SEVENTH ANNUAL REPORT

AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2009

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AND

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FAIRBANKS, ALASKA

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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 2009 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 5 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 2009, the ASDP comprised 8 satellite drill sites (4 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 (CD-1 and CD-2) 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) abuts the western edge of the Colville Delta and encompasses 5 proposed development sites that are part of the ASDP: drill sites CD-5, Fiord West, GMT-1, and GMT-2, and the Clover A gravel mine site.

Each year, 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 October 2009, 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 July 2009, elders from Nuiqsut met with field biologists to explain their families' history of occupation on the Colville Delta and surroundings. Locations of grave sites were identified, and field activities were modified to avoid those areas. 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 conducted the previous week (for example, type of aircraft used, altitude of aircraft, and species enumerated) and the schedule of surveys for the upcoming week. The open house meetings and weekly updates kept 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 2009 was an average year for overall numbers of large waterbirds in the Colville Delta and NPRA study areas, but productivity was generally low. Spring conditions started warm but then cooled during the nesting and early brood-rearing periods. The mean monthly temperature for May on the Colville Delta was 1.7° C warmer than the 13-year mean temperature, but June was 0.7° C cooler than the long-term mean. Breakup of the Colville River occurred on 23 May, snow disappeared from the tundra during the last week of May, and Greater White-fronted Geese began hatching as early as 26 June, all early dates for these seasonal events.

The number of pre-nesting Spectacled Eiders on the Colville Delta in 2009 was near the 16-year average. As in previous years, Spectacled Eiders were found primarily in the CD North subarea. Spectacled Eiders in the NPRA occurred at about half the density of the Colville Delta, with most occurring in the Fish Creek West subarea.

During pre-nesting, King Eiders were nearly as numerous as Spectacled Eiders on the Colville Delta in 2009, and most of the King Eiders were in the CD North subarea. The density of King Eiders on the Colville Delta study area in 2009 was just below the long-term average. King Eiders were much more abundant in NPRA than on the Colville

Delta; their density in NPRA in 2009 was about 50% higher than the long-term average.

We found the third highest number of Yellow-billed Loon nests (30) in the Colville Delta study area since aerial surveys began in 1993, but less than half of those nests (13) hatched young. The count of 13 broods in 2009 was equal to the 15-year average, but low compared to the number recorded in 2005–2008 (range 16–27 broods). In the NPRA study area, we counted 29 Yellow-billed Loon nests and 15 broods. The same number of nests and 4 more broods were recorded in the same survey area for loons in 2008. Apparent nesting success for Yellow-billed loons on the Colville Delta in 2009 was the lowest since monitoring surveys began in 2005. Overall, 13 of 30 nests of Yellow-billed Loons in the Colville Delta study area in 2009 hatched young for an apparent nesting success of 43%. In the NPRA study area, 15 of 29 nests hatched young for apparent nesting success of 52%. In the Colville Delta study area, most nests hatched between the surveys on 7 and 14 July, whereas in the NPRA study area, most nests hatched during the previous week. Two of the 13 broods in the Colville Delta study area and 3 of the 15 broods in the NPRA study area were lost between hatch and the next weekly survey. The presence of numerous (≥20) eggshell fragments indicated hatch occurred at those 5 nests; camera images at the 2 nests in the Colville Delta study area also verified the presence of chicks. Those were the only broods that failed to survive to the brood-rearing aerial survey and the last monitoring survey on 11 September.

During the first monitoring survey following hatch, only 1 of 13 Yellow-billed Loon pairs that hatched young had 2 chicks in the Colville Delta study area, whereas in the NPRA study area 9 of 15 pairs had a brood of 2. The remaining pairs either hatched only 1 egg or lost 1 of their chicks between hatching and the next weekly survey. On the last brood monitoring survey on 11 September, 11 pairs in the Colville Delta study area had 1 chick. In the NPRA study area, 3 pairs still retained 2 chicks and 9 pairs had 1 chick on that last survey. Loon chicks in both study areas were approximately 8–11 weeks old during the last monitoring survey and none were observed flying.

Sixteen Yellow-billed Loon nests on the Colville Delta were monitored with time-lapse cameras. Fourteen loons left nests during camera installation. During that time, most were observed swimming in their nest lake; however, 3 loons, all of which nested on small lakes, flushed to larger, adjacent brood-rearing lakes. All loons returned to their nests after cameras were installed (mean = 67 min off nest). Apparent nesting success for camera-monitored nests was 56%, 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 98.1% (n = 9) and 97.6% (n = 7) of monitored time on nests, respectively. Cameras documented the day of hatch or failure at all monitored nests. Of the 7 nests that failed to hatch, 2 failures were attributed to predation by red foxes, 1 to a brown bear, 3 to Glaucous Gulls, and 1 to a Parasitic Jaeger. The presence of cameras may have led to predation at 2 of the avian-depredated nests. Cameras without zoom lenses were used at both nests and their proximity (~20 m) may have decreased the loons' nest attendance, leaving the nest exposed to predation. The cameras also documented partial predation at 2 nests and verified that chicks were present at 2 nests where the presence of egg fragments indicated hatch, but where none were seen during weekly monitoring surveys.

Forty-eight nests and 12 broods of Pacific Loons were counted opportunistically during Yellow-billed Loon surveys in the Colville Delta study area in 2009. Two broods of Red-throated Loons but no nests were seen during the same aerial surveys. In the NPRA study area, we counted 106 nests and 15 broods of Pacific Loons and 1 nest and 1 brood of Red-throated Loons.

Forty Tundra Swan nests were found in the Colville Delta study area in 2009, which is near the average from 16 years of aerial surveys. The count of 17 swan broods in the Colville Delta study area was well below the long-term average of 25 broods. Apparent nesting success was poor, at 43%. The mean brood size of 2.8 young in 2009 was above average, but the 47 swan young counted on the delta was below the long-term average of 64.

In NPRA during 2009, we counted 73 nests and 52 broods of Tundra Swans. The density of swan nests and broods in NPRA was about 75% of that on the Colville Delta. Apparent nesting success was 71% in NPRA. The average brood size was 2.3 young, lower than that on the Colville Delta.

Brant and Snow Goose productivity appeared to be low in the Colville Delta and NPRA study areas in 2009. The total count for Brant on the Colville Delta during brood-rearing (679) was below average, and the gosling count (178) was the third lowest ever recorded along the survey route. Without exception, numbers of adult and young Brant and Snow Geese were well below 2008 levels in both the Colville Delta and NPRA study areas. In NPRA, we counted 2,628 total Brant, including 2,161 adults and 467 goslings. We counted 678 Snow Geese (463 adults and 215 goslings) in the Colville Delta, and 102 Snow Geese (60 adults and 42 goslings) in the NPRA study area.

During the fall-staging survey in 2009, we counted 259 Brant in the Colville Delta study area (all in the CD North subarea) and 4,245 Brant in the NPRA study area (all in the Fish Creek Delta subarea). A total of 28 Snow Geese were counted on the Colville Delta, all of which were located in the CD North subarea. No Snow Geese were seen in the NPRA study area during the fall-staging survey.

Although Brant were the most numerous species of goose observed, Greater White-Fronted Geese were the most frequently encountered goose during the fall-staging survey. A total of 363 White-Fronted Geese were recorded in 20 groups in the Colville Delta. We also counted 183 White-Fronted Geese in 14 groups in the NPRA study area. We counted 199 Canada Geese in the Colville Delta study area, and 220 in the NPRA study area. Snow Geese were the least abundant goose in the survey areas; 28 Snow Geese were counted in the Colville Delta, and none were counted in NPRA.

Fifty Glaucous Gull nests and at least 12 broods were counted incidentally during loon aerial surveys in the Colville Delta study area in 2009. This was the highest count of Glaucous Gull nests in the Colville Delta study area in 10 years of surveys, with the majority of nests occurring in the CD South subarea. In the NPRA, we found 17 Glaucous Gull nests and 4 broods in 2009. The largest number of nests was in the Alpine West subarea. Sabine's Gulls were seen flying and feeding in large flocks during the loon nesting survey in the Colville Delta and NPRA study areas but only one nesting location was found in each study area. One nest was found in the northwestern part of the Colville Delta study area and one colony of Sabine's Gulls containing 8 nests was observed in the Alpine West subarea of the NPRA study area.

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ACKNOWLEDGMENTS

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INTRODUCTION

During 2009, 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 2009 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, 2009; 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. 2009, Lawhead et al. 2010).

The primary goal of wildlife investigations in the region since 1992 has been to describe the seasonal distribution and abundance of selected species before, during, and after construction of oil development projects. We report here the results of avian surveys in 2009 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), GMT-1 (formerly CD-6 or Lookout), and GMT-2 (formerly CD-7 or 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 2009 were designed to collect 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 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 conducted in select areas on the Colville River delta and NPRA in 2009 as part of other studies (Seiser and Johnson 2010a, b). 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 2009 (Stickney et al. 2010). CPAI supported other studies of wildlife on the Arctic Coastal Plain in 2009. Studies of caribou (Tuttu) and other large mammals in the ASDP area are reported in Lawhead et al. (2010). 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 13 October 2009, biologists attended a science fair at the local school during the day, followed by an open community meeting in the evening where they presented findings of recent research. The open house was attended by approximately 35 people from the village of Nuiqsut. In addition, CPAI flew Joeb Woods, Sr., and Lydia Sovalik, 2 elders from Nuiqsut, and James Taallak as facilitator, to meet with biologists in the study site near Fiord West on 3 July 2009. The elders reviewed the boundaries of their native allotments and described their family's history in the area. The locations of 2 grave sites in the area were discussed, and our study plans were adjusted to stay a respectful distance away from those locations. During the summer field season in 2009, 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 conducted the previous week (for example, type of aircraft used, altitude of aircraft, and species enumerated) and the schedule of surveys for the upcoming week. The open house meetings and weekly updates kept 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 1950s, 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). Drilling at this satellite is conducted only 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.

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

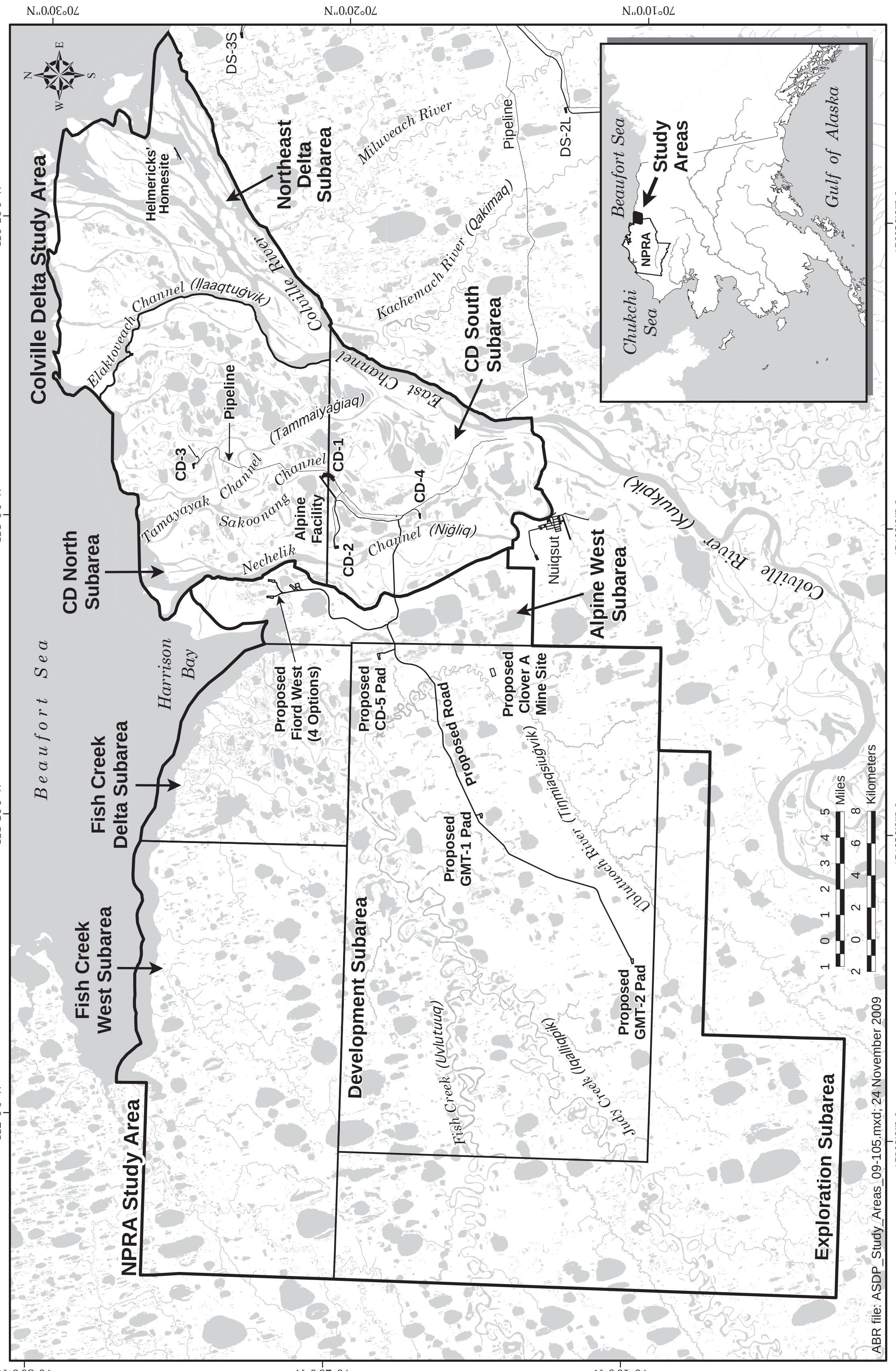

Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2009.

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—decreasing 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, 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

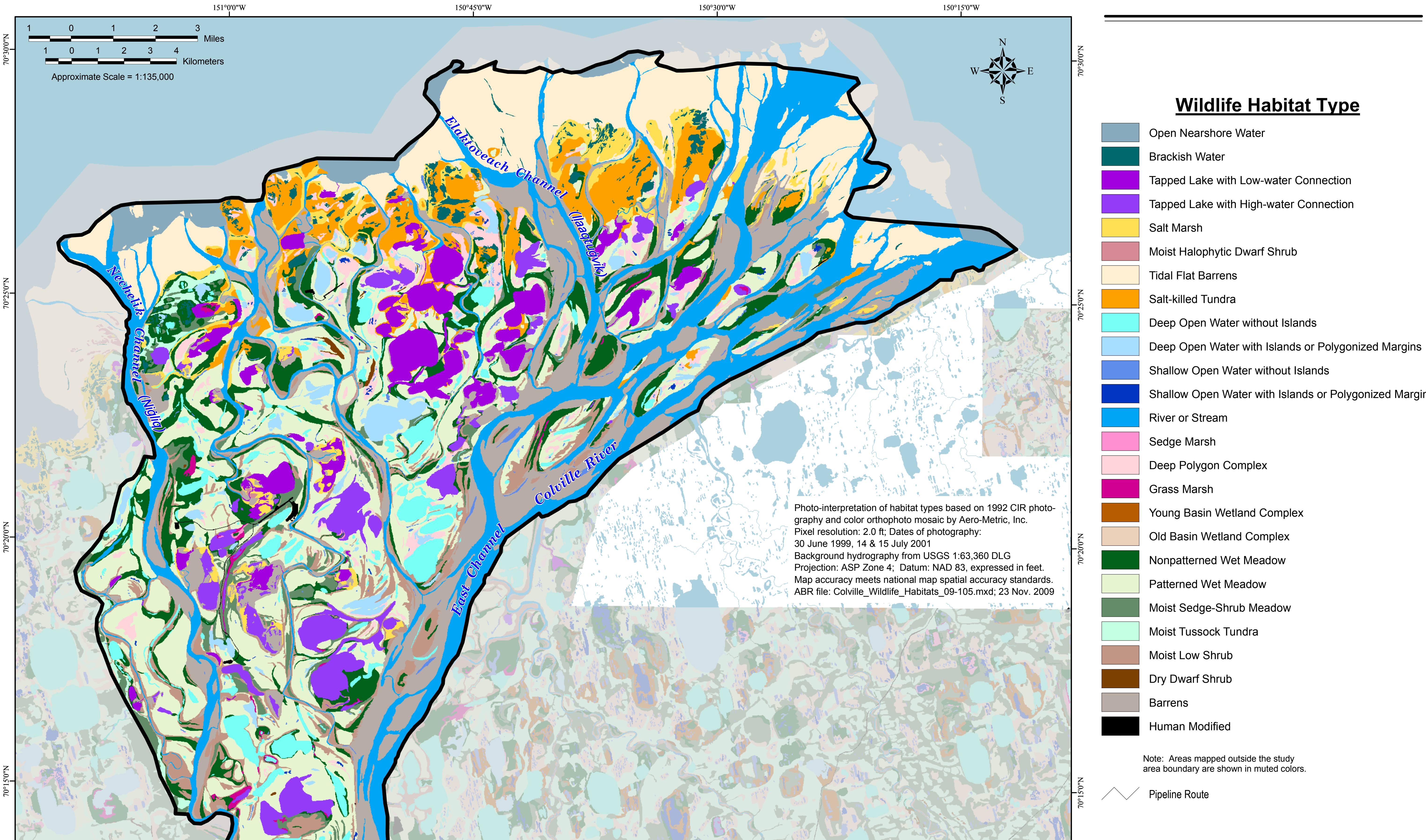

Figure 2. Wildlife habitats in the Colville Delta study area, Alaska, 2009.

Table 1. Habitat availability in the Colville Delta and the NPRA study areas, Alaska, 2009.

Habitat	Colville Delta Area (km²)	Colville Delta Availability (%)	NPRA Area (km²)	NPRA Availability (%)
Open Nearshore Water	10.12	1.8	22.32	2.7
Brackish Water	6.55	1.2	9.50	1.1
Tapped Lake with Low-water Connection	21.73	3.9	6.20	0.8
Tapped Lake with High-water Connection	20.77	3.8	4.87	0.6
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	2.38	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	826.01	100.0
Unknown (unmapped areas)	0		744.68	
Total	552.19		1,570.69	

that are part of the ASDP: CD-5, GMT-1, GMT-2, 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 near 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 (Jorgenson et al. 2003, 2004). Coastal plain and riverine landforms dominate the northeastern section of the NPRA. Coastal landforms 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 et al. 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. In 2009, 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). Eighteen aerial surveys (1 per week) for loons were conducted from a helicopter, 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, the Helmericks' homesite, and any active hunting parties. 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 entered 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 2009 (Figure 4) covered the same areas surveyed in 2008 in the Colville Delta and NPRA study areas (Figure 4). The pre-nesting survey was conducted 8–13 June using the same methods that were used on the Colville Delta in 1993–1998 and 2000–2008 and in the NPRA study area in 1999–2006 and 2008, although the survey

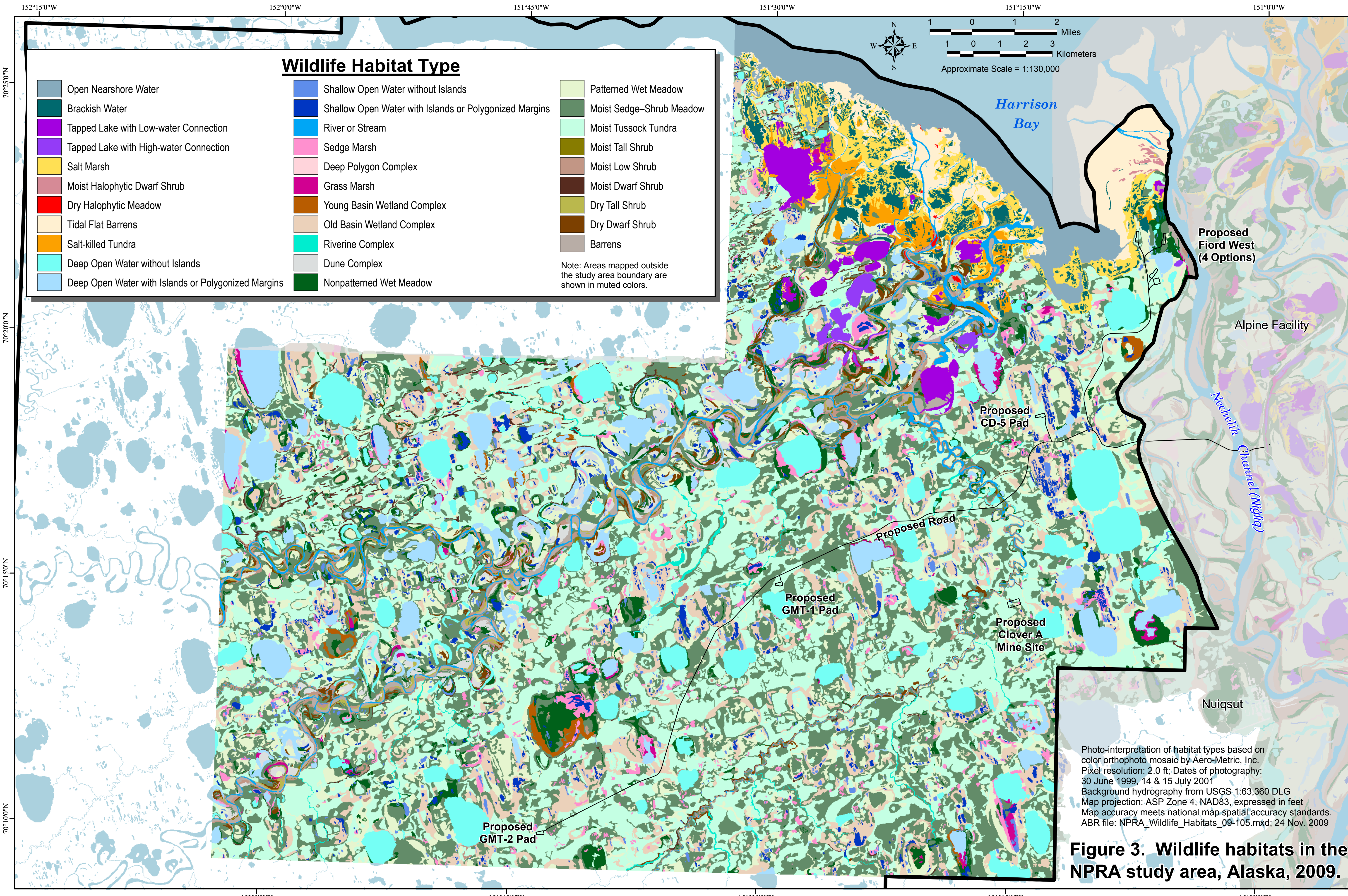

Figure 3. Wildlife habitats in the NPRA study area, Alaska, 2009.

Table 2. Avian surveys conducted in the Colville Delta and the NPRA study areas, Alaska, 2009.

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	8–9 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	22–27 June	206L	–	–	60	All lakes ≥5 ha and adjacent lakes
Nest monitoring	8 (1/week)	2 July–4 Aug.	206L	–	–	60–90	Lakes with active nests
Brood-rearing	1	17–19 Aug.	206L	–	–	60	All lakes ≥5 ha
Brood monitoring	11 (1/week)	6 July–11 Sept.	206L	–	–	60–90	Lakes with broods
Tundra Swan surveys							
Nesting	1	20–27 June	C185	1.6	1.6	150	100% coverage
Brood-rearing	1	18–20 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[d]	1	21 Aug.	C206	0.8	1.6	90	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] Western Colville Delta and Fish Creek Delta only

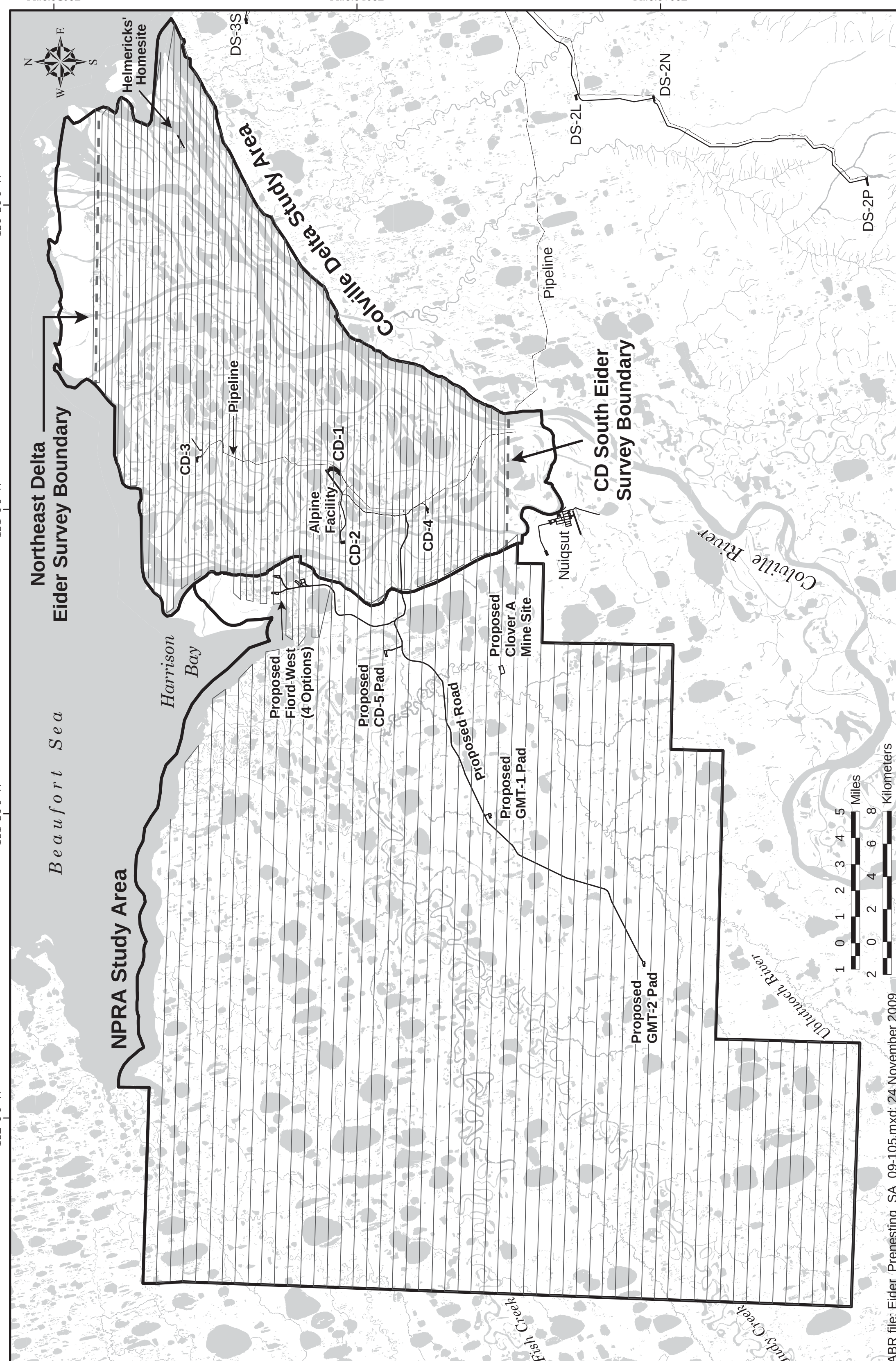

Figure 4. Transect lines for aerial surveys of pre-nesting eiders, Colville Delta and NPRA study areas, Alaska, 2009.

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, 2008b, 2009; 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 Spectacled and King eiders rarely use those habitats during the survey time period), 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

One aerial survey for nesting Yellow-billed Loons was conducted on 22–27 June 2009 and a single survey for brood-rearing loons was conducted on 17–19 August 2009 (Table 2). In the Colville Delta, surveys were flown in the CD North, CD South, and Northeast Delta subareas (Figure 5). The CD North and CD South subareas have been surveyed consistently since 1993 (Figure 5). The 6 large lakes in the Northeast Delta subarea have been surveyed occasionally in past years. In the NPRA study area, loon surveys were conducted in the Alpine West, Fish Creek Delta, and Fish and Judy Creek subareas. Alpine West was surveyed in 2002–2006, and 2008, and Fish Creek Delta was surveyed in 2005–2006, and 2008. The Fish and Judy Creek subarea was created in 2008 and comprises a series of lakes adjacent to the stream channels. The Fish and Judy Creek subarea was surveyed in 2001–2004 as part of what was then called the Development and Exploration subareas. Seven lakes outside the Fish and Judy Creek subarea also were surveyed because Yellow-billed Loon were observed there in previous years (Figure 5). The remainder of the previous 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 pre-determined 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 that were 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 changing 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 entered into a GIS database.

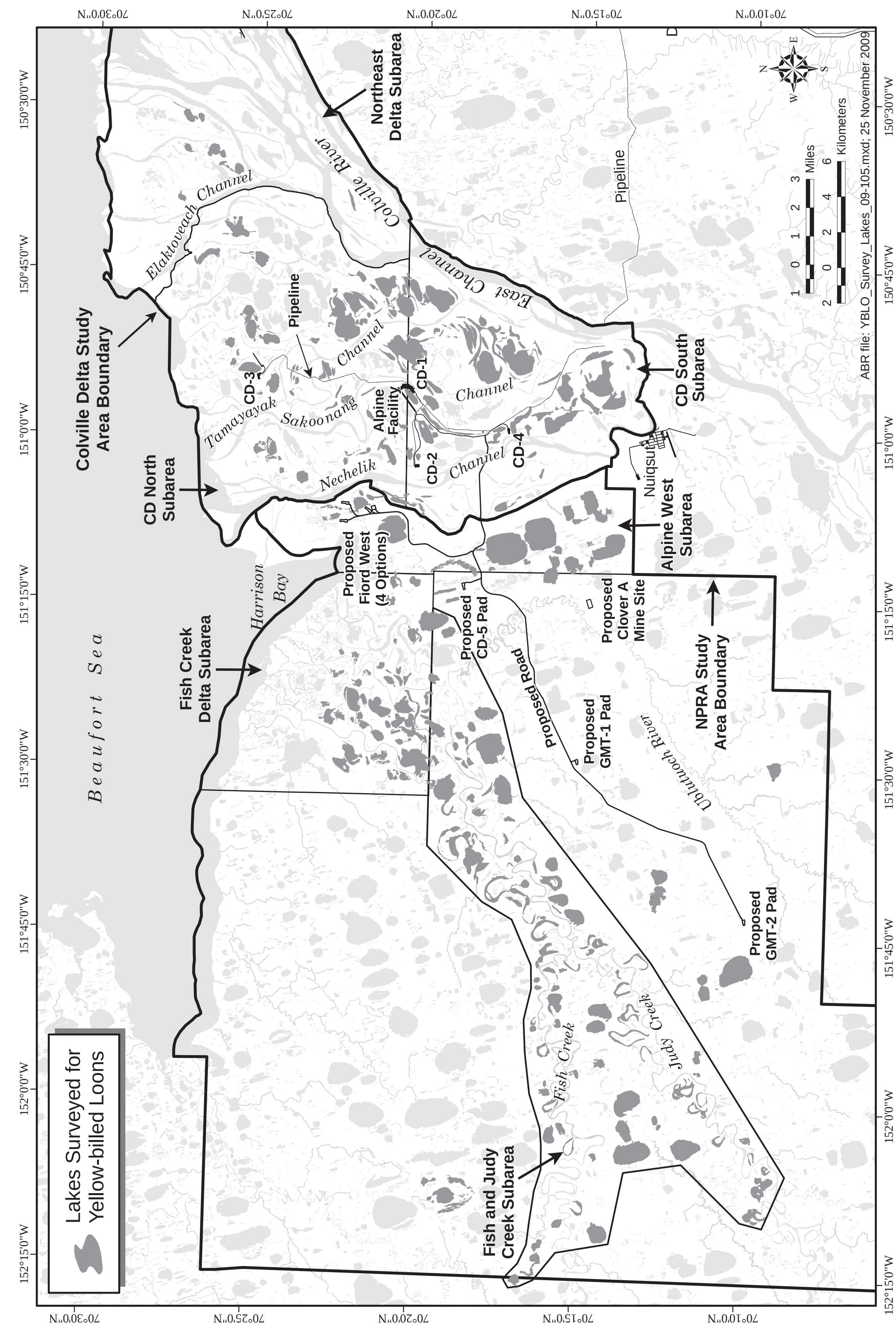

Figure 5. Lakes included in aerial surveys for Yellow-billed Loons, Colville Delta and NPRA study areas, Alaska, 2009.

The total numbers of adults, nests, broods, and young counted on aerial surveys were summarized for each species of loon. Densities of adults, nests, and broods were calculated only for Yellow-billed Loons because smaller lakes that typically 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 in the Colville Delta and NPRA study areas to monitor the status of Yellow-billed Loon nests found during the nesting survey. Traditional nest lakes without an active nest were revisited for 2 weeks after the nesting survey to confirm the presence or absence of nests. After 2 weeks, we only surveyed lakes with 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 an adult swimming near a nest with eggs. Nests were assumed inactive when adults were no longer incubating. When a nest appeared inactive, the nesting lake was immediately searched for a brood by flying along the shoreline and scanning across the lake. Adjacent lakes known from previous surveys to be brood-rearing lakes or part of a pair's territory also were surveyed.

Inactive nests were visited on the ground to inspect their contents and to confirm nest fate. 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. Nests were assumed failed if they contained <20 egg fragments, eggshells had signs of predation (holes, albumen, yolk, or blood), or if eggs were unattended and cold (Parrett et al. 2008). Nests were assumed successful if a brood was present, or if the nest contained >20 egg fragments. Egg fragments 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. If egg fragments were found, they were counted and, based on the length of their longest side, placed into 3 approximate size categories: 1–10, 11–20, 21–30-mm. Egg membranes or pieces of membranes also were counted and measured.

TIME-LAPSE CAMERAS

In the Colville Delta study area, we deployed time-lapse cameras at 16 Yellow-billed Loon nests primarily to monitor 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 3 d 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 AA-cell batteries and programmed to take 1 picture every 65 sec. At these settings, cameras could run 23–27 d without requiring maintenance (e.g., battery or memory changes). Cameras were removed when 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, 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 on the nest following a recess or after changing position, sitting 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. We identified predators in camera views to species, estimated their distance from the nest, and described their behavior.

Nest images were reviewed 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 was the last date on which adults were observed attending a nest at which chicks were not seen.

Nest initiation dates were estimated for successful nests by subtracting 28 d from the day of hatch. Twenty-eight days is the reported incubation period for Yellow-billed Loons (North 1994), which begins with laying of the first egg. For failed nests, we estimated nest initiation dates using an egg-floatation schedule that we developed from known-age Yellow-billed Loon nests in 2008 and 2009 (using a method developed for Semipalmated Sandpipers by Mabee et al. 2006). During visits to Yellow-billed Loon nests to set up cameras in 2008 and 2009 (n = 11 nests), we floated eggs in water and recorded the position of the egg in the water column (on the bottom [all eggs in this study], suspended in the water column, or on the surface), measured the angle between the central axis of the egg and the water surface (from 0° when egg is first laid to a maximum of 90° when the egg is upright in the water column), and estimated the percent volume of the egg above the surface (none in this study). For nests that were observed hatching on camera images (known-age nests), the clutch age on the day of egg floating was determined by backdating from hatch date to the day the eggs were floated. The relationship between the float angle and clutch age was plotted, and the correlation provided an egg-floatation schedule that could be used to estimate nest initiation date for failed nests. For nests with 2 eggs, the oldest egg was used for dating. Mabee et al. (2006) reported that eggs located at the bottom of the water column when measured (i.e., early in incubation) produced estimates of incubation age, on average, within 0.8 ± 0.2 d of the actual clutch age.

The number of days or minutes of monitoring and incubation statistics (constancy, recess and exchange frequency, and recess length) were calculated for each nest. The days of camera set-up, periods of poor visibility, and any other researcher disturbance were excluded. 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 and exchanges were calculated as the sum of that activity divided by number of days monitored.

BROOD MONITORING

In the Colville Delta and NPRA study areas, 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 all lakes known to be used by pairs during nesting or brood-rearing 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; however, we felt that brood detection was reduced when waves on the lake were breaking with occasional or frequent whitecaps. These conditions were considered poor, and any lake with such conditions was resurveyed the following week, regardless of observation history. Brood locations were hand-mapped and the number of adults and young was recorded.

We aged each brood from the date of initial observation of the first chick. To account for the unknown number of days the chick was alive before that period, we added one-half of the interval between the date of first observation of a chick and the previous nest-monitoring survey. In the same manner, we estimated age at death as the number of days from first observation of a chick to the last day of observation of that chick, plus one-half the interval between when the chick last seen and when was it was absent. For example, given a 7-day interval between surveys, each chick was assumed to be 4 days old when first observed and the date of death was 4 days after the last observation.

TUNDRA SWAN SURVEYS

One aerial survey for nesting Tundra Swans was flown 20–27 June and 1 aerial survey for brood-rearing Tundra Swans was flown 18–20 August 2009 (Table 2). Each aerial survey covered the entire Colville Delta and NPRA study areas (Figure 6). The surveys were conducted in

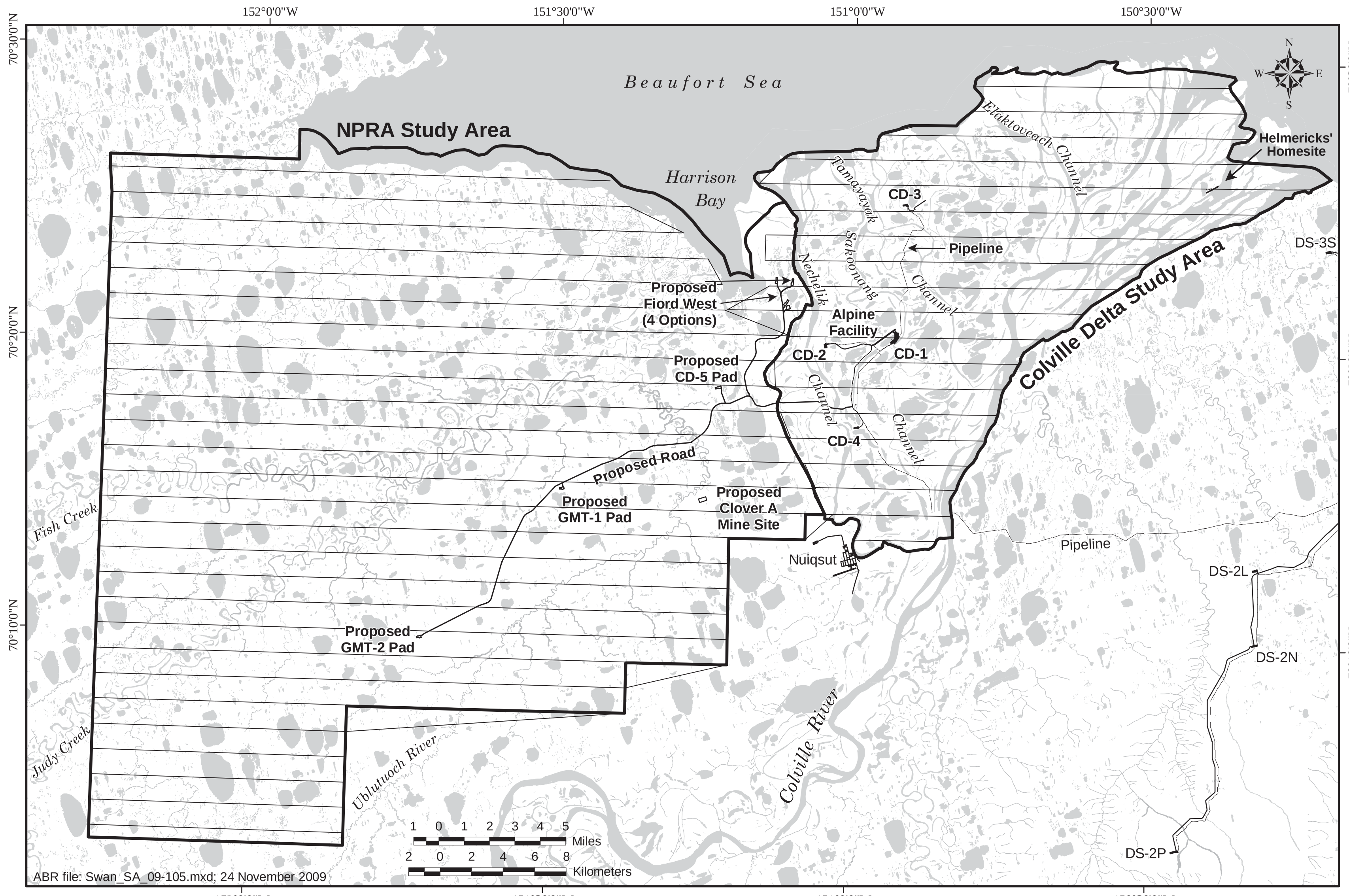

Figure 6. Transect lines for aerial surveys of nesting and brood-rearing Tundra Swans, Colville Delta and NPRA study areas, Alaska, 2009.

accordance with USFWS protocols (USFWS 1987b, 1991). East–west transects spaced 1.6 km apart were flown in a Cessna 185 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

One survey for brood-rearing and molting Brant and Snow Geese was conduced on 29 July 2009 and another survey for fall-staging geese was conducted on 21 August 2009. The brood-rearing survey covered 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 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 40D digital SLR camera (10.1 megapixel), and a 17–85 mm image-stabilizing lens.

The fall-staging survey covered 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 predetermined 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% 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 entered into a GIS database. In the Colville Delta study area, the fall-staging survey covered 102.1 km² of the CD North subarea (49.4% of the entire subarea) and 51.3 km² (32.9%) of the CD South subarea. In the NPRA study area, the staging survey covered 66.0 km² (50.5%) of the Fish Creek Delta subarea, 29.1 km² (36.6%) of the Alpine West subarea, and 43.8 km² (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 entered into a GIS database.

HABITAT MAPPING AND ANALYSIS

A wildlife habitat was assigned to each observation by plotting its coordinates on the wildlife habitat maps (Figures 2 and 3). 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).

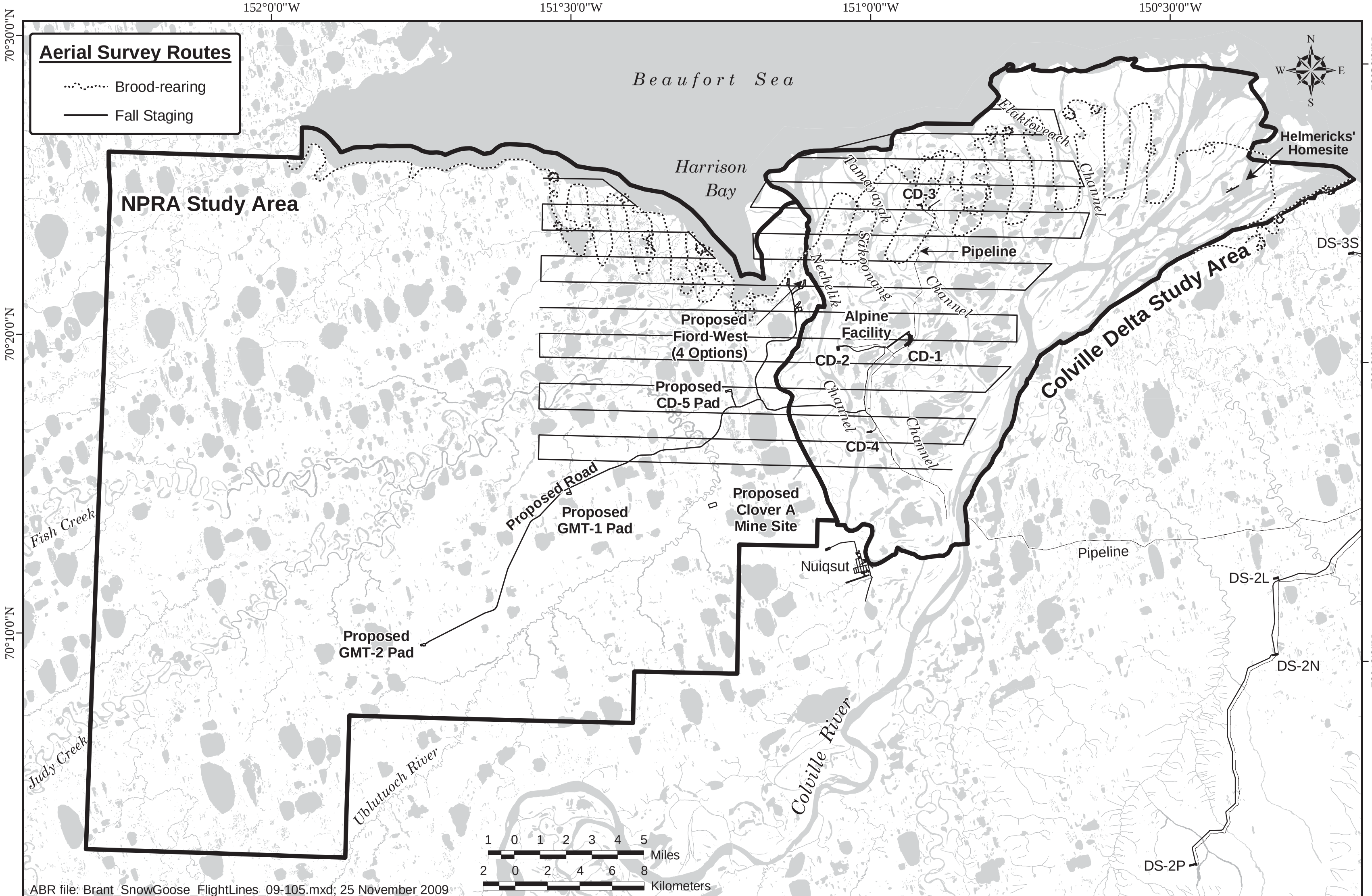

Figure 7. Flight lines for aerial surveys of brood-rearing and fall-staging geese, Colville Delta and NPRA study areas, Alaska, 2009.

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 (Colville Delta 1993–1998 and 2000–2009 and NPRA study area 2001–2006 and 2008–2009)
- nesting and brood-rearing Tundra Swans (Colville Delta 1992–1998 and 2000–2009 and NPRA study area 2001–2006 and 2008–2009)
- nesting and brood-rearing Yellow-billed Loons (Colville Delta 1993–1998 and 2000–2009 [nests] and 1995–1998 and 2000–2009 [broods]).

For other species, the number of observations from comparable annual surveys was inadequate for statistical analysis. Several habitats were merged, based on similar composition or physiography and low areal coverage, 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 merged with Tidal Flat Barrens, and all non-halophytic shrub types (all but one occupied <1% of each study area) were merged 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 2009). 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 2008, to maintain consistency and make it possible to join multiyear datasets into a single archival database, maintained by CPAI.

RESULTS

CONDITIONS IN THE STUDY AREAS

The summer nesting season in 2009 was advanced and relatively warm, particularly in early June. In 2009, break-up (peak water levels) of the Colville River occurred on 23 May, about 8 days earlier than the mean date over 23 years (Michael Baker 2009). During the period of waterfowl arrival and peak nest initiation (15 May–15 June), 62 cumulative thawing degree-days were recorded at the Colville Village site, well above the 13-year average of 39 thawing degree-days (Figure 8). Mean monthly temperatures in May 2009 (-3.9 ± 3.9° C [mean ± SD]) were slightly higher than the

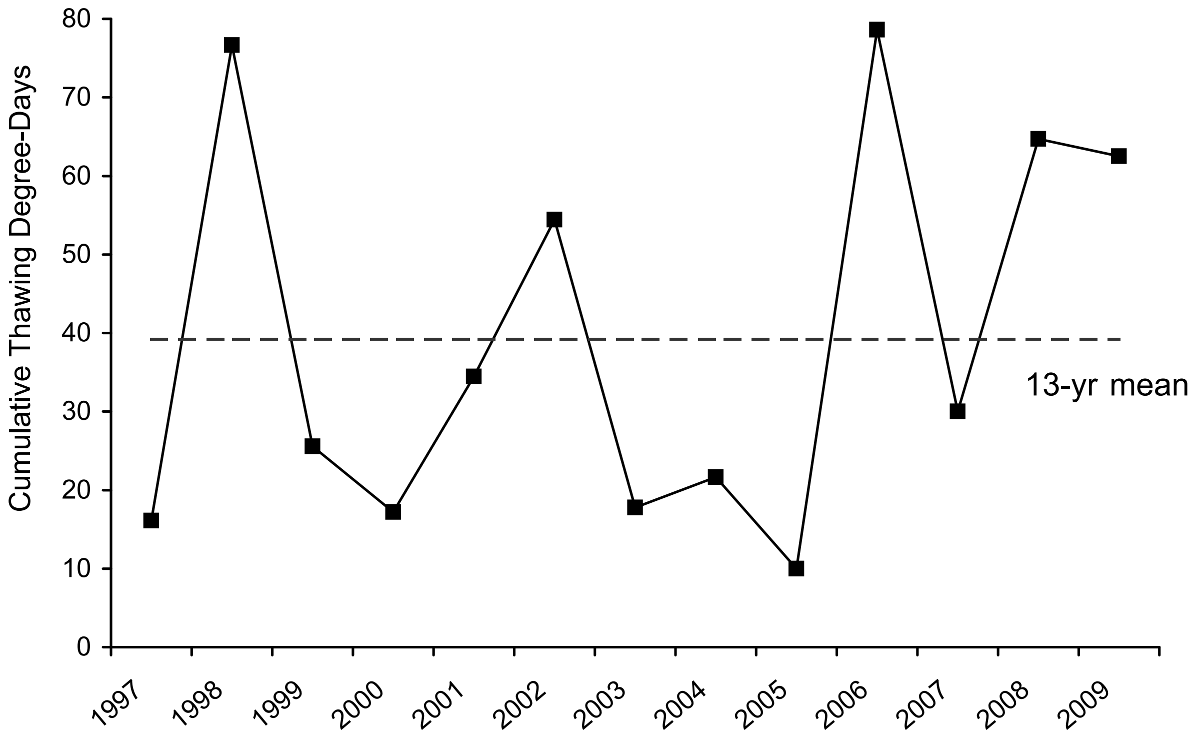

Figure 8. Cumulative number of thawing degree-days recorded for 15 May – 15 June at Colville Village, Colville River delta, Alaska, 1997–2009.

13-yr mean (-5.6 ± 5.2° C) and mean monthly temperatures in June (2.9 ± 1.7° C) were slightly lower than the 13-year mean (3.6 ± 3.9° C). Snow cover was gone by the last week of May at the Kuparuk airport (due east of Alpine), but remained patchy on open tundra until the second week of June (A. Prichard, pers. comm.). The first week of June was unseasonably warm, but was followed by 3 weeks that were cooler and windier than normal (see Figure 5, Seiser and Johnson 2010b). This cold, windy period occurred during the incubation period for waterfowl and loons. Despite the cool period in late June, conditions in 2009 were suitable for early nest initiation for most waterfowl. Mosquitoes were first noticeable and at severe levels on 30 June on the Colville Delta, which is about normal for recent years. The presence of Greater White Front broods on 26 June, our first day in the field, was evidence of early nest initiation in 2009. We also observed Spectacled Eider eggs pipping on 3 July (indicating the nest was hatching that day or the next) and a King Eider brood on 5 July. We conclude that nest initiation of waterfowl was advanced in 2009, but weather during the incubation and brood-rearing periods of most waterfowl was cool and windy.

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 number of Spectacled Eiders on the Colville Delta during pre-nesting in 2009 was near the 16-year average (Figure 9). We counted 41 Spectacled Eiders, of which 38 were observed on the ground and 3 were in flight (Table 3). All sightings of Spectacled Eiders in the Colville Delta study area during the pre-nesting survey in 2009 were in groups of 1–5 birds, and all but 8 Spectacled Eiders were found in the CD North subarea (Figure 10, Table 3). The density of observed birds in the CD North subarea was 0.16 birds/km² (on ground and in flight), and the density of indicated birds (USFWS 1987a) was 0.17 birds/km². The density in the entire Colville Delta study area was 0.08 observed birds/km² and 0.08 indicated birds/km². These densities were half the densities seen in 2008, which were the highest densities recorded since surveys began on the Colville Delta.

Habitat Use

Pre-nesting Spectacled Eiders used 17 of 24 available habitats during 16 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, Deep Open Water with Islands or Polygonized Margins, and Shallow Open Water with Islands or Polygonized Margins), and 1 terrestrial habitat (Deep Polygon Complex) (Table 4). Patterned Wet Meadow had high use (15%, 44 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.

NPRA

Distribution and Abundance

In NPRA in 2009, Spectacled Eiders were most abundant along the coast in the Fish Creek West subarea (Figure 10, Table 5). Over the entire NPRA study area, we counted 31 observed (on ground and in flight) and 30 indicated Spectacled Eiders resulting in a density of 0.04 observed

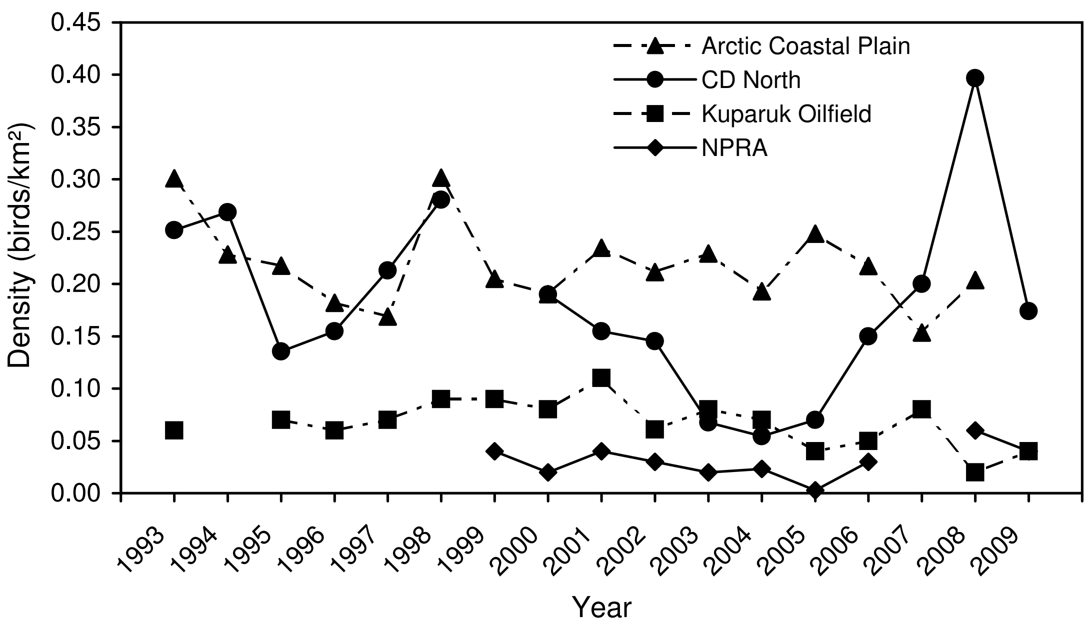

Figure 9. Density of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2009. Arctic Coastal Plain data from Larned et al. 2010, Kuparuk data from Stickney et al. 2010, and CD North and NPRA data from this study.

Table 3. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2009.

SPECIES Subarea Location	Observed Males	Observed Females	Observed Total	Observed Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a,b]
SPECTACLED EIDER							
CD North							
On ground	18	14	32	13	36	0.15	0.17
In flight	1	0	1	0	–	<0.01	–
All birds	19	14	33	13	–	0.16	–
Northeast Delta							
On ground	1	1	2	1	2	0.01	0.01
In flight	1	1	2	1	–	0.01	–
All birds	2	2	4	2	–	0.03	–
CD South							
On ground	2	2	4	2	4	0.03	0.03
In flight	0	0	0	0	–	0	
All birds	2	2	4	2	–	0.03	
Total (subareas combined)							
On ground	21	17	38	16	42	0.08	0.08
In flight	2	1	3	1	–	0.01	–
All birds	23	18	41	17	–	0.08	–
KING EIDER							
CD North							
On ground	8	6	14	6	16	0.07	0.08
In flight	4	1	5	0	–	0.02	–
All birds	12	7	19	6	–	0.09	–
Northeast Delta							
On ground	6	5	11	4	12	0.07	0.08
In flight	1	0	1	0	–	0.01	–
All birds	7	5	12	4	–	0.08	–
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	15	12	27	11	30	0.05	0.06
In flight	6	1	7	0	–	0.01	–
All birds	21	13	34	11	–	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

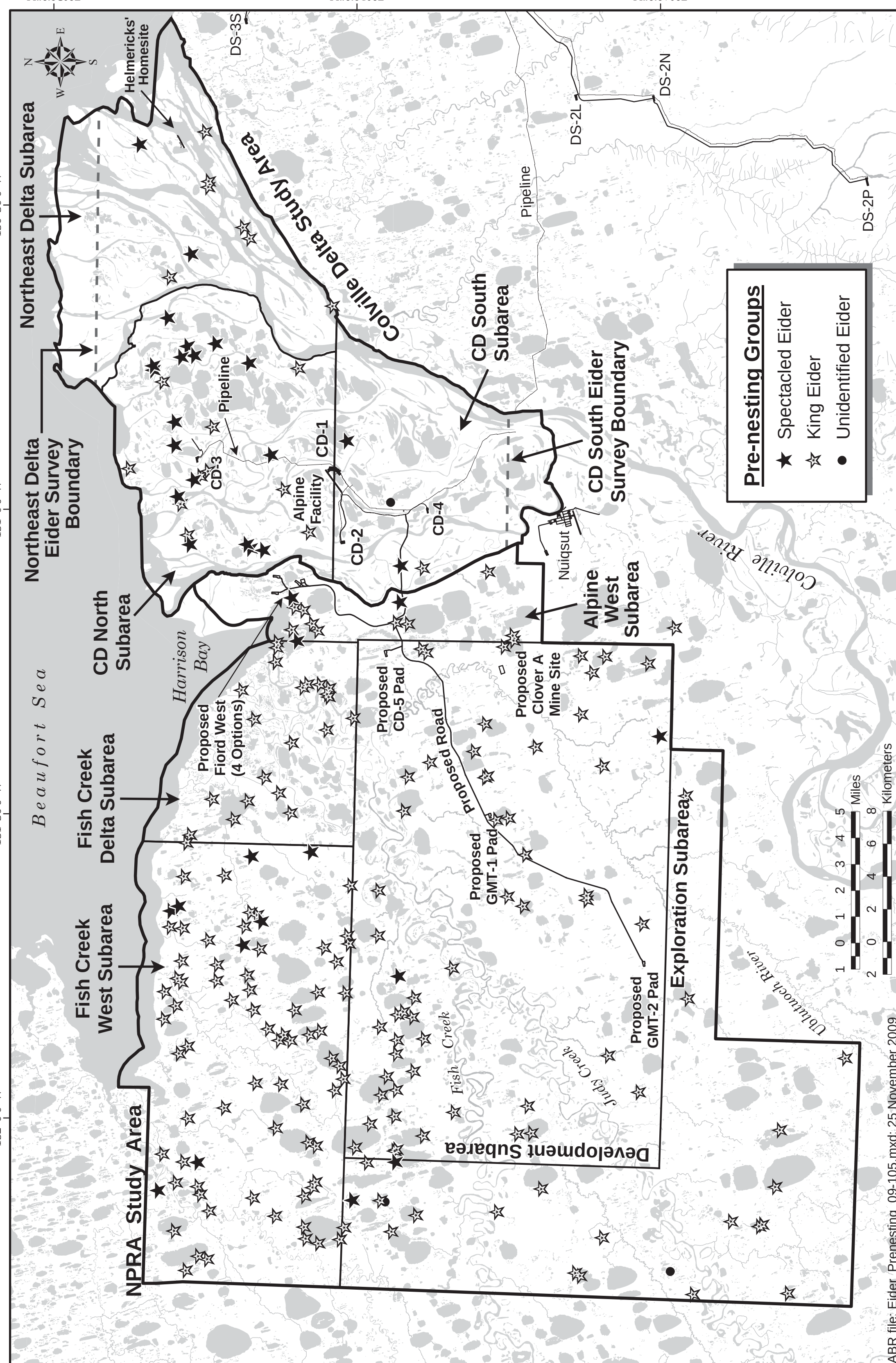

Figure 10. Spectacled and King eider groups during pre-nesting, Colville Delta and NPRA study areas, Alaska, 2009.

Table 4. Habitat selection by Spectacled and King eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998, and 2000–2009.

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	1.6	avoid	low
Brackish Water	69	30	10.4	1.3	prefer	low
Tapped Lake with Low-water Connection	29	12	4.2	4.5	ns	
Tapped Lake with High-water Connection	16	9	3.1	3.8	ns	
Salt Marsh	40	22	7.6	3.2	prefer	
Tidal Flat Barrens	2	1	0.3	7.0	avoid	
Salt-killed Tundra	50	27	9.3	5.1	prefer	
Deep Open Water without Islands	22	14	4.8	3.5	ns	
Deep Open Water with Islands or Polygonized Margins	25	13	4.5	2.1	prefer	low
Shallow Open Water without Islands	5	3	1.0	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	5	4	1.4	0.1	prefer	low
River or Stream	18	9	3.1	14.3	avoid	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	124	69	23.9	2.7	prefer	
Grass Marsh	6	4	1.4	0.2	prefer	low
Young Basin Wetland Complex	0	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	52	26	9.0	8.2	ns	
Patterned Wet Meadow	85	44	15.2	19.5	ns	
Moist Sedge-Shrub Meadow	0	0	0	2.3	avoid	
Moist Tussock Tundra	1	1	0.3	0.6	ns	low
Tall, Low, or Dwarf Shrub	0	0	0	4.9	avoid	
Barrens	2	1	0.3	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	551	289	100	100		
KING EIDER						
Open Nearshore Water	11	3	1.6	1.6	ns	low
Brackish Water	25	14	7.3	1.3	prefer	low
Tapped Lake with Low-water Connection	24	11	5.7	4.5	ns	
Tapped Lake with High-water Connection	8	3	1.6	3.8	ns	
Salt Marsh	16	7	3.6	3.2	ns	
Tidal Flat Barrens	4	2	1.0	7.0	avoid	
Salt-killed Tundra	33	17	8.8	5.1	prefer	
Deep Open Water without Islands	16	7	3.6	3.5	ns	
Deep Open Water with Islands or Polygonized Margins	11	5	2.6	2.1	ns	low
Shallow Open Water without Islands	4	2	1.0	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	1	0.5	0.1	ns	low
River or Stream	207	70	36.3	14.3	prefer	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	32	17	8.8	2.7	prefer	low
Grass Marsh	8	3	1.6	0.2	prefer	low
Young Basin Wetland Complex	0	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	5	4	2.1	8.2	avoid	
Patterned Wet Meadow	34	20	10.4	19.5	avoid	
Moist Sedge-Shrub Meadow	2	1	0.5	2.3	ns	low
Moist Tussock Tundra	0	0	0	0.6	ns	low
Tall, Low, or Dwarf Shrub	2	1	0.5	4.9	avoid	
Barrens	13	5	2.6	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	457	193	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/km²) of eiders during pre-nesting aerial surveys, NPRA study area, Alaska, 2009.

SPECIES Subarea Location	Observed Males	 Females	 Total	 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	3	0	3	0	–	0.01	–
All birds	4	1	5	1	–	0.02	–
Alpine West							
On ground	2	1	3	1	4	0.07	0.10
In flight	0	0	0	0	–	0	–
All birds	2	1	3	1	–	0.07	–
Fish Creek Delta							
On ground	1	1	2	1	2	0.03	0.03
In flight	0	0	0	0	–	0	–
All birds	1	1	2	1	–	0.03	–
Fish Creek West							
On ground	8	6	14	6	16	0.09	0.11
In flight	0	0	0	0	–	0	–
All birds	8	6	14	6	–	0.09	–
Exploration							
On ground	3	2	5	1	6	0.02	0.03
In flight	1	1	2	1	–	0.01	–
All birds	4	3	7	2	–	0.03	–
Total (subareas combined)							
On ground	15	11	26	10	30	0.03	0.04
In flight	4	1	5	1	–	0.01	–
All birds	19	12	31	11	–	0.04	–
KING EIDER							
Development							
On ground	50	39	89	34	100	0.29	0.33
In flight	19	9	28	8	–	0.09	–
All birds	69	48	117	42	–	0.38	–
Alpine West							
On ground	15	14	29	14	30	0.69	0.72
In flight	0	0	0	0	–	0.00	–
All birds	15	14	29	14	–	0.69	–
Fish Creek Delta							
On ground	21	16	37	16	42	0.65	0.73
In flight	2	0	2	0	–	0.03	–
All birds	23	16	39	16	–	0.68	–
Fish Creek West							
On ground	73	56	129	53	146	0.85	0.97
In flight	15	13	28	11	–	0.19	–
All birds	88	69	157	64	–	1.04	–
Exploration							
On ground	21	11	32	11	42	0.16	0.21
In flight	8	5	13	3	–	0.06	–
All birds	29	16	45	14	–	0.22	–
Total (subareas combined)							
On ground	180	136	316	128	360	0.42	0.48
In flight	44	27	71	22	–	0.09	–
All birds	224	163	387	150	–	0.51	–

[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

birds/km² and 0.04 indicated birds/km², exactly half the density on the Colville Delta study area in 2009.

Habitat Use

Pre-nesting Spectacled Eiders used 12 of 26 available habitats in the NPRA study area over 8 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 (38 groups total), resulting in low power in the selection analysis; 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 (34 observed birds) were almost as numerous as Spectacled Eiders (41 observed birds) during the 2009 pre-nesting period in the Colville Delta study area (Table 3). The indicated density (0.07 birds/km²) was similar to the mean of 16 years (0.06 birds/km²). Most King Eiders (56%) were seen in the CD North subarea (Figure 10). In previous years, the Northeast Delta subarea typically contained the highest number of King Eiders. Few King Eiders nest on the delta, so we assume most of those observed during pre-nesting are in transit to other breeding areas (Johnson et al. 2003b).

No Steller's or Common eiders were seen on the Colville Delta in 2009. 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 (Johnson et al. 2008b). 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 are more common in the nearshore marine waters and barrier islands 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 (Johnson et al. 2008b). 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 19 of 24 available habitats in the Colville Delta study area over 16 years of aerial surveys. King Eiders preferred 4 of the same habitats preferred by Spectacled Eiders on the Colville Delta: Brackish Water, Salt-killed Tundra, Deep Polygon Complex, and Grass Marsh (Table 4). King Eiders also preferred River or Stream, where the largest percentage (36%) of the groups was found. The high use of River or Stream, which includes river channels, suggests that many King Eiders were in transit to breeding areas farther east, because River or Stream is not potential breeding habitat, and because such large numbers of King Eiders are not found in the 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), affirming that most of the pre-nesting King Eiders seen on the delta are stopping over during migration.

NPRA

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 (157 observed total birds) and density (1.04 total birds/km²) of King Eiders among the subareas in NPRA. The indicated total of King Eiders in the NPRA study area in 2009 was 360 birds, and the indicated density was 0.48 birds/km², a 28% decrease from the 501 King Eiders counted in 2008 (Johnson et al. 2009).

Habitat Use

King Eiders used 20 of 26 available habitats and preferred 9 habitats over 8 years of pre-nesting surveys in the NPRA study area (Table 6). Old Basin Wetland Complex, both types of Deep Open

Table 6. Habitat selection by Spectacled and King eider groups during pre-nesting, NPRA study area, Alaska, 2001–2006 and 2008–2009.

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	0.4	ns	low
Brackish Water	10	5	13.2	1.0	prefer	low
Tapped Lake with Low-water Connection	0	0	0	0.5	ns	low
Tapped Lake with High-water Connection	0	0	0	0.6	ns	low
Salt Marsh	4	2	5.3	1.8	ns	low
Tidal Flat Barrens	0	0	0	1.0	ns	low
Salt-killed Tundra	0	0	0	0.6	ns	low
Deep Open Water without Islands	2	1	2.6	6.5	ns	low
Deep Open Water with Islands or Polygonized Margins	10	5	13.2	1.0	prefer	low
Shallow Open Water without Islands	5	4	10.5	5.6	ns	low
Shallow Open Water with Islands or Polygonized Margins	15	7	18.4	1.7	prefer	low
River or Stream	1	1	2.6	1.2	ns	low
Sedge Marsh	1	1	2.6	1.7	ns	low
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	2	1	2.6	0.3	ns	low
Young Basin Wetland Complex	0	0	0.0	0.3	ns	low
Old Basin Wetland Complex	12	7	18.4	8.3	ns	low
Riverine Complex	0	0	0	0.3	ns	low
Dune Complex	0	0	0	1.1	ns	low
Nonpatterned Wet Meadow	4	2	5.3	3.2	ns	low
Patterned Wet Meadow	4	2	5.3	11.2	ns	low
Moist Sedge-Shrub Meadow	0	0	0	21.7	avoid	
Moist Tussock Tundra	0	0	0	25.7	avoid	
Tall, Low, or Dwarf Shrub	0	0	0	3.2	ns	low
Barrens	0	0	0	1.1	ns	low
Human Modified	0	0	0	0	ns	
Total	70	38	100	100		
KING EIDER						
Open Nearshore Water	4	2	0.5	0.4	ns	low
Brackish Water	38	19	4.7	1.0	prefer	low
Tapped Lake with Low-water Connection	32	10	2.5	0.5	prefer	low
Tapped Lake with High-water Connection	0	0	0	0.6	ns	low
Salt Marsh	50	22	5.4	1.8	prefer	
Tidal Flat Barrens	10	4	1.0	1.0	ns	low
Salt-killed Tundra	2	1	0.2	0.6	ns	low
Deep Open Water without Islands	140	46	11.3	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	114	46	11.3	1.0	prefer	low
Shallow Open Water without Islands	67	34	8.3	5.6	prefer	
Shallow Open Water with Islands or Polygonized Margins	132	55	13.5	1.7	prefer	
River or Stream	76	30	7.4	1.2	prefer	low
Sedge Marsh	26	13	3.2	1.7	ns	
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	15	4	1.0	0.3	ns	low
Young Basin Wetland Complex	0	0	0	0.3	ns	low
Old Basin Wetland Complex	151	71	17.4	8.3	prefer	
Riverine Complex	6	3	0.7	0.3	ns	low
Dune Complex	0	0	0	1.1	avoid	low
Nonpatterned Wet Meadow	18	10	2.5	3.2	ns	
Patterned Wet Meadow	44	26	6.4	11.2	avoid	
Moist Sedge-Shrub Meadow	16	7	1.7	21.7	avoid	
Moist Tussock Tundra	7	4	1.0	25.7	avoid	
Tall, Low, or Dwarf Shrub	1	1	0.2	3.2	avoid	
Barrens	0	0	0	1.1	avoid	low
Human Modified	0	0	0	0	ns	
Total	949	408	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

Water, and Shallow Open Water with Islands or Polygonized Margins 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, Shallow Open Water without Islands, and River or Stream.

LOONS

YELLOW-BILLED LOON

Colville Delta

Distribution and Abundance

During the nesting survey in 2009, 67 Yellow-billed Loons and 30 nests were observed in the Colville Delta study area (Table 7, Figure 11), 8 nests more than the 15-year mean (Burgess et al. 2003a; Johnson et al. 2003b, 2004, 2005, 2006b, 2007b, 2008b, 2009). As in previous years, Yellow-billed Loon nests in 2009 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). One nest found in 2009 was on a small lake that had not been surveyed in previous years. We do not know whether that lake has had a history of Yellow-billed Loon nesting. Two of the 30 nests were found during the weekly monitoring surveys 1–2 weeks after the nesting survey and it is likely that these 2 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), to be consistent with data presentations from previous years.

During the brood-rearing survey in 2009, 13 Yellow-billed Loon broods were recorded in the Colville Delta study area (Figure 11, Table 7), which was equal to the 15-year average. Two of these broods were in the Northeast Delta subarea and 2 other broods were inferred by eggshell evidence that confirmed hatching although no broods were observed (see *Nest Fate*, below).

Habitat Use

During 15 years of nesting aerial surveys in the CD North and CD South subareas, 319 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 223 of 319 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 the aquatic habitat of the lake; otherwise nests were assigned to the terrestrial habitat on the lakeshore. Patterned Wet Meadow was the habitat used most frequently for nesting (38% 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 together occupied 48% of the CD North and CD South study areas.

One hundred fifty-seven 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). 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 Monitoring and Nest Fate

Overall, 13 of 30 Yellow-billed Loon nests hatched in the Colville Delta study area in 2009 for an apparent nesting success of 43% (Table 9). Although the number of nests was similar to previous years (mean = 32, SE = 2.2, n = 4 yrs), nesting success was the lowest since monitoring surveys began in 2005 (mean = 68%, SE = 3.8, n = 4 yrs; Johnson et al. 2006b, 2007b, 2008b, 2009). Young loons were observed during aerial surveys at all but 2 hatched nests. At those nests hatching was confirmed by eggshell fragments and by camera images of chicks, but the young did not survive the period between hatch and the following aerial survey. Of the 13 successful nests, 1 (8%) hatched between nest visits on 29 June and 6 July; 8 (61%) hatched between 7 and 14 July; and the remaining 4 (31%) hatched by 20 July. Aside from the 2 broods lost during the week after hatch, all other broods survived to the time of the brood-rearing aerial survey (17 August).

Table 7. Number and density of loons and their nests, broods, and young during aerial surveys, Colville Delta and NPRA study areas, Alaska, 2009.

STUDY AREA / Subarea[b] / Survey Type	Yellow-billed Loon Number Adults	Yellow-billed Loon Number Nests/Brood	Yellow-billed Loon Number Young	Yellow-billed Loon Density (number/km²) Adults	Yellow-billed Loon Density (number/km²) Nests/Broods	Pacific Loon[a] Number Adults	Pacific Loon[a] Number Nests/Broods	Pacific Loon[a] Number Young	Red-throated Loon[a] Number Adults	Red-throated Loon[a] Number Nests/Broods	Red-throated Loon[a] Number Young
COLVILLE DELTA											
CD North											
Nesting	35	16[e]	–	0.17	0.08	67	21	–	1	0	–
Brood-rearing	27	5[f]	3	0.13	0.02	76	5	7	10	2	2
CD South											
Nesting	28	12	–	0.18	0.08	57	23	–	3	0	–
Brood-rearing	27	6	6	0.17	0.04	45	4	4	0	0	0
Northeast Delta[c]											
Nesting	4	2	–	–	–	13	4	–	0	0	–
Brood-rearing	2	2	3	–	–	8	3	3	0	0	0
Total (subareas combined)[d]											
Nesting	67	30[e]	–	0.17	0.08	137	48	–	4	0	–
Brood-rearing	56	13[f]	12	0.15	0.03	129	12	14	10	2	2
NPRA											
Alpine West											
Nesting	2	1	–	0.03	0.01	60	20	–	0	0	–
Brood-rearing	2	1	1	0.03	0.01	42	4	4	5	0	0
Fish Creek Delta											
Nesting	17	6	–	0.13	0.05	66	22	–	5	1	–
Brood-rearing	16	3[f]	3	0.12	0.02	42	6	6	2	1	1
Fish and Judy Creek Corridor											
Nesting	42	19[e]	–	0.16	0.07	118	48	–	3	0	–
Brood-rearing	58	11[f]	13	0.23	0.04	135	5	6	0	0	0
Outside of Survey Subareas[c]											
Nesting	5	3	–	–	–	42	16	–	0	0	–
Brood-rearing	9	0	0	–	–	46	0	0	0	0	0
Total (subareas combined)[d]											
Nesting	66	29[e]	–	0.13	0.06	286	106	–	8	1	–
Brood-rearing	85	15[f]	17	0.16	0.03	265	15	16	7	1	1

[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 (<5 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 only portions of each subarea were surveyed

[d] Total is the sum of all subareas but density calculations included only 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] Number includes 3 nests in the CD North subarea of the Colville Delta study area and 2 nests in the Fish and Judy Creek Corridor subarea of the NPRA study area found only during monitoring surveys

[f] Number includes 2 broods in the CD North subarea of the Colville Delta study area, and 1 brood in the Fish Creek Delta subarea and 2 broods in the Fish and Judy Creek Corridor subarea of the NPRA study area determined by eggshell evidence

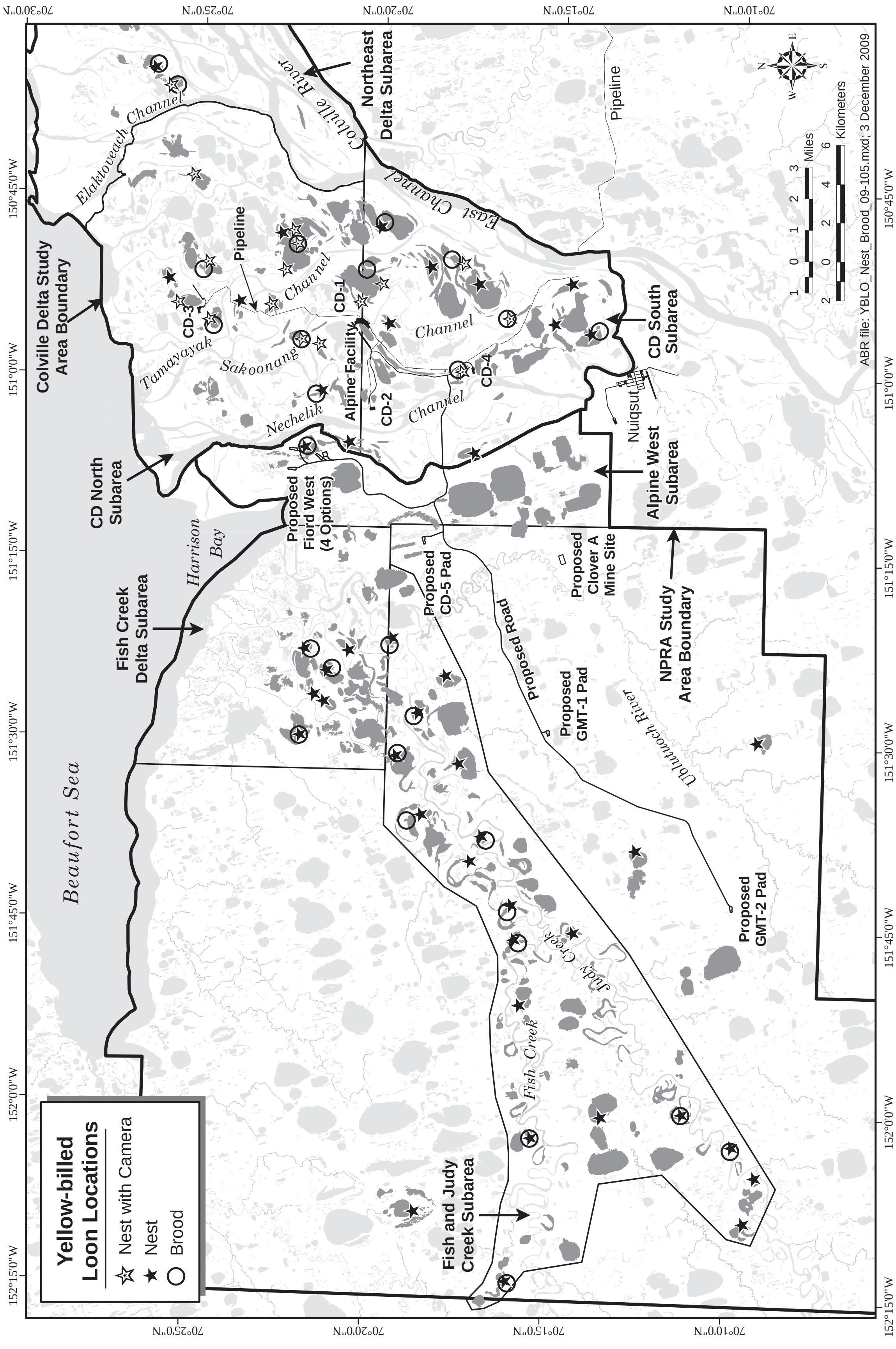

Figure 11. Yellow-billed Loon nests and broods, Colville Delta and NPRA study areas, Alaska, 2009.

Table 8. Habitat selection by nesting (1993–2009) and brood-rearing (1995–2009) Yellow-billed Loons, Colville Delta study area, Alaska.

SEASON Habitat	No. of Nests or Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	2.0	avoid	
Brackish Water	0	0	1.1	ns	low
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	17	5.3	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	21	6.6	4.9	ns	
Deep Open Water with Islands or Polygonized Margins	98	30.7	2.5	prefer	
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	0.6	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	5	1.6	<0.1	prefer	low
Deep Polygon Complex	14	4.4	2.8	ns	
Grass Marsh	3	0.9	0.3	ns	low
Young Basin Wetland Complex	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	34	10.7	8.7	ns	
Patterned Wet Meadow	121	37.9	24.6	prefer	
Moist Sedge–Shrub Meadow	3	0.9	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	ns	low
Tall, Low, or Dwarf Shrub	1	0.3	6.5	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.2	ns	low
Total	319	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	2.0	ns	low
Brackish Water	1	0.6	1.1	ns	low
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	31	19.7	5.4	prefer	
Salt Marsh	0	0	2.6	avoid	low
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	71	45.2	4.9	prefer	
Deep Open Water with Islands or Polygonized Margins	54	34.4	2.5	prefer	low
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	0	0	<0.1	ns	low
Deep Polygon Complex	0	0	2.8	avoid	low
Grass Marsh	0	0	0.3	ns	low
Young Basin Wetland Complex	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low
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	low
Tall, Low, or Dwarf Shrub	0	0	6.5	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.2	ns	low
Total	157	100	100		

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

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

[c] Expected number < 5

Table 9. Weekly status (A = active, I = inactive) and fate of Yellow-billed Loon nests, Colville Delta study area, Alaska, 2009. Status determined from camera-monitoring presented in parentheses where it differed from status determined from aerial surveys.

	June		July				August				
Territory	22–26	29	6–7	14	20	26	3	10	17	24	Fate/Total
1	A	A	A	I	–	–	–	–	–	–	Hatched
2[a]	A	A	A	A (I[b])	I	–	–	–	–	–	Hatched
4[a]	A	A	I	–	–	–	–	–	–	–	Failed
6[a]	A	A	A	I	–	–	–	–	–	–	Hatched
7	A	A	I	–	–	–	–	–	–	–	Failed
8[a]	A	A	I	–	–	–	–	–	–	–	Failed
9[a]	A	A	A	I	–	–	–	–	–	–	Hatched
10	I	A	A	A	A	A	A	A	A	I	Failed
12[a]	A	A	I	–	–	–	–	–	–	–	Failed
13[a]	A	A	A	A (I[c])	I	–	–	–	–	–	Hatched[d]
14[a]	A	I	–	–	–	–	–	–	–	–	Failed
16	A	I	–	–	–	–	–	–	–	–	Failed
17[a]	A	A	A (I[e])	I	–	–	–	–	–	–	Hatched
18[a]	A	A	I	–	–	–	–	–	–	–	Hatched
20	A	A	A	I	–	–	–	–	–	–	Failed
21	A	A	A	A	I	–	–	–	–	–	Hatched
22	A	A	I	–	–	–	–	–	–	–	Failed
23[a]	A	A	A	I	–	–	–	–	–	–	Hatched
25	A	A	A	A	I	–	–	–	–	–	Failed
27[a]	A	A	A	I	–	–	–	–	–	–	Hatched
29[a]	A	I	–	–	–	–	–	–	–	–	Failed
30	A	A	A	I	–	–	–	–	–	–	Hatched
36[a]	A	I	–	–	–	–	–	–	–	–	Failed
37[a]	A	A	A	A	I	–	–	–	–	–	Hatched[d]
38[a]	A	I	–	–	–	–	–	–	–	–	Failed
39	I	I	A	A	A	A	A	A	I	–	Failed
42	A	A	I	–	–	–	–	–	–	–	Failed
44	A	A	A	I	–	–	–	–	–	–	Failed
45	A	A	I	–	–	–	–	–	–	–	Failed
46	–[f]	A	A	I	–	–	–	–	–	–	Hatched
No. Active	27	24	17 (16)	7 (5)	2	2	2	2	1	0	30
No. Hatched	0	0	1 (2)	8 (10)	4 (2)	0	0	0	0	0	13
No. Failed	0	5	7	2	1	0	0	0	1	1	17

[a] Nest monitored by camera and by aerial survey
[b] Camera images show that this nest hatched on 12 July; young were being brooded in the nest on 14 July
[c] Camera images reveal this as the day of hatch
[d] No brood was seen but nest classified as hatched based on eggshell fragments at the nest and chicks detected on camera images
[e] Camera images show that this nest hatched 6 July; young were being brooded in the nest on 7 July
[f] Territory was not surveyed during the nesting surveys

Seventeen of 30 Yellow-billed Loon nests on the Colville Delta failed to hatch (Table 9). Five of 17 nests (29%) failed by 29 June, the week after the nest survey. Seven more nests failed by 7 July, 2 more by 14 July, and 1 more by 20 July. After 20 July, only 2 nests were active and both failed in late August. One of those nests was active for a minimum of 49 d, or ~21 days longer than the reported incubation period for Yellow-billed Loons (North 1994). Reasons for the extended incubation are unknown but may be attributed to infertile or damaged eggs or this loon may have suffered predation and renested between monitoring surveys.

The contents of all 30 Yellow-billed Loon nests were examined after nests were no longer active. Thirteen nests were classified as successful and 17 failed based on the presence or absence of eggshell fragments and other egg remains at the nest. Successful nests contained 27–76 eggshell fragments, and broods were observed at all of these nests, including 2 nests where chicks were seen only on camera images. Of >520 eggshell fragments found in successful nests, 69% were ≤10 mm in length. Six of 13 successful nests also contained pieces of thickened egg membrane. Membranes were whole at 1 nest but at all other pieces were 11–30 mm in length. The majority of egg membranes and eggshell fragments were found in nest bowls; only 87 fragments were found in the water or on shore adjacent to successful nests. Five of the 17 failed nests had egg remains in the nest or nearby. Broken whole eggs or eggs with holes in them were found within 8 m of 3 nests, and 2 nests contained ≤5 egg fragments with adhered egg membranes, some of which had yolk on them. The remaining 12 nests were empty.

Time-lapse Cameras

We monitored 16 of 30 Yellow-billed Loon nests with time-lapse cameras in 2009 (Table 10). Zoom cameras were placed 30–119 m from nests (mean = 60 m, n = 13) and standard cameras were placed 19–35 m from nests (mean = 25 m, n = 3). Researchers were transported to and from nesting areas by helicopter for camera setup and were at nests an average of 45 min (range 24–88 min, n = 16 nests). Fourteen of 16 loons left their nests during camera setup: 1 swam away from its nest as the helicopter landed, 10 left as researchers approached the camera setup location, and 1 loon left its nest when the helicopter increased power for take off after dropping off researchers. We could not discern whether the remaining 2 loons swam away as the helicopter landed or as we unloaded. Three loons flushed from nest lakes during camera installation: 2 nested on lakes <1.5 ha and 1 nested on a lake <0.5 ha with a narrow connection to a larger brood-rearing lake. All of those loons flushed to their adjacent brood-rearing lakes. Most loons did not flush, but stayed in the nest lake, although it is possible that we missed some flushing events while installing cameras.

All 14 of the loons that left nests returned to incubate after camera installation. Six returned before we departed in the helicopter, whereas the remaining 8 returned an average of 55 min (median = 25 min, range 6–180 min) after we departed in the helicopter. In total, loons were absent from nests an average of 67 min during camera installation (median = 37 min, range 23–245 min, n = 14 nests). An abnormally long absence from a nest (245 min) occurred where we were dropped off between 2 nests that were 800 m apart. Loons at the first nest left the nest during camera installation and did not return until we completed camera installation at the second nest, nearly doubling the duration of disturbance for that nesting pair.

Cameras successfully recorded daily nest survival data, and we were able to identify the day of hatch or failure from all camera-monitored nests. Of the 16 nests that were monitored, 9 hatched and 7 failed for an apparent nesting success of 56%. The median initiation date of camera-monitored nests was 11 June (range 8–23 June, n = 15), and the median hatch date for successful nests was 9 July (range 6–16 July; Table 10). Hatch dates determined from camera images agree with dates determined from monitoring surveys, which indicates that most nests hatched between visits on 7 and 14 July. Excluding the day of hatch or failure, loons at both hatched and failed nests exhibited high nest attendance, spending 98.1% (n = 9) and 96.6% (n = 5) of the time incubating, respectively.

Of the 7 nests that failed to hatch, 3 failures were attributed to Glaucous Gulls, 2 were attributed to predation by red foxes, 1 to a brown bear, and 1 to a Parasitic Jaeger (Table 10). At all 4 nests that failed because of gull or jaeger predation,

Table 10. Nest history and incubation activity at Yellow-billed Loon nests monitored by time-lapse digital cameras, Colville Delta study area, Alaska, 2009.

Territory	Fate[a]	Nest initiation date[b]	Predator	No. eggs[c]	No. chicks	Date camera setup	Date of hatch or failure	No. days monitored[d]	Incubation constancy[d] (%)	Exchange frequency[d] (no/d)	Recess frequency[d] (no/d)	Recess length[d] (min/recess)
2[e]	S	14 June		U	2	24 June	12 July	17.1	99.1	2.3	0.9	12.5
4	F	23 June	Glaucous Gull	1	0	24 June	30 June	5.5	92.2	0.2	4.0	22.5
6	S	9 June		2	2	24 June	7 July	12.6	99.2	2.2	0.9	8.5
8	F	11 June	Glaucous Gull	2	0	24 June	3 July	8.4	94.5	1.0	4.5	18.5
9	S	9 June		2	2	24 June	7 July	12.7	98.5	1.3	2.5	7.2
12	F	10 June	Brown Bear	2	0	22 June	29 June	6.4	98.9	1.9	1.2	7.3
13	S	16 June		2	1	22 June	14 July	21.1	95.8	1.4	2.6	20.5
14	F	16 June	Red Fox	2	0	24 June	25 June	<1.0[f]	–	–	–	–
17	S	8 June		U	2	23 June	6 July	11.8	99.1	1.6	1.4	7.4
18	S	8 June	Parasitic Jaeger	2	1	23 June	6 July	12.1	99.3	2.7	0.4	13.9
23	S	11 June		2	1	23 June	9 July	15.7	98.3	0.7	2.4	9.7
27	S	13 June	Parasitic Jaeger	2	1	23 June	11 July	16.7	97.4	1.3	2.3	14.6
29	F	–	Red Fox	U	0	24 June	29 June	4.0	98.8	5.2	0.5	4.3
36	F	8 June	Glaucous Gull	1	0	23 June	24 June	<1.0[f]	–	–	–	–
37	S	18 June	Golden Eagle	U	1	23 June	16 July	22.0	96.0	1.3	4.3	13.2
38	F	8 June	Parasitic Jaeger	2	0	24 June	26 June	1.8	98.7	2.3	1.7	8.3

[a] S = successfully hatched, F = failed to hatch
[b] Nest initiation dates for successful nests estimated by subtracting 28 d from hatch date; for failed nests, nest age estimated using egg floatation (see Methods: Loon Surveys)
[c] As known on day of camera setup; U = unknown
[d] Excludes day of camera installation and periods of time when photo images could not be interpreted because of poor weather conditions
[e] The incubating loon was inadvertently flushed from its nest twice by researchers (unrelated to this study) and that time off the nest was included in the incubation activity as 2 recesses
[f] Incubation statistics were not calculated for nests that were monitored for <1 d

nest attendance was poor prior to predation and all 4 nests were unattended at the time of predation. At both nests taken by foxes, an adult loon was incubating in a concealment posture prior to the appearance of the fox and both loons were observed swimming nearby during the predation event. Each fox predation event lasted 1–2 min. At the nest taken by a bear, the incubating loon left the nest 6 min prior to the image containing the bear and without exhibiting concealment postures. The bear was at the nest for ~1 min.

Although all loons returned to incubate after camera installations, we suspect that the presence of the camera may have contributed to poor nest attendance at 2 of the avian-depredated nests, resulting in the failure of those nests. Both nests were monitored with standard cameras (without zoom lenses) that were placed 20 m from nests. At one such nest (territory 36), 1 adult returned to the nest 163 min after we departed the area, but incubated for only 12 min before leaving for another 219 min. The loon then incubated for ~5 h before it left and did not return. A Glaucous Gull nested ~15 m from this nest and 7.5 h after the last departure of a loon, a gull was at the nest eating eggs. At the other nest (territory 38), avian predation may have occurred immediately following camera installation and before the loons returned to the nest. Twelve minutes after we departed in the helicopter, a Parasitic Jaeger landed at the nest for ~2 min. In the subsequent image, a loon was incubating and the jaeger was gone, but the loon only incubated for ~2 min before swimming away from the nest. A loon remained near the nest, but did not incubate for another 358 min. A Glaucous Gull was seen standing within 5–25 m of the nest on 3 occasions, including once while the loon was on recess. No additional predation was captured by camera images, but 2 d after camera installation, the loon swam away from the nest and did not return.

At nests which hatched successfully, cameras documented partial predation (i.e., loss of 1 of 2 eggs) at 2 nests, and documented or allowed us to infer complete brood loss at 2 nests. Partial predation occurred on the day of hatch at territory 18. The adults of this territory were swimming to and from the nest with 1 chick and were periodically returning to either brood the second chick or incubate the second egg. During one absence, 2 Parasitic Jaegers landed at the nest for ~4 min. Both jaegers had their heads in the nest and appeared to be eating the contents. We also observed partial nest predation by a Parasitic Jaeger at territory 27. While the incubating adult was on recess, a jaeger landed at the nest for ~2 min. In the next image that lacked the jaeger, a swimming loon appeared, suggesting that the loon may have chased the jaeger from the nest. No further predation was observed and the nest hatched 1 chick.

One chick each was observed at both territories 13 and 37, but neither survived to the following monitoring survey. Predation was not documented on the camera images at territory 13, and we do not know why that chick died. At territory 37, a Golden Eagle likely took the single chick. In the photo images, at least 1 young was being brooded by an adult and then both adults left the nest area. An eagle appeared ~11 min later and perched within 5 m of the nest for ~17 min. After the eagle left both adult loons returned and swam near the nest, but did not resume brooding. No chicks were visible in subsequent photo images and none were observed during the weekly brood-monitoring surveys.

Similar to 2008, cameras successfully documented daily nest survival. We moved the cameras with zoom lenses closer to nests in 2009 and were able to identify nest predators and record the number of chicks hatched. Also, with cameras placed closer to nests, the behavior of incubating loons was interpretable during foggy weather, unlike in 2008 when cameras were farther from nests. However, the proximity of standard cameras (~20 m) may have adversely affected incubation behavior at 2 nests, contributing to their failure. Last year, we deployed those cameras without negative reactions, indicating that some loons may be more tolerant of disturbance than others. From our experience, we do not recommend continued use of cameras without zoom lenses, and we do not recommend monitoring loon nests within 50 m of active gull nests. Because Glaucous Gulls tend to nest on islands similar to where Yellow-billed Loons nest, and because Glaucous Gulls are more numerous, it can be difficult to find loon nests with no gulls nearby. We have used cameras to monitor several successful nests with gull nests located 50–75 m away, so we suspect that nests farther than 50 m from gull nests may be more resistant to gull predation. We will evaluate the effect of distance to nearest gull nest on Yellow-billed Loon hatching success in future reports.

Brood Fate

During the monitoring survey following hatch, 10 of 13 (77%) Yellow-billed Loon pairs that hatched young were observed with a single chick, and 1 (8%) pair was observed with 2 chicks (Table 11). Broods were not observed at 2 territories during monitoring surveys but nests were judged successful based on the presence of eggshell fragments at the nest, and later confirmed by the detection of chicks on camera images at both nests. Chicks at both nests died between hatch and the next monitoring survey. Cameras also documented the deaths of chicks at 3 other territories, where 2 chicks were observed on camera images but only 1 was observed during subsequent monitoring surveys. Based on camera and brood-monitoring data, a minimum of 17 chicks were produced by 30 nests (0.57 chicks/nest).

Eleven of 13 (85%) Yellow-billed Loon pairs that hatched at least 1 egg retained 1 chick on the final monitoring survey on 11 September. No broods had 2 chicks on 11 September. Only 2 pairs suffered complete brood loss, both within 1–5 d after hatch.

One goal of brood monitoring was to estimate juvenile recruitment, or how many chicks survived to fledging. From the 30 known Yellow-billed Loon nests, 11 chicks survived until the last survey on 11 September (0.37 chicks/nest). Most loon chicks were ~10 weeks old (range = 9–11 weeks) and none were observed flying by that time (Table 11). 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 9–10 weeks old were observed exercising their wings by wing stretching or flapping and by running across the water while wing-flapping.

NPRA

Distribution and Abundance

During the nesting survey in 2009, 66 Yellow-billed Loons and 29 nests were recorded in the NPRA study area (Figure 11, Table 7). Two of those nests were found during the weekly monitoring survey on 29 June. Both 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 (0.16 birds/km²; 0.07 nests/km²), followed by the Fish Creek Delta subarea (0.13 birds/km²; 0.05 nests/km²), and the Alpine West subarea (0.03 birds/km²; 0.01 nests/km²). The density of adult Yellow-billed Loons in the NPRA study area during nesting in 2009 (0.13 birds/km²) was slightly less than in 2008 (0.17 birds/km²), but the density of nests (0.06 nests/km²) was the same. Three of the 29 nests were found outside of the survey subareas and were not included in density calculations in order to be consistent with data presentations from previous years. Two nests found in the Fish Creek Delta subarea were on lakes without a previous history of nesting by Yellow-billed Loons, although these lakes were within areas previously surveyed (in 2005, 2006, and 2008). However, at each of these lakes a pair of apparently non-nesting Yellow-billed Loons was recorded in 1 of the 3 previous survey years and Pacific Loons occupied both lakes in the other 2 years. All other Yellow-billed Loon nests found in NPRA in 2009 were on lakes where nesting was recorded during surveys in previous years (Johnson et al. 2005, 2006b, 2007b, 2009).

During brood-rearing in 2009, 85 adult Yellow-billed Loons and 15 broods were observed in the NPRA study area (Figure 11, Table 7). Most broods (73%) were found in the Fish and Judy Creek subarea. Three broods were observed in the Fish Creek Delta subarea and 1 brood in the Alpine West subarea. At 3 nests, hatching was confirmed by eggshell evidence although no brood was observed on aerial surveys. The density of Yellow-billed Loon broods in the NPRA study area in 2009 was 0.03 broods/km², slightly less than the density reported in 2008 (0.04 broods/km²).

Habitat Use

Habitat selection was evaluated for nesting and brood-rearing Yellow-billed Loons in 2008 and 2009 in the subareas surveyed for loons (Alpine West, Fish Creek Delta, and Fish and Judy Creek) in the NPRA study area. Yellow-billed

Table 11. Number of Yellow-billed Loon chicks observed during weekly aerial surveys, Colville Delta study area, Alaska, 2009. Status and number of chicks determined by camera-monitoring are presented in parentheses where it differed from counts determined during aerial surveys.

Territory	July				August					September		Age (d) when last seen	Brood fate[a]
	6–7	14	20	26	3	10	17	24	31	7	11		
1	Inc[b]	1	1	1	1	1	1	1	1	1	1	62.5	A
2[c]	Inc	Inc (2[d])	2	2	2	2	2	1	1	1	1	56.0 (61)	A
6[c]	Inc	1[e] (2)	1	1	1	1	1	1[e]	1[e]	1	1	63.0 (66)	A
9[c]	Inc	1[e] (2[d])	1	1	1	1	1	1	1	1	1	63.0 (66)	A
13[c]	Inc	Inc (1[d])	0[f]	0	0	–	–	–	–	–	–	3.0	F
17[c]	Inc (2[d])	1	1	1	1	1	1	1[e]	1	1	1	62.5 (67)	A
18[c]	1	1	1	1	1	1	1	1	1	1	1	70.0 (67)	A
21	Inc	Inc	1	1[d,e]	1	1	1	1[e]	1	1	1	56.0	A
23[c]	Inc	1	1	1	1	1	1	1	1	1	1	62.5 (64)	A
27[c]	Inc	1	1	1	1	1	1	1	1[e]	1	1	63.0 (62)	A
30	Inc	1	1	1	1	1	1	1	1[e]	1[e]	1	63.0	A
37	Inc	Inc	0[f]	0	0	–	–	–	–	–	–	3.0 (1)	F
46	Inc	1	1	1	1	1	1	1	1	1	1	62.5	A
Totals													
Broods of 2	0 (1)	0 (3)	1	1	1	1	1	0	0	0	0	–	–
Broods of 1	1	9 (10)	10	10	10	10	10	11	11	11	11	–	–
Chick loss	0	0 (1)	2 (4)	0	0	0	0	1	0	0	0	–	–

[a] A = active, young present on 11 September, F = failed
[b] Inc = loon incubating at the time of the survey
[c] Nest monitored by camera and by weekly aerial survey
[d] Adult brooding chick(s)
[e] No chick(s) observed; 1 chick assumed present based on subsequent aerial surveys
[f] No chick(s) observed; at least 1 egg hatched during previous week based on nest contents or camera images; chick did not survive to aerial survey and assume 1 chick died

Loon nests were found in 12 of 26 available habitats in the NPRA study area for loons (Table 12). Three habitats were preferred for nesting (Deep Open Water with Islands or Polygonized Margins, Tapped Lake with High-water Connection, and Sedge Marsh), altogether supporting 25 of 47 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 the aquatic habitat of the lake; otherwise nests were assigned to the terrestrial habitat on the lakeshore. Deep Open Water with Islands or Polygonized Margins was the most frequently used habitat for nesting (38% of all nests), and it also was the most abundant waterbody habitat in the loon survey area (7%; Table 12). Nesting Yellow-billed Loons avoided 2 habitats, Moist Sedge-Shrub Meadow and Moist Tussock Tundra, which together occupied 33% of the loon survey area in the NPRA study area.

Twenty-four Yellow-billed Loon broods were found in 4 habitats in the NPRA study area, 2 of which were preferred: Deep Open Water with Islands or Polygonized Margins and Tapped Lake with High-water Connection (Table 12). Deep Open Water with Islands or Polygonized Margins was the most frequently used habitat for brood-rearing (83% of all broods). 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 Monitoring and Nest Fate

Overall, 15 of 29 Yellow-billed Loon nests in the NPRA study area in 2009 hatched for an apparent nesting success of 52% (Table 13). The same number of nests occurred in 2008, but nesting success was higher in that year (65%; Johnson et al. 2009). At 3 successful nests, hatching was confirmed by eggshell evidence, although no young were observed. Of the 15 successful nests, most hatched during the first 2 weeks of July: 5 nests (33%) hatched by 7 July and 9 (60%) hatched by 14 July. The remaining nest (7%) hatched between nest visits on 26 July and 3 August. Aside from the 3 broods that were lost between hatch and the following monitoring survey, all other broods survived until the time of the last monitoring survey (11 September).

Fourteen of 29 Yellow-billed Loon nests in the NPRA study area failed to hatch (Table 13). Two of 14 (14%) nests failed between the nesting survey and the first monitoring survey on 29–30 June. Ten (71%) nests failed during the following week (30 June–7 July). One of those 10 nests had 2 cold eggs on 6 July, and was apparently abandoned. Two adult Yellow-billed Loons were present on the far side of the nest lake but did not appear defensive or agitated by the presence of a researcher at the nest. Both eggs were found broken near the nest during the next visit on 14 July. One additional nest (7%) failed between 7 and 14 July. The remaining nest (7%) failed between visits on 10 and 18 August and was active for a minimum of 40 days, or ~12 d longer than the reported incubation period for Yellow-billed Loons (North 1994). Reasons for the extended incubation are unknown but may be attributed to infertile or damaged eggs or this loon may have suffered predation and renested between monitoring surveys.

The contents of 27 of 29 Yellow-billed Loon nests were examined after nests were no longer active. Two nests were not examined because they were on islands that were inaccessible by helicopter; both nests hatched based on the presence of broods. In addition to those 2 nests, 13 nests were classified as successful based on the presence of eggshell fragments in the nest. These nests contained 25–80 small eggshell fragments inside the nest. Broods were observed at all but 3 of these nests. Of nearly 600 eggshell fragments found in successful nests, 69% were ≤10 mm in length. Five of 13 successful nests also contained pieces of thickened egg membrane. Membranes were whole at 1 nest while the remainder had pieces ranging 11–70 mm in length. The majority of egg membranes and eggshell fragments were found in nest bowls and only ~50 fragments were found in the water or on shore adjacent to successful nests. Six of the 14 failed nests, including the nest that was abandoned, were associated with broken eggs. Most broken eggs were found within 5 m of nests. In addition to a broken egg, 1 nest also contained a piece of dried egg membrane and 5 egg fragments with adhered

Table 12. Habitat selection by nesting and brood-rearing Yellow-billed Loons, NPRA study area, Alaska, 2008–2009.

SEASON Habitat	No. of Nests or Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	5.5	ns	low
Brackish Water	0	0	2.3	ns	low
Tapped Lake with Low-water Connection	0	0	1.5	ns	low
Tapped Lake with High-water Connection	5	10.6	1.2	prefer	low
Salt Marsh	0	0	4.1	ns	low
Tidal Flat Barrens	0	0	4.1	ns	low
Salt-killed Tundra	0	0	1.6	ns	low
Deep Open Water without Islands	1	2.1	5.5	ns	low
Deep Open Water with Islands or Polygonized Margins	19	40.4	6.5	prefer	low
Shallow Open Water without Islands	0	0	0.8	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	4.3	1.5	ns	low
River or Stream	0	0	2.2	ns	low
Sedge Marsh	4	8.5	1.5	prefer	low
Deep Polygon Complex	0	0	0.1	ns	low
Grass Marsh	1	2.1	0.4	ns	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	0	0	4.0	ns	low
Riverine Complex	0	0	0.1	ns	low
Dune Complex	2	4.3	2.0	ns	low
Nonpatterned Wet Meadow	2	4.3	3.3	ns	low
Patterned Wet Meadow	8	17.0	12.3	ns	
Moist Sedge-Shrub Meadow	2	4.3	16.7	avoid	
Moist Tussock Tundra	1	2.1	16.0	avoid	
Tall, Low, or Dwarf Shrub	0	0	4.6	ns	low
Barrens	0	0	2.1	ns	low
Human Modified	0	0	0	ns	
Total	47	100	100.0		
BROOD-REARING					
Open Nearshore Water	0	0	5.5	ns	low
Brackish Water	0	0	2.3	ns	low
Tapped Lake with Low-water Connection	0	0	1.5	ns	low
Tapped Lake with High-water Connection	3	12.5	1.2	prefer	low
Salt Marsh	0	0	4.1	ns	low
Tidal Flat Barrens	0	0	4.1	ns	low
Salt-killed Tundra	0	0	1.6	ns	low
Deep Open Water without Islands	1	4.2	5.5	ns	low
Deep Open Water with Islands or Polygonized Margins	20	83.3	6.5	prefer	low
Shallow Open Water without Islands	0	0	0.8	ns	low
Shallow Open Water with Islands or Polygonized Margins	0	0	1.5	ns	low
River or Stream	0	0	2.2	ns	low
Sedge Marsh	0	0	1.5	ns	low
Deep Polygon Complex	0	0	0.1	ns	low
Grass Marsh	0	0	0.4	ns	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	0	0	4.0	ns	low
Riverine Complex	0	0	0.1	ns	low
Dune Complex	0	0	2.0	ns	low
Nonpatterned Wet Meadow	0	0	3.3	ns	low
Patterned Wet Meadow	0	0	12.3	ns	low
Moist Sedge-Shrub Meadow	0	0	16.7	avoid	low
Moist Tussock Tundra	0	0	16.0	avoid	low
Tall, Low, or Dwarf Shrub	0	0	4.6	ns	low
Barrens	0	0	2.1	ns	low
Human Modified	0	0	0	ns	
Total	24	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 13. Weekly status (A = active, I = inactive) and fate of Yellow-billed Loon nests, NPRA study area, Alaska, 2009.

	June		July				August			
Territory	24–27	29–30	6–7	13–14	20–21	26	3	10	18	Fate/total
51	A	A	A	I	–	–	–	–	–	Hatched
52	A	A	A	I	–	–	–	–	–	Hatched
54	A	A	A	I	–	–	–	–	–	Failed
55	A	A	I	–	–	–	–	–	–	Hatched
57	A	A	A	I	–	–	–	–	–	Hatched
61	I	A	A	A	A	A	A	A	I	Failed
62	A	A	A	A	A	A	I	–	–	Hatched
64	–[a]	A	A	I	–	–	–	–	–	Hatched
65	A	A	I	–	–	–	–	–	–	Failed
71	A	A	I	–	–	–	–	–	–	Failed
72	A	A	I	–	–	–	–	–	–	Hatched
73	A	A	I	–	–	–	–	–	–	Hatched
75	A	A	I	–	–	–	–	–	–	Failed
78	A	A	I	–	–	–	–	–	–	Failed
80	A	A	A	I	–	–	–	–	–	Hatched
81	A	A	A	I	–	–	–	–	–	Hatched[b]
82	A	I	–	–	–	–	–	–	–	Failed
83	A	A	I	–	–	–	–	–	–	Hatched[b]
84	A	A	I	–	–	–	–	–	–	Failed
85	A	I	–	–	–	–	–	–	–	Failed
86	A	A	A	I	–	–	–	–	–	Hatched
87	A	A	I	–	–	–	–	–	–	Failed
89	A	A	I	–	–	–	–	–	–	Failed
91	A	A	I	–	–	–	–	–	–	Hatched
92	A	A	I	–	–	–	–	–	–	Failed
93	A	A	I	–	–	–	–	–	–	Failed
95	A	A	I	–	–	–	–	–	–	Failed
96	A	A	A	I	–	–	–	–	–	Hatched
97	A	A	A	I	–	–	–	–	–	Hatched[b]
No. Active	27	27	12	2	2	2	1	1	0	29
No. Hatched	0	0	5	9	0	0	1	0	0	15
No. Failed	0	2	10	1	0	0	0	0	1	14

[a] Nest not seen during the survey; it was either missed or the loon was off its nest
[b] No brood seen but nest classified as hatched based on eggshell remains at the nest

membranes. The remaining 8 nests were empty. Except for the abandoned nest and the nest that may have had infertile or damaged eggs, causes of nest failure were unknown.

Brood Fate

During the monitoring survey following hatch, 9 of 15 (60%) successful Yellow-billed Loon pairs in the NPRA study area were observed with 2 chicks, 3 had 1 chick, and 3 pairs lost their brood (unknown number of chicks) between hatching and the next weekly survey (Table 14). Assuming a minimum of 1 chick for each of these nests with an unknown number of chicks, a minimum of 24 chicks were produced at 29 detected nests (0.83 chicks/nest).

Table 14. Number of Yellow-billed Loon chicks observed during weekly surveys, NPRA study area, Alaska, 2009.

	July				August					September		Age (d) when last seen	Brood fate[a]
Territory	6–7	13–14	20–21	26	3	10	18	24	31	7	11		
51	Inc[b]	2	–[c]	1	1	1	1	1[d]	1[d]	1	1	63.0	A
52	Inc	2	2	2[e]	2	2	2	2[f]	2	1	1	63.5	A
55	1[d,g]	1	1	1	1	1	1	1	1	1	1	70.5	A
57	Inc	1	1[d]	1	1	1	1	1	1[d]	1[d]	1	63.5	A
62	Inc	Inc	Inc	Inc	2	1	1	1[d]	1	1	1	43.0	A
64	Inc	2	1	1	1	1	1	1	1	1	1	63.5	A
72	2[e,g]	2	2	2	2	2	2	2	2	2	2	70.0	A
73	2	2	2	1	1	1	1	1	1	1	1	70.0	A
80	Inc	2[f]	2	2[f]	2	2	2	1[d]	1	1	1	63.0	A
81	Inc	0[h]	0	0	–	–	–	–	–	–	–	4.0	F
83	0[h]	0	0	0	–	–	–	–	–	–	–	3.0	F
86	Inc	2[e,g]	2[e]	2	2	2[f]	2	2	2	2	2	63.0	A
91	2[f]	2	2	2[e]	2	2	2	2	2	2	2	70.5	A
96	Inc	1	1	1	1	1	1	1	1	1	1	63.5	A
97	Inc	0[h]	0	0	–	–	–	–	–	–	–	3.5	F
Totals													
Broods of 2	3	8	6	5	6	5	5	4	4	3	3	–	–
Broods of 1	1	3	4	6	6	7	7	8	8	9	9	–	–
Chick loss	1	2	1	2	0	1	0	1	0	1	0	–	–

[a] A = active, young present on 11 September, F = failed
[b] Inc = loons incubating at the time of the survey
[c] Not surveyed due to proximity of occupied hunting camp
[d] No chick observed; 1 chick assumed present based on subsequent aerial surveys
[e] No chick observed; 2 chicks assumed present based on subsequent aerial surveys
[f] One of 2 chicks observed; both assumed present based on subsequent aerial surveys
[g] Adult brooding chicks
[h] No chick observed; at least 1 egg hatched during previous week based on nest contents; chick did not survive to aerial survey and assume 1 chick died

Although most loons hatched 2 chicks, during the final weekly survey on 11 September only 3 pairs still had 2 chicks and 9 pairs had a single chick. We recorded 15 chicks at 12 territories during our last survey on 11 September (total chick production = 0.51 chicks/nest). Most loon chicks were ~10 weeks old (range 8–11 weeks) and none were observed flying by that time (Table 14). Assuming the fledging period is similar to that of Common Loons (McIntyre and Barr 1997, North 1994), the loon chicks were within a week or 2 of fledging. In this study, chicks 9–10 weeks old were observed exercising their wings by wing stretching or flapping and by running across the water while wing-flapping.

PACIFIC AND RED-THROATED LOONS

Colville Delta

We counted 137 Pacific Loons and 48 Pacific Loon nests and 4 Red-throated Loons (and no Red-throated Loon nests) in the Colville Delta study area during the nesting survey for Yellow-billed Loons in 2009 (Figure 12, Table 7). During the brood-rearing survey, 129 adult Pacific Loons with 12 broods and 10 Red-throated Loons with 2 broods were observed in the Colville Delta study area (Figure 12, Table 7). 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 for these 2 species. Nonetheless, Pacific Loons were clearly the most abundant loon on the delta in 2009 and in previous years.

NPRA

Pacific Loons also were the most abundant and widespread loon species breeding in the NPRA study area in 2009 (Figure 12, Table 7). On the loon nesting survey, we recorded 286 adult Pacific Loons with 106 nests and 8 Red-throated Loons with 1 nest. During the brood-rearing survey, 265 adult Pacific Loons (15 broods) and 7 Red-throated Loons (1 brood) were counted.

TUNDRA SWAN

COLVILLE DELTA

Distribution and Abundance

During the 2009 swan nesting survey, 389 swans, including 97 pairs, were counted in the Colville Delta study area (Figure 13). The count of swans in 2009 was somewhat greater than the 16-year mean of 378 swans found in the study area. Forty swan nests were found in the Colville Delta study area in 2009 (Table 15), greater than the annual mean of 35 nests. Fourteen nests were located in the CD North subarea, 13 were in the CD South subarea, and 13 were in the Northeast Delta subarea. Nine 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 15), for consistency with data presentations from previous years; however, all swan nests are shown in Figure 13.

Productivity of Tundra Swans was poor on the Colville Delta in 2009. During the brood-rearing survey, 17 Tundra Swan broods were observed in the Colville Delta study area; well below the 16-year mean of 25 broods. Apparent overall nesting success was low, at 43% (Table 15). Nesting success also was low (34%) in the adjacent Kuparuk oilfield (Stickney et al. 2010). The mean brood size of 2.8 young in 2009 was greater than the 16-year mean of 2.5; however, the total of 47 young counted on the delta was below the 16-year mean of 64 young per year.

Habitat Use

Habitat selection was evaluated for 556 Tundra Swan nests recorded on the Colville Delta since 1992 (Table 16). 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,

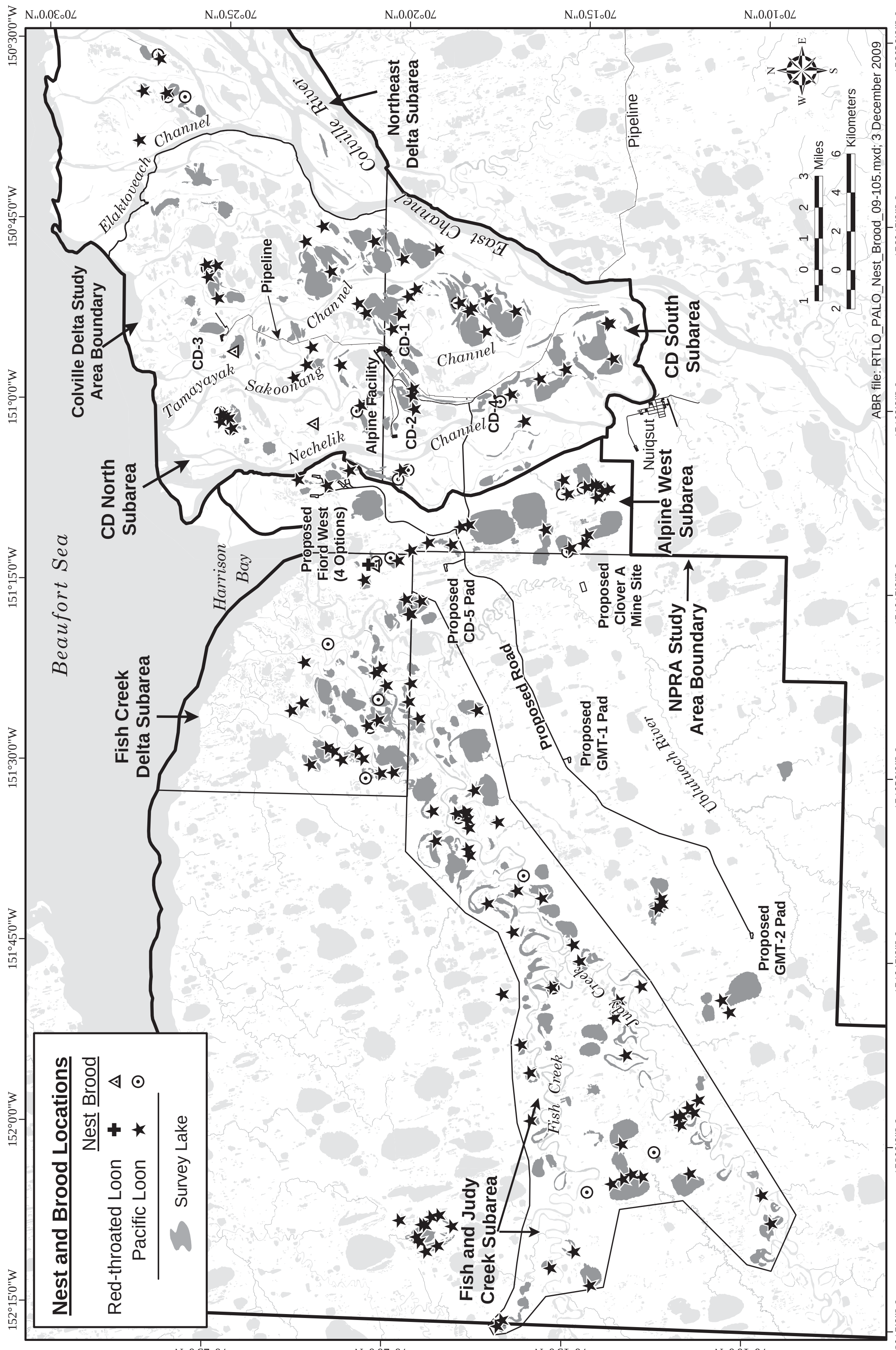

Figure 12. Pacific and Red-throated loon nests and broods, Colville Delta and NPRA study areas, Alaska, 2009.

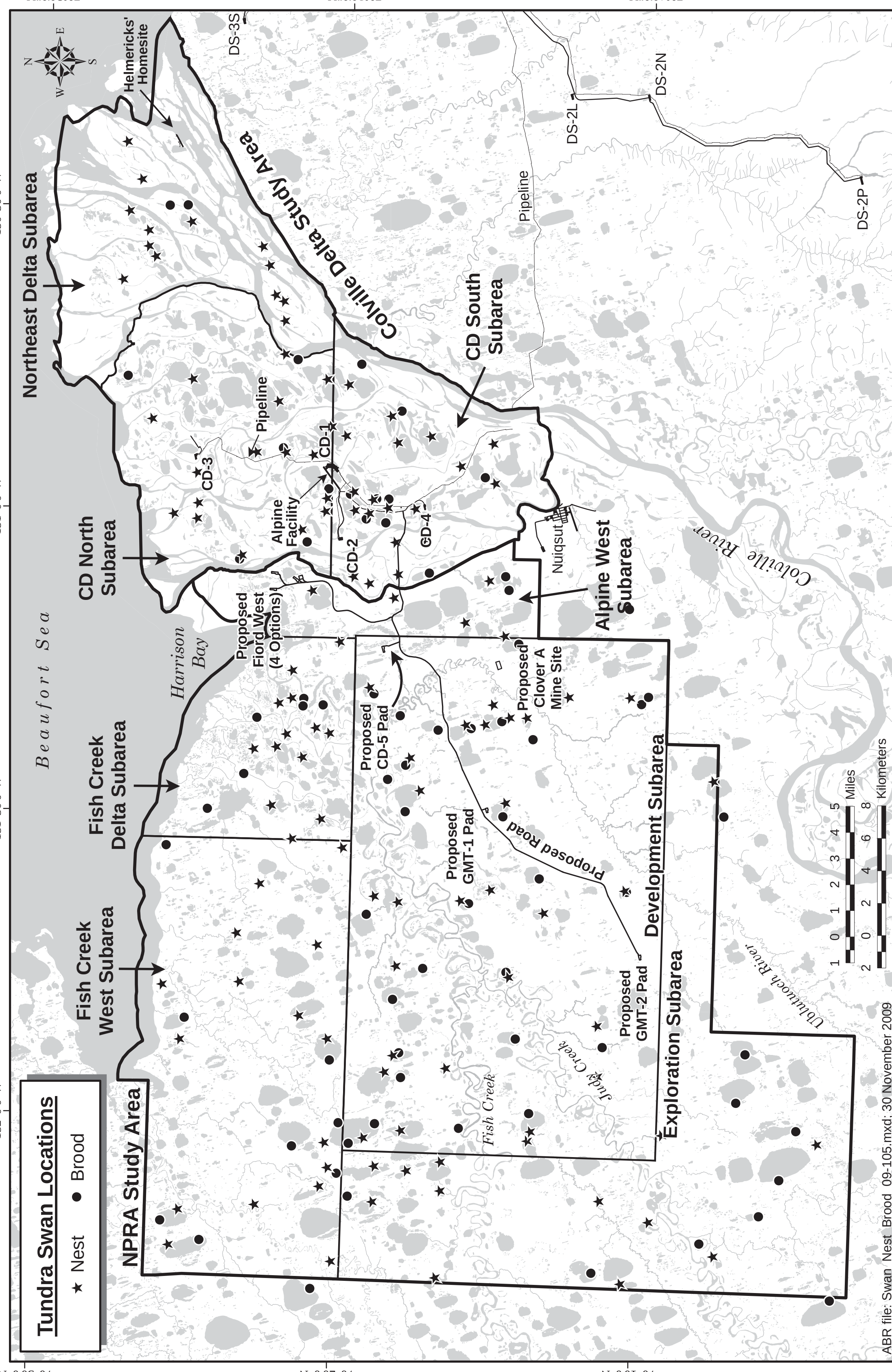

Figure 13. Tundra Swan nests and broods, Colville Delta and NPRA study areas, Alaska, 2009.

Table 15. Number and density of Tundra Swan nests and broods during aerial surveys, Colville Delta and NPRA study areas, Alaska, 2009.

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	43	6	0.03	3.0
CD South	13	0.08	69	9	0.06	2.9
Northeast Delta	13	0.07	15	2	0.01	1.5
Total (subareas combined)	40	0.07	43	17	0.03	2.8
NPRA[c]						
Development	27	0.04	100	28	0.05	2.5
Alpine West	5	0.06	40	2	0.03	2.5
Fish Creek Delta	12	0.09	50	6	0.05	2.3
Fish Creek West	16	0.05	50	8	0.02	2.3
Exploration	13	0.03	62	8	0.02	1.9
Total (subareas combined)	73	0.05	71	52	0.03	2.3

[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

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 16 years of surveys, Tundra Swans nested in 18 of 24 available habitats, of which 9 habitats were preferred and 7 were avoided (Table 16). Eighty-three percent of the nests were found in the 9 preferred habitats: Salt Marsh, Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Sedge Marsh, Deep Polygon Complex, Grass Marsh, Patterned Wet Meadow, Moist Sedge–Shrub Meadow, and Moist Tussock Tundra. Nests occurred most frequently in Patterned Wet Meadow (37% of all nests), Deep Polygon Complex (14%), and Salt-killed Tundra (11%).

Habitat selection was evaluated for 404 Tundra Swan broods recorded on the Colville Delta since 1992 (Table 16). 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 (14% of all broods), and Patterned Wet Meadow (13%), and Tapped Lake with High-water Connections (11%).

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 36% of all swan broods on the delta were in salt-affected habitats, compared with only 20% of all nests (Table 16). Similar patterns have been reported by previous investigations (Spindler and Hall 1991, Monda et al. 1994).

Table 16. Habitat selection by nesting and brood-rearing Tundra Swans, Colville Delta study area, Alaska, 1992–1998 and 2000–2009.

SPECIES Habitat	No. of Adults	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	1.8	avoid	
Brackish Water	7	1.3	1.2	ns	
Tapped Lake with Low-water Connection	2	0.4	3.9	avoid	
Tapped Lake with High-water Connection	5	0.9	3.8	avoid	
Salt Marsh	36	6.5	3.0	prefer	
Tidal Flat Barrens	5	0.9	10.6	avoid	
Salt-killed Tundra	63	11.3	4.6	prefer	
Deep Open Water without Islands	15	2.7	3.8	ns	
Deep Open Water with Islands or Polygonized Margins	33	5.9	1.4	prefer	
Shallow Open Water without Islands	3	0.5	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns	low
River or Stream	0	0	15.0	avoid	
Sedge Marsh	2	0.4	<0.1	prefer	low
Deep Polygon Complex	75	13.5	2.4	prefer	
Grass Marsh	11	2.0	0.3	prefer	low
Young Basin Wetland Complex	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	38	6.8	7.5	ns	
Patterned Wet Meadow	204	36.7	18.6	prefer	
Moist Sedge-Shrub Meadow	26	4.7	2.2	prefer	
Moist Tussock Tundra	8	1.4	0.6	prefer	low
Tall, Low, or Dwarf Shrub	10	1.8	5.0	avoid	
Barrens	13	2.3	13.8	avoid	
Human Modified	0	0	0.1	ns	low
Total	556	100	100		
BROOD-REARING					
Open Nearshore Water	1	0.2	1.8	avoid	
Brackish Water	26	6.4	1.2	prefer	low
Tapped Lake with Low-water Connection	58	14.4	3.9	prefer	
Tapped Lake with High-water Connection	44	10.9	3.8	prefer	
Salt Marsh	30	7.4	3.0	prefer	
Tidal Flat Barrens	3	0.7	10.6	avoid	
Salt-killed Tundra	29	7.2	4.6	prefer	
Deep Open Water without Islands	35	8.7	3.8	prefer	
Deep Open Water with Islands or Polygonized Margins	12	3.0	1.4	prefer	
Shallow Open Water without Islands	6	1.5	0.4	prefer	low
Shallow Open Water with Islands or Polygonized Margins	2	0.5	0.1	ns	low
River or Stream	21	5.2	15.0	avoid	
Sedge Marsh	0	0	<0.1	ns	low
Deep Polygon Complex	10	2.5	2.4	ns	
Grass Marsh	9	2.2	0.3	prefer	low
Young Basin Wetland Complex	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	22	5.4	7.5	ns	
Patterned Wet Meadow	53	13.1	18.6	avoid	
Moist Sedge-Shrub Meadow	7	1.7	2.2	ns	
Moist Tussock Tundra	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	7	1.7	5.0	avoid	
Barrens	28	6.9	13.8	avoid	
Human Modified	0	0	0.1	ns	low
Total	404	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.

NPRA

Distribution and Abundance

During the 2009 nesting survey, 348 swans were counted in the NPRA study area. The total included 139 pairs, of which 73 pairs were nesting (Table 15). An additional 3 nests were discovered during helicopter-based loon-nesting surveys of limited portions of the NPRA study area. Nests were distributed unevenly throughout the 5 subareas, probably reflecting the differing quality of available nesting habitat in each (Figure 13, Table 15). Apparent nesting success among the subareas ranged from a low of 40% to a high of 100%. Over all subareas, apparent nesting success was 71%, which is high relative to the 43% apparent success of the adjacent Colville Delta.

Fifty-two swan broods were counted during the August brood-rearing survey, with an average of 2.3 young/brood; noticeably less than the 2.8 young /brood found on the Colville Delta in 2009.

Habitat Use

Habitat selection was calculated for 287 Tundra Swan nests recorded in the NPRA study area since 2001 (Table 17). Tundra Swans nested in 21 of 26 available habitats, but preferred only 4 habitats—Salt Marsh, Shallow Open Water with Islands or Polygonized Margins, Grass Marsh, and Young Basin Wetland Complex—in which 38 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 175 Tundra Swan broods recorded in the NPRA study area since 2001 (Table 17). Tundra Swan broods used 20 of 26 available habitats. One hundred and eleven broods were located in the 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 12% of swan broods were observed using the 2 avoided habitats.

GEESE

COLVILLE DELTA

Distribution and Abundance

During the goose brood-rearing aerial survey in 2009, we counted 679 Brant (501 adults and 178 young) in 6 groups in the Colville Delta study area (Figure 14, Table 18). All Brant groups included broods, and goslings comprised 26% of the total number of birds. Five Brant brood-rearing groups were located in the CD North subarea (652 total birds), and 1 was located in the Northeast Delta subarea (27 total birds). Comparable surveys have been conducted in the area for 11 years and the total count in 2009 was well below the average (mean = 1,194 Brant, range 45–3,847, n = 11 years: 1988, 1990–1993, 1995, and 2005–2009; Bayha et al. 1992; Johnson et al. 1999a, 2006b, 2008b, 2009). The gosling count was the third lowest, and gosling percentage the second lowest, in 9 years that goslings were recorded (1992–1993, 1995, and 2005–2009).

In 2009, 678 Snow Geese (463 adults and 215 goslings) in 15 groups were counted in the Colville Delta study area (Figure 14, Table 18), representing a sharp decline from the record 1,967 Snow Geese (834 adults and 1,133 goslings) recorded in 2008, and the lowest count since at least 2005 (Johnson et al. 2006b, 2007b, 2008b, 2009). Twelve (80%) groups contained broods, but goslings comprised only 32% of the total number of birds. Eight groups were located in the Northeast Delta subarea (400 total birds), and 7 were located in the CD North subarea (278 total birds).

During the fall-staging survey in 2009, we counted 259 Brant in 5 groups in the Colville Delta study area (Figure 15, Table 19). All 5 groups were located in the CD North subarea. Brant density was 1.7 birds/km² in the Colville Delta, slightly higher than 2008 levels (1.3 birds/km²; Johnson et al. 2009).

Greater White-Fronted Geese were the most frequently encountered goose in the Colville Delta during the staging survey. A total of 363 Greater White-Fronted Geese were recorded in 20 groups. Seventeen groups (269 birds) were located in the CD North subarea and 3 groups (94 birds) were located in the CD South subarea. Unlike the pattern observed in 2008, White-Fronted Geese did not increase in abundance inland from the coast in 2009; densities were 2.6 birds/km² in the CD North subarea and 1.8 birds/km² in the CD South subarea, compared to 2008 densities of 2.8 birds/km² in CD North and 9.5 birds/km² in CD South (Johnson et al. 2009).

Table 17. Habitat selection by nesting and brood-rearing Tundra Swans, NPRA study area, Alaska, 2001–2006 and 2008–2009.

SPECIES Habitat	No. of Adults	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0.0	0.8	ns	low
Brackish Water	4	1.4	0.8	ns	low
Tapped Lake with Low-water Connection	1	0.3	0.6	ns	low
Tapped Lake with High-water Connection	2	0.7	0.4	ns	low
Salt Marsh	12	4.2	1.5	prefer	low
Tidal Flat Barrens	1	0.3	1.1	ns	low
Salt-killed Tundra	2	0.7	0.5	ns	low
Deep Open Water without Islands	12	4.2	6.5	ns	
Deep Open Water with Islands or Polygonized Margins	23	8.0	5.2	ns	
Shallow Open Water without Islands	3	1.0	1.0	ns	low
Shallow Open Water with Islands or Polygonized Margins	16	5.6	1.6	prefer	low
River or Stream	0	0.0	1.1	ns	low
Sedge Marsh	6	2.1	1.7	ns	low
Deep Polygon Complex	0	0.0	<0.1	ns	low
Grass Marsh	6	2.1	0.3	prefer	low
Young Basin Wetland Complex	4	1.4	0.3	ns	low
Old Basin Wetland Complex	25	8.7	8.2	ns	
Riverine Complex	1	0.3	0.4	ns	low
Dune Complex	1	0.3	1.0	ns	low
Nonpatterned Wet Meadow	13	4.5	3.0	ns	
Patterned Wet Meadow	34	11.8	11.2	ns	
Moist Sedge-Shrub Meadow	48	16.7	22.1	avoid	
Moist Tussock Tundra	69	24.0	26.2	ns	
Tall, Low, or Dwarf Shrub	4	1.4	3.2	ns	
Barrens	0	0.0	1.0	ns	low
Human Modified	0	0	0	ns	
Total	287	100	100		
BROOD-REARING					
Open Nearshore Water	1	0.6	0.8	ns	low
Brackish Water	5	2.9	0.8	prefer	low
Tapped Lake with Low-water Connection	6	3.4	0.6	prefer	low
Tapped Lake with High-water Connection	0	0.0	0.4	ns	low
Salt Marsh	2	1.1	1.5	ns	low
Tidal Flat Barrens	0	0.0	1.1	ns	low
Salt-killed Tundra	0	0.0	0.5	ns	low
Deep Open Water without Islands	47	26.9	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	39	22.3	5.2	prefer	
Shallow Open Water without Islands	2	1.1	1.0	ns	low
Shallow Open Water with Islands or Polygonized Margins	3	1.7	1.6	ns	low
River or Stream	10	5.7	1.1	prefer	low
Sedge Marsh	3	1.7	1.7	ns	low
Deep Polygon Complex	0	0.0	<0.1	ns	low
Grass Marsh	4	2.3	0.3	prefer	low
Young Basin Wetland Complex	1	0.6	0.3	ns	low
Old Basin Wetland Complex	7	4.0	8.2	ns	
Riverine Complex	1	0.6	0.4	ns	low
Dune Complex	0	0.0	1.0	ns	low
Nonpatterned Wet Meadow	8	4.6	3.0	ns	
Patterned Wet Meadow	9	5.1	11.2	avoid	
Moist Sedge-Shrub Meadow	16	9.1	22.1	avoid	
Moist Tussock Tundra	5	2.9	26.2	avoid	
Tall, Low, or Dwarf Shrub	5	2.9	3.2	ns	
Barrens	1	0.6	1.0	ns	low
Human Modified	0	0	0	ns	
Total	175	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

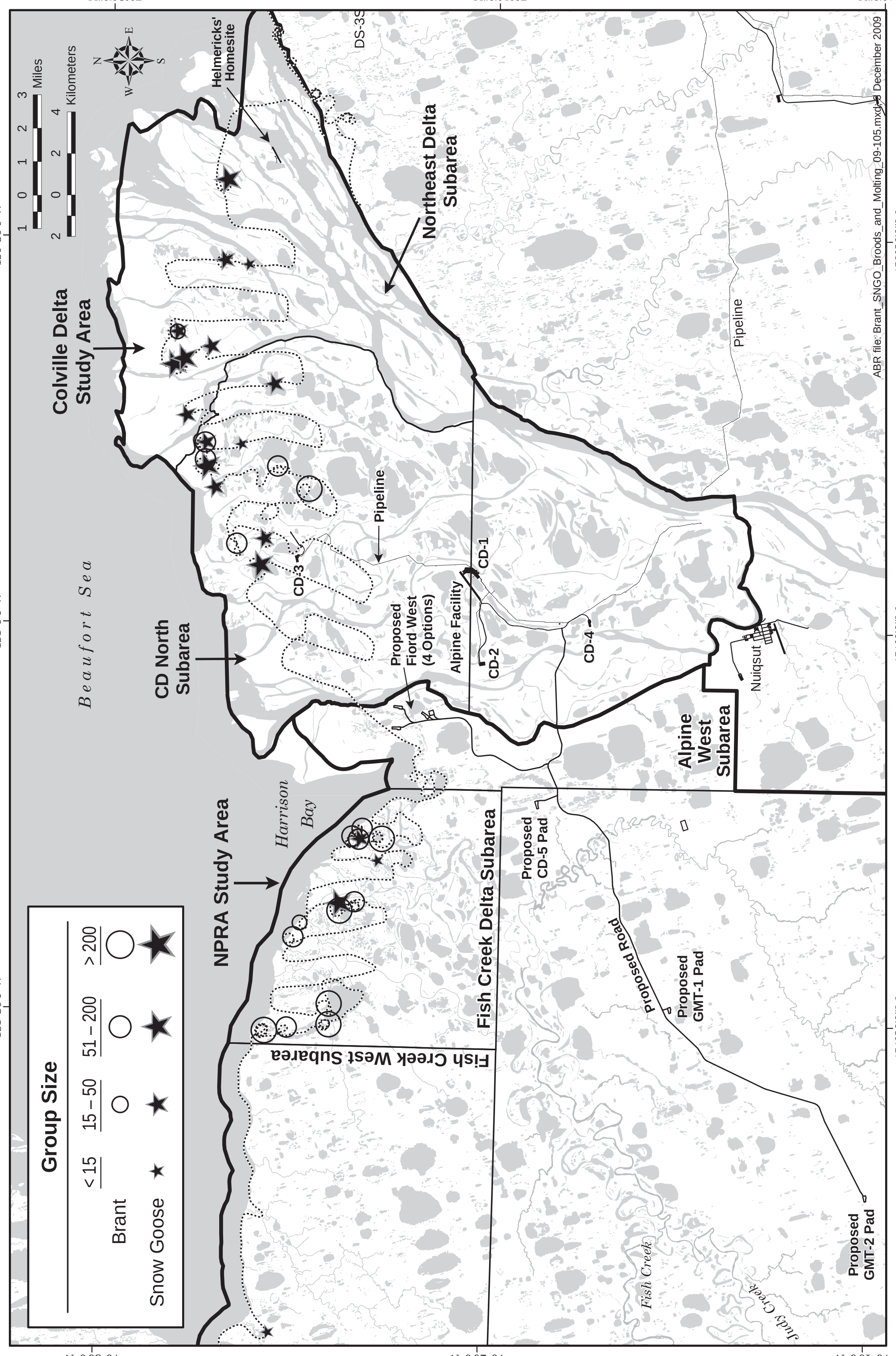

Figure 14. Brant and Snow Goose brood-rearing and molting groups, Colville Delta and NPRA study areas, Alaska, 2009.

Table 18. Numbers of Brant and Snow Goose adults and young during brood-rearing aerial surveys, Colville Delta and NPRA study areas, Alaska, 2009.

SPECIES Study Area Subarea	Total Birds	Adults	Young	% Young	No. of Groups
BRANT					
Colville Delta[a]					
CD North	652	484	168	26	5
Northeast Delta	27	17	10	37	1
Total (subareas combined)	679	501	178	26	6
NPRA[b]					
Fish Creek Delta	2,628	2,161	467	18	12
SNOW GEESE					
Colville Delta[a]					
CD North	278	187	91	33	7
Northeast Delta	400	276	124	31	8
Total (subareas combined)	678	463	215	32	15
NPRA[b]					
Fish Creek Delta	100	58	42	42	3
Fish Creek West	2	2	0	0	1
Total (subareas combined)	102	60	42	41	4

[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. No Brant or Snow Geese were observed in the Alpine West subarea, and no Brant were seen in the Fish Creek West subarea

During fall staging, Snow Geese were the least abundant goose in the survey area. Three groups (28 total birds) were recorded in the CD North subarea. Snow Goose density was 0.2 birds/km² in the Colville Delta, down from 0.6 birds/km² in 2008. A total of 199 Canada Geese (Iqsraġutilik) were counted in 6 groups during the fall-staging survey, all in the CD North subarea. Canada Goose density was 1.3 birds/km² in the Colville Delta, up from 0.4 birds/km² in 2008 (Johnson et al. 2009).

Habitat Use

Brant brood groups primarily occupied coastal salt-affected habitats in the Colville Delta study area (Table 20). Five of 6 Brant brood groups (83%) were found in 3 habitats: Brackish Water (3 groups), Salt-killed Tundra (1 group) and Salt Marsh (1 group).

Snow Geese also favored coastal salt-affected habitats for brood-rearing and molting in the Colville Delta. Of 15 Snow Goose groups observed, 4 groups (27%) were in Salt-killed Tundra, 3 groups (20%) were in Salt Marsh, and 3 groups (20%) were in Brackish Water.

During the fall-staging survey, All 4 Brant groups in the Colville Delta were found in salt-affected habitats (Table 21): Salt Marsh (2 groups), Brackish Water (1 group), and Salt-killed Tundra (1 group). No Snow Goose groups were observed on the ground in the Colville Delta.

Greater White-fronted Geese occupied a variety of habitats during fall staging (Table 21). The 18 groups observed occupied 8 different habitats, including 4 groups (22%) in Salt Marsh, and 4 groups (22%) 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 Salt-killed Tundra.

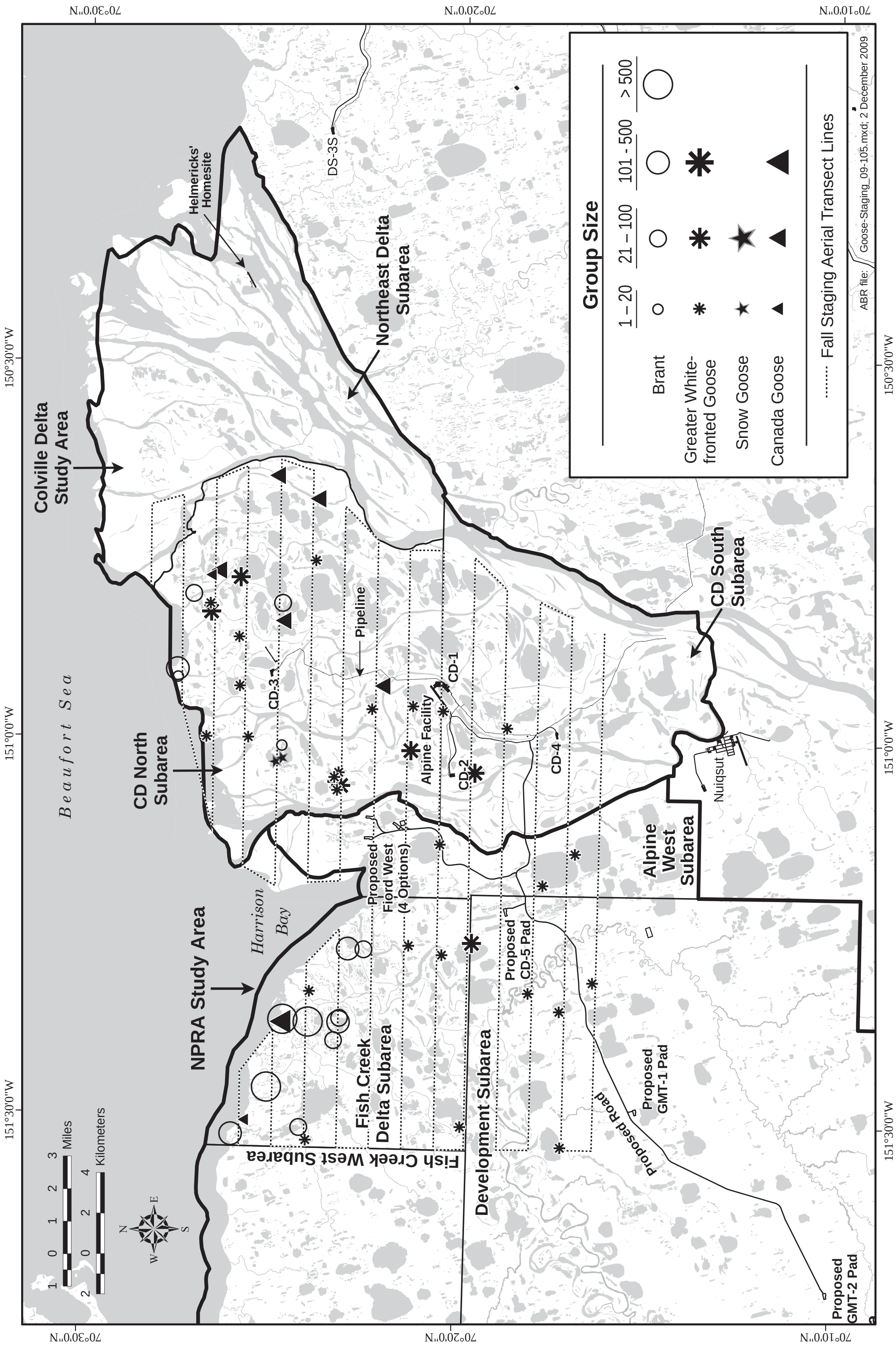

Figure 15. Fall-staging geese in portions of the Colville Delta and NPRA study areas, Alaska, 2009.

Table 19. Numbers and densities of geese during fall-staging aerial surveys in the Colville Delta and NPRA study areas, Alaska, 2009.

SPECIES Study Area Subarea	No. on Ground	No. in Flight	Total	No. of Groups	Mean Group Size	Density[a] (birds/km²)
BRANT						
Colville Delta						
CD North	184	75	259	5	51.8	2.5
Total (all subareas)	184	75	259	5	51.8	1.7
NPRA						
Fish Creek Delta	4,245	0	4,245	10	424.5	64.3
Total (all subareas)	4,245	0	4,245	10	424.5	30.6
GREATER WHITE-FRONTED GOOSE						
Colville Delta						
CD North	219	50	269	17	15.8	2.6
CD South	90	4	94	3	31.3	1.8
Total (all subareas)	309	54	363	20	18.2	2.4
NPRA						
Alpine West	34	10	44	3	14.7	1.5
Development	31	73	104	6	17.3	2.4
Fish Creek Delta	31	4	35	5	7.0	0.5
Total (all subareas)	96	87	183	14	13.1	1.3
SNOW GOOSE						
Colville Delta						
CD North	0	28	28	3	9.3	0.3
Total (all subareas)	0	28	28	3	9.3	0.2
NPRA						
Total (all subareas)	0	0	0	0	0	0
CANADA GOOSE						
Colville Delta						
CD North	144	55	199	6	33.2	1.9
Total (all subareas)	144	55	199	6	33.2	1.3
NPRA						
Fish Creek Delta	220	0	220	2	110.0	3.3
Total (all subareas)	220	0	220	2	110.0	1.6

[a] Density estimates include flying birds. Areal coverage was 102.0 km² in CD North, 51.3 km² in CD South, 29.1 km² in Alpine West, 66.0 km² in Fish Creek Delta, and 43.8 km² in the Development subareas

Table 20. Habitat use by brood-rearing/molting Brant and Snow Geese, Colville Delta and NPRA study areas, Alaska, 2009.

	Colville Delta				NPRA			
	Brant		Snow Geese		Brant		Snow Geese	
Habitat	No. of Groups	Use (%)	No. of Groups	Use (%)	No. of Groups	Use (%)	No. of Groups	Use (%)
Open Nearshore Water	0	0	0	0	3	25.0	0	0
Brackish Water	3	50.0	3	20.0	2	16.7	2	66.7
Tapped Lake with Low-water Connection	1	16.7	2	13.3	1	8.3	0	0
Tapped Lake with High-water Connection	0	0	1	6.7	0	0	0	0
Salt Marsh	1	16.7	3	20.0	4	33.3	0	0
Tidal Flat Barrens	0	0	0	0	2	16.7	1	33.3
Salt-killed Tundra	1	16.7	4	26.7	0	0	0	0
Patterned Wet Meadow	0	0	2	13.3	0	0	0	0
Total	6	100	15	100	12	100	3[a]	100

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

Table 21. Habitat use by fall-staging geese, Colville Delta and NPRA study areas, Alaska, 2009.

	Brant		Greater White-fronted Goose		Canada Goose	
STUDY AREA Habitat	No. of Groups	Use (%)	No. of Groups	Use (%)	No. of Groups	Use (%)
COLVILLE DELTA						
Brackish Water	1	25.0	0	0	0	0
Tapped Lake with Low-water Connection	0	0	2	11.1	1	25.0
Salt Marsh	2	50.0	4	22.2	0	0
Salt-killed Tundra	1	25.0	2	11.1	2	50.0
Deep Open Water without Islands	0	0	4	22.2	0	0
Deep Open Water with Islands or Polygonized Margins	0	0	1	5.6	0	0
Nonpatterned Wet Meadow	0	0	1	5.6	0	0
Patterned Wet Meadow	0	0	1	5.6	0	0
Barrens	0	0	3	16.7	1	25.0
Total[a]	4	100	18	100	4	100
NPRA						
Brackish Water	5	50.0	0	0	0	0
Salt Marsh	2	20.0	0	0	0	0
Tidal Flat Barrens	2	20.0	1	10.0	2	100
Deep Open Water without Islands	0	0	5	50.0	0	0
Deep Open Water with Islands or Polygonized Margins	0	0	3	30.0	0	0
River or Stream	1	10.0	0	0	0	0
Nonpatterned Wet Meadow	0	0	1	10.0	0	0
Total[a]	10	100	10	100	2	100

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

NPRA

Distribution and Abundance

During the aerial brood-rearing survey in 2009, we counted 2,628 Brant (2,161 adults and 467 goslings) in 12 groups in the NPRA study area (Figure 14, Table 18), down from 4,012 Brant (2,617 adults and 1,395 goslings) in 2008. Nine (75%) of Brant groups included broods, but goslings comprised only 18% of the total number of birds in all groups and 19% of birds in brood-rearing groups (excluding the 3 groups of molting adults). All 12 Brant brood-rearing and molting groups were located in the Fish Creek Delta subarea.

In 2009, 102 Snow Geese (60 adults and 42 goslings) in 4 groups were counted in the NPRA study area (Figure 14, Table 18), down from 234 Snow Geese (107 adults and 127 goslings) in 2008. Two groups included broods, and goslings comprised 41% of the total number of birds in all groups. The 2 groups without broods were a pair of adults and a single adult goose. Three Snow Goose groups were located in the Fish Creek Delta subarea, and 1 group (a pair of adults with no goslings) was located in the Fish Creek West subarea.

Brant were the most abundant goose in the NPRA study area during the fall-staging survey in 2009. We counted 4,245 Brant in 10 groups (Figure 15, Table 19), all in the Fish Creek Delta subarea. Brant density was 30.6 birds/km² in the NPRA study area, up from 5.0 birds/km² in 2008 (Johnson et al. 2009). The sizeable increase was due to the presence of 3 large groups (600–1,700 birds each) on outer Fish Creek Delta in 2009 (Figure 14).

We counted 183 Greater White-Fronted Geese in 14 groups in the NPRA study area; the highest numbers (104 total birds) and densities (2.4 birds/km²) were recorded in the Development subarea. Greater White-Fronted Goose density in the surveyed portion of the NPRA study area was 1.3 birds/km², down slightly from 1.8 birds/km² in 2008 (Johnson et al. 2009). Two groups of Canada Geese totaling 220 birds were recorded in the NPRA study area, both in the Fish Creek Delta subarea. Canada Goose density was 1.6 birds/km², up from 0.9 birds/km² in 2008.

Habitat Use

As in the Colville Delta, Brant and Snow Goose brood groups primarily used salt-affected habitats in the NPRA study area (Table 20). Eleven of 12 Brant brood groups (92%) were found in 4 habitats: Salt Marsh (33%), Open Nearshore Water (25%), Brackish Water (17%), and Tidal Flat Barrens (17%). The 3 Snow Goose brood-rearing and molting groups were located in Brackish Water (2 groups) and Tidal Flat Barrens (1 group).

During the fall-staging survey in the NPRA study area, 9 of 10 (90%) Brant groups were found in 3 habitats (Table 21): Brackish Water (50%), Salt Marsh (20%), and Tidal Flat Barrens (20%). No Snow Geese were observed in the NPRA study area in 2009.

Most Greater White-fronted Geese occupied deep lakes during the fall-staging survey in the NPRA study area (Table 21). Of 10 groups observed, 50% were found in Deep Open Water without Islands, and 30% were found in Deep Open Water with Islands or Polygonized Margins. Both Canada Goose staging groups observed in 2009 were found in Tidal Flat Barrens.

GLAUCOUS AND SABINE'S GULLS

COLVILLE DELTA

Distribution and Abundance

Fifty Glaucous Gull nests were counted in the Colville Delta study area during the aerial survey for nesting loons in 2009 (Figure 16, Table 22). This was the highest count of Glaucous Gull nests in the Colville Delta study area in 10 years of surveys. Six of the 19 nests in the CD North subarea in 2009 were located together in a colony, where 1–2 nests were observed in 2001–2003 and 4–7 nests were recorded in 2004–2008 (Johnson et al. 2005, 2006b, 2007b, 2008b, 2009). Nineteen of the 29 nests in the CD South subarea in 2009 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, 2009). Two of the 49 nests were found on lakes in the Northeast Delta subarea and were not included in density calculations (Table 22), to be consistent with data presentations from previous years. Nest density was 0.13 nests/km² in 2009 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 2009 during the aerial survey for brood-rearing loons. Thirty adults and 26 young in a minimum of 12 broods were recorded in the Colville Delta study area, of which 14 adults and 12 young were in the CD North subarea and 16 adults and 14 young were in the CD South subarea (Figure 16). Five young were counted at the colony site in the CD North subarea and 9 young were recorded at the colony site in the CD South subarea. Young from some nests were flight capable at the time of the loon brood-rearing survey and consequently some young may have been missed because they were no longer near their nest site.

One Sabine's Gull nest was observed in the Colville Delta study area during the aerial survey for nesting loons in 2009 (Figure 16). In 2008, we found 15 Sabine Gull nests at 2 different colonies. Numerous Sabine's Gulls were observed in large flocks flying and feeding in the Colville Delta study area but they did not appear to have nests. The water level of many lakes was high from snow melt and river discharge, and perhaps traditional nesting sites, which tend to be in nonpatterned wet meadow habitats close to lake shorelines, were flooded, or the loon nesting survey occurred earlier than nest initiation by Sabine's Gulls.

Habitat Use

Twenty of the 48 Glaucous Gull nests (42%) found in the CD North and CD South subareas of the Colville Delta in 2009 were in Patterned Wet Meadow (Table 23). Nineteen of those 20 nests were from the colony in the CD South subarea, which is a large island of Patterned Wet Meadow in a lake classified as Deep Open Water with Islands and Polygonized Margins. Eleven nests (23%)

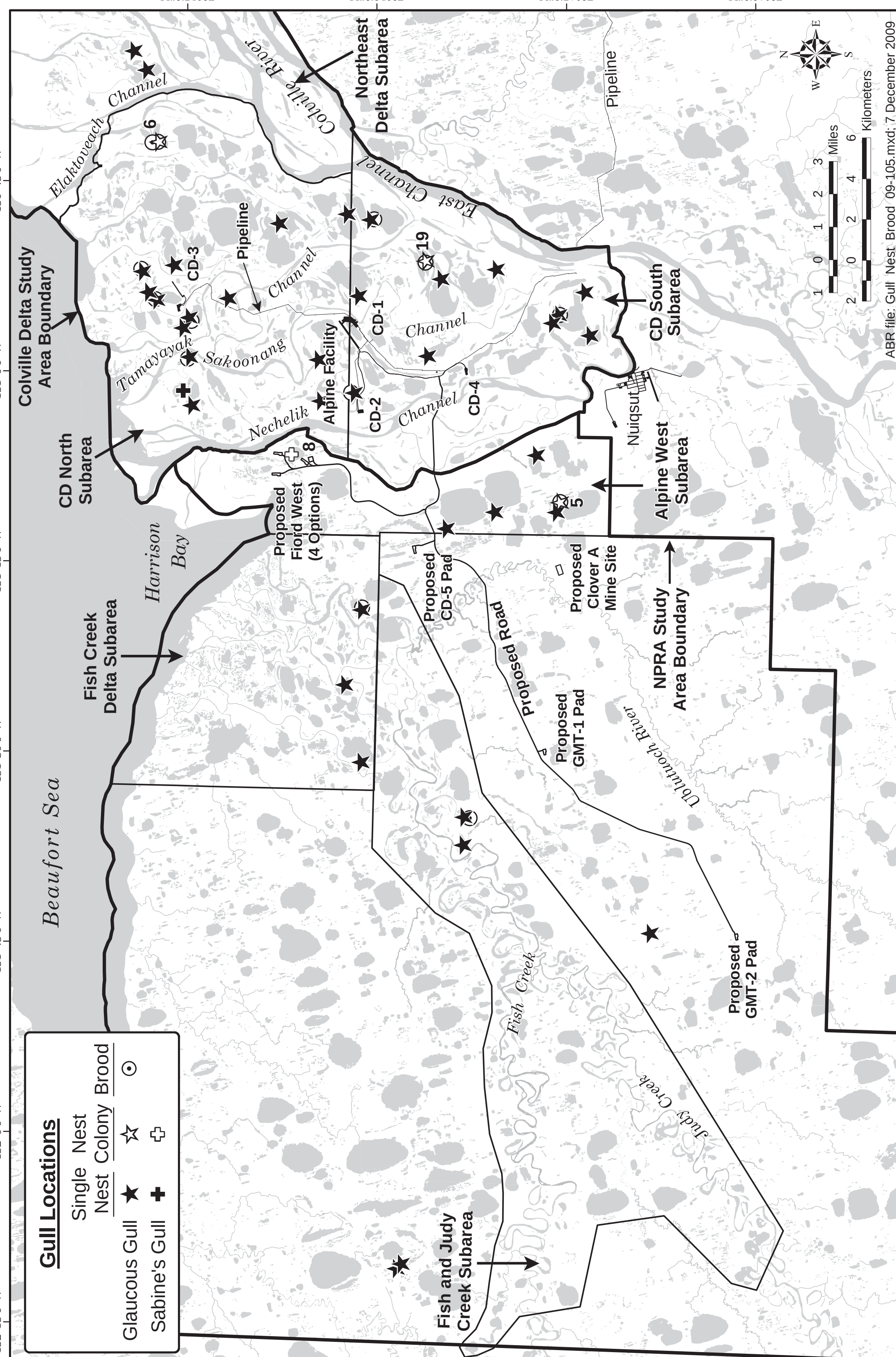

Figure 16. Glaucous and Sabine's gull nests and broods, Colville Delta and NPRA study areas, Alaska, 2009. Numbers of nests are listed for colony locations.

Table 22. Number and density of Glaucous and Sabine's gull nests, Colville Delta and NPRA study areas, Alaska, 2009.

STUDY AREA / Subarea[b]	Sabine's Gull[a]	Glaucous Gull	
	Number of Nests[c]	Number of Nests[c]	Nest Density (nests/km²)
COLVILLE DELTA			
CD North	1	19	0.09
CD South	0	29	0.19
Northeast Delta[d]	0	2	–
Total (subareas combined)[e]	1	50	0.13
NPRA			
Alpine West	8	9	0.11
Fish Creek Delta	0	3	0.02
Fish and Judy Creek Corridor	0	2	0.01
Outside of Survey Subareas[d]	0	3	–
Total (subareas combined)[e]	8	17	0.03

[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] Total is the sum of all subareas but density calculations included only 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 23. Habitat use by nesting Glaucous Gulls, Colville Delta and NPRA study areas, Alaska, 2009.

Habitat	Colville Delta		NPRA	
	Nests	Use (%)	Nests	Use (%)
Brackish Water	1	2.1	0	0
Tapped Lake with High-water Connection	11	22.9	1	7.1
Deep Open Water without Islands	0	0	1	7.1
Deep Open Water with Islands or Polygonized Margins	11	22.9	1	7.1
Shallow Open Water without Islands	0	0	1	7.1
Shallow Open Water with Islands or Polygonized Margins	1	2.1	9	64.3
Sedge Marsh	0	0	1	7.1
Deep Polygon Complex	1	2.1	0	0
Grass Marsh	3	6.3	0	0
Old Basin Wetland Complex	0	0	0	0
Patterned Wet Meadow	20	41.7	0	0
Total	48[a]	100	14[b]	100

[a] Excludes 2 nests that occurred outside the 2009 study area

[b] Excludes 3 nests that occurred outside the 2009 study area

were found in Tapped Lake with High-water Connection, including the colony of 6 nests located on 2 islands in the CD North subarea. Eleven additional nests were found in the Colville Delta study area in Deep Open Water with Islands or Polygonized Margins (23%). The remaining 6 nests were found on islands or complex shorelines of 4 other habitats. Glaucous Gull broods observed during aerial surveys were located near nests and in the same habitats as were the nests. The single Sabine's Gull nest was located in Non-patterned Wet Meadow.

NPRA

Distribution and Abundance

Seventeen Glaucous Gull nests were counted in the NPRA study area in 2009 during aerial surveys for loons (Figure 16, Table 22). Nine nests were counted in the Alpine West subarea, 3 in the Fish Creek Delta subarea, 2 in the Fish and Judy Creek subarea, and 3 nests were recorded outside of those subareas. The number of nests found in each subarea in 2009 was 4–10 nests less than the number found in 2008 (Johnson et al. 2009). Much of this decrease is attributable to the failure of all nests at 1 traditional colony near the proposed CD-5 Pad in the Alpine West subarea prior to our survey (E. Weiser, University of Alaska, Fairbanks, pers. comm.). In previous survey years (2002–2006 and 2008), 4–7 nests were found at this colony location (Burgess et al. 2003b, Johnson et al. 2004, 2005, 2006b, 2007b, 2009). A second traditional colony location in the southern part of the Alpine West subarea was active with 5 nests in 2009 (Figure 16). All other Glaucous Gull nests found in the NPRA study area in 2009 were individual nest locations, including 3 nests found outside of the 2009 study area. Nest density was 0.03 nests/km^2 in 2009 for all 3 subareas combined in the NPRA study area. Because Glaucous Gulls were counted on aerial surveys designed to survey loons, some nests probably were missed. Four Glaucous Gull broods (8 adults and 7 young) were observed during the brood-rearing aerial survey for loons in 2009 in the NPRA study area.

One Sabine's Gull colony of 8 nests was found in the Alpine West subarea of the NPRA study area during the loon nesting survey in 2009 (Figure 16, Table 22). No other nests were found but numerous Sabine's Gulls were observed in large flocks flying and feeding in the NPRA study area. The water level of many lakes during the loon nesting survey was high from snow melt and river discharge, and perhaps traditional nesting sites, which tend to be on lake shorelines, were flooded, or the loon nesting survey occurred earlier than nest initiation by Sabine's Gulls. In 2008, we found 4 single Sabine's Gull nests and 49 nests in 5 nesting colonies. 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 6 different habitats in the NPRA study area (Table 23). Most nests were located on islands in Shallow Open Water with Islands or Polygonized Margins (64% of all nests). The remaining 5 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. The Sabine's Gull colony found in the Alpine West subarea was on an island of Nonpatterned Wet Meadow in a lake classified as Deep Open Water with Islands or Polygonized Margins.

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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 on the Colville River delta or in the NPRA study area, Alaska, 2009. Species associations of some habitats vary between the Colville River delta and the NPRA study area

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.