shrub	3	2.0	3.2	ns
Barrens	1	0.7	1.0	ns
Total	148	100	100	

[a] 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.

6 preferred habitats: Brackish Water, Tapped Lake with Low-water Connection, both types of Deep Open Water, River or Stream, and Grass Marsh. A total of 18% of swan broods were observed using the 4 avoided habitats (Table 16).

GEESE

COLVILLE DELTA

Distribution and Abundance

During the brood-rearing aerial survey in 2008, we counted 3,637 Brant (1,839 adults and 1,798 young) in 22 groups in the Colville Delta study area (Figure 14, Table 17). All Brant groups included broods, and goslings comprised 49% of the total number of birds. Eighteen Brant brood-rearing groups were located in the CD North subarea (3,145 total birds), and 4 were located in the Northeast Delta subarea (492 total birds). The total count was the second highest recorded, and the gosling count was the highest ever recorded along the same survey route during 1988, 1990–1993, 1995, and 2005–2007 (range = 45–3,847 Brant; Bayha et al. 1992; Johnson et al. 1999a, 2006b, 2008b).

In 2008, a record 1,967 Snow Geese (834 adults and 1,133 young) in 28 brood-rearing groups were counted in the Colville Delta study area (Figure 14, Table 17). The previous high counts were 1,154 Snow Geese in 2007 and 997 in 2006 (Johnson et al. 1999a, 2006b, 2007b, 2008b). With the exception of 1 lone adult goose, all Snow Goose groups contained broods, and goslings comprised 58% of the total number of birds. Nineteen groups were located in the CD North subarea (1,241 total birds), and 9 were located in the Northeast Delta subarea (726 total birds).

During the fall-staging survey in 2008, we counted 200 Brant in 9 groups in the Colville Delta study area (Figure 15, Table 18). Seven Brant groups (140 total birds) were located in the CD North subarea, and 2 Brant groups (60 total birds) were located in the CD South subarea.

A total of 96 Snow Geese were counted in 7 groups during the fall-staging survey on the Colville Delta. All 7 groups were located in the CD North subarea.

Greater White-Fronted Geese were the most frequently encountered goose during the staging survey. A total of 773 White-Fronted Geese were recorded in 47 groups on the Colville Delta. Twenty-three groups (287 birds) were located in the CD North subarea and 24 groups (486 birds) were located in the CD South subarea. White-Fronted Geese increased in abundance inland from the coast; densities were 2.81 birds/km^2 in the CD North subarea and 9.47 birds/km^2 in the CD South subarea. Canada Geese (Iqsraġutilik) were the least abundant goose in the survey area. Four groups (55 total birds) were recorded in the CD North subarea.

Habitat Use

Brant brood groups primarily occupied coastal salt-affected habitats in the Colville Delta study area (Table 19). Seventeen of 22 Brant brood groups (77%) were found in three habitats: Salt-killed Tundra (32 %), Salt Marsh (27%) and Brackish Water (18%).

Snow Geese also favored coastal salt-affected habitats for brood-rearing and molting in the Colville Delta. Of 28 Snow Goose groups observed, 9 groups (32%) were in Salt Marsh, 5 groups (18%) were in Salt-killed Tundra, and 4 groups each were in Brackish Water (14%) and River or Stream (14%).

During the fall-staging survey, 7 of 9 (77%) Brant groups were found in 3 habitats (Table 20): Salt Marsh (33%), Tapped Lake with High-water Connection (22%) and Tapped Lake with Low-water Connection (22%). Only 4 Snow Goose staging groups were observed in the Colville Delta study area, and no habitat was occupied by more than 1 group (Table 20).

Greater White-fronted Geese primarily occupied lakes during fall staging (Table 20). Of the 35 groups observed, 10 (29%) occupied Tapped lakes with Low-water Connections, 7 (20%) occupied Tapped Lakes with High-water Connections, and 5 (14%) were found in Deep Open Water without Islands. Four groups of Canada Geese were recorded in the Colville Delta study area, and 2 of those groups were located in Patterned Wet Meadow.

NPRA

Distribution and Abundance

During the aerial brood-rearing survey in 2008, we counted 4,012 Brant (2,617 adults and 1,395 young) in 36 groups in the NPRA study area

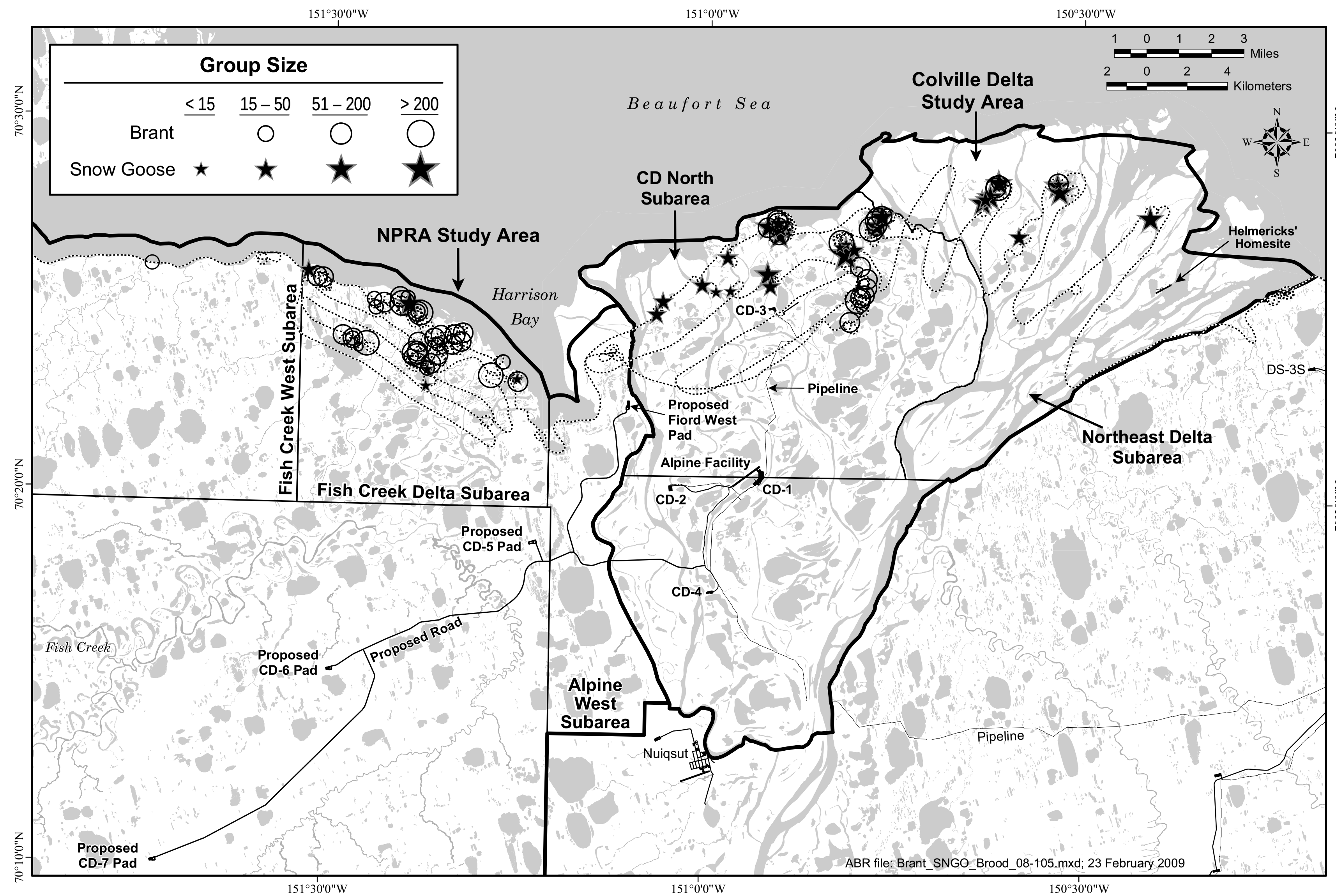

Figure 14. Brant and Snow Goose brood-rearing and molting groups, Colville Delta and NPRA study areas, Alaska, 2008.

Table 17. Numbers of Brant and Snow Goose adults and young during brood-rearing aerial surveys, Colville Delta and NPRA study areas, Alaska, 2008.

SPECIES Study Area Subarea	Total Birds	Adults	Young	% Young	No. of Groups
BRANT					
Colville Delta[a]					
CD North	3,145	1,572	1,573	50	18
Northeast Delta	492	267	225	46	4
Total (subareas combined)	3,637	1,839	1,798	49	22
NPRA[b]					
Fish Creek Delta	3,992	2,597	1,395	35	35
Fish Creek West	20	20	0	0	1
Total (subareas combined)	4,012	2,617	1,395	35	36
SNOW GEESE					
Colville Delta[a]					
CD North	1,241	547	694	56	19
Northeast Delta	726	287	439	60	9
Total (subareas combined)	1,967	834	1,133	58	28
NPRA[b]					
Fish Creek Delta	234	107	127	54	5

[a] Only the CD North and Northeast Delta subareas were surveyed

[b] Only the Fish Creek Delta, Fish Creek West, and Alpine West subareas were surveyed, but no Brant or Snow Geese were observed in the Alpine West subarea

(Figure 14, Table 17). Twenty-six (72%) of Brant groups included broods, and goslings comprised 35% of the total number of birds in all groups. Goslings comprised 42% of birds in brood-rearing groups (excluding the 10 groups of molting adults). Thirty-five Brant brood-rearing and molting groups were located in the Fish Creek Delta subarea (3,992 total birds), and 1 was located in the Fish Creek West subarea (20 total birds).

In 2008, 234 Snow Geese (107 adults and 127 young) in 5 groups were counted in the NPRA study area (Figure 14, Table 17). Three groups included broods, and goslings comprised 54% of the total number of birds in all groups. Goslings comprised 59% of birds in brood-rearing groups (excluding the 2 groups of molting adults). All 5 Snow Goose groups were located in the Fish Creek Delta subarea.

Brant were the most abundant goose in the NPRA study area during the fall-staging survey in 2008. We counted 692 Brant in 19 groups (Figure 15, Table 18). Eighteen Brant groups (622 total birds) were located in the Fish Creek Delta subarea, and 1 group (70 total birds) was located in the Alpine West subarea.

We counted 54 Snow Geese in 1 group during the fall-staging survey in the NPRA study area, and that group was located in the Fish Creek Delta subarea. We also counted 246 White-Fronted Geese in 22 groups in the NPRA study area; the highest numbers (141 total birds) and densities (3.22 birds/km^2) were recorded in the Development subarea. Eight groups of Canada Geese totaling 122 birds were recorded in the NPRA study area, chiefly in the Fish Creek Delta subarea (89 birds).

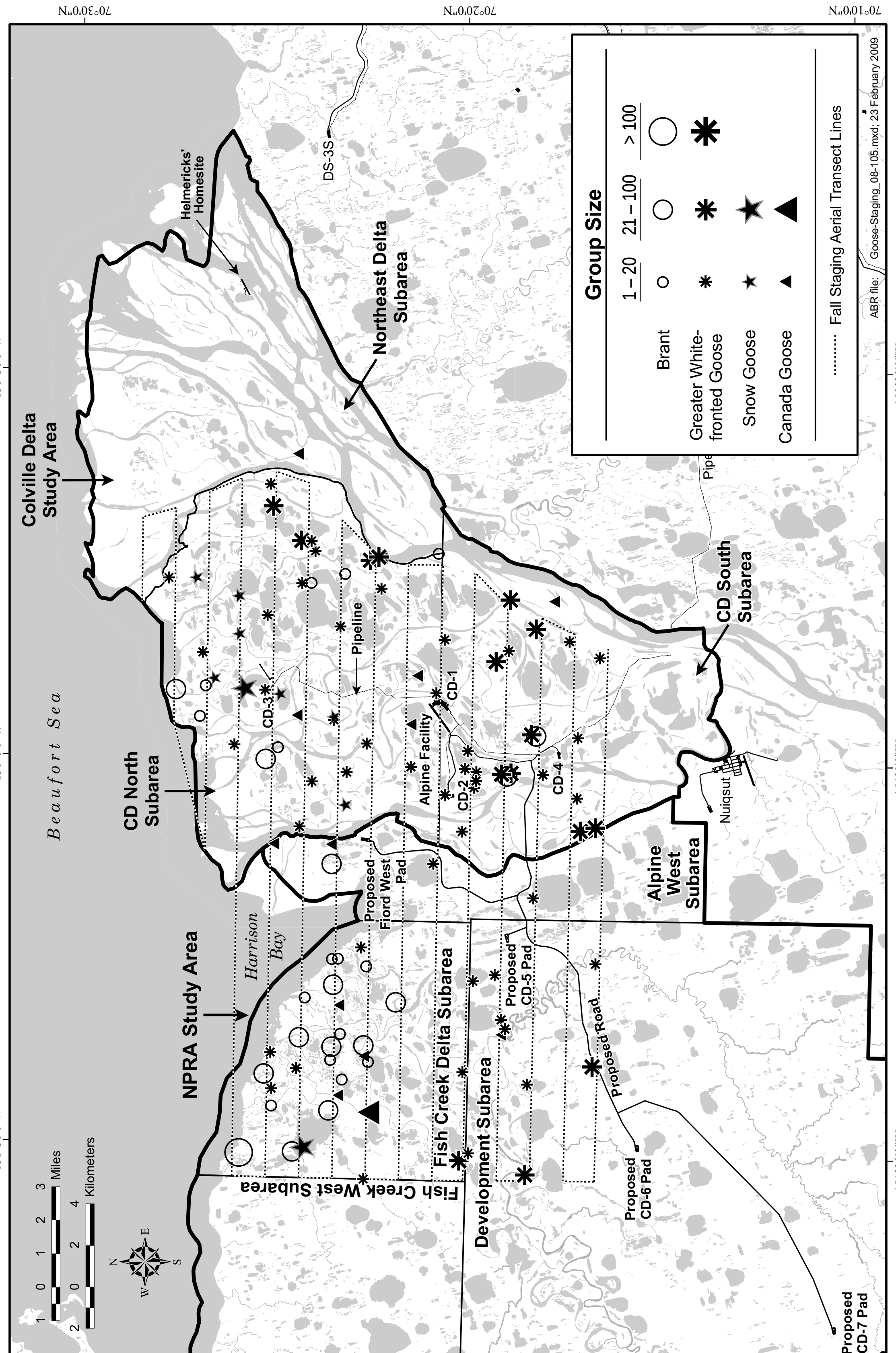

Figure 15. Fall-staging geese in the western Colville Delta and Fish Creek Delta survey areas, Alaska, 2008.

Table 18. Numbers and densities of geese during fall-staging aerial surveys in the western Colville Delta and Fish Creek Delta survey areas, Alaska, 2008.

	No. on Ground	No. in Flight	Total	No. of Groups	Mean Group Size	Density[a] (birds/km^2)
BRANT						
Colville Delta						
CD North	140	0	140	7	20.0	1.37
CD South	60	0	60	2	30.0	1.17
Total (all subareas)	200	0	200	9	22.2	1.30
NPRA						
Alpine West	70	0	70	1	70.0	2.40
Fish Creek Delta	592	30	622	18	34.6	9.42
Total (all subareas)	662	30	692	19	36.4	4.98
GREATER WHITE-FRONTED GOOSE						
Colville Delta						
CD North	242	45	287	23	12.5	2.81
CD South	449	37	486	24	20.3	9.47
Total (all subareas)	691	82	773	47	16.4	5.04
NPRA						
Alpine West	13	0	13	2	6.5	0.45
Development	107	34	141	11	12.8	3.22
Fish Creek Delta	78	14	92	9	10.2	1.39
Total (all subareas)	198	48	246	22	11.2	1.77
SNOW GOOSE						
Colville Delta						
CD North	40	56	96	7	13.7	0.94
Total (all subareas)	40	56	96	7	13.7	0.63
NPRA						
Fish Creek Delta	0	54	54	1	54.0	0.82
Total (all subareas)	0	54	54	1	54.0	0.39
CANADA GOOSE						
Colville Delta						
CD North	55	0	55	4	13.8	0.54
Total (all subareas)	55	0	55	4	13.8	0.36
NPRA						
Alpine West	22	0	22	2	11.0	0.76
Development	11	0	11	1	11.0	0.25
Fish Creek Delta	73	16	89	5	17.8	1.35
Total (all subareas)	106	16	122	8	15.3	0.88

[a] Density estimates include flying birds

Table 19. Habitat use by brood-rearing/molting Brant and Snow Geese in the Colville Delta and NPRA study areas, Alaska, 2008.

	Colville Delta				NPRA			
	Brant		Snow Geese		Brant		Snow Geese	
Habitat	Groups	Use (%)	Groups	Use (%)	Groups	Use (%)	Groups	Use (%)
Open Nearshore Water	0	0	0	0	5	14.3	1	20.0
Brackish Water	4	18.2	4	14.3	1	2.9	0	0
Tapped Lake with Low-water Connection	2	9.1	2	7.1	3	8.6	0	0
Salt Marsh	6	27.3	9	32.1	13	37.1	3	60.0
Tidal Flat Barrens	1	4.5	1	3.6	11	31.4	0	0
Salt-killed Tundra	7	31.8	5	17.9	1	2.9	1	20.0
Shallow Open Water with Islands or Polygonized Margins	1	4.5	0	0	0	0.0	0	0
River or Stream	0	0	4	14.3	1	2.9	0	0
Patterned Wet Meadow	0	0	2	7.1	0	0.0	0	0
Moist Sedge-Shrub Meadow	0	0	1	3.6	0	0.0	0	0
Barrens	1	4.5	0	0	0	0.0	0	0
Total	22	100	28	100.0	35[a]	100.0	5	100

[a] Excludes 1 group that occurred outside the area mapped for habitat

Table 20. Habitat use by fall-staging geese in the Colville Delta and NPRA study areas, Alaska, 2008.

STUDY AREA	Brant		Greater White-fronted Goose		Snow Goose		Canada Goose	
Habitat	Groups	Use (%)	Groups	Use (%)	Groups	Use (%)	Groups	Use (%)
COLVILLE DELTA								
Tapped Lake with Low-water Connection	2	22.2	10	28.6	0	0	0	0
Tapped Lake with High-water Connection	2	22.2	7	20.0	0	0	0	0
Salt Marsh	3	33.3	2	5.7	0	0	1	25.0
Salt-killed Tundra	1	11.1	0	0	1	25.0	0	0
Deep Open Water without Islands	0	0	5	14.3	0	0	0	0
Deep Open Water with Islands or Polygonized Margins	0	0	1	2.9	0	0	0	0
Shallow Open Water without Islands	0	0	1	2.9	0	0	0	0
River or Stream	1	11.1	3	8.6	1	25.0	1	25.0
Deep Polygon Complex	0	0	0	0	1	25.0	0	0
Nonpatterned Wet Meadow	0	0	1	2.9	1	25.0	0	0
Patterned Wet Meadow	0	0	2	5.7	0	0	2	50.0
Moist Low Shrub	0	0	2	5.7	0	0	0	0
Barrens	0	0	1	2.9	0	0	0	0
Total[a]	9	100	35	100	4	100	4	100
NPRA								
Open Nearshore Water	0	0	1	5.6	0	0	0	0
Brackish Water	3	16.7	0	0	0	0	0	0
Tapped Lake with Low-water Connection	0	0	2	11.1	0	0	1	14.3
Salt Marsh	8	44.4	3	16.7	0	0	1	14.3
Tidal Flat Barrens	1	5.6	0	0	0	0	1	14.3
Salt-killed Tundra	2	11.1	0	0	0	0	0	0
Deep Open Water without Islands	0	0	2	11.1	0	0	0	0
Deep Open Water with Islands or Polygonized Margins	0	0	3	16.7	0	0	0	0
River or Stream	1	5.6	2	11.1	0	0	1	14.3
Old Basin Wetland Complex	0	0	1	5.6	0	0	0	0
Patterned Wet Meadow	1	5.6	0	0	0	0	1	14.3
Moist Sedge-Shrub Meadow	1	5.6	0	0	0	0	2	28.6
Moist Tussock Tundra	0	0	1	5.6	0	0	0	0
Moist Low Shrub	0	0	2	11.1	0	0	0	0
Barrens	1	5.6	1	5.6	0	0	0	0
Total[a]	18	100	18	100	0	0	7	100

[a] Excludes birds in flight or outside the survey area

Habitat Use

As in the Colville Delta, Brant brood groups primarily used salt-affected habitats in the NPRA study area (Table 19). Twenty-nine of 35 Brant brood groups (83%) were found in 3 habitats: Salt Marsh (37%), Tidal Flat Barrens (31%), and Open Nearshore Water (14%). Similarly, 3 of 5 Snow Goose brood-rearing and molting groups were located in Salt Marsh habitat.

During the fall-staging survey in the NPRA study area, 13 of 18 (72%) Brant groups were found in 3 habitats (Table 20): Salt Marsh (44%), Brackish Water (17%) and Salt-killed Tundra (11%). Habitat could not be evaluated for Snow Geese because the only group observed in the NPRA study area was in flight.

Eighteen groups of Greater White-fronted Goose were recorded in 10 different habitats in the NPRA study area during the fall-staging survey (Table 20). The only habitats used by more than 2 groups were Salt Marsh (3 groups) and Deep Open Water with Islands or Polygonized Margins (3 groups). Staging Canada Geese were also spread among habitats. Seven Canada Goose staging groups used 6 habitats; the only habitat used by more than 1 group was Moist Sedge-Shrub Meadow (2 groups).

GLAUCOUS AND SABINE'S GULLS

COLVILLE DELTA

Distribution and Abundance

Forty-nine Glaucous Gull nests were counted in the Colville Delta study area during the aerial survey for nesting loons in 2008 (Figure 16, Table 21). This was the highest count of Glaucous Gull nests in the Colville Delta study area in 9 years of surveys. Five of the 19 nests in the CD North subarea in 2008 were located together in a colony, where 1–2 nests were observed in 2001–2003 and 4–7 nests were recorded in 2004–2007 (Johnson et al. 2005, 2006b, 2007b, 2008b). Eighteen of the 28 nests in the CD South subarea in 2008 were in a colony located ~5 km southeast of the Alpine Facility (Figure 16), where counts have ranged from 10 to 18 nests since that site was first surveyed in 1998 (Johnson et al. 2005, 2006b, 2007b, 2008b). Two of the 49 nests were found on lakes in the Northeast Delta subarea and were not included in density calculations (Table 7), in order to be consistent with data presentations from previous years. Nest density was 0.14 nests/km² in 2008 for the CD North and CD South subareas combined, but because Glaucous Gulls were counted on aerial surveys designed to survey for loons, some nests probably were missed.

Glaucous Gull adults with young were recorded incidentally in 2008 during the aerial survey for brood-rearing loons. Thirty-three adults and 62 young in a minimum of 25 broods were recorded in the Colville Delta study area, of which 12 adults and 26 young were in the CD North subarea and 21 adults and 36 young were in the CD South subarea (Figure 16). Ten young were counted at the colony site in the CD North subarea and 27 young were recorded at the colony site in the CD South subarea.

Two Sabine's Gull colonies were observed in the northwestern part of the Colville Delta study area during the aerial survey for nesting loons (Figure 16). One colony contained an estimated 5 nests and the other contained 10 nests. Sabine's Gull densities were not calculated for the Colville Delta study area because sightings were opportunistic and not comprehensive for that area.

Habitat Use

Eighteen of the 47 Glaucous Gull nests (38%) found in the CD North and CD South subareas of the Colville Delta in 2008 were from the colony in the CD South subarea, which is a large island classified as Patterned Wet Meadow (Table 22) in Deep Open Water with Islands or Polygonized Margins. Eleven nests (23%) were found in Tapped Lake with High-water Connection, including the colony of 5 nests located on 2 islands in the CD North subarea. Ten additional nests were found in the Colville Delta study area in Deep Open Water with Islands or Polygonized Margins (21%). The remaining 8 nests were found on islands or complex shorelines of 6 other habitats (Table 22). Glaucous Gull broods observed during aerial surveys were located near nests and in the same habitats as were the nests. Both Sabine's Gull colonies were located in Non-patterned Wet Meadow.

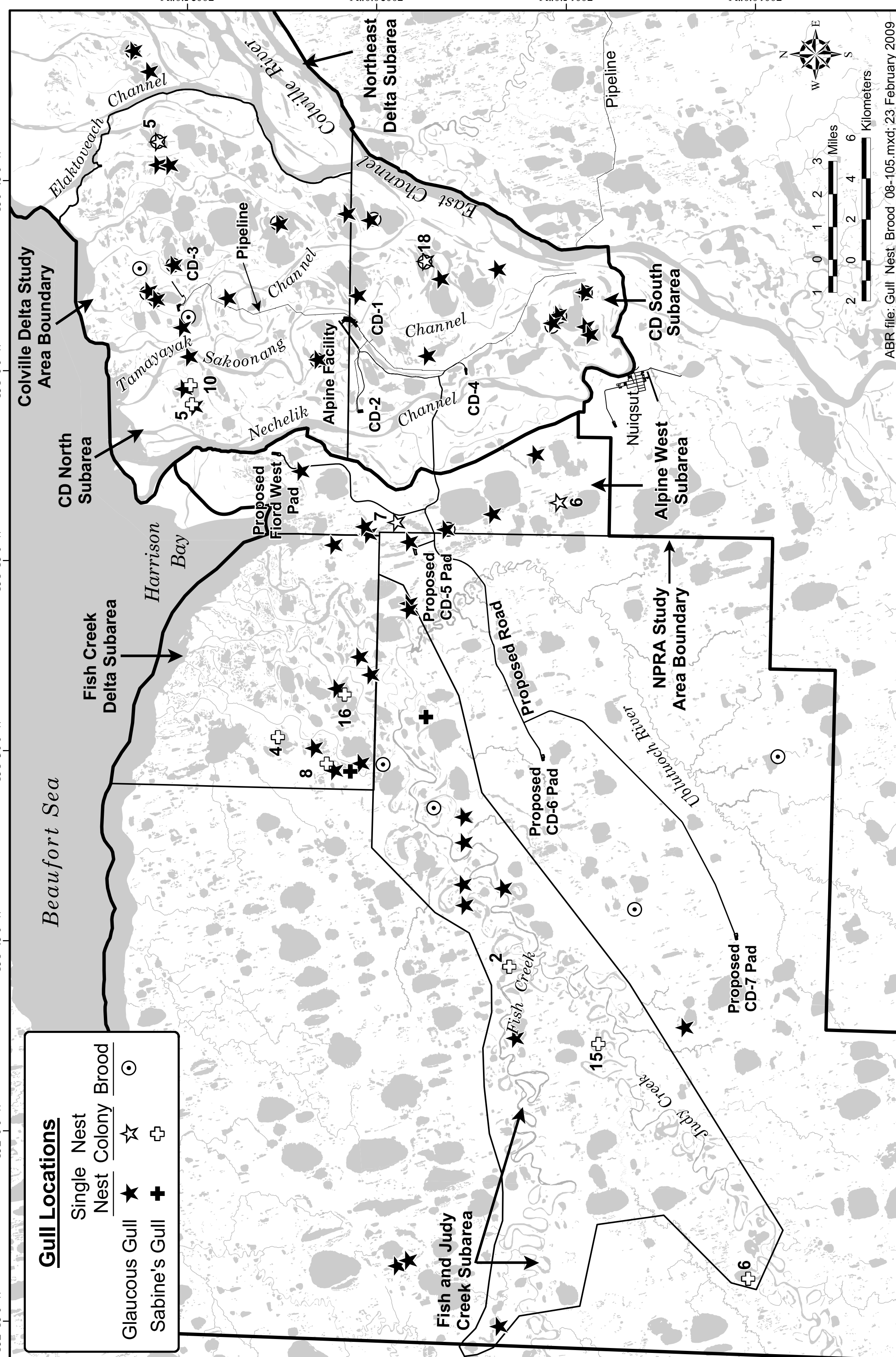

Figure 16. Glaucous and Sabine's gull nests and broods, Colville Delta and NPRA study areas, Alaska, 2008. Numbers of nests are listed for colony locations.

NPRA

Distribution and Abundance

Forty Glaucous Gull nests were counted in the NPRA study area in 2008 during aerial surveys for loons (Figure 16, Table 21). Nineteen nests were counted in the Alpine West subarea, 7 in the Fish Creek Delta subarea, 10 in the Fish and Judy Creek subarea, and 4 nests were recorded outside of those subareas during surveys for Yellow-billed Loons. Of the 19 nests found in the Alpine West subarea, 13 nests were in 2 colonies—1 colony of 7 nests was found near the proposed CD-5 Pad and another colony of 6 nests was located in the southern part of the subarea (Figure 16). These colonies were active every year that surveys were conducted in the Alpine West subarea (2002–2006) and 4–7 nests were found at each location during those surveys (Burgess et al. 2003b, Johnson et al. 2004, 2005, 2006b, 2007b). All other Glaucous Gull nests found in the NPRA study area in 2008 were individual nest locations, including 4 additional nests found outside of the 2008 study area. Nest density was 0.09 nests/km² in 2008 for all 3 subareas in the NPRA study area (Table 21), but because Glaucous Gulls were counted on aerial surveys designed to survey loons, some nests probably were missed. Five Glaucous Gull broods (6 adults and 7 young) were observed during the brood-rearing aerial survey for Yellow-billed Loons in 2008 in the NPRA study area.

During the loon nesting survey in 2008, 53 Sabine's Gull nests were found in the NPRA study area, either as single nests, pairs of nests, or colonies (Figure 16, Table 21). Forty-nine of the Sabine's Gull nests were located in 5 nesting colonies of 4–16 nests each. Sabine's Gull colonies and nests were located in the Fish Creek Delta and Fish and Judy Creek subareas. Sabine's Gull densities were not calculated for the NPRA study area because sightings were opportunistic and not comprehensive for that area.

Habitat Use

Glaucous Gulls nested in 7 different habitats in the NPRA study area (Table 22). Most nests were located on islands in Shallow Open Water with Islands or Polygonized Margins (60% of all nests) and Deep Open Water with Islands or Polygonized Margins (23%). The remaining 7 nests were found on islands or complex shorelines of 5 other habitats. Glaucous Gull broods were found in aquatic habitats near nest locations, often in the same habitat as the nest.

Sabine's Gull nests were located in 7 different habitats, with the largest colonies in Sedge Marsh (16 nests) and Grass Marsh (15 nests). The remaining nests were in both types of Shallow Open Water, Deep Open Water with Islands or Polygonized Margins, Non-patterned Wet Meadow, and Moist Tussock Tundra; all nests in terrestrial habitats were on the shorelines of lakes.

Table 21. Number and density of Glaucous and Sabine's gull nests, Colville Delta and NPRA study areas, Alaska, 2008.

STUDY AREA Subarea[b]	Sabine's Gull[a] Number of Nests[c]	Glaucous Gull Number of Nests[c]	Glaucous Gull Nest Density (nests/km²)
COLVILLE DELTA			
CD North	15	19	0.09
CD South	0	28	0.18
Northeast Delta[d]	0	2	–
Total (subareas combined)[e]	15	49	0.14
NPRA			
Alpine West	0	19	0.24
Fish Creek Delta	29	7	0.05
Fish and Judy Creek Corridor	24	10	0.04
Outside of Survey Subareas[d]	0	4	–
Total (subareas combined)[e]	53	40	0.08

[a] Nest density was not calculated for Sabine's Gull because detectability of nesting pairs on aerial surveys is low and surveys were not comprehensive

[b] CD North = 206.7 km², CD South = 155.9 km², Alpine West = 79.7 km², Fish Creek Delta = 130.5 km²; see Figure 5

[c] Data for Colville Delta and NPRA study areas were collected during aerial surveys for nesting Yellow-billed Loons

[d] Densities were not calculated for the Northeast Delta subarea and the survey area outside of the Alpine West, Fish Creek Delta, and Fish and Judy Creek Corridor subareas because the entire area was not surveyed

[e] Density includes CD North and CD South for Colville Delta (362.6 km² total), and Alpine West, Fish Creek Delta, and Fish and Judy Creek Corridor for NPRA (466.1 km² total)

Table 22. Habitat use by nesting Glaucous Gulls, Colville Delta and NPRA study areas, Alaska, 2008.

Habitat	Colville Delta Nests	Colville Delta Use (%)	NPRA Nests	NPRA Use (%)
Brackish Water	1	2.1	0	0
Tapped Lake with High-water Connection	11	23.4	1	2.9
Deep Open Water with Islands or Polygonized Margins	10	21.3	8	22.9
Shallow Open Water without Islands	0	0	1	2.9
Shallow Open Water with Islands or Polygonized Margins	1	2.1	21	60.0
Sedge Marsh	0	0	1	2.9
Deep Polygon Complex	2	4.3	0	0
Grass Marsh	2	4.3	2	5.7
Old Basin Wetland Complex	0	0	1	2.9
Nonpatterned Wet Meadow	1	2.1	0	0
Patterned Wet Meadow	18	38.3	0	0
Moist Sedge–Shrub Meadow	1	2.1	0	0
Total	47[a]	100	35[b]	100

[a] Excludes 2 nests that occurred outside the 2008 study area

[b] Excludes 1 nest that occurred outside the area mapped for habitat and 2 nests outside the 2008 study area

LITERATURE CITED

Anderson, B. A., and C. B. Johnson. 1999. Baseline avian surveys in four lease blocks within the National Petroleum Reserve–Alaska, 1999. Report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 18 pp.

Anderson, B. A., A. A. Stickney, T. Obritschkewitsch, and J. E. Shook. 2009. Avian studies in the Kuparuk Oilfield, Alaska, 2008. Data summary report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Arthur, S. M., and P. A. Del Vecchio. 2003. Effects of oilfield development on calf production and survival in the Central Arctic caribou herd. Research Progress Report, June 2001–September 2003. Alaska Department of Fish and Game, Division of Wildlife Conservation, Fairbanks. 20 pp.

Bayha, K., R. Meehan, and T. Jennings. 1992. Synthesis of Brant data for the Colville Delta. Unpubl. draft report by U.S. Fish and Wildlife Service, Anchorage.

BLM (Bureau of Land Management). 1998. Northeast National Petroleum Reserve–Alaska: Final Integrated Activity Plan / Environmental Impact Statement. Vol. 1. U.S. Department of the Interior, Bureau of Land Management, with assistance from Minerals Management Service, Anchorage, AK.

BLM. 2004. Alpine Satellite Development Plan Final Environmental Impact Statement. U.S. Department of the Interior, Bureau of Land Management, with assistance from Minerals Management Service, Anchorage, AK.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, P. E. Seiser, A. A. Stickney, and J. R. Rose. 2002a. Wildlife studies in the CD South study area, 2001. Second annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 98 pp.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, P. E. Seiser, A. A. Stickney, and J. R. Rose. 2003a. Wildlife studies in the CD South study area, 2002. Third annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 126 pp.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, A. A. Stickney, and J. R. Rose. 2000. Wildlife studies in the CD South study area, 2000. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 84 pp.

Burgess, R. M., C. B. Johnson, P. E. Seiser, A. A. Stickney, A. M. Wildman, and B. E. Lawhead. 2002b. Wildlife studies in the Northeast Planning Area of the National Petroleum Reserve–Alaska, 2001. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 71 pp.

Burgess, R. M., C. B. Johnson, A. M. Wildman, P. E. Seiser, J. R. Rose, A.K. Prichard, T. J. Mabee, A. A. Stickney, and B. E. Lawhead. 2003b. Wildlife studies in the Northeast Planning Area of the National Petroleum Reserve–Alaska, 2002. Report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 126 pp.

ConocoPhillips Alaska, Inc. 2007. GPS/GIS Data Management Protocols, North Slope, Alaska, Version 3.4.

Haefner, J. W. 1996. Modeling Biological Systems: Principles and Applications. Chapman and Hall, New York, NY. 473 pp.

Johnson, C. B. 1995. Abundance and distribution of eiders on the Colville River Delta, Alaska, 1994. Report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 12 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2000a. Wildlife studies in the CD North study area, 2000. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 96 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. Neville, J. P. Parrett, A. K. Prichard, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2003a. Alpine Avian Monitoring Program, 2001. Fourth annual and synthesis report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 194 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. P. Parrett, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2003b. Wildlife studies in the CD North study area, 2002. Third annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 104 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2002. Wildlife studies in the CD North study area, 2001. Second annual report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 114 pp.

Johnson, C. B., R. M. Burgess, A. M. Wildman, A. A. Stickney, P.E. Seiser, B. E. Lawhead, T. J Mabee, A. K. Prichard, and J. R. Rose. 2005. Wildlife studies for the Alpine Satellite Development Project, 2004. Second annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 129 pp.

Johnson, C. B., R. M. Burgess, A. M. Wildman, A. A. Stickney, P. E. Seiser, B. E. Lawhead, T. J. Mabee, J. R. Rose, and J. E. Shook. 2004. Wildlife studies for the Alpine Satellite Development Project, 2003. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 155 pp.

Johnson, C. B., M. T. Jorgenson, R. M. Burgess, B. E. Lawhead, J. R. Rose, and A. A. Stickney. 1996. Wildlife studies on the Colville River Delta, Alaska, 1995. Fourth annual report for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 154 pp.

Johnson, C. B., B. E. Lawhead, D. C. Payer, J. L. Petersen, J. R. Rose, A. A. Stickney, and A. M Wildman. 2001. Alpine Avian Monitoring Program, 2000. Third annual report for PHILLIPS Alaska, Inc. and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 92 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, J. E. Roth, S. F. Schlentner, A. A. Stickney, and A. M. Wildman. 2000b. Alpine Avian Monitoring Program, 1999. Second annual report for PHILLIPS Alaska, Inc. and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 86 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1998. Wildlife studies on the Colville River Delta, Alaska, 1997. Sixth annual report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 144 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1999a. Wildlife studies on the Colville River Delta, 1998. Seventh annual report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 102 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1997. Wildlife studies on the Colville River Delta, Alaska, 1996. Fifth annual report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 139 pp.

Johnson, C. B., W. Lentz, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1999b. Alpine Avian Monitoring Program, 1998. First annual report for ARCO Alaska, Inc. and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 46 pp.

Johnson, C. B., J. P. Parrett, and P. E. Seiser. 2006a. Spectacled Eider monitoring at the CD-3 development, 2005. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., J. P. Parrett, and P. E. Seiser. 2007a. Spectacled Eider monitoring at the CD-3 development, 2006. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., J. P. Parrett, and P. E. Seiser. 2008a. Spectacled Eider monitoring at the CD-3 development, 2007. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., and A. A. Stickney. 2001. Avian surveys of exploration sites within the National Petroleum Reserve–Alaska, 2001. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 24 pp.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, and J. E. Shook. 2006b. Avian studies for the Alpine Satellite Development Project, 2005. Third annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 30 pp.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, and T. Obritschkewitsch. 2007b. Avian studies for the Alpine Satellite Development Project, 2006. Fourth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 31 pp.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, T. Obritschkewitsch, and J. E. Shook. 2008b. Avian studies for the Alpine Satellite Development Project, 2007. Fifth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Jorgenson, M. T., J. E. Roth, M. Emers, S. Schlentner, D. K. Swanson, E.R. Pullman, J. Mitchell, and A. A. Stickney. 2003. An ecological land survey for the Northeast Planning Area of the National Petroleum Reserve–Alaska, 2002. Report prepared for ConocoPhillips Alaska, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 84 pp.

Jorgenson, M. T., J. E. Roth, M. Emers, W. Davis, E.R. Pullman, and G. J. Frost. 2004. An ecological land survey for the Northeast Planning Area of the National Petroleum Reserve–Alaska, 2003. Addendum to 2002 report prepared for ConocoPhillips Alaska, Anchorage, AK and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 40 pp.

Jorgenson, M. T., J. E. Roth, E. R. Pullman, R. M. Burgess, M. Raynolds, A. A. Stickney, M. D. Smith, and T. Zimmer. 1997. An ecological land survey for the Colville River Delta, Alaska, 1996. Report prepared for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 160 pp.

Larned, W., R. Stehn, and R. Platte. 2009. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2008. Unpublished report, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK. 42 pp.

Lawhead, B. E., and A. K. Prichard. 2009. Mammal surveys in the Greater Kuparuk Area, Northern Alaska, 2008. Draft report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks.

Manly, B. F. J. 1997. Randomization, bootstrap, and Monte Carlo methods in biology. 2nd edition. Chapman and Hall, London. 399 pp.

McIntyre, J. W., and J. F. Barr. 1997. Common Loon (*Gavia immer*). *In* The Birds of North America, No. 313 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.; The American Orthithologists' Union. 32 pp

Murphy, S. M., and B. A. Anderson. 1993. Lisburne Terrestrial Monitoring Program: The effects of the Lisburne Development Project on geese and swans, 1985–1989. Synthesis report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 202 pp.

Murphy, S. M., and A. A. Stickney. 2000. Baseline avian surveys within the National Petroleum Reserve–Alaska, 2000. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 28 pp.

North, M. R. 1986. Breeding biology of Yellow-billed Loons on the Colville River Delta, arctic Alaska. M. S. thesis, North Dakota State University, Fargo. 109 pp.

North, M. R. 1994. Yellow-billed Loon (*Gavia adamsii*). *In* The Birds of North America, No. 121 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.; The American Orthithologists' Union. 24 pp.

North, M. R., and M. R. Ryan. 1989. Characteristics of lakes and nest sites used by Yellow-billed Loons in arctic Alaska. Journal of Field Ornithology 60: 296–304.

Parrett, J., A. Wildman, and C. Johnson. 2008. Using evidence found at the nest to judge nest fate for Yellow-billed Loons (*Gavia adamsii*). Page 35 *in* Proceedings of the 2008 Alaska Bird Conference, March 3–7, 2008, Fairbanks, Alaska. [abstract only]

Pennycuick, C. J., and D. Western. 1972. An investigation of some sources of bias in aerial transect sampling of large mammal populations. East African Wildlife Journal 10: 175–191.

Prichard, A. K., S. M. Murphy, and M. D. Smith. 2001. Analysis and mapping of satellite telemetry data for the Teshekpuk Caribou Herd, 1990–1999, with a note on five Western Arctic caribou. Report prepared for North Slope Borough Department of Wildlife Management, Barrow; Alaska Department of Fish and Game, Barrow; and U.S. Department of the Interior, Bureau of Land Management, Fairbanks, by ABR, Inc., Fairbanks, AK. 102 pp.

Rothe, T. C., C. J. Markon, L. L. Hawkins, and P. S. Koehl. 1983. Waterbird populations and habitat analysis of the Colville River Delta, Alaska: 1981 summary report. U.S. Fish and Wildlife Service, Anchorage, AK. 131 pp.

Sjölander, S., and G. Ågren. 1976. Reproductive behavior of the Yellow-billed Loon, *Gavia adamsii*. Condor 78: 454–463.

Smith, L. N., L. C. Byrne, C. B. Johnson, and A. A. Stickney. 1994. Wildlife studies on the Colville River Delta, Alaska, 1993. Report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 95 pp.

Smith, L. N., L. C. Byrne, and R. J. Ritchie. 1993. Wildlife studies on the Colville River Delta, Alaska, 1992. Report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 69 pp.

Stickney, A. A., R. J. Ritchie, B. A. Anderson, and D. A. Flint. 1993. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Sagavanirktok River, 1993. Report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 83 pp.

USFWS (U.S. Fish and Wildlife Service). 1987a. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. Unpublished report, Migratory Bird and Habitat Research Laboratory, Patuxent Wildlife Research Center, Laurel, MD. 96 pp.

USFWS. 1987b. Trumpeter and Tundra swan survey protocol update. Unpublished memorandum, Office of Migratory Bird Management, Juneau, AK. 8 pp.

USFWS. 1991. Trumpeter and Tundra swan survey protocol. Unpublished memorandum, Office of Migratory Bird Management, Juneau, AK. 4 pp.

Walker, H. J. 1978. Lake tapping in the Colville River Delta, Alaska. Pages 233–238 *in* Proceedings of the 3rd International Conference on Permafrost, Vol. 1. Natural Research Council of Canada, Edmonton, AB.

Walker, H. J. 1983. Guidebook to permafrost and related features of the Colville River Delta, Alaska. Guidebook 2. Alaska Divisionof Geological and Geophysical Surveys, Anchorage, AK. 34 pp.

Appendix A. Common, Iñupiaq, and scientific names of birds and mammals referenced in this report.

COMMON NAME	IÑUPIAQ NAME	SCIENTIFIC NAME
BIRDS		
Greater White-fronted Goose	Niġliviq	*Anser albifrons*
Snow Goose	Kaŋuq	*Chen caerulescens*
Brant	Niġlinġaq	*Branta bernicla*
Canada Goose	Iqsraġutilik	*Branta canadensis*
Tundra Swan	Qugruk	*Cygnus columbianus*
Steller's Eider	Igniqauqtuq	*Polysticta stelleri*
Spectacled Eider	Qavaasuk	*Somateria fischeri*
King Eider	Qiŋalik	*Somateria spectabilis*
Common Eider	Amauligruaq	*Somateria mollissima*
Red-throated Loon	Qaqsrauq	*Gavia stellata*
Pacific Loon	Malġi	*Gavia pacifica*
Yellow-billed Loon	Tuullik	*Gavia adamsii*
Glaucous Gull	Nauyavasrugruk	*Larus hyperboreus*
Sabine's Gull	Iqirgagiak	*Xema sabini*
MAMMALS		
Brown (Grizzly) Bear	Akłaq	*Ursus arctos*
Polar Bear	Nanuq	*Ursus maritimus*
Caribou	Tuttu	*Rangifer tarandus*

Appendix B. Classification and descriptions of wildlife habitat types found in the Colville Delta or NPRA study areas, Alaska, 2008.

Habitat Class	Description
Open Nearshore Water (Estuarine Subtidal)	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. An important habitat for some species of waterfowl for molting during spring and fall staging.
Brackish Water (Tidal Ponds)	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. Sediments may contain peat, reflecting a 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 by erosion of banks by adjacent river channels and are connected to rivers by distinct, permanently flooded channels. The water typically is brackish and the lakes are subject to flooding every year. Because water levels have dropped, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shorelines. Deeper lakes in this habitat do not freeze to the bottom during winter. Sediments are fine-grained silt and clay with some sand. These lakes form important over-wintering habitat for fish.
Tapped Lake with High-water Connection	Similar to Tapped Lake with Low-water Connection 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 channel due to deposition during seasonal flooding. These lakes form 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 tidal flats associated with river deltas. The surface 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 and Halophytic Sedge or Grass Wet Meadows. Moist Halophytic Dwarf Shrub and small barren areas also may occur in patches too small to map separately. Dominant plant species usually include *Carex subspathacea, C. ursina, C. ramenskii, Puccinellia phryganodes, Dupontia fisheri, P. andersonii, Salix ovalifolia, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea*. Salt Marsh is important habitat for brood-rearing and molting waterfowl.
Moist Halophytic Dwarf Shrub	Tidal flats and regularly flooded riverbars of tidal rivers with vegetation dominated by dwarf willow and graminoids. Tide flat communities have brackish, loamy (with variable organic horizons), saturated soils, with ground water depths ~ 25 cm and active layer depths ~50 cm. Vegetation is dominated by *Salix ovalifolia, Carex subspathacea*, and *Calamagrostis deschampsioides*. On sandy sites *Elymus arenarius mollis* is a co-dominant. On active tidal river depostis, soils are loamy, less brackish, and vegetation is dominated by *Salix ovalifolia* with *Carex aquatilis* and *Dupontia fisheri*.

Appendix B. Continued.

Habitat Class	Description
Dry Halophytic Meadow	Somewhat poorly vegetated, well-drained meadows on regularly inundated tidal flats and riverbars of tidal rivers, characterized by the presence of *Elymus arenarius mollis*. Soils are brackish sands with little organic material and deep active layers. Commonly associated species include *Salix ovalifolia, Sedum rosea, Stellaria humifusa*, (on tide flats) and *Deschampsia caespitosa* (on tidal river deposits).
Tidal Flat Barrens	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal Flat Barrens occur on the seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal Flat Barrens frequently are associated with lagoons and estuaries and may vary widely in actual salinity levels. Tidal Flat Barrens 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 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 originally supported Patterned Wet Meadows and Basin Wetland Complexes or, less commonly, along drier coastal bluffs that originally supported Moist Sedge–Shrub Meadow and Dry Dwarf 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 colonizers.
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 and usually are not connected to rivers. Sediments are fine-grained silt in centers with sandy margins. Deep Open Waters without Islands are differentiated from those with islands because of the lack of nest sites for waterbirds that prefer islands.
Deep Open Water with Islands or Polygonized Margins	Similar to above except that they 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's 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. Sediments are loamy to sandy.
Shallow Open Water with Islands or Polygonized Margins	Shallow lakes and ponds with islands or complex low-center polygon shorelines, otherwise similar to Shallow Open Water without Islands. 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	All permanently flooded channels large enough to be mapped as separate units. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The distributaries of Fish Creek are slightly saline, whereas other streams are non-saline.

Appendix B. Continued.

Habitat Class	Description
Sedge Marsh	Permanently flooded waterbodies dominated by *Carex aquatilis*. Typically, emergent sedges occur in water ≤0.5 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 loam or sand.
Deep Polygon Complex	A habitat associated with inactive and abandoned floodplains and deltas in which thermokarst of ice-rich soil has produced deep (>0.5 m), permanently flooded polygon centers. Emergent vegetation, mostly *Carex 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 *Carex aquatilis, Eriophorum angustifolium, C. bigelowii, Dryas integrifolia, Salix reticulata,* and *S. ovalifolia*.
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 fulva* stem densities and annual productivity can vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in recently drained lake basins and is more productive than Sedge Marsh. This habitat tends to have abundant invertebrates and is important to many waterbirds.
Young Basin Wetland Complex (Ice-poor)	Complex habitat found in recently drained lake basins and characterized by a mosaic of open water, Sedge and Grass Marshes, Nonpatterned Wet Meadows, and Moist Sedge–Shrub Meadows in patches too small (<0.5 ha) to map individually. During spring breakup, basins may be entirely inundated, though water levels recede by early summer. Basins often have distinct banks marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of thaw basins and the presence of several thaw lake stages. Soils generally are loamy to sandy, moderately to richly organic, and ice-poor. Because there is little segregated ground ice the surface form is nonpatterned ground or disjunct polygons and the margins of waterbodies are indistinct and often interconnected. Ecological communities within young basins appear to be much more productive than are those in older basins: this was the primary rationale for differentiating these two types.
Old Basin Wetland Complex (Ice-rich)	Similar to above but characterized by well-developed low- and high-centered polygons resulting from ice-wedge development and aggradation of segregated ice. Complexes in basin margins generally include Sedge Marsh, Patterned Wet Meadow, Moist Sedge–Shrub Meadows, and small ponds (<0.25 ha). The waterbodies in old basins tend to have smoother, more rectangular shorelines and are not as interconnected as those in more recently drained basins. The vegetation types in basin centers generally include Moist Sedge–Shrub Meadow and Moist Tussock Tundra on high-centered polygons, and Patterned Wet Meadows. Grass Marsh generally is absent. Soils have a moderately thick (0.2–0.5 m) organic layer overlying loam or sand.

Appendix B. Continued.

Habitat Class	Description
Riverine Complex	Permanently flooded streams and floodplains characterized by a complex mosaic of water, Barrens, Dry Dwarf Shrub, Moist Tall Shrub and Moist Low Shrub, Sedge and Grass Marsh, Nonpatterned and Patterned Wet Meadow, and Moist Sedge–Shrub Meadow in patches too small (<0.5 ha) to map individually. Surface form varies from nonpatterned point bars and meadows to mixed high- and low-centered polygons and small, stabilized dunes. Small ponds tend to have smooth, rectangular shorelines resulting from the coalescing of low centered polygons. During spring flooding these areas may be entirely inundated, following breakup water levels gradually recede.
Dune Complex	Complex formed from the action of irregular flooding on inactive sand dunes, most commonly on river point bars. A series of narrow swale and ridge features develop in parallel with river flow that are too small to map separately. Swales are moist or saturated while ridges are moist to dry. Habitat classes in swales typically are Moist Low Shrub, Nonpatterned Wet Meadow, or Sedge Marsh, while ridges commonly are Dry Dwarf Shrub or Moist Low Shrub.
Nonpatterned Wet Meadow	Sedge-dominated meadows that occur within recently 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 strang cover <5% of the ground surface. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but water remains close to 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 occurs in polygonized habitats. Usually dominated by *Carex aquatilis* and *Eriophorum angustifolium*, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be present. Low and dwarf willows (*Salix lanata richardsonii, S. reticulata, S. planifolia pulchra*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying loam or sand.
Patterned Wet Meadow	Lowland areas with low-centered polygons or strang within drained lake basins, level floodplains, and flats and water tracks on terraces. Polygon centers are flooded in spring and water remains close to the surface throughout the growing season. Polygon rims or strang 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 sedges, usually *Carex aquatilis* and *Eriophorum angustifolium*, although other sedges may be present including *C. rotundata, C. saxatilis, C. membranacea, C. chordorrhiza,* and *E. russeolum*. On polygon rims, willows (e.g., *Salix lanata richardsonii, S. reticulata, S. planifolia pulchra*) and the dwarf shrubs *Dryas integrifolia* and *Cassiope tetragona* may be abundant along with other species typical of moist tundra.
Moist Sedge–Shrub Meadow	High-centered, low-relief polygons and mixed high- and low-centered polygons on gentle slopes of lowland, riverine, drained basin, and solifluction deposits. Soils are saturated at intermediate depths (>0.15 m) but generally are free of surface water during summer. Vegetation is dominated by *Dryas integrifolia*, and *Carex bigelowii*. Other common species include *C. aquatilis*, *Eriophorum angustifolium*, *Salix reticulata, S. lanata richardsonii,* and the moss *Tomentypnum nitens*. The active layer is relatively shallow and the organic horizon is moderate (0.1–0.2 m).

Appendix B. Continued.

Habitat Class	Description
Moist Tussock Tundra	Gentle slopes and ridges of coastal deposits and terraces, pingos, and the uplifted centers of older drained lake basins. Vegetation is dominated by tussock-forming plants, most commonly *Eriophorum vaginatum***.** High-centered polygons of low or high relief are associated with this habitat. Soils are loamy to sandy, somewhat well-drained, acidic to circumneutral, with moderately thick (0.1–0.3 m) organic horizons and shallow (<0.4 m) active layer depths. On acidic sites, associated species include *Ledum decumbens, Betula nana, Salix planifolia pulchra, Cassiope tetragona* and *Vaccinium vitis-idaea*. On circumneutral sites common species include *Dryas integrifolia, S. reticulata, Carex bigelowii,* and lichens. Mosses are common at most sites.
Moist Tall Shrub	Most commonly found on actively flooded banks and bars of meander and tidal rivers dominated by tall (> 1.5 m) shrubs. Sites are nonpatterned and subject to variable flooding frequency, soils are well-drained, alkaline to circumneutral, and lack organic material. Vegetation is defined by an open canopy of *Salix alaxensis*. Understory species include *Equisetum arvense, Gentiana propinqua, Chrysanthemum bipinnatum, Festuca rubra* and *Aster sibiricus*. Moist Tall Shrub occasionally occurs on protected lowland sites where the dominant species may be *Salix* spp.or *Alnus crispa*.
Moist Low Shrub	Any community on moist soils dominated by willows < 1.5m tall. Upland sites are well-drained sands and loams characterized by *Salix glauca* (or infrequently, *Betula nana*), *Dryas integrifolia*, and *Arctostaphylos rubra*. Recently drained basins are somewhat poorly drained loams with moderate organic horizons dominated by either *S. lanata richardsonii* or *S. planifolia pulchra* with *Eriophorum angustifolium* and *Carex aquatilis*. Riverbank deposits also are dominated by either *S. lanata richardsonii* or *S. planifolia pulchra*, but with *Equisetum arvense*, *Arctagrostis latifolia*, or *Petasites frigidus*. Somewhat poorly-drained lowland flats and lower slopes have the greatest organic horizon development and are dominated by *S. planifolia pulchra*. Associated species are similar to those in drained basin communities. Thaw depths are deepest in riverine and upland communities and shallowest in lowland areas.
Moist Dwarf Shrub	Well-drained upland slopes and banks, and the margins of drained lake basins dominated by *Cassiope tetragona*. Soils are well-drained, loamy to sandy and circumneutral to acidic. Vegetation is species rich, associated species include *Dryas integrifolia, Salix phlebophylla, Vaccinium vitis-idaea, Carex bigelowii, Arctagrostis latifolia, Hierochloe alpina, Pyrola grandiflora,* and *Saussurea angustifolia*. Lichens and mosses also are common.
Dry Tall Shrub	Crests of active sand dunes with vegetation dominated by the tall willow *Salix alaxensis*. Soils are sandy, excessively drained, alkaline to circumneutral, with deep active layers (>1 m) and no surface organic horizons. The shrub canopy usually is open with dominant shrubs >1m tall. Other common species include *Chrysanthemum bipinnatum, Festuca rubra*, and *Equisetum arvense*.

Appendix B. Continued.

Habitat Class	Description
Dry Dwarf Shrub	Well-drained riverbank deposits and windswept, upper slopes and ridges dominated by the dwarf shrub *Dryas integrifolia*. Soils are sandy to loamy, alkaline to circumneutral, with deep active layers. Upland sites are lacking in organics, and in riverine sites organic accumulation is shallow. Riverbank communities have *Salix reticulata, Carex bigelowii, Arctagrostis latifolia, Equisetum variegatum, Oxytropis deflexa, Arctostaphylos rubra,* and lichens as common associates, while upland sites have *S. reticulata, S. glauca, S. arctica, C. bigelowii, Arctostaphylos alpina, Arctagrostis latifolia*, and lichens.
Barrens (Riverine, Eolian, or Lacustrine)	Includes barren and partially vegetated (<30% plant cover) areas related to riverine, eolian, or thaw basin processes. Riverine Barrens on river flats and bars are underlain by moist sands and are flooded seasonally. Early colonizers are *Deschampsia caespitosa, Poa hartzii, Festuca rubra, Salix alaxensis*, and *Equisetum arvense.* Eolian Barrens are active sand dunes that are too unstable to support more than a few pioneering plants (<5% cover). Typical species include *Salix alaxensis, Festuca rubra,* and *Chrysanthemum bipinnatum*. Lacustrine Barrens occur within recently drained lakes and ponds. These areas may be flooded seasonally or can be well drained. Typical colonizers are forbs, graminoids, and mosses including *Carex aquatilis, Dupontia fisheri, Scorpidium scorpioides*, and *Calliergon* sp. on wet sites and *Poa* spp., *Festuca rubra, Deschampsia caespitosa, Stellaria humifusa, Senecio congestus,* and *Salix ovalifolia* on drier sites. Barrens may receive intense use seasonally by caribou as mosquito-relief habitat.
Human Modified (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, the Alpine facilities, and at the Helmericks' residence near the mouth of the Colville River.