AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2013

ELEVENTH ANNUAL REPORT

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ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES
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EXECUTIVE SUMMARY

Aerial and ground-based surveys of bird populations were conducted in the Colville Delta and in the northeastern National Petroleum Reserve in Alaska (NE NPR-A) in 2013 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 NE NPR-A. Surveys focused on the abundance, distribution, and habitat use of 5 focal species groups: Spectacled Eider, King Eider, Tundra Swan, Yellow-billed Loon, and geese. These 5 taxa were selected because of 1) threatened or sensitive status, 2) indications of declining populations, 3) restricted breeding range, and/or 4) concern of regulatory agencies regarding development impacts. A new task was added in 2013—a ground-based nesting study of Greater White-fronted Geese in the CD5 area—because of concerns by the North Slope Borough for an important subsistence species. Aerial surveys for eiders, swans, and geese were conducted from a fixed-wing airplane. Surveys for Yellow-Billed Loons were conducted from a helicopter.

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 (CD1 and CD2) began oil production on the Colville Delta in 2000. Two ASDP satellite drill sites were built in the winter of 2005: CD3 was designed as a roadless drill site to reduce its gravel footprint in Spectacled Eider (a federally listed threatened species) breeding habitat on the outer delta, and CD4 was connected by a road on the south side of the Alpine Facility. The CD3 site began producing oil in August 2006, and CD4 began producing in November 2006. The NE NPR-A study area (reduced in size to 322 km² in 2011–2013) abuts the western edge of the Colville Delta and encompasses 3 proposed development sites that are part of the ASDP: drill site CD5, drill site GMT1, and the Clover A gravel mine site.

Aerial surveys in the Colville Delta and NE NPR-A study areas in 2013 generally indicated average to above average numbers of breeding adults and below average productivity as measured by number of nests, nesting success, or production of young, although there were exceptions. Production of young was particularly poor for Yellow-billed Loons in both the Colville Delta and NE NPR-A study areas, whereas Tundra Swans did much better in NE NPR-A than on the Colville Delta, where the fewest broods were recorded since 1992. Weather conditions during nesting probably contributed to low productivity in 2013.

Spring weather was cool in mid-May with above average snow depths followed by warm temperatures in June, which contributed to ice jams and extensive flooding of the Colville River and surface runoff elsewhere. Cumulative thawing degree-days (an index to days with temperatures above freezing) were below average for the last half of May, but higher than average by mid-June. Water levels on the Colville River peaked at the head of the delta (Monument 1) on 3 June and at the mouth of the delta (Colville Village) on 7 June.

The indicated number of pre-nesting Spectacled Eiders on the Colville Delta in 2013 (66 indicated birds) was higher than the 20-year mean. As in previous years, Spectacled Eiders were found primarily in the CD North subarea. Some of the highest counts of Spectacled Eiders during the last 2 decades have been recorded on the Colville Delta study area over the last 6 years, reversing the depressed numbers recorded in this area during the early 2000s. The long-term trend for Spectacled Eiders on the Colville Delta is slightly positive (growth rate = 1.007) whereas the trend for the entire Arctic Coastal Plain (ACP) is slightly negative (growth rate = 0.99). Neither trend is significantly different from equilibrium, however, indicating that the population likely is stable. During 2013, Spectacled Eiders in the NE NPR-A were at record high numbers, nonetheless they occurred at 62% of the density found on the Colville Delta study area. Spectacled Eiders preferred 6 habitats on the Colville Delta study area, all consistent with their primarily coastal distribution: 3 coastal salt-affected habitats, 2 aquatic habitats, and 1 terrestrial habitat. Spectacled Eiders in the NE NPR-A preferred 5 habitats, 3 of which were also preferred on the Colville Delta.

King Eiders (24 indicated birds) were 36% as numerous as Spectacled Eiders on the Colville Delta during pre-nesting in 2013, with densities below the long-term mean. Annually we record high numbers of King Eiders on the Colville Delta in habitats unsuitable for nesting, particularly the eastern channels of the Colville River. Those records during pre-nesting and the low frequency of King Eider nests relative to Spectacled Eider nests in areas searched, lead us to conclude that King Eiders primarily use the Colville Delta as a stopover while moving to breeding areas farther east. In contrast, King Eiders breed in high numbers in the NE NPR-A study area (96 indicated birds); in 2013 the density of King Eiders in the NE NPR-A study area was about 10 times the density in the Colville Delta study area. King Eiders have increased at a significant rate in the NE NPR-A study area (growth rate = 1.084) and on the ACP (growth rate = 1.047), but not on the Colville Delta (growth rate = 1.002), where they breed in relatively low numbers.

Yellow-billed Loons produced one of the lowest numbers of chicks and broods in 2013 since surveys began in either study area. River flooding caused by rapid warming and ice jams in early June had a major effect on Yellow-billed Loons on the Colville Delta in 2013. Although the number of Yellow-billed Loons counted during the nesting survey (67 birds) was above the 19-year mean, the number of nests (12) was the 3rd lowest counted and territory occupancy by nests (40%) was the lowest ever. High water on lakes did not appear to delay nesting, but rather prevented pairs from nesting on many traditional territories. The median nest incubation start date in 2013 (17 June) was only 1 day later than that of all nests that have been aged (n = 73 nests) since 2008. Although the number of Yellow-billed Loons seen on the brood-rearing survey (42 birds) was slightly below the long-term mean, apparent nesting success (47%), the number of broods (7), and occupation of territories by broods (16%) were among the lowest ever recorded. Despite the low breeding success in 2013, the number of Yellow-billed Loon adults appears to be increasing on the ACP (growth rate = 1.05) and Colville Delta (growth rate = 1.034 [when the flood years are excluded]), over 10 and 11 years, respectively.

In contrast to the Colville Delta, the NE NPR-A study area was unaffected by major river flooding and had an average number of Yellow-billed Loon nests in 2013 (12), yet nesting success (7%) was much worse than it was on the Colville Delta. Only 1 out of 14 nests hatched and that brood did not survive; 2013 had the lowest apparent nesting success (7%), brood occupancy (5%), and chick production (0.14 chicks/nest at hatch) recorded in NE NPR-A over the 6 years that we have conducted intensive monitoring. Predators were responsible for nest losses, but warm temperatures may have contributed by keeping loons off nests for longer periods.

Despite low nesting success and chick production at hatch on the Colville Delta in 2013, Yellow-billed Loon chick survival was high. The number of chicks at hatch (0.6 chicks/nest) was the lowest recorded, yet only 1 chick was lost by the last survey in mid-September (0.53 chicks/nest), which was the smallest loss in 6 years of records. Loon chicks were ~11 weeks old during the last monitoring survey and 2 broods were observed flying at ~9–10 weeks of age.

Eleven cameras were deployed in 2013 to record nest initiation in late May at nest sites repeatedly used by Yellow-billed Loons. Five cameras shorted out when flood waters filled the battery cases. The start of incubation was documented at 4 nests; incubation began an average of 7 days after nest sites appeared accessible; the median start of incubation was 17 June (range = 15–22 June). One nest with a known start date hatched on day 29 of incubation, and the chick was seen swimming that day.

Thirteen Yellow-billed Loon nests on the Colville Delta and 9 in NE NPR-A were monitored with time-lapse cameras. Apparent nesting success for camera-monitored nests on the Colville Delta and NE NPR-A was 31% and 13%, respectively. Of the 9 nests that failed in the Colville Delta study area, 3 failures were attributed to predation by Glaucous Gulls, 2 to brown bears, 1 to a red fox, and 1 to Parasitic Jaegers. One nest failed after abandonment and another from apparently nonviable eggs. Of 8 camera-monitored nests that failed in the NE NPR-A study area, 2 were attributed to Glaucous Gulls, 2 to Brown Bears, 1 to a Parasitic Jaeger, 1 to a Bald Eagle and 2 nests failed from unidentified predators. Four of the above nests failed while the incubating loons interacted with intruding Yellow-billed loons, at which time gulls and jaegers took advantage of the unprotected nests. Incubation constancy was lower in 2013 than previous years in both study areas. Yellow-billed Loons at hatched nests on the Colville Delta exhibited slightly higher nest attendance than those at failed nests, spending 92.8% and 87.2% of monitored time on nests, respectively. Similar incubation constancy was recorded at hatched and failed nests in the NE NPR-A study area (94.0% and 93.2%, respectively).

Thirteen nests and 21 broods of Pacific Loons and 2 Red-throated Loon broods (no nests) were counted incidentally during Yellow-billed Loon surveys in the Colville Delta study area in 2013. Pacific and Red-throated loons are undercounted during surveys conducted on large lakes for Yellow-billed Loons, because both species use smaller lakes and are more difficult to detect. In the NE NPR-A study area, we counted 8 nests and 21 broods of Pacific Loons. Red-throated Loon adults were observed in NE NPR-A, but no nests or broods were found because of the greater difficulty at detecting this species from the air.

Although Tundra Swan abundance was average in 2013, productivity on the Colville Delta was the lowest in 20 years of surveys. Thirty-nine Tundra Swan nests were found in the Colville Delta study area, slightly above the long-term mean of 35 nests/year, but apparent nesting success (33%) was the second lowest since surveys began in 1992. Both number of broods (13) and brood size (1.8 cygnets/brood) in the Colville Delta study area were below long-term means (25 broods, 2.5 cygnets/brood). In the NE NPR-A study area, 15 Tundra Swan nests were found in June and 13 broods were seen in August, for a relatively high apparent nesting success of 87%, but with brood sizes (1.9 cygnets) similar to those on the Colville Delta. The number of pairs of Tundra Swans has grown at a significant rate on the Colville Delta (growth rate = 1.033) as has the total number of adult Tundra Swans on the ACP (growth rate = 1.046).

Nest survival of Greater White-fronted Geese was studied on 40 10-ha plots in the CD5 drill site area of NE NPR-A. Plots contained 0–8 Greater White-fronted Goose nests, for an overall density of 21.8 nests/km². In 2013, the mean date of nest initiation was 9 June and the mean start date of incubation was 13 June. Thirty-eight of 87 nests on plots were instrumented with temperature thermistors to monitor nest survival. Apparent nesting success was 54% for nests without thermistors and 53% for nests with thermistors. The daily survival rate for instrumented nests was 0.97, with a calculated nesting success of 47% for a 24-day incubation period. The most common predators recorded on timed predator scans were jaegers (57% of observations, comprising Parasitic, Long-tailed and Pomarine jaegers) and Glaucous Gulls (39%); no mammalian predators were seen although foxes and brown bears were recorded at loon nests in the larger NE NPR-A study area.

Brant and Snow Goose production was low in both the Colville Delta and NE NPR-A study areas in 2013. The count of adult Brant during brood-rearing surveys in the Colville Delta (439) was well below average, as was the number of goslings (356), but the percentage of goslings equaled the long-term mean. The number of Snow Goose adults on the Colville Delta (1,568) exceeded the long-term mean, but goslings (866) fell short, resulting in the second lowest gosling percentage in the 9 years of records. Brant did somewhat better in NE NPR-A with roughly an average number of adults (1,346) and slightly less than an average number of goslings (403). Snow Geese in NE NPR-A did as well as on the Colville Delta with a higher than average number of adults (182) but below average number of goslings (130). The numbers of goslings produced by both species in both study areas were below their respective long-term mean values.

The number of Glaucous Gull nests in the Colville Delta study area in 2013 was above the 12-year mean. Sixty-seven Glaucous Gull nests were counted during loon aerial surveys in the Colville Delta study area in 2013. Based on 50 lakes monitored annually in the Colville River study area, the number of Glaucous Gull nests increased significantly (growth rate = 1.054) between 2002 and 2013, which is nearly identical to the rate reported for Glaucous Gulls on the entire ACP over the last 10 years (growth rate = 1.058).

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INTRODUCTION

The Colville River delta and Northeast Planning Area of the National Petroleum Reserve in Alaska (NE NPR-A) have been a focal point of exploration and development for oil and gas since at least the 1990s. During 2013, ABR, Inc. conducted wildlife surveys for selected birds and mammals in the Colville River delta and NE NPR-A in support of the Alpine Satellite Development Project (ASDP) of ConocoPhillips Alaska, Inc. (CPAI) and Anadarko Petroleum Corporation (APC). The avian studies in 2013 were a continuation of work initiated by CPAI's predecessors, ARCO Alaska, Inc., and Phillips Alaska, Inc., on 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, 2010, 2011, 2012, 2013a; Burgess et al. 2000, 2002a, 2003a) and in the NE NPR-A 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, 2009, 2010, 2011, 2012, 2013a). Avian surveys in the NE NPR-A were interrupted in 2007 due to delays in permitting for the CD5 drill site, but resumed in 2008. Surveys were conducted in NE NPR-A only for Spectacled Eiders and Yellow-billed Loons in 2010, because of their sensitive status under the Endangered Species Act. In 2011, we resumed surveys for Tundra Swans, geese, and gulls along with eiders and loons, but those surveys were conducted only in the eastern portion of the NE NPR-A study area.

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 (ACP) since the early 1980s (see Murphy and Anderson 1993, Stickney et al. 1993, Stickney et al. 2013, Lawhead et al. 2013). 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. CPAI began producing oil on the Colville River delta (henceforth, Colville Delta) in 2000 with the development of the CD1 and CD2 drill sites. Production increased in 2006 with oil produced from the CD3 and CD4 drill sites, which were constructed in 2005 and winter of 2006. CPAI has proposed additional oil and gas development sites in NE NPR-A as part of the Alpine Satellite Development Project (BLM 2004) at CD5 (Alpine West) and GMT1 (Lookout) (Figure 1). Readers are directed to prior reports for wildlife information from previous years.

In this report we present the results of avian surveys that were conducted in the Colville Delta and NE NPR-A in 2013 along with brief comparisons of results from previous years and other surveys. The surveys 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 are listed in Appendix A). These 5 taxa were selected in consultation with resource agencies and communities because of 1) threatened or sensitive status, 2) indications of declining populations, 3) restricted breeding range, 4) importance to subsistence hunting, and/or 5) concern by regulatory agencies for development impacts. A sixth species, the Greater White-fronted Goose (Niġlivik), was added as a focal species in 2013 at the request of the North Slope Borough Department of Wildlife Management, out of concern for development effects on this important subsistence species. Annual monitoring of a collection of focal species can provide 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 without studying all species that breed in the study area. Ground-based surveys for nesting Spectacled Eiders were conducted in select areas on the Colville Delta in 2013 as part of other studies (Seiser and Johnson 2014). Required state and federal permits were obtained for authorized survey activities, including a Scientific or Educational Permit (Permit No. 13-008-A1) from the State of Alaska and a Federal Fish and Wildlife Permit—Threatened and Endangered Species [Permit No. TE012155-1 issued under

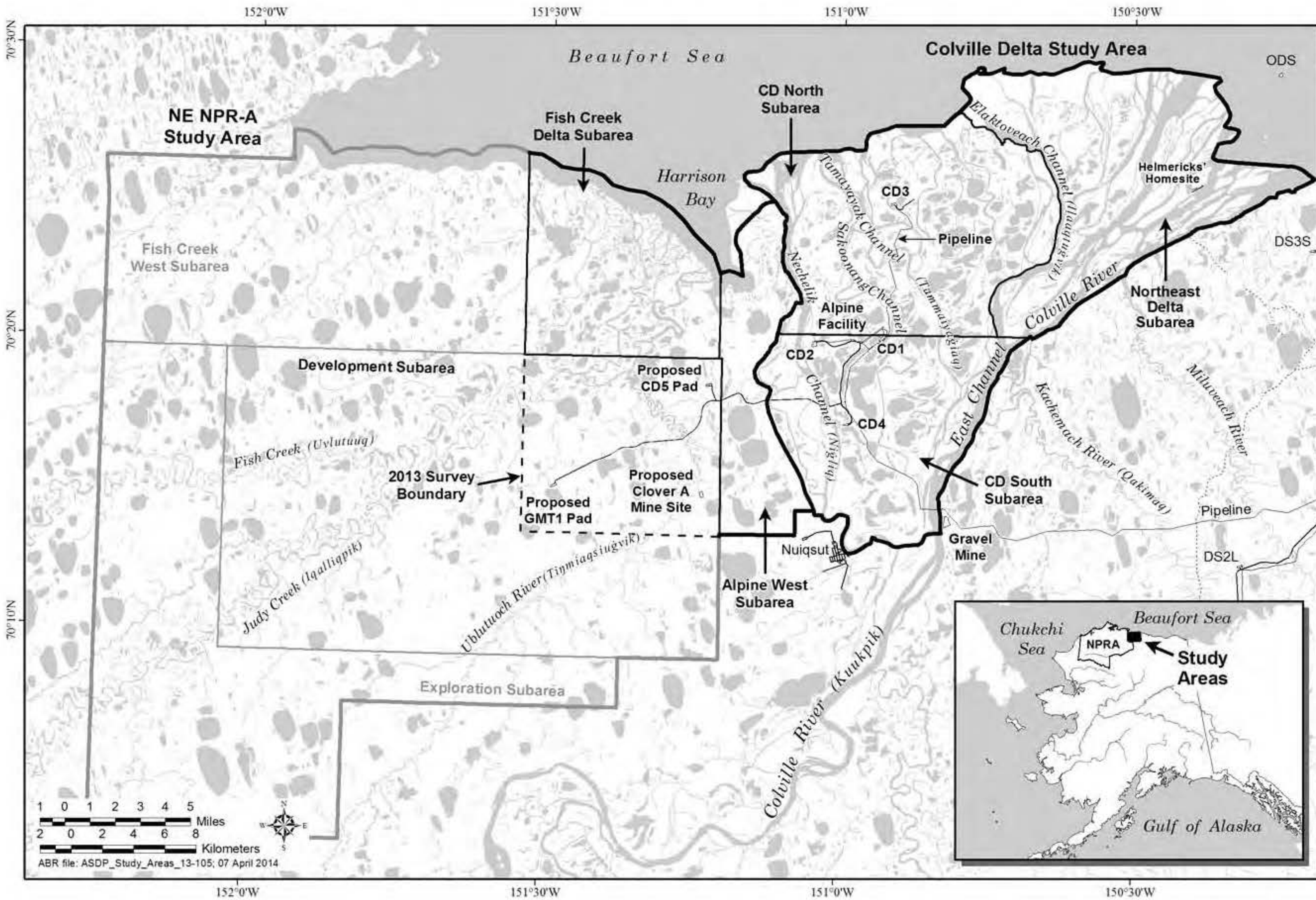


Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2013.

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 Delta in 2013 (Stickney et al. 2014). CPAI supported other avian research on the Arctic Coastal Plain in 2013 including a collaborative study of Yellow-billed Loon lake habitat by the University of Alaska Fairbanks, U.S. Geological Survey (USGS), Bureau of Land Management (BLM), and the Alaska Department of Fish and Game and a study of the effects of forage phenology and timing of reproduction on juvenile growth in Brant by USGS.

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 in Nuiqsut most years to allow residents to visit with CPAI biologists and other scientists to discuss information and concerns about resources in the Colville Delta and NE NPR-A areas. CPAI attends meetings with the Kuukpik Corporation board of directors twice annually to share information on activities on the Colville Delta and in NE NPR-A. In October 2010, CPAI staff 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 monitoring efforts. CPAI anticipates attending similar events in the future. In June 2009, CPAI flew Lydia Sovalik and the late Joeb Woods, Sr., 2 elders from Nuiqsut, and James Taallak as facilitator, to meet with biologists in the study site northeast of CD5. The elders reviewed the boundaries of their native allotments and described their family histories 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. In many years, a subsistence representative from the village of Nuiqsut has joined biologists on various surveys. In 2011, Nuiqsut resident Chris Long flew along on several aerial surveys, sharing his local knowledge with biologists. James Taallak helped with wildlife studies in 2009, Mark Ahmakak in 2002–2004, Doreen Nukapigak in 2001 and 2003, and Gordon Matumeak in 2002, all as representatives of the Kuukpik Subsistence Oversight Panel (KSOP). During the summer field season in 2013, CPAI emailed weekly updates to the North Slope Borough Department of Wildlife Management, various state and federal agencies, several environmental organizations, and key representatives of KSOP and the Kuukpik Corporation for posting in Nuiqsut. The updates reported on surveys conducted the previous week (for example, type of aircraft used, altitude of aircraft, and species enumerated) and provided the schedule of surveys for the upcoming week. Daily conference calls were held between CPAI, KSOP, and the Native Village of Nuiqsut during 2013, so that local residents could report potential conflicts between helicopter flights and subsistence activities. In further efforts to reduce subsistence-helicopter conflicts, a subsistence advisor was hired by CPAI through Umiaq to participate in the daily calls and provide information about hunting activities being conducted by Nuiqsut residents. The open house meetings and weekly project updates, initiated in 2001, were a means of keeping the local residents informed on the progress and results of studies conducted by CPAI in the area near Nuiqsut.

STUDY AREA

The ASDP study area comprises separate study areas on the Colville Delta and in the easternmost portion of the NE NPR-A (Figure 1). Wildlife studies began on the Colville Delta in 1992, and studies were initiated in NE NPR-A in 1999. The 2 study areas were combined into 1 project and report in 2003 (Johnson et al. 2004). In the same year, CPAI proposed to develop drill sites CD3–CD7 on the Colville Delta and adjacent NE NPR-A, which were evaluated together under the National Environmental Protection Act of 1970 (42 USC 4321) in an environmental impact statement as the Alpine Satellite Development Plan (BLM 2004).

The place names used throughout this report are those depicted on 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 recognize that the published USGS names for some streams (notably the Ublutuoch and Tiŋmiaqsiuġvik rivers) do not correctly reflect local usage. The Iñupiaq names we use for Fish (Uvlutuuq) and Judy (Iqalliqpik) creeks in NE NPR-A 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 channels on the Colville Delta (E. Wilson, ANLC, pers. comm.).

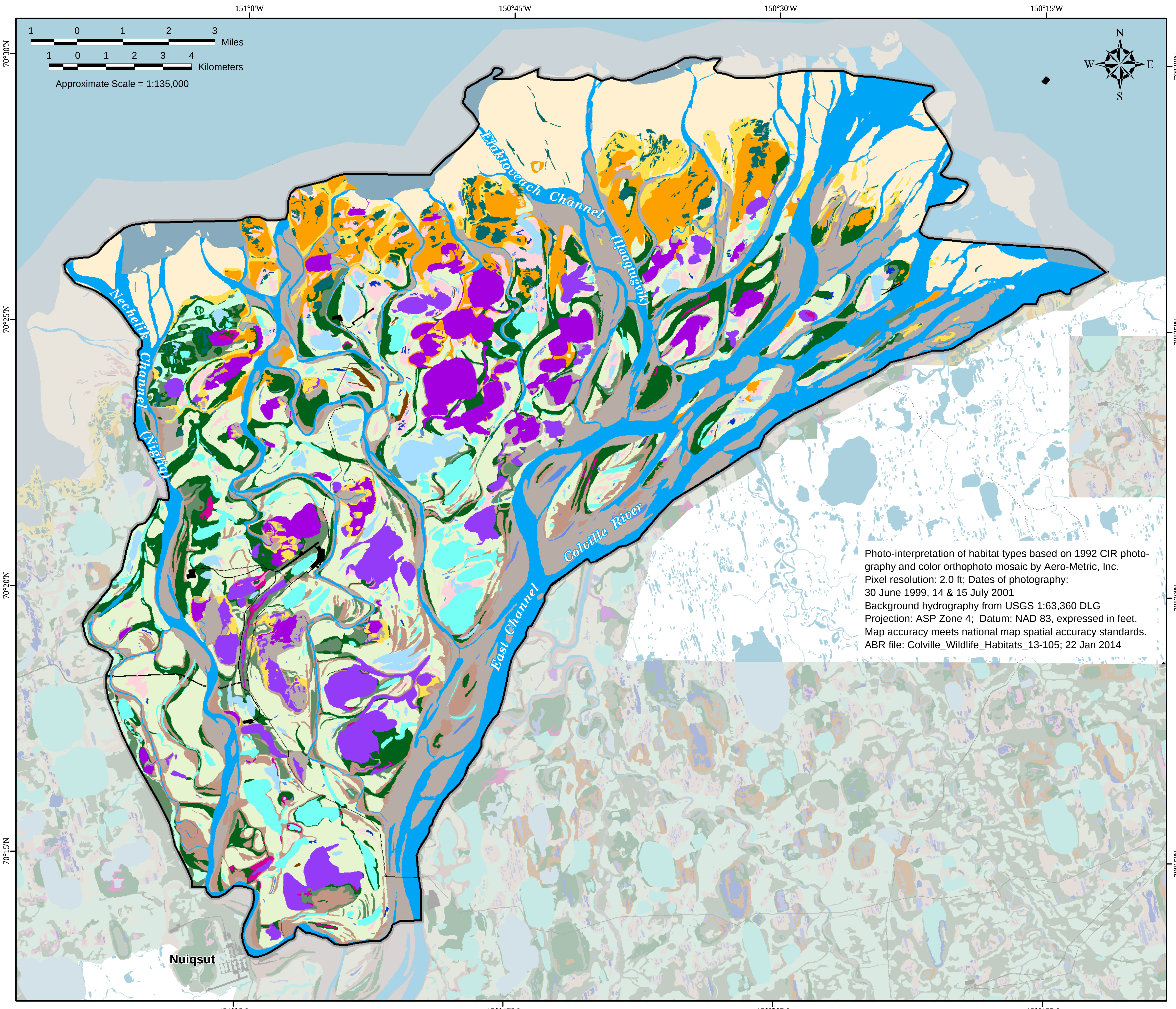
COLVILLE DELTA

The Colville Delta is one of the most prominent and important landscape features on the ACP 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 roadless oilfield including a full-production facility (comprising a processing plant, camp, airstrip, and the CD1 and CD2 drill sites) (Figure 1). Oil began flowing from Alpine east through the pipeline to Kuparuk in 2000. In 2005, construction began on 2 satellite drill sites, whose oil is also processed at Alpine. The CD3 satellite is a roadless drill site accessible by aircraft and boat during the summer and fall and by ice roads during winter. Drilling at this satellite is conducted only during the winter months when ice roads are used for access. The CD4 satellite is connected to Alpine by an all-season road. Both the CD3 and CD4 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 to unify it with similar mapping of the surrounding Coastal Plain (Figure 2; Jorgenson et al. 2004).

Coastal and riverine landforms dominate the delta. Fluvial processes are most prominent, 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 33% of the total area. Coastal salt-affected habitats—Tidal Flat Barrens, Salt-killed Tundra, Salt Marsh, Moist Halophytic Dwarf Shrub, Open Nearshore Water, and Brackish Water—together compose 21% of the total area and contribute greatly to avian diversity. Tapped lakes (Tapped Lake with Low-water Connection and Tapped Lake with High-water Connection, so named because their connections to river channels are dependent on river levels) are unique to delta environments and contribute 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, Sedge Marsh, and Salt Marsh) and waterbodies with islands or complex shorelines (Deep Open Water with Islands or Polygonized Margins and Shallow Open Water with Islands or Polygonized Margins), which account for a combined total of <8% of the delta. Wildlife habitat types are described in detail in Appendix B. A strong north–south gradient occurs across the delta in the distribution of many of these habitats, with coastal habitats—Salt Marsh, Salt-killed Tundra, Brackish Water, and to a lesser extent, Deep Polygon Complex—decreasing in abundance with increasing distance from the coast, whereas Tapped Lakes with High-water Connections, Sedge Marsh, Grass Marsh,



Wildlife Habitat Type

- Open Nearshore Water
- Brackish Water
- Tapped Lake with Low-water Connection
- Tapped Lake with High-water Connection
- Salt Marsh
- Moist Halophytic Dwarf Shrub
- Tidal Flat Barrens
- Salt-killed Tundra
- Deep Open Water without Islands
- Deep Open Water with Islands or Polygonized Margins
- Shallow Open Water without Islands
- Shallow Open Water with Islands or Polygonized Margins
- River or Stream
- Sedge Marsh
- Deep Polygon Complex
- Grass Marsh
- Young Basin Wetland Complex
- Old Basin Wetland Complex
- Nonpatterned Wet Meadow
- Patterned Wet Meadow
- Moist Sedge-Shrub Meadow
- Moist Tussock Tundra
- Moist Low Shrub
- Dry Dwarf Shrub
- Barrens
- Human Modified

Note: Areas mapped outside the study area boundary are shown in muted colors.

Figure 2. Wildlife habitats in the Colville Delta study area, Alaska, 2013

Table 1. Habitat availability in the Colville Delta and the NE NPR-A study areas, Alaska, 2013.

Habitat	Colville Delta		NE NPR-A	
	Area (km^2)	Availability (%)	Area (km^2)	Availability (%)
Open Nearshore Water	10.12	1.8	8.73	2.7
Brackish Water	6.55	1.2	9.47	2.9
Tapped Lake with Low-water Connection	22.28	4.0	6.20	1.9
Tapped Lake with High-water Connection	20.77	3.8	4.87	1.5
Salt Marsh	16.31	3.0	16.51	5.1
Moist Halophytic Dwarf Shrub	0.14	<0.1	0.40	0.1
Dry Halophytic Meadow	0	0	0.21	0.1
Tidal Flat Barrens	58.42	10.6	11.56	3.6
Salt-killed Tundra	25.63	4.6	6.49	2.0
Deep Open Water without Islands	18.42	3.3	20.68	6.4
Deep Open Water with Islands or Polygonized Margins	9.55	1.7	15.84	4.9
Shallow Open Water without Islands	2.01	0.4	2.95	0.9
Shallow Open Water with Islands or Polygonized Margins	0.54	0.1	5.49	1.7
River or Stream	82.79	15.0	6.17	1.9
Sedge Marsh	0.13	<0.1	4.91	1.5
Deep Polygon Complex	13.17	2.4	0.35	0.1
Grass Marsh	1.44	0.3	1.03	0.3
Young Basin Wetland Complex	<0.01	<0.1	0.63	0.2
Old Basin Wetland Complex	0.14	<0.1	22.33	6.9
Riverine Complex	0	0	0.49	0.2
Dune Complex	0	0	1.25	0.4
Nonpatterned Wet Meadow	41.50	7.5	8.96	2.8
Patterned Wet Meadow	102.45	18.6	37.45	11.6
Moist Sedge–Shrub Meadow	12.25	2.2	57.62	17.9
Moist Tussock Tundra	3.24	0.6	58.39	18.1
Moist Tall Shrub	0	0	0.33	0.1
Moist Low Shrub	27.10	4.9	4.09	1.3
Moist Dwarf Shrub	0	0	1.05	0.3
Dry Tall Shrub	0	0	0.26	0.1
Dry Dwarf Shrub	0.47	0.1	3.31	1.0
Barrens	76.11	13.8	4.11	1.3
Human Modified	0.66	0.1	0	0
Total	552.19		322.15	

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, which are far from uniformly abundant across 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 too small to be mapped (<0.25 ha), 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 ACP. 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 as late as 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 thermokarsting 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 stop-over 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.

NE NPR-A

The NE NPR-A study area (1,571 km²) abuts the western edge of the Colville Delta and comprises 5 subareas, which are useful sub-divisions for comparisons with past years: the Development, Exploration, Alpine West, Fish Creek Delta, and Fish Creek West subareas (Figure 1). The NE NPR-A study area is the northeastern portion of the Northeast Planning Area of the NPR-A (BLM 2008), where CPAI has funded wildlife surveys since 1999. The study area extends from 6 to 39 km west of the village of Nuiqsut and 1 to 43 km west of the Alpine Facility. The NE NPR-A study area encompasses 1 permitted and 1 proposed development site (CD5 and GMT1, respectively) and exploration sites that may be proposed for development in the future. The CD5 pad will connect to the Alpine Facility near CD4 by an all-season gravel road, a pipeline, and a bridge across the Niġliq channel (Figure 1). In 2011–2013, avian surveys were conducted in the eastern portions of the NE NPR-A study area; the Fish Creek Delta and Alpine West subareas were surveyed in their entirety, whereas only the northeast corner of the Development subarea was surveyed. Neither the Fish Creek West nor the Exploration subareas were included in the avian studies in 2011–2013.

Three major streams flow through the NE NPR-A study area (Figure 1). On USGS topographic maps (Harrison Bay Quad, 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.

Landforms, vegetation, and wildlife habitats in the NE NPR-A were described in the Environmental Impact Statement for the lease area and the Alpine Satellite Development Project (BLM 2004) and in Jorgenson et al. (2003, 2004). Coastal plain and riverine landforms dominate the NE NPR-A. 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

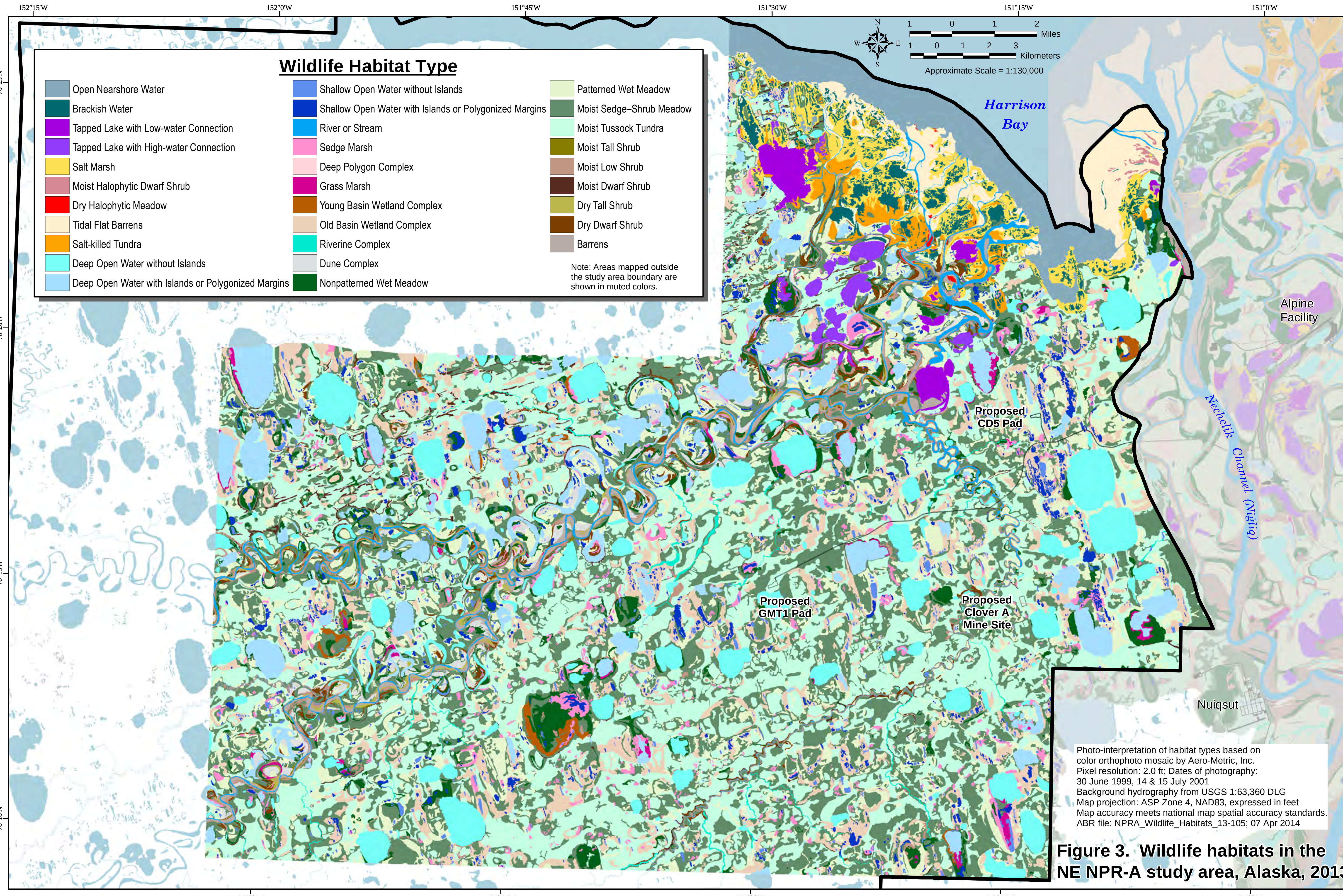


Figure 3. Wildlife habitats in the NE NPR-A study area, Alaska, 2013.

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 NE NPR-A study area are not present on the Colville Delta study area (Figure 3, Table 1). Three habitats dominate the NE NPR-A landscape: Moist Tussock Tundra (18% of area), Moist Sedge–Shrub Meadow (18%), and Patterned Wet Meadow (12%; Table 1). Aquatic habitats comprise 27% of the study area. Although the NE NPR-A 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 NE NPR-A than they are on the Colville Delta.

Like the Colville Delta, the NE NPR-A is an important area for wildlife and for subsistence harvest activities. The NE NPR-A 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 NE NPR-A study area are a regionally important nesting area for Yellow-billed Loons, annually supporting a similar number of nesting pairs as does the Colville Delta (Burgess et al. 2003b, Johnson et al. 2004).

METHODS

Aerial surveys were the primary means for collecting data on bird species using the Colville Delta and NE NPR-A 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 2013, 4 aerial surveys were conducted using fixed-wing aircraft: 1 for eiders during pre-nesting, 2 for Tundra Swans during nesting and brood-rearing, and 1 for geese (primarily Brant and Snow Geese) during brood-rearing. 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). Fifteen aerial surveys (1 per week) for loons were conducted from a helicopter, targeting specific lakes suitable to Yellow-billed Loons. The NE NPR-A study area was surveyed in 2011–2013 for eiders, loons, swans and geese, but the area surveyed was reduced from that surveyed earlier to the Alpine West and Fish Creek Delta subareas and the northeastern corner of the Development subarea (total area = 322 km², Figure 1). 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 (see survey protocols for each species group below). 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 submitted to the Kuukpik Corporation and the Kuukpik Subsistence Oversight Panel.

During the surveys, locations of eiders, loons, and swans were recorded on digital orthophoto mosaics of 1 ft resolution natural color imagery acquired in 2004–2012 (Colville Delta and Alpine West subarea in NE NPR-A, by Quantum Spatial), 2 ft resolution natural color imagery acquired in 1999–2004 (Development Area and Fish Creek Delta subareas in NE NPR-A, by Quantum Spatial), or 8.2 ft resolution color infrared imagery acquired in 2002 (Fish Creek West and Exploration subareas in NE NPR-A, by USGS). Bird locations plotted on maps 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.

In this report, we typically present data summaries with means plus or minus standard errors (mean ± SE). In some cases we report the median values. Statistical significance is assigned at $P \leq 0.05$ unless otherwise stated. Analyses were conducted in Microsoft® Excel (Office 2010) and SPSS 18 (IBM SPSS Inc., Chicago, IL).

EIDER SURVEYS

We evaluated the regional abundance, distribution, and habitat selection of 2 species of eiders with data collected on 1 aerial survey flown during the pre-nesting period (Table 2), when male

Table 2. Avian surveys conducted in the Colville Delta and the NE NPR-A study areas, Alaska, 2013.

Survey Type / Season / Survey Area	Number of Surveys	Survey Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
Eider survey							
Pre-nesting							
Colville Delta	1	14–15 June	C185	0.4	0.4	30–35	100% coverage
NE NPR-A	1	13–14 June	C185	0.4	0.8	30–35	50% coverage
Yellow-billed Loon surveys[b]							
Nesting	1	19–21 June	206L	–	–	60–75	All lakes ≥5 ha and adjacent lakes
Brood-rearing	1	21–22 Aug.	206L	–	–	60–90	Yellow-billed Loon territory lakes
Nest and brood monitoring	15 (1/week)[c]	26 June–24 Sept.	206L	–	–	60–90	Lakes with active nests and broods
Tundra Swan surveys							
Nesting	1						
Colville Delta		20–26 June	C185	1.6	1.6	150	100% coverage
NE NPR-A		26–27 June	C185	1.6	1.6	150	100% coverage
Brood-rearing	1	20–21 Aug.	C185	1.6	1.6	150	100% coverage, all areas
Goose surveys							
Brood-rearing	1	26 July	PA-18	–	–	75–150	Coastal and lake-to-lake pattern
Greater White-fronted Goose							
Ground nest searches	1	12–21 June	–	–	–	–	40 plots, 10 ha in size, CD-5 area
Nest fate monitoring	1	16–17 July	–	–	–	–	Post-hatch visits to nest sites

[a] C185 = Cessna 185 fixed-wing airplane; 206L = Bell "Long Ranger" helicopter; PA-18 = Piper PA-18 "Super Cub" fixed-wing airplane
[b] Pacific and Red-throated loons, nests, and broods, and Glaucous and Sabine's gull nests and broods were recorded incidentally
[c] Total includes the brood-rearing survey conducted on 21–22 August

eiders (the more visible of the 2 sexes in breeding plumage) were still present on the breeding grounds. Spectacled and King eiders are the only species of eiders that are consistently abundant in the Colville Delta and NE NPR-A; the other 2 species, Common Eiders and Steller's Eiders, are seen infrequently. The pre-nesting survey in 2013 covered the same areas surveyed in 2012 and prior years in the Colville Delta. In the NE NPR-A, the survey area for eiders in 2011–2013 was contracted eastward from the survey boundary in 2010 (Figure 4). We conducted the pre-nesting survey during 13–15 June using the same methods that were used on the Colville Delta in 1993–1998 and 2000–2012 and in the NE NPR-A study area in 1999–2006, 2008–2013 although the survey areas and survey coverage differed among years (see Anderson and Johnson 1999; Burgess et al. 2000, 2002a, 2003a; Johnson 1995; Johnson and Stickney 2001; Johnson et al. 1996, 1997, 1998, 1999a, 2000a, 2002, 2003b, 2004, 2005, 2006b, 2007b, 2008b, 2009, 2010, 2011, 2012, 2013a; Murphy and Stickney 2000; Smith et al. 1993, 1994). The survey was flown in a Cessna 185 airplane at 30–35 m above ground level (agl) and approximately 145 km/h. Two observers each counted eiders in a 200-m-wide transect on each side of the airplane (400 m total transect width) and the pilot viewed the area ahead of the aircraft. A Global Positioning System (GPS) receiver was used to navigate pre-determined east–west transect lines that were spaced 800 m apart, achieving 50% coverage in the NE NPR-A study area and 400 m apart achieving 100% coverage over the Colville Delta study area (Figure 4). The lower coverage in the NE NPR-A was intended to sample the larger area with its lower densities of Spectacled Eiders relative to the Colville Delta study area. Three areas were not surveyed on the Colville Delta: the extensive tidal flats and marine waters on the northernmost delta (Spectacled and King eiders rarely use those habitats during the survey time period; Johnson et al. 1996), a ~1.6-km-radius circle around the Helmericks' homesite, and the southernmost portion of the delta near Nuiqsut (Figure 4). The latter 2 areas were avoided to limit disturbance to residents. Eider locations were recorded on color photomosaic maps (1:63,360-scale) and digital voice recorders were used to record species, number of identifiable pairs, and the sex and activity (flying or on the ground) of each individual.

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 in singles, pairs, or flocks (flocked males are 2–4 males with no females), plus the number of birds in groups (groups are defined as >3 birds of mixed sex that cannot be separated into singles or pairs; however, 1 female with 2 males are a pair and single male, and 1 female with 3 males is considered a pair and 2 single males). Annual growth rate for pre-nesting adults was calculated with log-linear regression on adjusted counts for the period from 1993–2013. Adjusted counts were calculated from the density of indicated birds, multiplied by the maximal area surveyed in all years (501 km²).

LOON SURVEYS

We conducted 1 aerial survey for nesting Yellow-billed Loons on 19–21 June and 1 aerial survey for brood-rearing Yellow-billed Loons on 21–22 August in 2013 (Table 2). In the Colville Delta study area, we surveyed 160 lakes for nesting loons and 127 lakes for brood-rearing loons (Figure 5). Both surveys were conducted annually on the Colville Delta during 19 years from 1993 to 2013; surveys were not conducted in 1994 or 1999. The CD North and CD South subareas were surveyed each year and part of the Northeast Delta subarea was surveyed in all survey years except 2000. The number of lakes surveyed increased in 2002 because of a small expansion in the study area to include lakes between the eastern boundary of the NE NPR-A and the Niġliq Channel, and again in 2008 because the minimum size of lakes surveyed was reduced from 10 ha to 5 ha.

In the NE NPR-A study area during 2013, we surveyed 97 lakes for nesting Yellow-billed Loons and 74 lakes for brood-rearing loons (Figure 5, Table 2). We have conducted surveys for nesting and brood-rearing Yellow-billed Loons in the NE NPR-A in all years during 2001–2013 except for 2007. During these 11 years of surveys, we surveyed 5 different subareas in the NE NPR-A study area: the Development subarea in 2001–2004, the Exploration subarea in 2002–2004,

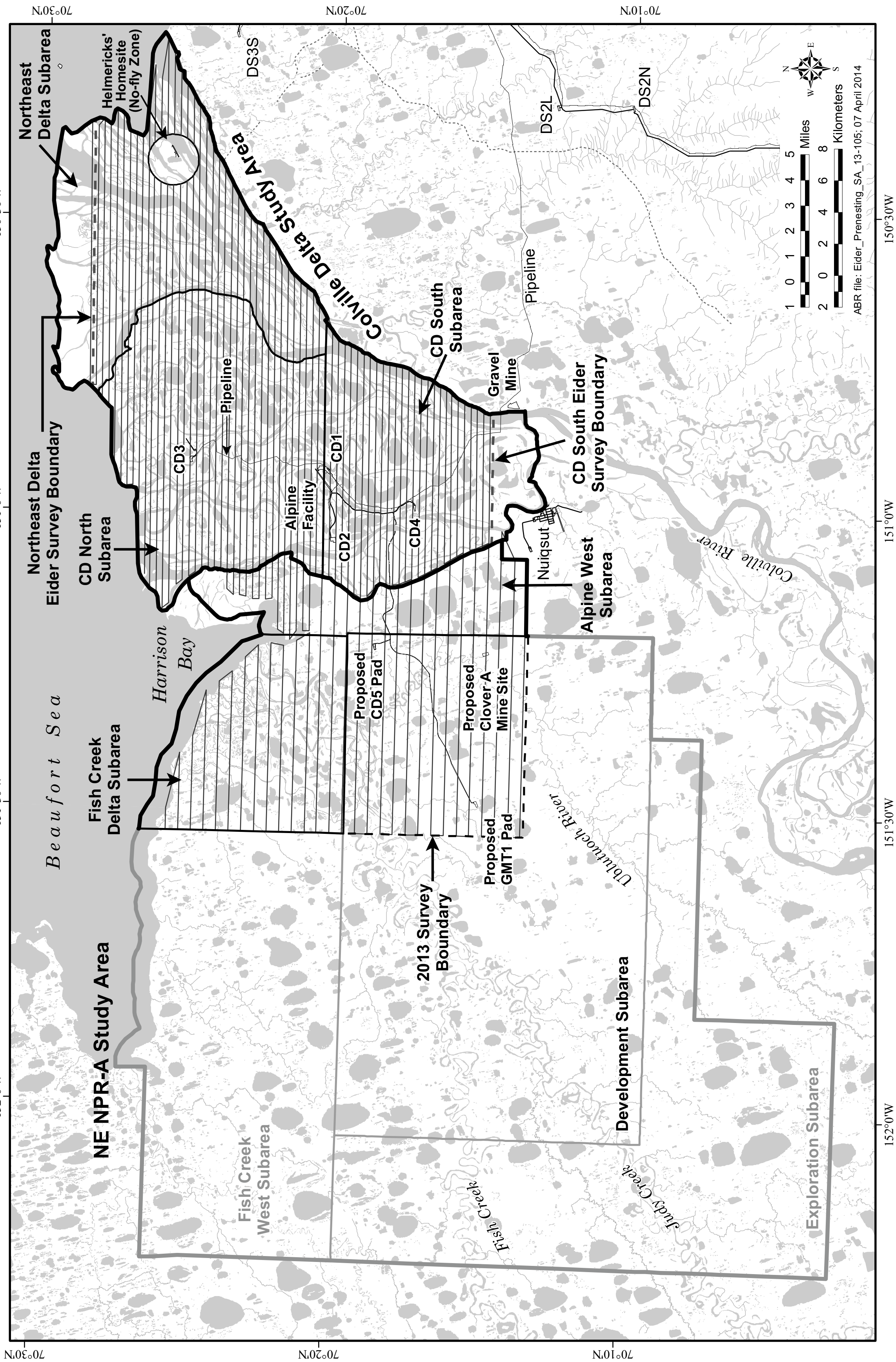


Figure 4. Transect lines for aerial surveys of pre-nesting eiders, Colville Delta and NE NPR-A study areas, Alaska, 2013.

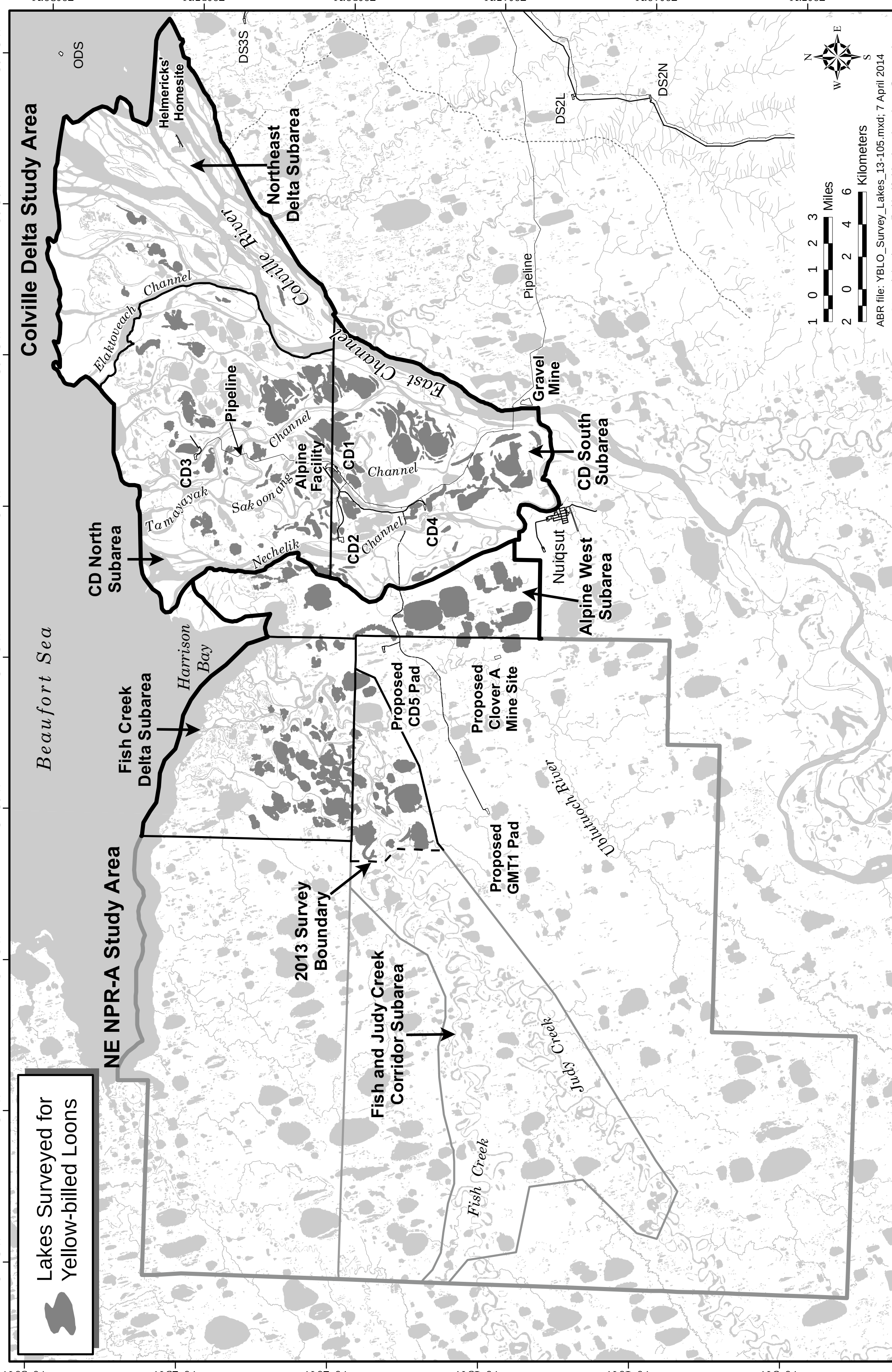


Figure 5. Lakes included in aerial surveys for Yellow-billed Loons, Colville Delta and NE NPR-A study areas, Alaska, 2013.

the Alpine West subarea in 2002–2006 and 2008–2013, and the Fish Creek Delta subarea in 2005–2006 and 2008–2013 (Figure 5). The fifth subarea, the Fish and Judy Creek Corridor subarea, was created in 2008 only for loon surveys and it comprises a series of deep lakes adjacent to Fish and Judy creeks within the Development and Exploration subareas. We surveyed the Fish and Judy Creek Corridor in 2008–2010, along with 4 additional Yellow-billed Loon territories in the Development and Exploration subareas that were identified in previous years. In 2011–2013, the surveyed portion of the Fish and Judy Creek Corridor subarea was reduced to its eastern quarter.

Each year the nesting survey was conducted between 19 and 30 June and the brood-rearing survey between 15 and 27 August. In 2011 and 2012, we added a survey for nests on 13 June, 1 week prior to the nesting survey, to document early nesting phenology and nest survival. During the 13 June survey, only lakes where Yellow-billed Loons nests had been recorded in previous years were surveyed. Nesting surveys were conducted from a Cessna 185 or PA-18 Super Cub fixed-wing airplane during 1993–1998 and a Bell 206L during 2000–2013. Brood-rearing surveys were conducted from a Cessna 185 in 1993 and a Bell 206L in all other years. All surveys were flown in a lake-to-lake pattern at 60–90 m above ground level. The perimeter of each lake was circled while 1 observer searched lake surfaces and shorelines for loons and nests during the nesting survey and loons and young during the brood-rearing survey. Survey lakes were selected before each survey and included most lakes ≥10 ha in size in 1993–2007 and most lakes ≥5 ha in size in 2008–2013. We reduced the minimum survey lake size to 5 ha for nesting surveys to increase survey efficiency. During nesting surveys each year, we also surveyed small lakes (1–10 ha) and aquatic habitats adjacent to survey lakes because Yellow-billed Loons sometimes nest on small lakes next to larger lakes that are used for brood-rearing (North and Ryan 1989). Tapped Lakes with Low-water Connections (lakes whose levels fluctuate with changing river levels) were excluded from surveys during all years because Yellow-billed Loons do not use such lakes for nesting (North 1986, Johnson et al. 2003b).

We recorded incidental observations of Pacific (Malġi) and Red-throated loons (Qaqsrauq) during all nesting and brood-rearing surveys. All locations of loons and their nests were recorded on USGS maps (1:63,000) in 1993, 1995–1998, and 2000–2002, and on color photomosaics (1:30,000 scale) in 2003–2013. In 2005–2013, Yellow-billed Loon nest locations also were marked on high resolution color images of nest site areas (~1:1,500). All loon locations were digitized into a GIS database.

We summarized numbers of adults, nests, broods, and young for each species counted on aerial surveys. Densities of adults, nests, and broods were calculated only for Yellow-billed Loons because Pacific and Red-throated loons commonly nest on lakes <5 ha in size and only a subset of lakes that size were included in the survey. Counts of Yellow-billed Loon adults, young, nests, and broods are presented from previous years of nesting and brood-rearing surveys, and additionally, from ground-based, revisit, and monitoring surveys. Ground-based surveys mostly occurred near drill sites and facility areas and were conducted within a week of the nesting survey during 1992–2007 in the Colville Delta study area and 1999–2004, 2009, 2010, and 2013 in the NE NPR-A study area. Revisit and monitoring aerial surveys (described below) occurred after the nesting survey. We conducted revisit surveys in 1996–1998 and 2000–2002 to search for nests on previously identified Yellow-billed Loon breeding lakes where no nest was found on the nesting survey. Revisit surveys consisted of 1 or more surveys that took place anywhere from 3 to 12 days after the nesting survey. Weekly monitoring of active nests began in 2005, but lakes without nests identified on the nesting survey were not resurveyed that year. From 2006 on, all previously identified Yellow-billed Loon breeding lakes plus other lakes where Yellow-billed Loons were observed during the nesting survey were surveyed weekly for 2 weeks after the nesting survey to search for nests that were initiated later or were missed on previous surveys. In 2013, we surveyed lakes for 3 weeks because high water may have delayed nesting on some territories.

To make annual comparisons among years when different numbers of territories were sampled, we calculated territory occupancy by dividing the number of territories with nests, adults, or broods by the number of territories surveyed. We defined a territory as a single lake, several lakes, or portion of a lake occupied exclusively by 1 breeding pair with a nest or brood in 1 or more years. Territories were identified using data from all years; boundaries between territories were determined by where nests and broods occurred, and additionally, by the locations of adults on multi-territory lakes. To adjust counts of adults, nests, and young for the number of territories surveyed in the Colville Delta study area, we divided those counts by the number of territories surveyed and multiplied by the highest number of territories surveyed in all years (43). Population growth rates for adults, nests, and young were estimated in the Colville Delta study area with log-linear regression on adjusted counts for the period from 2000 to 2013, when helicopters were used for all surveys.

NEST MONITORING AND NEST FATE

Weekly monitoring surveys were conducted in the Colville Delta and NE NPR-A study areas in 2005–2013 and 2008–2013, respectively. Weekly surveys monitored the fate of Yellow-billed Loon nests, in addition to the objective listed above, which was to find nests that may have been missed or that were initiated later in the season. In 2005, we monitored the lakes with active nests. From 2006 on, we resurveyed lakes with active nests and all other lakes previously identified as breeding territories or lakes occupied by Yellow-billed Loons for 2 weeks after the nesting survey. After 2 weeks, we continued to monitor lakes with confirmed nests, but no attempt was made to search for additional nests.

Each active nest was surveyed weekly from a helicopter until the nest was no longer active. Active nests had an incubating adult or a nest with eggs, whereas inactive nests lacked eggs or, as in the case of abandonment, had eggs that were no longer being incubated. When a nest appeared inactive, we immediately searched the nesting lake for a brood by flying along the shoreline and across the lake. Adjacent lakes known from previous surveys to be brood-rearing lakes or part of a pair's territory also were searched.

Camera-monitored nests (see below) were not included in weekly surveys, because we used camera images to determine nest status. The weekly status of camera-monitored nests was determined from the camera images taken at 14:00 on the day of the monitoring survey, which approximated the middle of the period when we typically flew our aerial surveys. For monitoring surveys that spanned multiple days, we used camera data from the first survey day. We resumed visiting camera-monitored nests during the week of hatch, which was estimated from the nest age at the time of camera installation (see below).

We inspected the contents of inactive nests to confirm nest fate. The nest and the surrounding area within 5 m, including the water adjacent to the nest, were examined closely for egg remains, including eggshell fragments, egg membranes, and broken eggs. 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. In general, nests were assumed failed if they contained <20 egg fragments, eggshells had signs of predation (i.e., 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. We used egg fragments in addition to the presence of broods to classify nest fate because some broods may not survive the period between hatch and the following monitoring survey. Nest fate was based on the number of fragments as long as there was no conflicting evidence (e.g. too many or too few days of incubation for a particular fate). Images from time-lapse cameras (see below) were used to confirm nest fate where possible. 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, and 21–30 mm. Egg membranes or pieces of membranes also were counted and measured.

TIME-LAPSE CAMERAS

We began using time-lapse digital cameras in the Colville Delta and NE NPR-A study areas in 2008 and 2010, respectively, primarily to monitor nest survival and, secondarily, to record nest attendance patterns and identify causes of nest failures. Cameras were installed at active nests within several days of the nesting survey. We used 3 models of Silent Image® Professional cameras: PM35 cameras with custom 8× telephoto lens taking 0.3-megapixel images, and PC85 and PC800 cameras with custom 2.5× and 2× telephoto lens taking 3.1-megapixel images (Reconyx, Lacrosse, WI). The cameras were mounted on tripods that were tied down to stakes to stabilize them against the wind. The PM35 cameras were equipped with 2-GB memory cards and programmed to take 1 image/60 sec. The PC85 and PC800 cameras were equipped with 32-GB memory cards and programmed to take 1 image/30 sec. All cameras were run on external 12V sealed lead acid batteries. We chose settings, memory cards, and batteries so that cameras could take the maximum number of photos possible for 23–28 d without requiring maintenance (i.e., battery or memory card changes).

In late May 2013, prior to nesting, we deployed 11 cameras (10 PC800 and 1 PC85) in the Colville Delta study area at territories with reliably-used nest sites in an effort to observe pre-nesting behavior and the start of incubation. Incubation length in Yellow-billed Loons has received little study and is an important variable in nest survival analyses. In addition, confirming nest age at the time of egg flotation will refine the float schedule used to estimate egg ages at other nests. Cameras were not deployed during pre-nesting in NE NPR-A to reduce air traffic and potential conflicts with goose hunters from Nuiqsut.

Cameras deployed during late May were revisited after the nesting survey. If a nest was in camera view, we replaced the camera with one that contained a new memory card and a fresh battery; otherwise cameras were collected, serviced, and redeployed at territories with active nests found during the nesting survey. Nests were not monitored if they lacked suitable views for camera-monitoring or if they were close to a nesting Glaucous Gull. A total of 13 nests were monitored in the Colville Delta using 4 PM35, 5 PC85, and 5 PC800 cameras (1 nest was monitored in part by 2 different camera types). Nine nests were monitored in NE NPR-A with 2 PM35, 4 PC85, and 3 PC800 cameras. Three cameras deployed in May captured the start of incubation; otherwise, cameras were installed within 1–6 d (median = 3 days, n = 19) of nest discovery. We removed cameras when nests were no longer active.

We reviewed digital images on personal computers with Irfanview software (version 4.33). Loon activity was classified into 3 major types of activity: incubation, break, and recess. Incubation included sitting postures of normal incubation (head up and posture relaxed, or head resting on back), alert incubation (head up in a rigid, attentive posture), concealed incubation (head and body down and flattened in vegetation), and gathering nest material while on the nest. Break activities included brief standing activities at the nest, including changing positions, settling on the nest after changing position, standing over the nest, and egg moving. Recess activities were absences from the nest, including incubation exchanges, sitting beside the nest, and those activities immediately preceding and following the recess or incubation exchange, including egg moving, swimming beside the nest, flying, and gone from view. We identified predators in camera view 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 or when adults were seen removing egg membranes from the nest, whichever was observed first. Sometimes young were not detectable on images due to vegetation around the nest or a narrow camera field of view. If eggshell evidence and/or aerial surveys indicated hatch, the day of hatch was identified by the increased presence of the non-incubating loon at the nest as it begins to feed the hatchlings. If the mate's presence also was obscured, then egg flotation data were used to estimate hatch date. We judged a nest to be failed if the loons did not resume incubation after a predator was seen at the nest. The time of failure was taken from the first image containing the predator. Not all predation events were captured on images, and in those cases we assigned nest failure as the time when the loons stopped incubating the nest. After predation, loons swim next to the nest, often in alert posture, followed by frequent trips back to the nest before ending nest attendance. Eggshell evidence was used to confirm failure at such nests.

The date incubation started was estimated for successful nests by backdating 28 d from the day of hatch. North (1994) reported 27 and 28 d for the incubation period of Yellow-billed Loons, which begins with laying of the first egg. For failed nests, we estimated the start of incubation by using nest ages derived from an egg-flotation schedule that we developed from known-age Yellow-billed Loon nests in 2008–2013 (using a method developed for Semipalmated Sandpipers by Mabee et al. [2006]). During visits to Yellow-billed Loon nests to set up cameras in 2008–2013, we floated eggs in water and recorded the position of the egg in the water column (on the bottom [all eggs in 2013], suspended in the water column, or on the surface), measured the angle between the central axis of the egg and the water surface (from 0º when egg is first laid to a maximum of 90º when the egg is vertical 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 in 2008–2013 ("known-age" nests; n = 49 nests), the clutch age on the day of egg floating was determined by backdating from the hatch date to the day the eggs were floated. These known- age nests were used to develop a regression to estimate egg ages from flotation data for use with nests without hatch dates. If a known-age nest had 2 eggs, we used the average of the float angles in the clutch age regression. The relationship between the float angle and clutch age for nests 1–14 d old was determined by linear regression (clutch age = 2.33 × float angle – 3.91, R^2 = 0.93, n = 49 nests). For nests with unknown ages, we used the regression equation to estimate nest age at discovery and backdated to the incubation start date. For unknown-aged nests with 2 eggs, the older of the 2 eggs was used for determining nest age. Because we did not revisit active nests after camera installation in June, eggs were floated only once and only in the early stages of incubation.

The number of days monitored and incubation parameters (constancy, recess and exchange frequency, and recess length) were calculated for each nest from the time the loon returned to the nest after camera installation to the day before hatch, or to the time of nest failure. Periods of time when images could not be interpreted because of poor weather conditions were excluded. Mean daily number of recesses and exchanges were calculated as the sum of that activity divided by number of days monitored. Incubation constancy was compared between successful and failed nests with a Mann-Whitney U test; nests monitored for <1 day were excluded from analysis.

BROOD MONITORING

We conducted weekly brood monitoring surveys after hatch to estimate chick survival and document juvenile recruitment of Yellow-billed Loons during 2008–2013 in the Colville Delta and 2009–2013 in NE NPR-A. Brood-monitoring surveys were flown in a manner similar to the brood-rearing survey described above. We surveyed all territories with nests or broods by flying above the shoreline and scanning for loons on the water. If no young were seen, lakes were circled 2–3 more times, and for some large lakes, the helicopter was flown down the center of the lake at a higher altitude. If young still were not seen, the territory was revisited at the end of the survey, if time allowed. We considered a brood failed if no young were observed during 2 consecutive weekly surveys, unless conditions on those surveys may have prevented detection of young. Windy conditions with waves breaking in whitecaps during the surveys can hide young loons. When >2 adult Yellow-billed Loons (e.g., the breeding pair and intruding adults) are present on a brood lake, young often hide in shoreline vegetation. When either of those conditions occurred on a lake previously containing young, the lake was resurveyed the following week to compensate for reduced brood detection. Brood locations were mapped by hand and recorded with the number of adults and young.

The final age of each brood was calculated by subtracting the date of initial observation of the first chick from the date of the last observation, adjusting for the uncertainty of the actual dates. To account for the unknown number of days the brood was alive before the first observation, we used the midpoint between the date of first observation of young and the last observation of incubation. Similarly, to account for the number of days the brood was alive after its last observation, we used the midpoint of the interval between the date of its last observation alive and the first observation of its loss (absence). In the case of the typical 7-day interval between surveys, each chick was assumed to be 4 d old when first observed, and for the same interval, the date of death was assumed to be 4 d after it was last observed.

Chick production was estimated at hatch and again during the final monitoring survey in mid-September. Chick production at hatch was estimated as the number of chicks seen during the monitoring survey following hatch divided by the number of nests found. If a nest was classified as successful based on eggshell fragments and no chicks were observed, we assumed 1 chick was produced. Because only a sample of nests were monitored with a camera and because the images often revealed additional chicks at hatching that were not observed during surveys, we present chick production at hatch both with and without chicks only seen on images. Chick production in September is estimated as the number of chicks seen on our last survey divided by the total number of nests found.

TUNDRA SWAN SURVEYS

We flew 1 aerial survey for nesting Tundra Swans on 20 and 26 June and 1 survey for brood-rearing Tundra Swans on 20–21 August 2013 (Table 2). With the exception of an area within ~1.6 km radius of the Helmericks' family homesite on Anachlik Island in the northeastern Colville Delta, each aerial survey covered the entire Colville Delta and NE NPR-A study areas (Figure 6). We conducted the surveys in accordance with USFWS (1987b, 1991) protocols, using the same methods employed for 20 years during 1992–2013 on the Colville Delta (no surveys occurred in 1994 or 1999) and 11 years during 2001–2013 in the NE NPR-A (no surveys occurred in 2007 or 2010). We followed east–west transects spaced 1.6 km apart 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 was photographed for site verification using a Canon PowerShot SX10 IS (10 megapixel) or a Canon PowerShot SD850 IS (8 megapixel).

Numbers of swans, nests, and broods were summarized and densities were calculated for subareas and the larger study areas. Apparent nesting success was estimated from the ratio of broods to nests counted in each study area 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. Population growth rates for adults, nests, broods, and young on the Colville Delta study area were calculated with log-linear regression for the period from 1992 to 2013.

GOOSE SURVEYS

NEST PLOT SELECTION

In 2013, we initiated a new task to study nesting by Greater White-fronted Geese (henceforth White-fronted Geese) before and after construction of the proposed CD5 drill site. We randomly selected plot locations for conducting nest searches from a 6 × 6 km grid centered on the proposed CD5 drill site. The grid contained 3,600 total points spaced 100 m apart, of which 60 points were randomly selected. Each point was used to locate the start of a 100 m × 1,000 m (10 ha) plot, oriented parallel to the proposed road or pad, whichever was closest. Plots were discarded if they overlapped a previously selected plot or had more than 25% of area in lakes. In the field, plots were completed in clusters of 1–5 a day, all within walking distance (<2 km from the end of one to the start of another). Each successive day we alternated between clusters of plots that were near the proposed facility locations and those that were far from facility locations.

NEST SEARCHING

We conducted a nest search to determine the abundance, distribution, and nest survival of White-fronted Geese in the area proposed for construction of the CD5 drill site. We recorded nests of other large waterbirds as they were encountered. One nest search was conducted on foot during 12–21 June in a 4.0-km^2 area comprising 40 plots (Figure 7). A crew of 4 people

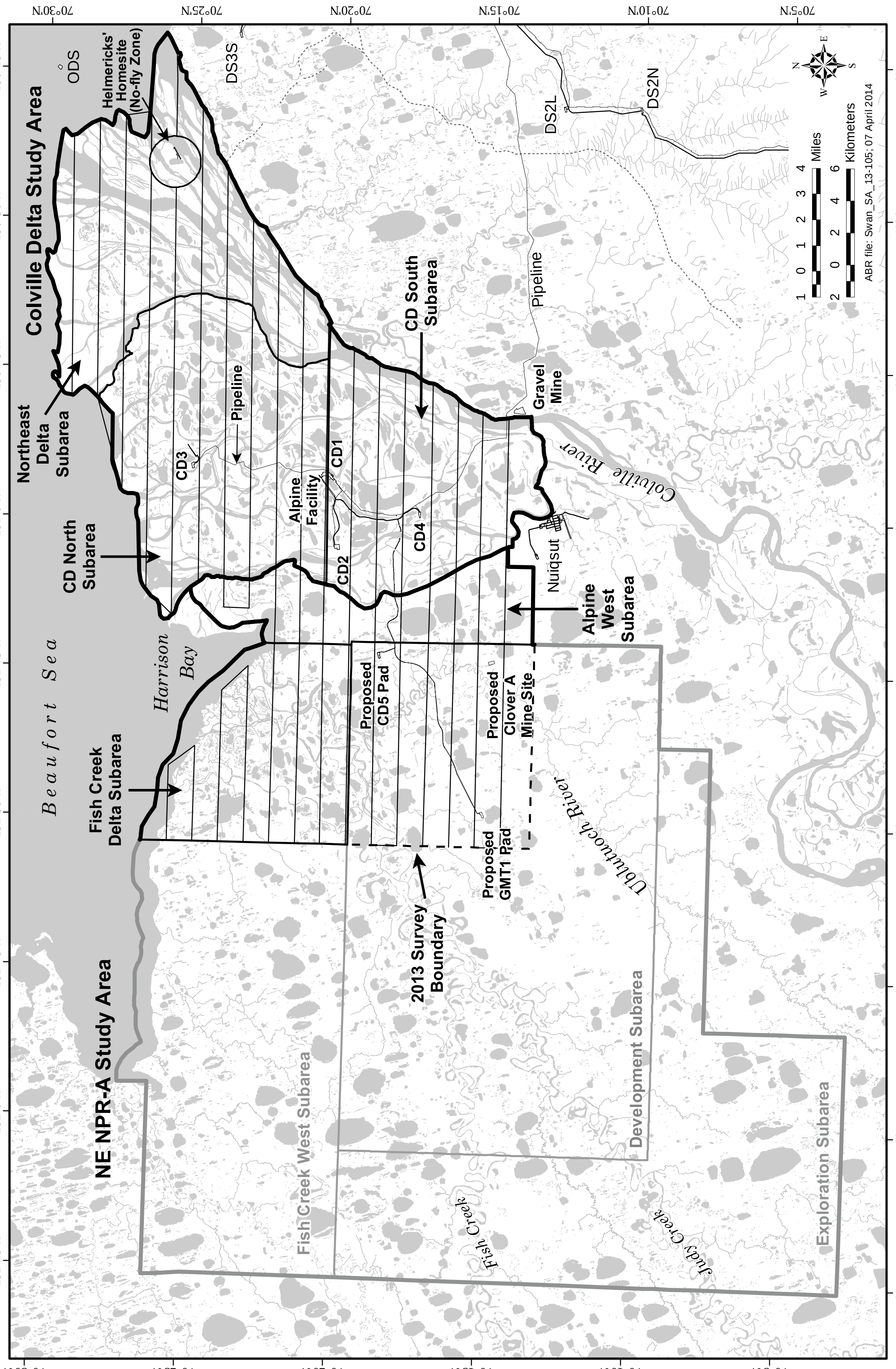


Figure 6. Transect lines for aerial surveys of nesting and brood-rearing Tundra Swans, Colville Delta and NE NPR-A study areas, Alaska, 2013.

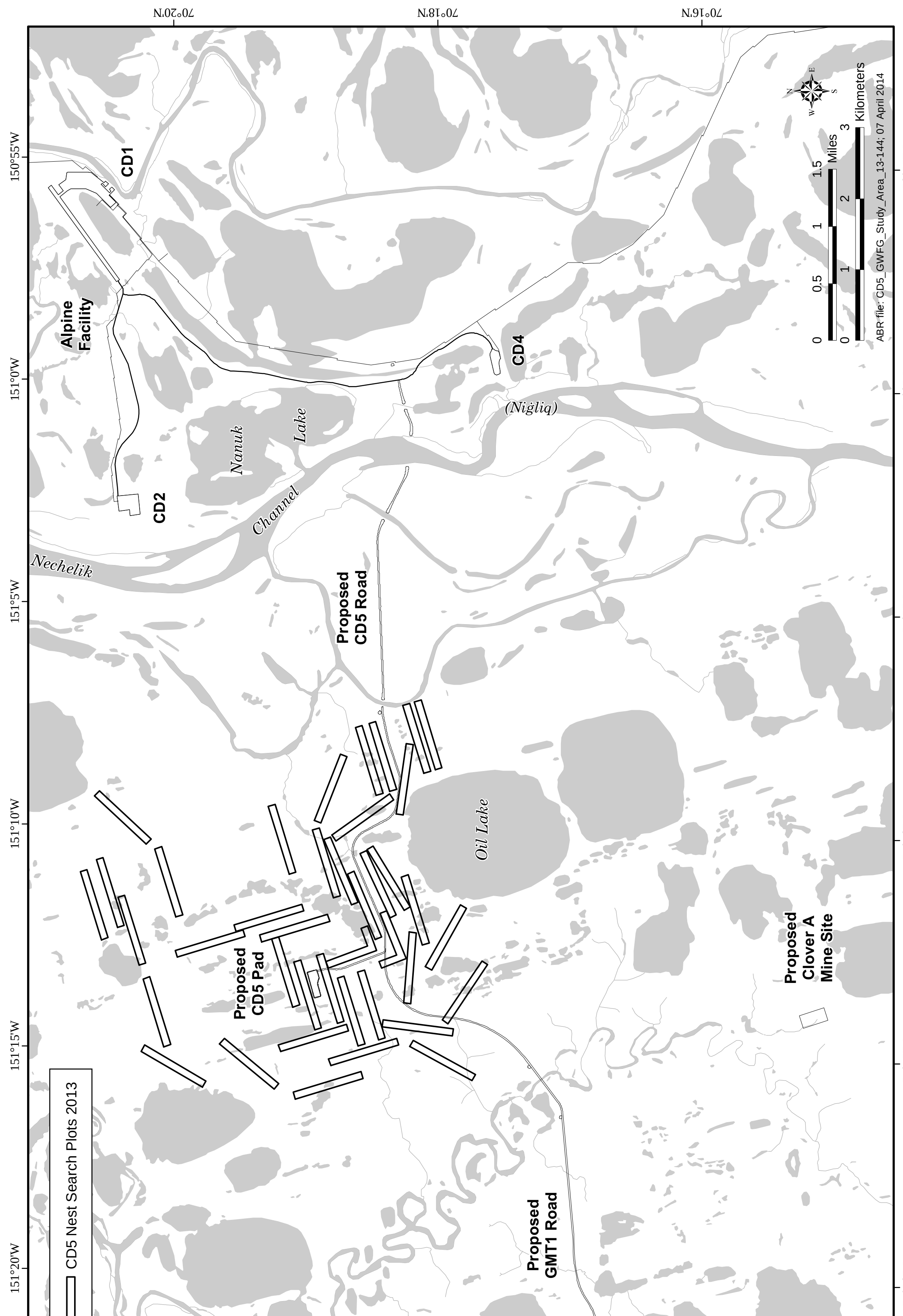


Figure 7. Plot locations for ground-based survey of nesting Greater White-fronted Geese in the proposed CD5 area, NE NPR-A, Alaska, 2013.

spaced 20 m apart searched for nests by walking a zigzag pattern, to achieve total coverage of the tundra within a plot's boundaries. Plot boundaries were displayed on a moving map on handheld GPS units. Crew members looked for nests of large birds (excluding songbird and shorebird nests) in the area around and ahead of themselves and communicated with hand-held radios when nests were spotted to avoid flushing incubating birds. For each nest found, we recorded the species, location, active status, distance to nearest water, distance to nearest waterbody, waterbody class, whether or not the bird flushed, the distance at which it flushed, and for the flushed nests we recorded the number of eggs and the nest age. Nests were recorded as active (nest attended or eggs were warm), potentially active (unattended nests with ambient-temperature eggs, indicating laying or abandonment), or inactive (unattended and without eggs). We also floated 1–3 eggs in water (Westerkov 1950, Mabee et al. 2006) from all nests of White-fronted Geese and Cackling/ Canada Geese to determine egg age and to estimate incubation start dates. Nest data were recorded on a GPS and downloaded to a database at the end of the day.

Unattended nests were identified to species or species group based on the size and color pattern of contour feathers, down, or eggs (Anderson and Cooper 1994, Bowman 2004). Some nests were unidentified because too few feathers were in the nest or feathers were not clearly definitive in determining species. Wooden survey stakes (18 in high) were placed ≥15 m from active nest sites to assist in relocating the nest. Before we departed from waterfowl nests where the incubating bird was absent, eggs were covered with nest material and additional vegetation to conceal the nest from predators.

TEMPERATURE SENSING THERMISTORS

Temperature-sensing thermistors and data loggers were installed in 38 White-fronted Goose nests to record incubation activity and assist in determining nest survival. The thermistor (TMC6-HD; Onset Computer Corporation, Bourne, MA) consisted of a 2.5 cm temperature sensor on a thermistor cable ranging from 0.3 m to 1.8 m long connected to a small data logger (HOBO® H8, Onset Computer Corporation, Bourne, MA).

Eggs were removed from all goose nests before installing temperature sensors. The thermistor cable was hidden in a shallow trench (2–3 cm deep) leading 15–30 cm from the nest to the data logger, which was sealed in a waterproof bag and buried 3–5 cm under the vegetation mat. To prevent the removal of equipment by geese or nest predators, the thermistor was attached to a 15 cm toggle-bolt and pressed into the center of the nest bowl and a tent stake was used to anchor the thermistor cable to the ground. After installation, the eggs were returned to the nest and covered with down and vegetation. After the nesting season, thermistors and data loggers were retrieved and the temperature data were exported using BoxCar Pro version 4.3.1.1 (Onset Computer Corporation, Bourne, MA). This software provides a graphical representation of the temperature data recorded at each nest. Termination of nesting is indicated when there is a sharp drop in temperature followed by a cyclical pattern that tracks ambient temperatures. We used this information to determine hatch or failure dates for nests.

NESTING SUCCESS

On 16–17 July, we revisited all nests to determine nest fates. For all species, a nest was considered successful if evidence suggested that at least 1 egg hatched. Hatch was determined by the presence at the nest of detached egg membranes, eggshells with thickened membranes that were easily peeled from the shell, eggshell pipping fragments (>5 mm), and eggshell tops or bottoms. The presence of yolk, blood, eggshells with holes, egg fragments with attached membranes, or the total absence of egg remains indicated predation of eggs. Temperature data from nests installed with thermistors (see above) were reviewed for indications of hatch or failure. Any evidence of predation (fox smell, fox scat, or a disturbed nest site) was noted.

Apparent nesting success was estimated by dividing the number of nests that hatched by the number of nests found, including nests that were inactive at discovery. Apparent nesting success is generally acknowledged to overestimate success because it does not take into the account the length of time nests are exposed to predators and other risk factors (Mayfield 1961). We report apparent nesting success for all nests found, because it is easily calculated for large numbers of nests without the added disturbance or expense of periodic monitoring or monitoring devices. We also calculated nesting success for a sample of nests with daily survival rates (DSR). Daily survival rates can be used to calculate unbiased estimates of nesting success, but they require periodic monitoring of nests to determine status. We used temperature sensing thermistors to monitor nests and collect data to calculate DSR (see above). Daily survival rates were estimated in program MARK (White and Burnham 1999), where we used 31 d as our nesting period for White-fronted Geese. Nesting period is defined in program MARK as the number of days from the date the first nest is found to the date the last nest is hatched or failed. Incubation period success was calculated by raising the DSR to the exponent of the number of days of incubation. The incubation period for White-fronted Geese is 22–27 d (Ely and Dzubin 1994); the modal incubation length for geese at CD5 in 2013 was 24 d, which is the value we used to estimate the success rate for the incubation period. We estimated incubation and nest initiation dates for White-fronted Geese and Canada Geese using the egg-flotation data or backdating in the case of nests with known hatch dates. Each floated egg was assigned an age from a float schedule based on the angle and position of the egg in the water column (unpublished data provided by Jerry Hupp, USGS). The float schedule provided estimates of ages in 2- to 4-day ranges; we used the midpoint of the range or the earlier date in the case of 2-day ranges. We used the youngest (last-laid) egg sampled in each nest to arrive at the start date for incubation. Nest initiation was calculated by subtracting 5 d (4 eggs × 1.33 days/egg; Ely and Dzubin 1994, Mowbray et al. 2002, Johnson et al. 2003a) from the incubation start date.

PREDATOR SCANS

We conducted predator scans on all of our plots to determine the types and numbers of potential nest predators in the CD5 area. On each plot, we conducted 2 (but occasionally 1 or 3), 10 min scans for avian (i.e., jaegers, gulls, raptors, and ravens) and mammalian (i.e., foxes, bear) predators observed within plot boundaries and ≤300 m of plot boundaries. Predator scans were initiated on the center line at the beginning and end of each plot (1 km apart) at the start and end of the nest-searching effort on each plot. During each scan, binoculars were used to search for predators. Observations were summarized by the number of predators per 10 min scan. Incidental observations of predators seen during nest searches also were recorded.

BROOD-REARING

We conducted 1 survey for brood-rearing and molting Brant and Snow Geese on 26 July 2013 in the coastal zone of the Colville Delta and NE NPR-A study areas (Table 2). We used similar methods for surveys conducted in prior years beginning in 2005. The 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 8). 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. Most groups were counted on photographs taken with a Nikon D80 digital SLR camera (10.2 megapixel) equipped with a 17–85 mm image-stabilizing lens. Geese in some small groups were counted visually from the airplane. All groups that contained ≥50 geese and included goslings were counted on photographs.

GULL SURVEYS

We recorded Glaucous Gulls during the nesting and brood surveys conducted for Yellow-billed Loons in the Colville Delta and NE NPR-A study areas (see LOON SURVEYS, above, for methods). Nests and broods were recorded incidentally as they were encountered and traditional nest locations, including colony sites, within the study areas were checked for activity. We considered a group of 3 or more Glaucous Gulls nests occurring in proximity on the same lake or wetland complex to be a colony.

Sabine's Gulls (Iqirgagiak) that were confirmed or suspected to be nesting also were recorded opportunistically during the loon nesting survey. Sabine's Gull nests are difficult to detect during aerial surveys because of their relatively

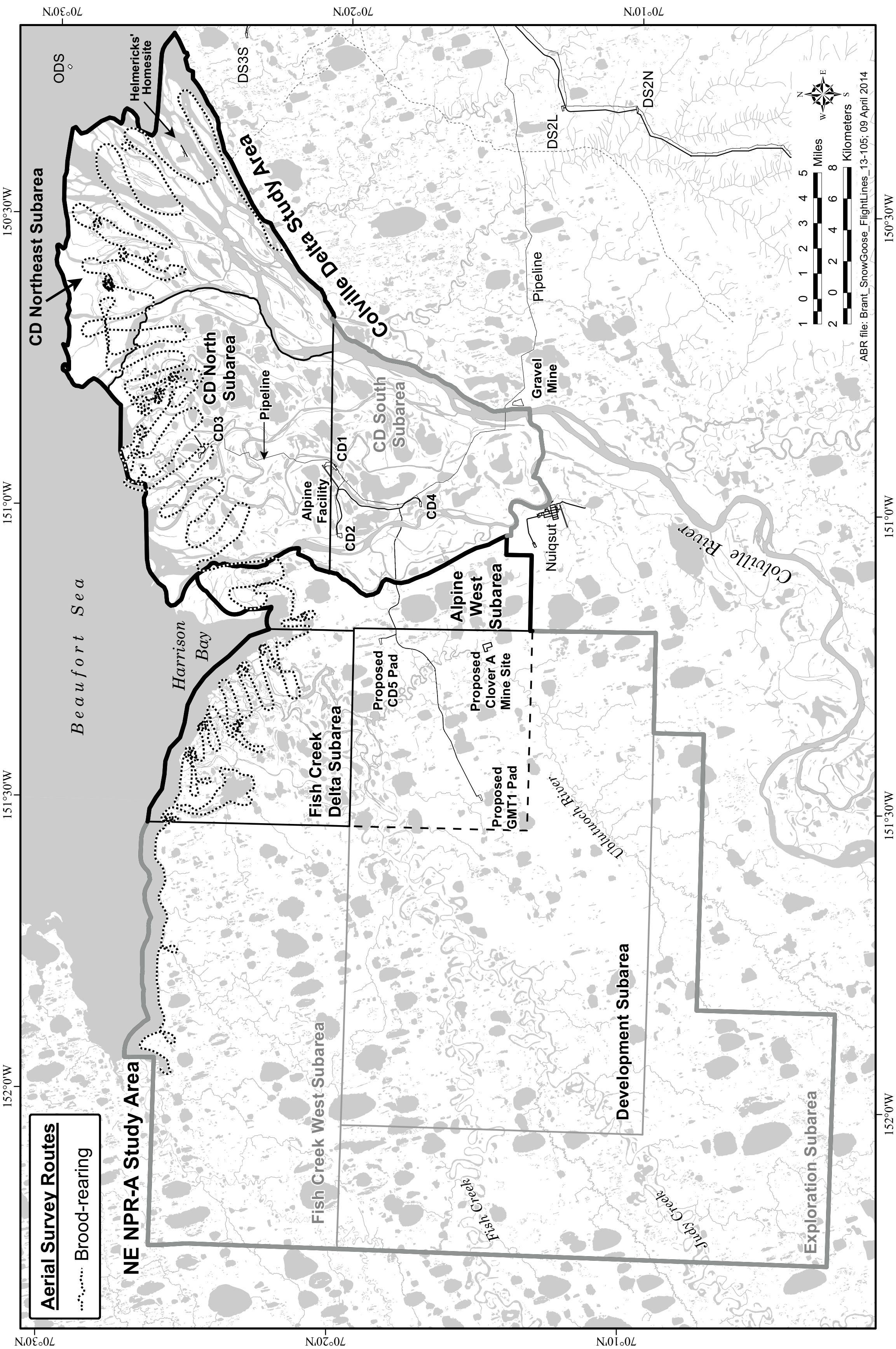


Figure 8. Flight lines for aerial surveys of brood-rearing Brant and Snow Geese, Colville Delta and NE NPR-A study areas, Alaska, 2013.

small size compared to Glaucous Gulls; therefore, the number of Sabine's Gulls nesting in the study areas was underestimated, because colony locations rather than single nesting pairs comprised most of the observations. All nest and brood observations of both Glaucous and Sabine's gulls were recorded on color photomosaic field maps (1:30,000 scale) and later entered into a GIS database.

We chose 50 lakes in the Colville Delta study area that were surveyed for Yellow-billed Loons annually since 2002 to serve as index lakes monitored for the presence of Glaucous Gull nests. Lakes selected included lakes with previously identified Glaucous Gull colonies, all Yellow-billed Loon breeding lakes, and lakes with Glaucous Gull nests near Yellow-billed Loon breeding lakes. Of the 50 lakes, 2 were in the Northeast Delta subarea, 20 in the CD South subarea, and 28 in the CD North subarea. The number of Glaucous Gull nests was summarized annually by subarea as an index for monitoring the population of nesting Glaucous Gulls in the Colville Delta study area.

HABITAT MAPPING AND ANALYSIS

A wildlife habitat was assigned to each observation of birds, nests, or broods by plotting their coordinates on the wildlife habitat maps (Figures 2 and 3). We merged several habitats, 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 into Salt Marsh, Dry Halophytic Meadow (<0.1% of NE NPR-A) was merged into Tidal Flat Barrens, and all non-halophytic shrub types (all but 1 occupied <1% of each study area) were merged into Tall, Low, or Dwarf Shrub.

For each bird species, habitat use (% of all 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, 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 individuals in groups are not likely to be independent in location or habitat selection (i.e., a few large groups could bias results). We also calculated habitat availability, the percent of each habitat in a survey area, separately for each species and season because the survey areas often differed among species, seasons, and years.

For a subset of species/surveys, a statistical analysis of habitat selection was used to evaluate whether habitats were used in proportion to their availability. When multiple years of survey data were available, all comparable data were used in the analysis of habitat selection. For this purpose, annual surveys were considered comparable only when the survey areas were similar in habitat composition, because overall habitat availability was calculated by summing annual habitat availability over years.

Habitat selection was evaluated for the following species, seasons, and years:

- pre-nesting Spectacled Eiders and King Eiders (Colville Delta—1993–1998 and 2000–2013 and NE NPR-A study area—2001–2006 and 2008–2013)
- nesting and brood-rearing Tundra Swans (Colville Delta—1992–1998 and 2000–2013 and NE NPR-A study area—2001–2006, 2008–2009 and 2011–2013)
- nesting and brood-rearing Yellow-billed Loons (Colville Delta nests—1993–1998 and 2000–2013 and Colville Delta broods—1995–1998 and 2000–2013, and NE NPR-A nests and broods—2008–2013).
- nesting White-fronted Geese (CD5 area—2013)

For other species, the number of observations or number of comparable annual surveys was inadequate for statistical analysis.

We inferred habitat selection 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 data management protocols (ver. 8.4, CPAI 2013). Locations of geese were recorded on a GPS receiver with decimal-degree coordinates in the WGS 84 map datum and later transferred into the NAD 83 map datum. All other nest, brood, bird, and bird group locations were digitized from survey maps directly 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.

RESULTS AND DISCUSSION

CONDITIONS IN THE STUDY AREAS

Birds arriving in mid-May 2013 experienced deep snow followed by extensive river flooding in early June, both of which contributed to high water levels during the period of nest initiation (1–15 June). The snow depth on 15 May 2013 (40 cm) was the deepest recorded on that date at Colville Village in 17 years (25 ± 2 cm [mean ± SE]). Snow cover was replaced by flood water at Colville Village on 5 June before snow had melted away.

Cold mid-May temperatures in northern Alaska delayed the onset of river breakup on the Colville Delta, until 3 June (average date of break-up is 31 May; Michael Baker Jr. Inc. 2013a). Two days of extremely warm temperatures (~15.5 °C) in the foothills of the Brooks Range unleashed a large volume of meltwater into the ice-covered channels of the Colville River resulting in a peak stage of 6.3 m above mean sea level at the head of the Colville Delta (Monument 1) on 3 June, which was the highest in 22 years of record keeping (Michael Baker Jr. Inc. 2013a). Peak discharge was 497,000 cubic feet/sec on 3 June 2013, the third highest discharge recorded since 1992 (Michael Baker Jr. Inc. 2013a). Ice jams formed on the Niġliq diverting water onto the tundra as far as 1.6 km from the river banks (http:/aprfc.arh.noaa.gov/php/rivnotes/rmkriv.php). Flooding at CD1 and CD4 began to recede on 5 June, and peak flood stage at Colville Village on the outer delta (2 m above mean sea level), occurred a few days later on 7 June (Michael Baker Jr. Inc. 2013a).

During the period of waterfowl arrival and peak nest initiation (15 May–15 June), 60 cumulative thawing degree-days were measured at Colville Village, which was well above the long-term mean (38 ± 5.6 thawing degree-days, n = 17 years; Figure 9). An unusually warm period in mid-June contributed to the higher than normal temperatures. Mean monthly temperatures were cooler in May (–7.0 °C) and warmer in June (5.1 °C) than the 17-year means (May: –5.7 ± 0.5 °C; June: 3.6 ± 0.4 °C). Daily mean temperatures at Alpine (24 km southwest of Colville Village) averaged 2.5 °C warmer than at Colville Village on the outer delta, indicating an earlier thaw in the central and southern delta.

Nighttime temperatures did not remain above freezing levels until 8 June. Although water levels were receding on the Colville Delta by 8 June (Michael Baker Jr. Inc. 2013a), loon surveys and time-lapse photos provided evidence that water levels in larger waterbodies were relative high during June. Water levels in Fish Creek in NE NPR-A also were reported consistently higher over the summer of 2013 than the previous 2 summers (http://ine.uaf.edu/werc/projects/npra-hydrology/fish-creek/). High water levels may have reduced the availability of nesting habitat for waterfowl and loons in low lying areas during the middle of June. The warm conditions in June also led to the early emergence of flying insects. The first mosquitos were judged to be at moderate levels by nest searchers in the CD5 area on 20 June and reached severe levels on 21 June, which is earlier than most

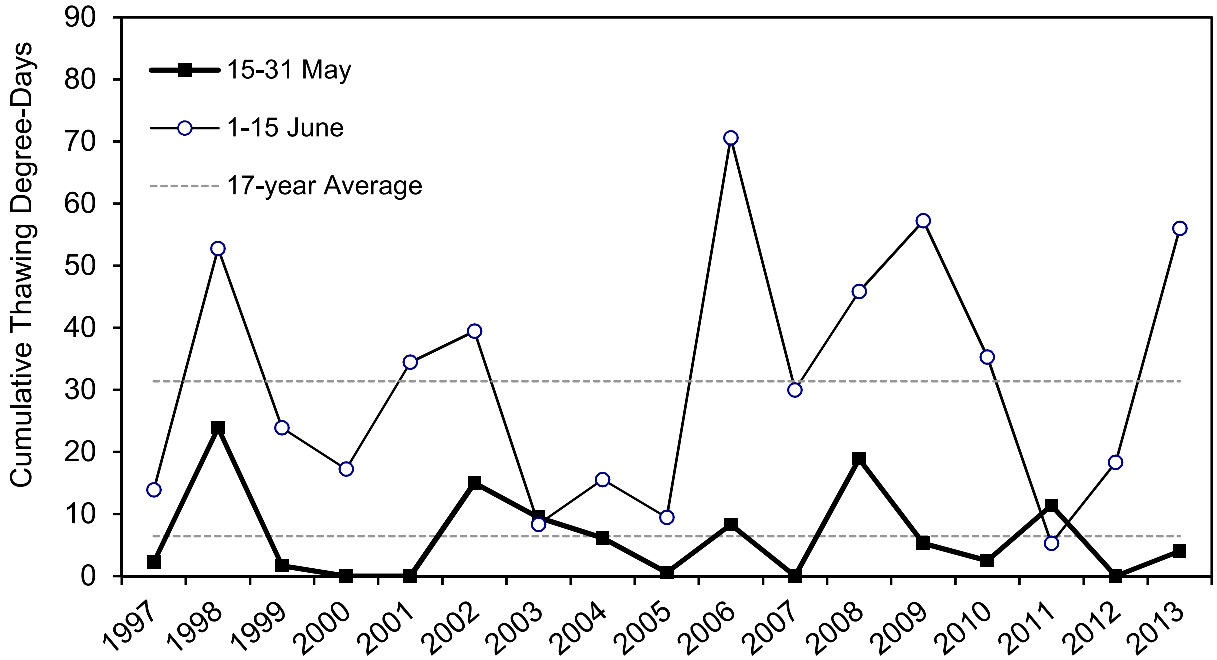


Figure 9. Cumulative number of thawing degree-days recorded 15 May–15 June at Colville Village, Colville Delta, Alaska, 1997–2013.

previous years when mosquitos typically emerge in late June or early July.

In 2013, evidence of freeze up first was observed in mid-September. On 17 September water temperatures were below freezing in Fish Creek (http://ine.uaf.edu/werc/projects/npra-hydrology/fish-creek/BLM—UAF website). On 24 September during the last loon survey of the season, the majority of the waterbodies on the Colville Delta were covered with surface ice.

EIDERS

Four species of eiders may occur in the ASDP area, but each occurs at different frequencies and widely varying numbers. Of the 2 species of eiders that commonly occur in the Colville Delta and NE NPR-A study areas, the Spectacled Eider has received the most attention because it was listed as "threatened" in 1993 (58 FR 27474–27480) under the Endangered Species Act of 1973, as amended. The outer Colville Delta is a concentration area for breeding Spectacled Eiders relative to surrounding areas; nonetheless, Spectacled Eiders nest there at low densities and nest at even lower densities at inland parts of the delta and in scattered wetland basins in the NE NPR-A 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 were listed as a threatened species in 1997 (62 FR 31748–31757). Steller's Eiders are rare on the Colville Delta and NE NPR-A study areas as these areas are east of their current Alaska breeding range centered around Barrow. Both study areas are within the range of Common Eiders, which nest primarily on barrier islands and coastlines but are seen rarely on surveys of the Colville Delta and NE NPR-A study areas.

SPECTACLED EIDER

Colville Delta

Distribution and Abundance

Although Spectacled Eiders were not as abundant on the pre-nesting aerial survey in 2013 as they were in the record years of 2008 and 2010–2011, their numbers were higher than average (Figure 10, Tables 3 and 4). In 2013, we

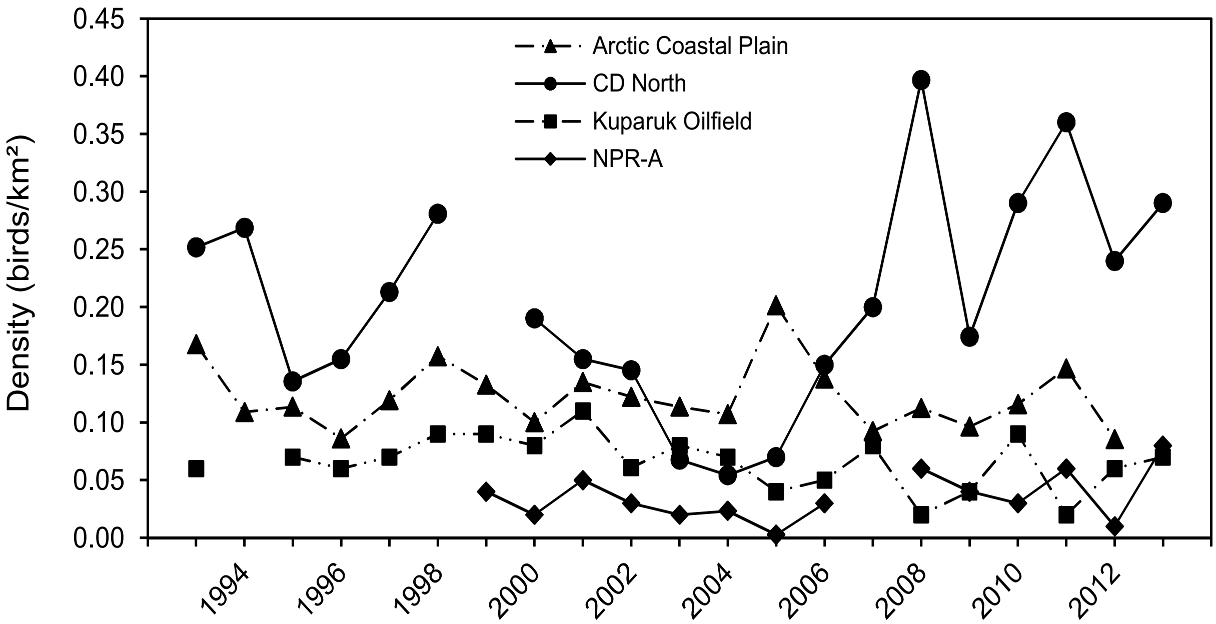


Figure 10. Density of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2013. Arctic Coastal Plain data from Stehn et al. 2013, Kuparuk data from Stickney et al. 2014, and CD North and NE NPR-A data from this study.

Table 3. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2013.

SPECIES Location	Observed Males	 Females	 Total	 Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
SPECTACLED EIDER							
On ground	33	23	56	23	66	0.11	0.13
In flight	5	2	7	2	–	0.01	–
All birds	38	25	63	25	–	0.13	–
KING EIDER							
On ground	12	12	24	12	24	0.05	0.05
In flight	11	3	14	3	–	0.03	–
All birds	23	15	38	15	–	0.08	–

[a] Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a)
[b] Numbers not corrected for sightability. Density based on 100% coverage of 501.4 km²

Table 4. Annual number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 1993–2013.

		SPECTACLED EIDER				KING EIDER			
		Total[a]		Density[b]		Total[a]		Density[b]	
Year	Surveyed Area (km²)	Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
1993	248.8	31	32	0.12	0.13	39	30	0.16	0.12
1994	455.7	79	57	0.17	0.13	58	35	0.13	0.08
1995	501.4	61	40	0.12	0.08	34	23	0.07	0.05
1996	501.4	41	40	0.08	0.08	59	43	0.12	0.09
1997	501.4	59	58	0.12	0.12	49	54	0.10	0.11
1998	501.4	71	70	0.14	0.14	57	18	0.11	0.04
2000	300.0	40	38	0.13	0.13	22	24	0.07	0.08
2001	501.4	38	36	0.08	0.07	35	22	0.07	0.04
2002	501.4	26	30	0.05	0.06	61	42	0.12	0.08
2003	501.4	24	20	0.05	0.04	50	38	0.10	0.08
2004	353.0	12	10	0.03	0.03	17	14	0.05	0.04
2005	501.4	16	14	0.03	0.03	46	22	0.09	0.04
2006	501.4	31	30	0.06	0.06	63	60	0.13	0.12
2007	501.4	52	48	0.10	0.10	30	28	0.06	0.06
2008	501.4	80	89	0.16	0.18	33	40	0.07	0.08
2009	501.4	41	42	0.08	0.08	33	30	0.07	0.06
2010	501.4	103	78	0.21	0.16	57	34	0.11	0.07
2011	501.4	99	95	0.20	0.19	133	129	0.27	0.26
2012	501.4	59	60	0.12	0.12	25	20	0.05	0.04
2013	501.4	63	66	0.13	0.13	38	24	0.08	0.05
Mean				0.11	0.10			0.10	0.08
SE				0.01	0.01			0.01	0.01

[a] Observed total includes flying and non-flying eiders. Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a)
[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of surveyed area

recorded 63 Spectacled Eiders on the Colville Delta, of which 56 were on the ground and 7 were in flight (Figure 11, Table 3). The density of Spectacled Eiders in the CD North subarea during 2013 (0.29 birds/km²) was above the 20-year mean (0.20 birds/km², SE = 0.02) as was the density in the larger Colville Delta study area (Table 4). All observations of Spectacled Eiders in the Colville Delta study area during the pre-nesting survey in 2013 were in small groups of 1–4 birds, and 94% of those counted were found in the CD North subarea, where Spectacled Eiders traditionally have been most concentrated (Figure 11, Appendix C). The density of both observed birds (birds on ground and in flight) and indicated birds (USFWS 1987a) in the CD North subarea (0.29 birds/km²) was more than twice the density in the entire Colville Delta study area (0.13 birds/km², for both observed and indicated birds).

Habitat Use

Pre-nesting Spectacled Eiders used 17 of 24 available habitats during 20 years of aerial surveys on the Colville Delta study area (Table 5). Six habitats were preferred (i.e., use significantly greater than availability) by pre-nesting Spectacled Eiders: 3 primarily coastal salt-affected habitats (Brackish Water, Salt Marsh, and Salt-killed Tundra), 2 aquatic habitats (Shallow Open Water with Islands or Polygonized Margins, and Grass Marsh), and 1 terrestrial habitat (Deep Polygon Complex). Deep Polygon Complex, which consists

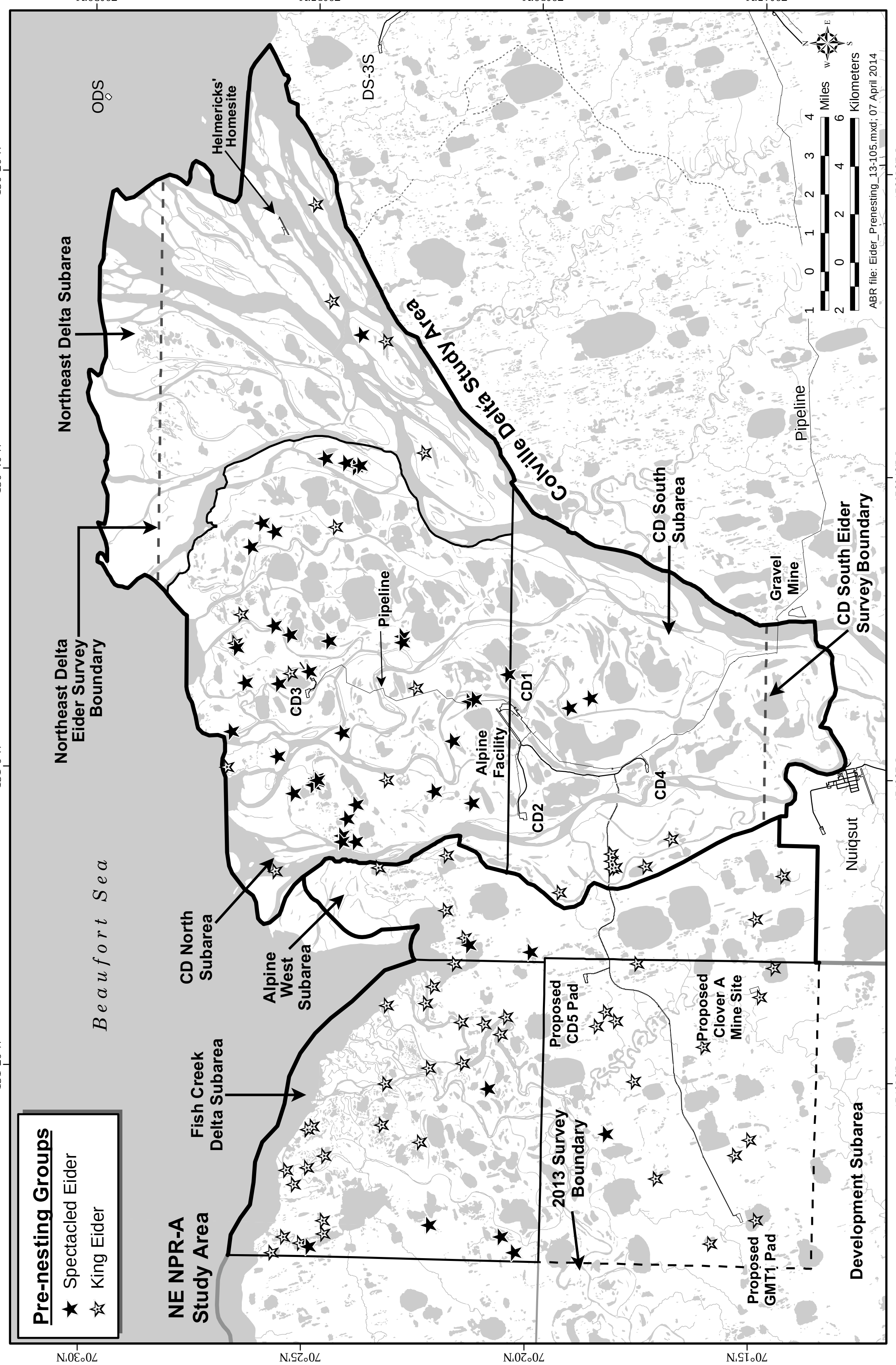


Figure 11. Spectacled and King eider groups during pre-nesting, Colville Delta and NE NPR-A study areas, Alaska, 2013.

Table 5. Habitat selection by Spectacled and King eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998 and 2000–2013.

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	
Brackish Water	78	35	8.1	1.3	prefer	
Tapped Lake with Low-water Connection	31	13	3.0	4.4	ns	
Tapped Lake with High-water Connection	19	11	2.6	3.7	ns	
Salt Marsh	60	33	7.7	3.2	prefer	
Tidal Flat Barrens	2	1	0.2	7.0	avoid	
Salt-killed Tundra	63	35	8.1	5.1	prefer	
Deep Open Water without Islands	31	19	4.4	3.5	ns	
Deep Open Water with Islands or Polygonized Margins	29	15	3.5	2.0	ns	
Shallow Open Water without Islands	6	4	0.9	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	6	5	1.2	0.1	prefer	low
River or Stream	20	10	2.3	14.4	avoid	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	220	125	29.1	2.7	prefer	
Grass Marsh	10	6	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	73	37	8.6	8.2	ns	
Patterned Wet Meadow	151	79	18.4	19.4	ns	
Moist Sedge-Shrub Meadow	0	0	0	2.3	avoid	
Moist Tussock Tundra	1	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	0	0	0	4.9	avoid	
Barrens	2	1	0.2	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	802	430	100	100		
KING EIDER						
Open Nearshore Water	11	3	1.2	1.6	ns	low
Brackish Water	35	19	7.4	1.3	prefer	low
Tapped Lake with Low-water Connection	25	12	4.7	4.4	ns	
Tapped Lake with High-water Connection	8	3	1.2	3.7	avoid	
Salt Marsh	31	15	5.8	3.2	prefer	
Tidal Flat Barrens	4	2	0.8	7.0	avoid	
Salt-killed Tundra	47	25	9.7	5.1	prefer	
Deep Open Water without Islands	22	10	3.9	3.5	ns	
Deep Open Water with Islands or Polygonized Margins	11	5	1.9	2.0	ns	
Shallow Open Water without Islands	4	2	0.8	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	1	0.4	0.1	ns	low
River or Stream	326	93	36.0	14.4	prefer	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	40	22	8.5	2.7	prefer	
Grass Marsh	8	3	1.2	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	12	8	3.1	8.2	avoid	
Patterned Wet Meadow	50	28	10.9	19.4	avoid	
Moist Sedge-Shrub Meadow	2	1	0.4	2.3	avoid	
Moist Tussock Tundra	0	0	0	0.6	ns	low
Tall, Low, or Dwarf Shrub	2	1	0.4	4.9	avoid	
Barrens	13	5	1.9	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	653	258	100	100		

[a] Use = (groups / total groups) x 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

of a mosaic of small, deep, polygon ponds with relatively narrow vegetated rims and sometimes with islets, is notable because of its disproportionate use; it was used by 29% of the Spectacled Eider groups yet was available on only 2.7% of the delta. Deep Polygon Complex is also preferred during the nesting season (Johnson et al. 2008a). Patterned Wet Meadow also had high use (18% of Spectacled Eider groups) but was not preferred because of its higher availability (19%). All other habitats were avoided or used in proportion to their availabilities.

NE NPR-A

Distribution and Abundance

Compared with 14 previous years of pre-nesting surveys, 2013 produced a record density of Spectacled Eiders in NE NPR-A (Table 6). Relative to the Colville Delta, the reduced study area for the NE NPR-A in 2013 contained a slightly lower density of Spectacled Eiders, a geographic difference that has been more pronounced in previous years (Figure 10, Tables 4 and 6). Over the entire NE NPR-A study area, we counted 17 observed (on ground and in flight) and 14 indicated Spectacled Eiders resulting in a density of 0.10 observed birds/km² and 0.08 indicated birds/km², which was ~62% of the density on the Colville Delta study area in 2013 (Tables 3 and 7). Spectacled Eiders were observed in all 3 subareas in the NE NPR-A in 2013, with the highest density in the Fish Creek Delta subarea (0.14 indicated birds/km²; Appendix D).

Habitat Use

Pre-nesting Spectacled Eiders used 13 of 26 available habitats in the NE NPR-A study area over 12 years of aerial surveys that were used for the selection analysis (Table 8). Spectacled Eiders preferred 5 habitats in NE NPR-A, 3 of which also were preferred in the Colville Delta survey area: Brackish Water, Shallow Open Water with Islands or Polygonized Margins, and Grass Marsh. The other preferred habitats were Shallow Open Water without Islands and Old Basin Wetland Complex, of which the latter was a new addition in 2013 to the list of preferred habitats. However, the sample size remains small (54 groups total) resulting in low power in the selection analysis; we expect that additional habitats will become preferred as more Spectacled Eiders are added to the pre-nesting selection analysis in the future.

OTHER EIDERS

Colville Delta

Distribution and Abundance

The number of King Eiders recorded on the Colville Delta in 2013 was slightly below average (Figure 12, Table 4). The indicated density of King Eiders (0.05 birds/km²) in 2013 was about 63% of the 20-year mean (Table 3). King Eiders (24 indicated birds) also were less numerous than Spectacled Eiders (66 indicated birds) during the 2013 pre-nesting period (Table 3). No groups larger than 4 King Eiders were seen. King Eiders were seen in all 3 of the subareas, but they achieved their highest density in the CD North subarea in 2013 (Figure 11, Appendix C). In most years, King Eiders are more abundant in the Northeast Delta subarea. Few King Eiders nest on the Colville 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 2013. Steller's Eiders rarely are seen in the vicinity of the Colville Delta, but 5 birds were sighted flying on the Colville Delta in 1995 (J. Bart, pers. comm.), a pair was spotted on the ground in the CD North subarea in 2001, single flying males were seen in the NE NPR-A in 2001 and on the Colville Delta in 2007 (Johnson and Stickney 2001, Johnson et al. 2008b), and several sightings of singles or pairs were reported in the Kuparuk Oilfield during 1995, 2000, 2001, and 2007 (not all sightings in the Kuparuk Oilfield were confirmed; see Anderson et al. 2008). Nest searches have been conducted since 1992 in multiple locations on the Colville Delta, in the Kuparuk Oilfield, and, during a subset of years, in NE NPR-A; in over 2 decades of nest searches in those study areas, no nests or indications of breeding by Steller's Eiders have been observed.

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 also

Table 6. Annual number and density (birds/km²) of eiders during pre-nesting aerial surveys, NE NPR-A study area, Alaska, 1999–2013.

		SPECTACLED EIDER				KING EIDER			
		Total[a]		Density[b]		Total[a]		Density[b]	
Year	Surveyed Area (km²)	Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
1999	143.4	4	6	0.03	0.04	41	16	0.29	0.11
2000	278.3	6	6	0.02	0.02	68	44	0.24	0.16
2001	511.0	14	14	0.03	0.03	134	98	0.26	0.19
2002	550.1	12	14	0.02	0.03	208	211	0.38	0.38
2003	557.6	10	12	0.02	0.02	191	128	0.34	0.23
2004	430.3	14	10	0.03	0.02	168	130	0.39	0.30
2005	755.1	9	2	0.01	<0.01	253	192	0.34	0.25
2006	755.1	31	26	0.04	0.03	318	332	0.42	0.44
2007	–	–	–	–	–	–	–	–	–
2008	755.1	41	46	0.05	0.06	489	506	0.65	0.67
2009	755.1	29	30	0.04	0.04	387	360	0.51	0.48
2010	755.1	23	24	0.03	0.03	617	457	0.82	0.61
2011	172.0	9	10	0.05	0.06	119	94	0.69	0.55
2012	172.0	4	2	0.02	0.01	81	90	0.47	0.52
2013	172.0	17	14	0.10	0.08	118	96	0.69	0.56
Mean				0.04	0.03			0.46	0.39
SE				0.01	0.01			0.05	0.05

[a] Observed total includes flying and non-flying eiders. Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a)

[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of surveyed area. Some numbers and densities differ from those in original reports because they refer to different study areas or because minor corrections were made in future years

Table 7. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, NE NPR-A study area, Alaska, 2013.

SPECIES	Observed						
Location	Males	Females	Total	Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
SPECTACLED EIDER							
On ground	7	6	13	6	14	0.08	0.08
In flight	2	2	4	2	–	0.02	–
All birds	9	8	17	8	–	0.10	–
KING EIDER							
On ground	48	45	93	42	96	0.54	0.56
In flight	13	12	25	12	–	0.15	–
All birds	61	57	118	54	–	0.69	–

[a] Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a)

[b] Numbers not corrected for sightability. Density based on 50% coverage of the area; surveyed area = 172.0 km². Fish Creek West, Exploration, and the western portion of the Development subareas were not surveyed in 2013

Table 8. Habitat selection by Spectacled and King eider groups during pre-nesting, NE NPR-A study area, Alaska, 2001–2006 and 2008–2013.

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	0.7	ns	low
Brackish Water	11	6	11.1	1.3	prefer	low
Tapped Lake with Low-water Connection	0	0	0	0.8	ns	low
Tapped Lake with High-water Connection	0	0	0	0.5	ns	low
Salt Marsh	8	4	7.4	2.4	ns	low
Tidal Flat Barrens	0	0	0	1.3	ns	low
Salt-killed Tundra	0	0	0	0.8	ns	low
Deep Open Water without Islands	4	2	3.7	6.5	ns	low
Deep Open Water with Islands or Polygonized Margins	11	6	11.1	5.3	ns	low
Shallow Open Water without Islands	9	5	9.3	1.0	prefer	low
Shallow Open Water with Islands or Polygonized Margins	15	7	13.0	1.6	prefer	low
River or Stream	1	1	1.9	1.2	ns	low
Sedge Marsh	1	1	1.9	1.7	ns	low
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	3	2	3.7	0.3	prefer	low
Young Basin Wetland Complex	2	1	1.9	0.3	ns	low
Old Basin Wetland Complex	17	10	18.5	8.1	prefer	low
Riverine Complex	0	0	0	0.3	ns	low
Dune Complex	0	0	0	1.0	ns	low
Nonpatterned Wet Meadow	4	2	3.7	3.2	ns	low
Patterned Wet Meadow	16	7	13.0	11.1	ns	low
Moist Sedge-Shrub Meadow	0	0	0	21.4	avoid	
Moist Tussock Tundra	0	0	0	25.0	avoid	
Tall, Low, or Dwarf Shrub	0	0	0	3.1	ns	low
Barrens	0	0	0	1.1	ns	low
Human Modified	0	0	0	0	ns	
Total	102	54	100	100		
KING EIDER						
Open Nearshore Water	14	7	1.2	0.7	ns	low
Brackish Water	78	35	5.8	1.3	prefer	
Tapped Lake with Low-water Connection	45	15	2.5	0.8	prefer	low
Tapped Lake with High-water Connection	9	3	0.5	0.5	ns	low
Salt Marsh	85	38	6.3	2.4	prefer	
Tidal Flat Barrens	14	5	0.8	1.3	ns	
Salt-killed Tundra	6	4	0.7	0.8	ns	low
Deep Open Water without Islands	182	63	10.5	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	148	57	9.5	5.3	prefer	
Shallow Open Water without Islands	95	49	8.1	1.0	prefer	
Shallow Open Water with Islands or Polygonized Margins	210	81	13.5	1.6	prefer	
River or Stream	117	44	7.3	1.2	prefer	
Sedge Marsh	51	24	4.0	1.7	prefer	
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	17	5	0.8	0.3	ns	low
Young Basin Wetland Complex	0	0	0	0.3	ns	low
Old Basin Wetland Complex	192	94	15.6	8.1	prefer	
Riverine Complex	6	3	0.5	0.3	ns	low
Dune Complex	0	0	0	1.0	avoid	
Nonpatterned Wet Meadow	32	18	3.0	3.2	ns	
Patterned Wet Meadow	71	42	7.0	11.1	avoid	
Moist Sedge-Shrub Meadow	19	9	1.5	21.4	avoid	
Moist Tussock Tundra	9	5	0.8	25.0	avoid	
Tall, Low, or Dwarf Shrub	1	1	0.2	3.1	avoid	
Barrens	0	0	0	1.1	avoid	
Human Modified	0	0	0	0	ns	
Total	1401	602	100	100		

[a] Use = (groups / total groups) x 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

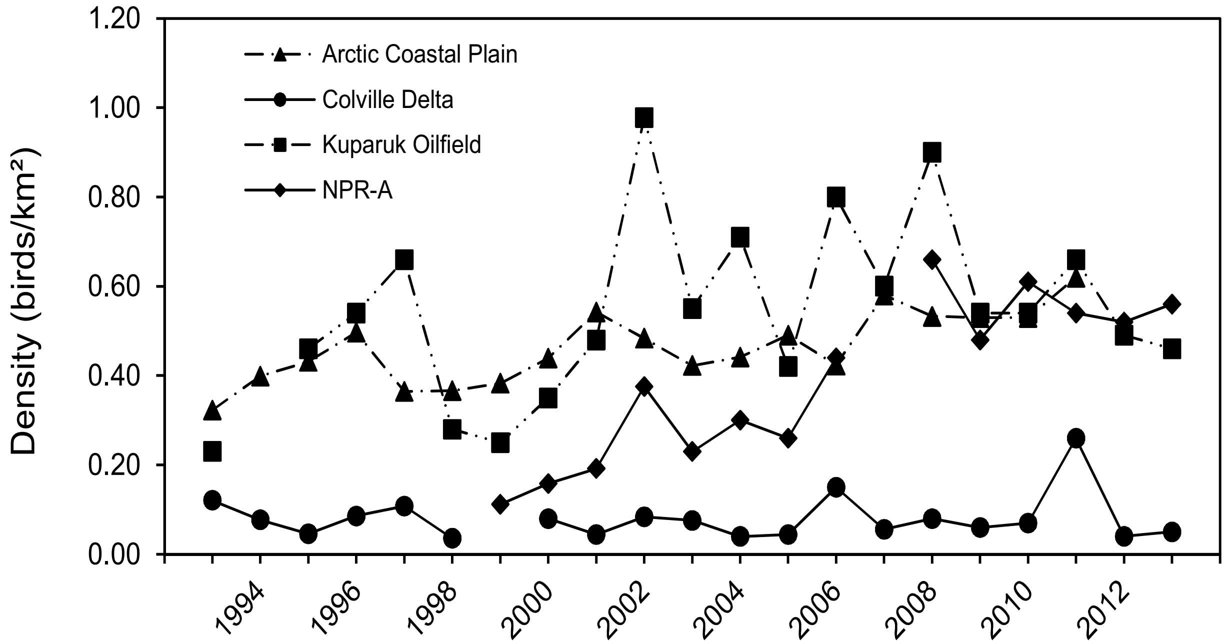


Figure 12. Density of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2013. Arctic Coastal Plain data from Stehn et al. 2013, Kuparuk data from Stickney et al. 2014, and Colville Delta and NE NPR-A data from this study.

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 19 years of aerial surveys (Table 5). King Eiders preferred 5 of the same habitats preferred by pre-nesting Spectacled Eiders on the Colville Delta: Brackish Water, Salt Marsh, Salt-killed Tundra, Deep Polygon Complex, and Grass Marsh. King Eiders also preferred River or Stream, where the largest percentage (36%) of the groups was found. The high usage of River or Stream, which includes river channels, suggests that many King Eiders were moving through to breeding areas farther east, because River or Stream is not potential breeding habitat. In contrast, Spectacled Eiders, which occur in high numbers during pre-nesting and nest in relative concentrations on the outer Colville Delta (0.8–1.0 nests/km², ABR unpubl. data) avoid River or Stream. Moreover, 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, Seiser and Johnson 2010, 2011a, 2011b, 2012, 2013), affirming that most of the pre-nesting King Eiders seen on the delta are stopping over during migration.

NE NPR-A

Distribution and Abundance

King Eiders were abundant in the NE NPR-A study area in 2013, occurring at 8–11 times the density recorded on the Colville Delta (Tables 4 and 6). The indicated total of King Eiders in the NE NPR-A study area was 96 birds, and the density was 0.56 indicated birds/km², the third highest density in 14 years of surveys (Figure 12, Table 6). King Eiders were 7 times more abundant than Spectacled Eiders in the NE NPR-A study area in 2013 (Table 7), which is typical for these species in this area. The highest number of King Eiders was seen in the Fish Creek Delta subarea (58 indicated birds; 1.0 indicated birds/km² (Figure 11, Appendix D).

Habitat Use

King Eiders used 21 of 26 available habitats and preferred 10 habitats in the NE NPR-A study area during the set of 12 years of pre-nesting surveys that were used to evaluate habitat selection (Table 8). Old Basin Wetland Complex and both types of Deep and Shallow Open Water were the most frequently used habitats and also were preferred. The habitats preferred by King Eiders overlap with those preferred by Spectacled Eiders, but King Eiders have a broader array of preferences. River or Stream and Tapped Lake with Low-water Connection are likely being used by birds in transit or not yet settled into nesting habitat, because the fluctuating water levels of these waterbodies make their shorelines poor locations for nesting.

DISCUSSION

The annual number of pre-nesting Spectacled Eiders on the Colville Delta has displayed dramatic swings over the last 20 years, particularly in the CD North subarea, which is the core of their distribution on the delta (Figure 10, Appendix C). (To simplify this discussion, all numbers and densities refer to indicated total birds.) The 2013 breeding season was the seventh year in a row of relatively high numbers of pre-nesting Spectacled Eiders on the Colville Delta. Our long-term records show 3 periods of high numbers: the early 1990s, the late 1990s, and the recent period of 2007–2013 (Figure 10). These fluctuations in abundance are unexplained, but the recent upswing in Spectacled Eiders is encouraging because numbers were quite low during 2003–2005. The overall population trend for Spectacled Eiders in the CD North subarea exhibits a slightly positive slope ($\ln(y) = 0.013x - 23.35$, $R^2 = 0.024$, $P = 0.52$, $n = 20$ years). That slope translates to an annual growth rate of 1.01, which is not significantly different from equilibrium. The growth rate (1.007) for the larger Colville Delta study area is similar ($\ln(y) = 0.007x - 10.95$, $R^2 = 0.007$, $P = 0.72$, $n = 20$ years). A recent reanalysis combining 2 separate datasets of pre-nesting Spectacled Eiders, the ACP breeding pair waterfowl survey conducted in late June with North Slope eider surveys conducted in early–mid June, estimated a slight decline in Spectacled Eiders for the entire ACP (growth rate = 0.99, $n = 21$ years; Stehn et al. 2013). None of the above trend lines has a slope significantly different from 1.0 (a growth rate of 1.0 equals 0% annual change or equilibrium), however, which suggests that the breeding population of Spectacled Eiders is relatively stable.

The NE NPR-A study area appears to be less important than the Colville Delta to breeding Spectacled Eiders. The density of Spectacled Eiders in the NE NPR-A study area has been consistently low (0.04 ± 0.006 [mean ± SE] indicated birds/km², $n = 14$ years). The Spectacled Eider density in NE NPR-A averaged 41% ($n = 13$ years) of the density in the Colville Delta study area and 21% of the density in the CD North subarea. An evaluation of the regional distribution of Spectacled Eiders shows that the NE NPR-A study area is not a significant concentration area for Spectacled Eiders on the ACP (Figure 17 in Larned et al. 2006, Figure 19 in Larned et al. 2011). The population trend for Spectacled Eiders in NE NPR-A is slightly positive (1.06), but not significantly different from 1.0 ($\ln(y) = 0.055x - 106.71$, $R^2 = 0.059$, $P = 0.449$, $n = 12$ years).

Unlike Spectacled Eiders, King Eiders are clearly increasing on the breeding grounds. On breeding pair surveys of the ACP, the growth rate for King Eiders is 1.047, which is significantly different from 1.0 ($n = 27$ years; Stehn et al. 2013.). Similarly, our surveys have recorded a positive growth rate (1.084) for King Eiders in the NE NPR-A study area ($\ln(y) = 0.084x - 162.32$, $R^2 = 0.684$, $P = 0.001$, $n = 12$ years). However, the growth rate on the Colville Delta (0.998) is not significantly different from 1.0 ($\ln(y) = -0.002x + 7.57$, $R^2 = 0.001$, $P = 0.916$, $n = 20$ years). The abundance of King Eiders in the 2 study areas is the reverse of that observed for Spectacled Eiders. NE NPR-A supports high densities of King Eiders (0.39 ± 0.05 indicated birds/km², $n = 14$ years), in contrast to low densities on the Colville Delta (0.08 ± 0.01 indicated birds/km², $n = 20$ years). Breeding Spectacled Eiders appear to prefer the aquatic and halophytic habitats that are relatively abundant on the Colville Delta, whereas King Eiders use a broader range of habitats, and nest farther from waterbodies (Anderson and Cooper 1994). Although there is extensive overlap in habitat use by these 2 species, breeding season concentration areas for each species appear to be separated at the regional scale, with Spectacled Eiders most prevalent in the coastal regions of the ACP west of Harrison Bay and King Eiders most prevalent in more inland areas south of Teshekpuk Lake and to the east, where lower densities of Spectacled Eiders occur (see Figures 17 and 19 in Larned et al. 2006 and Figures 19 and 21 in Larned et al. 2011). The exception to this generalized distribution pattern of the 2 species is the Colville Delta, where Spectacled Eiders outnumber King Eiders.

LOONS

YELLOW-BILLED LOON

Colville Delta

Distribution and Abundance

Beginning in 2011, we conducted a survey during the second week of June, 1 week prior to the traditional nesting survey, to better document Yellow-billed Loon nesting phenology and to record nests that might fail prior to the nesting survey. The Colville River flooded extensively in 2013, which caused us to cancel the early survey as most nesting lakes were still heavily ice-covered or flooded at that time. We deployed time-lapse cameras during late May at 11 loon territories to document nest initiation (see *Time-Lapse Cameras*, below). Camera images documented 2 nests that were not seen on the nesting or monitoring surveys: 1 that failed prior to the nesting survey and 1 that was initiated and failed between the nesting survey and the first monitoring survey. During the nesting survey on 19–21 June, we counted 67 Yellow-billed Loons and 12 nests (Figure 13, Table 9). Two more nests were found on the 26 June monitoring survey. The final nest was not found but was inferred by the presence of a brood seen during the brood-rearing survey. Of the 17 nests found in the Colville Delta study area in 2013, 6 nests were located in the CD North subarea, 9 nests in the CD South subarea, and 1 nest in the Northeast Delta subarea; the subarea for the remaining nest (indicated by a brood) was unknown (Figure 13, Appendix E). The total number of nests found in 2013 (17 nests) was the second lowest number found in 19 years of surveys in the Colville Delta study area. The count of 67 adults on the nesting survey, however, was higher than the long-term mean (55.8 ± 2.5 [mean ± SE] adults) and, with the exception of 2012, nearly identical to the counts recorded since 2006 (Table 9; for densities see Appendix F). The counts of adults and nests suggest that most loons returned to territories in 2013 but fewer than normal attempted to nest (Figure 14). However, the distribution of adults and nests on the Colville Delta was not uniform. Whereas, the density of adult loons in 2013 was the same in the CD North and CD South subareas (0.18 birds/km²), the density of nests found on all surveys was twice as high in the CD South subarea (0.06 nests/km²) as in the CD North subarea (0.03 nests/km²; Appendix E).

All 17 Yellow-billed Loon nests recorded in the Colville Delta study area in 2013 were on lakes where Yellow-billed Loons have nested previously (Figure 13) (Johnson et al. 2009, 2010, 2011, 2012, 2013a). Eleven of the 17 nests were located at the same nest sites used in 2012, 3 were at or very close to nest sites used in years prior to 2012, and 2 were at new nest sites on lakes previously used for nesting.

Since the nesting survey was initiated in 1993, the number of nests recorded in the Colville Delta study area ranged from 10 nests in 1993 and 1997 to 33 nests in 2008 (n = 19 years; Table 9). In most years, an additional 1–12 nests were found during ground, revisit, and/or monitoring surveys, and in some years inferred from the presence of a brood found during the brood-rearing survey on a nest lake where no nest was found during previous surveys. With the addition of these nests, the counts of nests ranged from 16 in 1993 and 2000 to 38 in 2008. These counts of nests are not directly comparable because survey coverage varied annually from 37 to 43 territories. To adjust for variable coverage, we used territory occupancy by nests, calculated as the number of nests found divided by the number of territories surveyed, to compare annual occupation by nests. Based on counts of all nests found, 40% of the territories surveyed in 2013 were occupied by nests, which was the lowest occupancy rate in 19 years of surveys (Table 9).

During the brood-rearing survey on 21 August 2013, 42 Yellow-billed Loons, 7 broods, and 9 young were recorded in the Colville Delta study area (Figure 13, Table 10). All broods detected during monitoring surveys survived until the brood-rearing survey in August. Of the 7 broods recorded in the Colville Delta study area, 4 were found in the CD South subarea (Appendix E). The

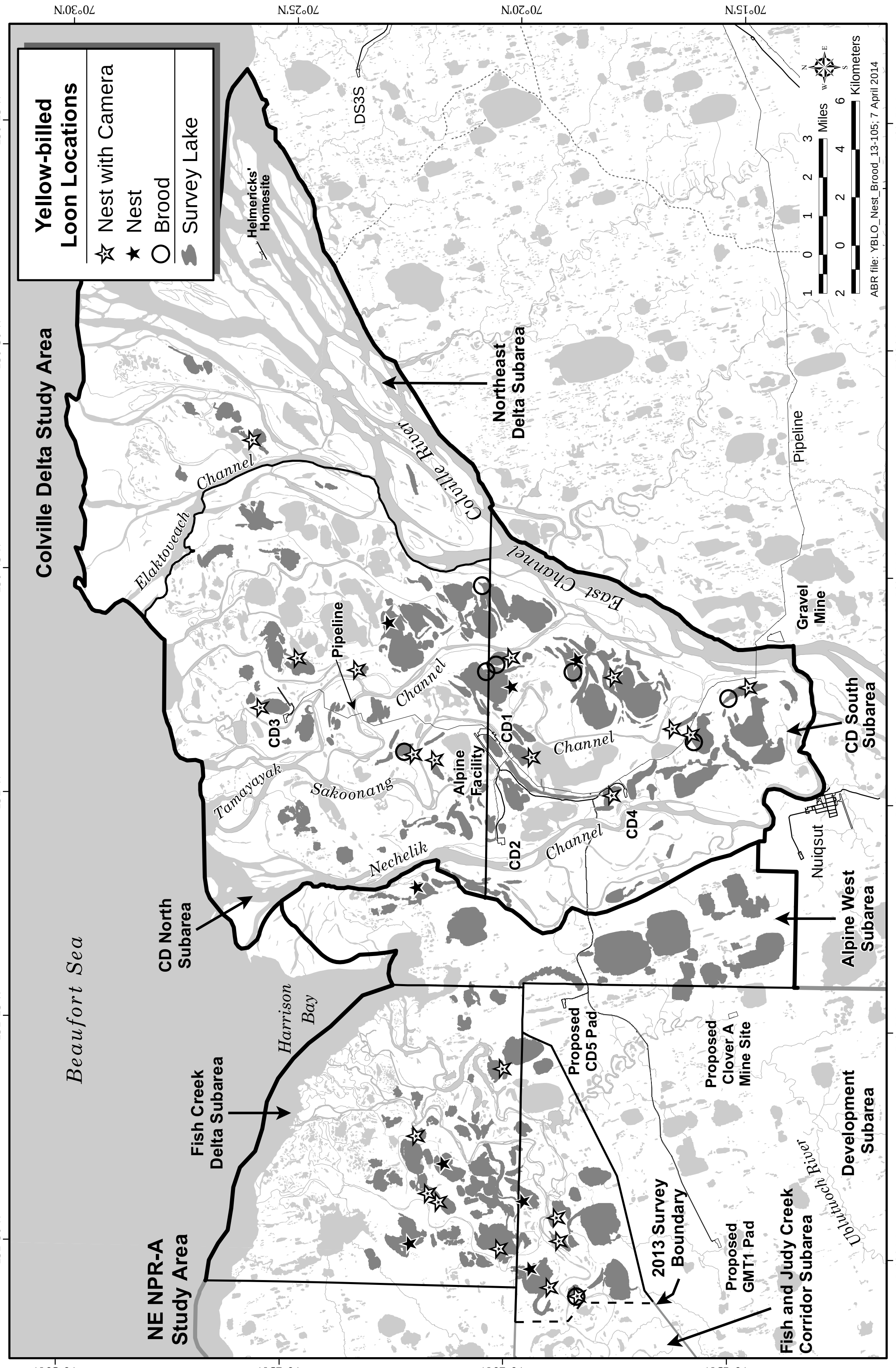


Figure 13. Yellow-billed Loon nests and broods, Colville Delta and NE NPR-A study areas, Alaska, 2013.

Table 9. Number of Yellow-billed Loons, nests, and territory occupancy by nests, Colville Delta (1993–2013) and NE NPR-A (2001–2013) study areas, Alaska.

STUDY AREA	Nesting Survey[a]		All Surveys[b]		
Year	No. Adults	No. Nests	No. Nests	No. Territories Surveyed	Nest Occupancy (%)[c]
COLVILLE DELTA[d]					
1993	50	10	16[e, f]	40	40
1995	42	12	21[e, f]	39	54
1996	45	11	21[e, f, g]	37	57
1997	48	10	18[e, g]	38	47
1998	36	17	24[e, f, g]	40	60
2000	53	16	16	37	43
2001	54	19	20[e]	37	54
2002	47	18	22[e, f, g]	41	54
2003	53	25	27[f]	41	66
2004	41	24	26[f]	41	63
2005	58	30	31[f]	40	78
2006	65	24	28[g]	41	68
2007	66	27	31[g]	42	71
2008	69	33	38[g]	42	90
2009	67	27	30[g]	43	70
2010	69	23	35[g]	42	83
2011	72	23	29[g]	42	67
2012	59	25	32[g]	43	70
2013	67	12	17[f, g, h]	43	40
Mean	55.8	20.3	25.4		61.8
SE	2.5	1.6	1.5		3.2
NE NPR-A[i]					
2001	44	20	23[e]	36	64
2002	65	27	27	42	64
2003	53	26	28[e, f]	41	66
2004	60	23	24[e]	42	57
2005	23	8	8	13	62
2006	23	8	8	13	62
2008	82	23	29[g]	51	57
2009	66	27	29[g]	51	57
2010	76	29	36[g]	51	71
2011	30	8	13[g]	21	62
2012	36	15	18[g]	21	86
2013	39	12	14[g]	21	67
Mean[j]					64.2
SE					2.3

[a] Nesting survey was conducted sometime between 19–30 June
[b] Includes all nests found on nesting survey and any additional nests found during other types of surveys as footnoted
[c] Calculated as the number of nests from all surveys divided by the number of territories surveyed. Excludes 1 renest in 2007 and 2011 and 2 renests in 2012 in the Colville Delta study area. Excludes 1 renest in 2003 in the NE NPRA study area
[d] Survey area included CD North, CD South, and Northeast Delta subareas for all years except 2000, when only CD North and CD South were surveyed
[e] Includes nest(s) found during ground surveys
[f] Includes nest(s) inferred by the presence of a brood observed on a territory lake during ground or aerial surveys
[g] Includes nest(s) found during revisit (1996–2002), monitoring (2006–2013), and early nesting (2011) surveys
[h] Includes nest(s) documented on camera images only
[i] Survey area included 5 subareas: Development surveyed in 2001–2004, Exploration in 2002–2004, Alpine West in 2002–2006 and 2008–2013, Fish Creek Delta in 2005–2006 and 2008–2013, and Fish and Judy Creek Corridor in 2008–2010. In 2008–2010, 4 Yellow-billed Loon territories were surveyed outside of the Fish and Judy Creek Corridor subarea but within the Development and Exploration subareas. In 2011–2013, the Fish and Judy Creek Corridor included only 11Yellow-billed Loon territories in the eastern part of the subarea
[j] Mean numbers not calculated because survey area differed among years

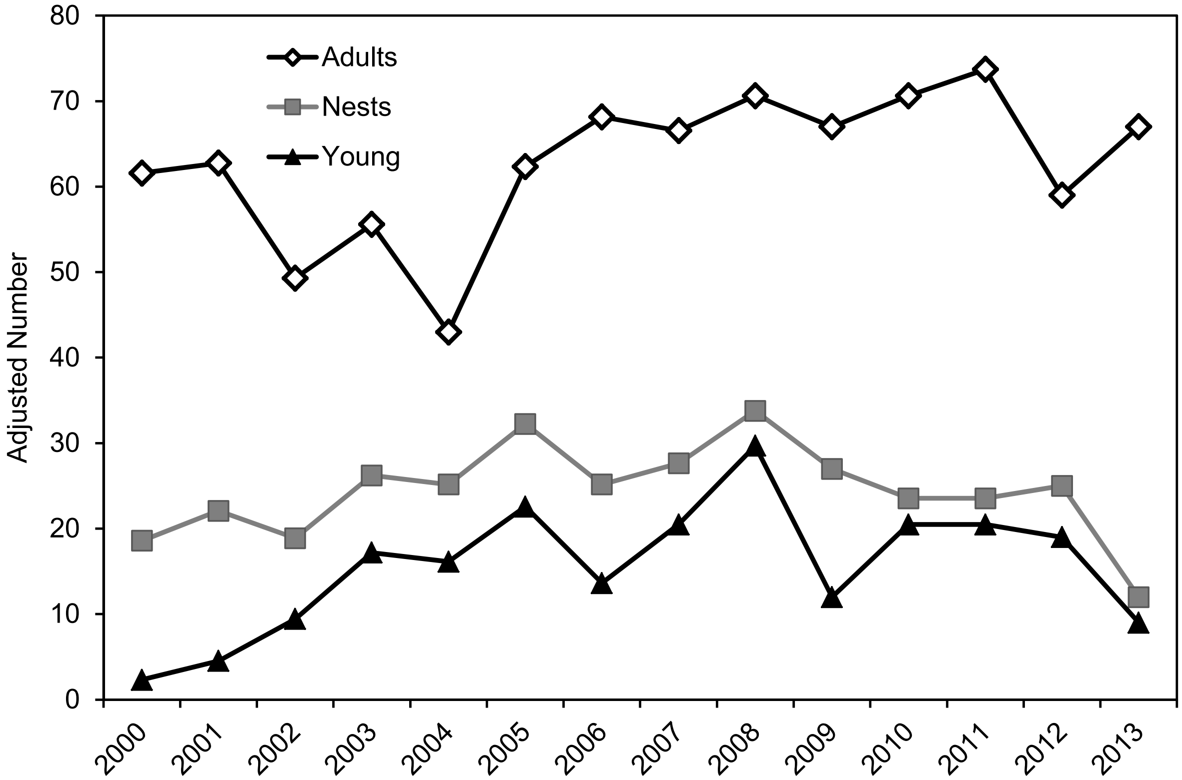


Figure 14. Annual numbers of Yellow-billed Loon adults and nests during the nesting survey and young during the brood-rearing survey, 2000–2013. Numbers are adjusted for the number of territories surveyed each year (number observed/number of territories surveyed × 43).

count of 42 adults on brood-rearing survey was only slightly lower than the 19-year mean (49.7 ± 3.2), but the number of broods detected (7) was among the lowest observed (mean = 10.9 ± 1.2, n = 19 years; Table 10; for densities see Appendix F).

During the 19 years of brood-rearing surveys in the Colville Delta study area, the lowest number of broods recorded was 2 broods in 2000 and the highest was 22 broods in 2008 (Table 10). In most years, an additional 1–6 broods were found during ground and/or monitoring surveys, or were determined by eggshell fragments at the nest indicating that hatching occurred (see *Nest Monitoring and Nest Fate*, below). With the addition of these broods, the range of brood counts was 3–27. Like nest counts, these raw counts of broods are not directly comparable because survey coverage varied annually from 34 to 43 territories (Table 10). We calculated territory occupancy by broods (the number of all broods seen divided by the number of territories surveyed) to standardize for survey effort. In 2013, brood occupancy (16%) was approximately half of the long-term mean (mean = 31.7 ± 3.4); the only years with lower occupancy were in 1997, 2000, and 2001.

Habitat Use

Yellow-billed Loons nested in 11 of 24 available habitats during 19 years of nesting aerial surveys in the Colville Delta study area (Table 11). Six habitats were preferred for nesting (Deep Open Water with Islands or Polygonized Margins, Deep Open Water without Islands, Sedge Marsh, Grass Marsh, Nonpatterned Wet Meadow, and Patterned Wet Meadow), altogether supporting 369 of 426 nests. Within these habitats, 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

Table 10. Number of Yellow-billed Loons, broods, and territory occupancy by broods, Colville Delta (1993–2013) and NE NPR-A (2001–2013) study areas, Alaska.

STUDY AREA	Brood-rearing Survey[a]			All Surveys[b]		Brood
Year	No. Adults	No. Young	No. Broods	No. Broods	No. Territories Surveyed	Occupancy (%)[c]
COLVILLE DELTA[d]						
1993	29	7	7	10[e]	34	29
1995	53	15	11	12[e]	40	30
1996	62	6	6	10[e]	37	27
1997	66	8	5	5	38	13
1998	55	15	12	12	40	30
2000	16	2	2	3[f]	37	8
2001	26	4	4	4	38	11
2002	66	9	8	9[e]	41	22
2003	47	16	14	14	40	35
2004	54	15	12	12	40	30
2005	39	21	17	21[f, g]	40	53
2006	66	13	13	16[f]	41	39
2007	53	20	17	23[f, g]	42	55
2008	57	29	22	27[f, g]	42	64
2009	56	12	11	13[g]	43	30
2010	59	19	13	15[f, g, h]	42	36
2011	45	20	12	15[f, g, h]	42	36
2012	52	19	14	17[g, h]	43	40
2013	42	9	7	7	43	16
Mean	49.7	13.6	10.9	12.9		31.7
SE	3.2	1.6	1.2	1.4		3.4
NE NPR-A[i]						
2001	47	5	5	7[e]	29	24
2002	47	7	6	6	34	18
2003	54	18	16	16	33	48
2004	67	12	10	10	36	28
2005	12	3	3	3	13	23
2006	16	2	2	2	12	17
2008	70	15	12	19[f, g]	50	38
2009	85	17	12	15[g]	51	29
2010	70	18	15	16[g]	49	33
2011	31	5	4	4	21	19
2012	42	14	12	12	21	57
2013	21	0	0	1[f]	21	5
Mean[j]						28.2
SE						4.2

[a] Brood-rearing surveys were conducted sometime between 15–27 August
[b] Includes all broods found on brood-rearing survey and any additional broods found during other types of surveys as footnoted
[c] Calculated as the number of broods from all surveys divided by the number of territories surveyed
[d] Survey area included CD North, CD South, and Northeast Delta subareas for all years except 2000, when only CD North and CD South were surveyed
[e] Includes brood(s) found during ground surveys
[f] Includes brood(s) found during monitoring surveys
[g] Includes broods from territories where no brood was seen but presence of a brood was determined from eggshell evidence
[h] Includes broods from territories where broods were seen on camera images
[i] Survey area included 5 subareas: Development surveyed in 2001–2004, Exploration in 2002–2004, Alpine West in 2002–2006 and 2008–2012, Fish Creek Delta in 2005–2006 and 2008–2012, and Fish and Judy Creek Corridor in 2008–2010. In 2008–2010, 4 Yellow-billed Loon territories were surveyed outside of the Fish and Judy Creek Corridor subarea but within the Development and Exploration subareas. In 2011–2013, the Fish and Judy Creek Corridor included only 11Yellow-billed Loon territories in the eastern part of the subarea
[j] Mean numbers not calculated because survey area differed among years

Table 11. Habitat selection by nesting (1993–1998 and 2000–2013) and brood-rearing (1995–1998 and 2000–2013) 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	avoid	low
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	28	6.6	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	39	9.2	4.9	prefer	
Deep Open Water with Islands or Polygonized Margins	117	27.5	2.4	prefer	
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	0.5	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	5	1.2	<0.1	prefer	low
Deep Polygon Complex	19	4.5	2.8	ns	
Grass Marsh	7	1.6	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	49	11.5	8.7	prefer	
Patterned Wet Meadow	152	35.7	24.6	prefer	
Moist Sedge–Shrub Meadow	6	1.4	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	avoid	low
Tall, Low, or Dwarf Shrub	2	0.5	6.5	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.1	ns	low
Total	426	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	2.0	avoid	low
Brackish Water	1	0.5	1.1	ns	low
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	44	21.8	5.4	prefer	
Salt Marsh	0	0	2.6	avoid	
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	91	45.0	4.9	prefer	
Deep Open Water with Islands or Polygonized Margins	66	32.7	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	
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	0.1	ns	low
Total	202	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

was the habitat used most frequently for nesting (36% of all nests), and it also was the most abundant habitat on the delta (25% of the loon survey area; Table 11). Nesting Yellow-billed Loons avoided 11 habitats, which together occupied 50% of the Colville Delta study area.

Yellow-billed loons were highly selective in their use of brood-rearing habitat. All Yellow-billed Loon broods (202 broods over 19 years) were found in 4 lake habitats, 3 of which were preferred: Tapped Lake with High-water Connection, Deep Open Water without Islands, and Deep Open Water with Islands or Polygonized Margins (Table 11). The preferred habitats occupied only 13% of the delta. No shallow-water habitats were used during brood-rearing. The selection analyses for nesting and brood-rearing reaffirm the importance of large, deep waterbodies to breeding Yellow-billed Loons.

Nest Monitoring and Nest Fate

We recorded 15 Yellow-billed Loon nests during the nesting, monitoring, and brood-rearing surveys in the Colville Delta study area in 2013; 2 more nests were seen only on images from cameras set up before surveys began and were not included in the summaries for consistency with previous years data collection (Table 12). The number of nests found was the lowest since monitoring surveys began and was nearly 50% lower than the 9-year mean (29.4 ± 2.2 nests; Table 13). The majority of nests failed. Only 7 nests hatched for an apparent nesting success of 47%, well below the 9-year mean (57.3 ± 4.0%; Table 13). The 2 additional nests seen only on camera survived <7 d

Table 12. Weekly status and fate of Yellow-billed Loon nests monitored by aerial surveys, Colville Delta study area, Alaska, 2013. Status (A = active, I = inactive) determined from camera-monitored nests is presented in parentheses where it differed from status determined from aerial surveys.

	June		July					
Territory	19–21	26[a]	3[a]	10	17	24	31	Fate/Total
2[b]	A	A	I	–	–	–	–	Failed
6[b]	A	A	I	–	–	–	–	Failed
8[b]	I[c]	–	–	–	–	–	–	Failed
11[b]	A	A	I	–	–	–	–	Failed
13[b]	A	A	A	A	I	–	–	Hatched
14[b]	I	I[d]	–	–	–	–	–	Failed
15[b]	A	A	I	–	–	–	–	Failed
17[b]	A	A	A	A	A	A	I	Failed
18[b]	A	I	–	–	–	–	–	Failed
20[b]	A	A	A	A	I	–	–	Hatched
19[b]	A	A	A	A	I	–	–	Hatched
22[b]	I	A	A	I	–	–	–	Failed
25	I	A	A	A	A	I	–	Hatched
26[b]	A	A	A	A	I	–	–	Hatched
27	A	A	A	A	I	–	–	Hatched
31[e]	–	–	–	–	–	–	–	Hatched
39	A	I						Failed
No. Active	12	12	8	7	2	1	0	15 (17)
No. Hatched	0	0	0	0	5	1	0	7
No. Failed	0 (1)	2 (3)	4	1	0	0	1	8 (10)

[a] Camera-monitored nests not surveyed by helicopter; nest status determined from camera images
[b] Nest monitored by camera
[c] Nest active on camera images 16–20 June; territory was surveyed on 21 June, the day after nest failure
[d] Nest active on camera images 22–25 June
[e] Nest was not found on nesting or monitoring surveys but a brood was seen during the brood-rearing survey on 21 August; nest is not included in total count by week

Table 13. Number of nests, apparent nesting success, and number of chicks of Yellow-billed Loons observed during aerial monitoring surveys or determined from nest fate visits, Colville Delta (2005–2013) and NE NPR-A (2008–2013) study areas, Alaska.

STUDY AREA Year	No. Territories Surveyed	No. Nests	Nesting Success (%)	At Hatch No. Chicks	At Hatch Chicks/Nest	Mid-September No. Chicks	Mid-September Chicks/Nest
COLVILLE DELTA							
2005	40	31	68	29	0.94	–	–
2006	41	28	57	22	0.79	–	–
2007	42	31	74	36	1.16	–	–
2008	42	38	71	43	1.13	24[a]	0.63
2009	43	30	43	14	0.47	11	0.37
2010	42	35	43	22	0.63	17	0.49
2011	42	25[b]	60	24	0.96	19	0.76
2012	43	32	53	25	0.78	17	0.53
2013	43	15[c]	47	9[d]	0.60	8	0.53
Mean		29.4	57.3	24.9	0.83	16.0	0.55
SE		2.2	4.0	3.4	0.08	2.3	0.05
NE NPR-A							
2008	51	29	66	27	0.93	–	–
2009	51	29	52	24	0.83	15	0.52
2010	51	36	44	22	0.61	17	0.47
2011	21	12[e]	33	6	0.50	5	0.42
2012	21	18	67	14	0.78	14	0.78
2013	21	14	7	2	0.14	0	0
Mean		–[f]	44.8	–[f]	0.63	–[f]	0.44
SE		–	9.1	–	0.12	–	0.13

[a] Data are from 8 September because survey conditions were poor on 16 September
[b] Total does not include 4 nests that were only seen prior to the nesting survey
[c] Total does not include 2 nests that were only seen on camera images
[d] Assumes 1 chick at a nest that was not found but inferred from a brood discovered during the brood-rearing survey on 21 August
[e] Total does not include 1 nest that was only seen prior to the nesting survey
[f] Mean numbers not calculated because the study area differed among years

and failed prior to detection on aerial surveys. Their inclusion lowers apparent nesting success to 41%.

The majority of successful nests on the Colville Delta in 2013 hatched in mid-July: 5 (71%) hatched by 17 July, 1 nest hatched between 17 July and 24 July, and the hatch date at 1 nest was unknown (Tables 12 and 14). Broods were observed at all hatched nests. Evidence from eggshell remains and camera images did not document any additional broods or chicks.

Eight of 15 Yellow-billed Loon nests recorded during aerial surveys failed to hatch (Table 12). Two nests seen only on camera images also failed. Most nests were ≤14 d old at the time of nest failure. Of the 15 nests documented by surveys, 2 (13%) failed between the nesting survey on 19–21 June and the first monitoring survey on 26 June. Four more nests (27%) failed by 3 July and 1 more by 10 July. The remaining nest failed by 31 August and was active for 35–42 days, which is beyond the 28-day incubation period reported for Yellow-

Table 14. Number of Yellow-billed Loon chicks observed during weekly aerial surveys, Colville Delta and NE NPR-A study areas, Alaska, 2013.

STUDY AREA	July			August				September						
Territory	17	24	31	8	14	21	28	4	11	18	24	No. Chicks Hatched	Age (d) When Last Seen	Brood Fate
COLVILLE DELTA														
13[a]	1[b,c]	1[b,c]	1	1	1	1	1	1	1	1	0[d]	1	67	Fledged
19[a]	2	2[b,c]	2	2	2	2	2	1	1	1[e]	1	2	73	Active
20[a]	1[b,c]	1	1	1	1	1	1	1	1	1	1	1	73	Active
25	Inc[f]	2[b,g]	2	2	2	2	2	2	2	2[e]	2	2	66	Active
26[a]	1[h]	1	1	1	1	1	1	1	1	1	0[d]	1	67	Fledged
27	1	1	1	1	1	1	1	1	1	1	1	1	73	Active
31	–[i]	–[i]	–[i]	–[i]	–[i]	1	1	1	1	1	1	1[j]	–[i]	Active
Totals														
Broods of 2	1	2	2	2	2	2	2	1	1	1	1	–	–	–
Broods of 1	3	4	4	4	4	5	5	6	6	6	4	–	–	–
Chick Loss	0	0	0	0	0	0	0	1	0	0	0	–	–	–
NE NPR-A														
59[a]	Inc	2	0	–	–	–	–	–	–	–	–	2	4	Failed

[a] Nest monitored by camera
[b] Adult brooding chick(s)
[c] No chick(s) observed; chick assumed present based on subsequent aerial surveys
[d] Territory was 95% ice-covered; no adults or young were observed but were assumed to have dispersed to an area with more open water
[e] One chick observed flying over brood-rearing lake
[f] Inc = loon incubating at the time of the survey
[g] Only 1 chick observed; 2 chicks assumed present based on subsequent aerial surveys
[h] Adults were not incubating but 1 pipped egg was found in the nest
[i] Unknown since brood was not discovered until brood-rearing survey
j Assumes 1 chick at a nest that was not found but inferred from a brood discovered during the brood-rearing survey on 21 August

billed Loons (North 1994). Reasons for the extended incubation are unknown but may have been caused by infertile or damaged eggs. We did not detect any second nesting attempts by loons after nest failure in 2013.

The contents of 16 Yellow-billed Loon nests were examined after nests were no longer active. Seven nests were classified as successful based on the presence of a brood. Five of those nests contained >20 eggshell fragments or membranes, 1 contained <20 fragments, and 1 nest was not inspected because a brood was discovered but no nest was found. Nine nests were judged failed based on the absence of a brood and of eggshell fragments, or the presence of <20 eggshell fragments. One failed nest contained 21 fragments but that nest likely contained nonviable eggs since it was active for >35 d (see *Time-lapse Cameras*, below). Five of 6 successful nests contained between 30 and 80 eggshell fragments. The remaining nest only contained 2 egg fragments but was associated with a brood. The paucity of fragments at that nest may have been caused by the adults removing eggshells after hatch or by the difficulty in detecting fragments in the water due to the thick pendant grass *(Arctophila fulva)* surrounding the nest. Of ~240 eggshell fragments found and measured within 5 m of successful nests, 54% were ≤10 mm in length. Of the hatched nests that were inspected (*n* = 6), 5 nests contained pieces of membrane that were either separate or loosely attached to fragments. One nest contained an entire membrane. The majority of egg membranes and eggshell fragments were found in nest bowls; <40 fragments were found in the water or on shore adjacent to successful nests. Seven of the 10 failed nests that were inspected contained 2–21 egg fragments; 2 of those nests also had a broken egg next to the nest. An additional nest was abandoned (see *Time-lapse Cameras,* below) with 2 entire eggs. The remaining 2 nests did not contain any egg remains within 5 m.

Time-lapse Cameras

In 2013, we deployed 11 cameras in late May at repeatedly used nest sites in an attempt to document pre-nesting behavior and the start of incubation. Nine of the territories were flooded by the Colville River causing 5 cameras to malfunction after water seeped into the battery case and corroded the battery terminals (Table 15). The median flood date at those territories was 3 June (range = 1–4 June, *n* = 9 territories). Loons generally were seen in camera view within 3 d of when the flooding started. Flooding by the Colville River was extensive and camera-monitored nest sites flooded by the river were submerged for 4–19 d (median = 7 days, *n* = 4 territories). Nesting was not observed at the territory where the nest site was submerged for 19 days; the nest bowl appeared to be above water on 23 June, although the nesting island was still flooded. Two of 11 territories did not flood from the Colville River. Instead, a moat formed on those lakes on 5 and 9 June. At 1 of those territories, a pair of loons was seen on the day of moat formation whereas at the other territory, loons were seen 3 d after moat formation. Eventually nests were found at 5 of 9 river-flooded territories and nests were found at both territories flooded by local runoff.

The start of incubation was documented by 3 cameras deployed in May (Table 15). The start of incubation was inferred at a 4th nest, which was not seen during the nesting survey but was found during camera retrieval on the following day. The median start date of incubation observed was 17 June (range = 15–22 June, *n* = 4 nests), which was an average of 7 d after nest sites appeared accessible (range = 4–11 days). Only 1 of the nests with a known start date hatched. Unfortunately, the camera at that nest was bumped by wind-blown ice on day 14 of incubation so that the nest was no longer in camera view when hatch occurred. A pipped egg, however, was found in the nest during a nest fate visit on 17 July, on day 29 of incubation. A chick was seen swimming near the nest on 18 July, which supports observations made by North (1994) who observed first-day chicks swimming with adults.

After the nesting survey in 2013, we set up an additional 9 time-lapse cameras on Yellow-billed Loon nests on the Colville Delta. In total, we monitored 13 of 17 nests in the Colville Delta study area with time-lapse cameras (Table 16). Eight-power telephoto cameras were placed 50–90 m from nests (65 ± 12.7 m, *n* = 3) and 2× and 2.5× telephoto cameras were placed 30–75 m from nests (47 ± 3.7 m, *n* = 13). Three nests were monitored in part by 2 different cameras. Following the nesting survey, 2 researchers were transported to and from

Table 15. Nesting chronology and observations of Yellow-billed Loons at territories monitored by time-lapse cameras deployed in late May, Colville Delta study area, Alaska, 2013.

FLOOD SOURCE[a] Territory	Dates Monitored	Nesting Observed on Camera	Date Lake Started Flooding	Date Loons First Seen	Date Nest Site Appeared Accessible[b]	Incubation Start Date
COLVILLE RIVER						
1	27 May–22 June	No	2 June	3 June	7 June	–
2	27 May–2 June	No[c]	1 June	–	–	–
13	29 May–9 June	No[c]	4 June	6 June	–	–
14	29 May–22 June	No[d]	2 June	6 June	11 June[e]	22 June[f]
17	28 May–16 June	No[c]	3 June	10 June	–	–
18	29 May–23 June	Yes	4 June	9 June	8 June	15 June
34	29 May–23 June	No	4 June	7 June	23 June	–
45	29 May–2 June	No	2 June	–	–	–
46	28 May–8 June	No	4 June	7 June	–	–
LOCAL RUNOFF						
8	27 May–22 June	Yes	9 June	9 June	12 June	16 June
26	29 May–23 June	Yes	5 June	8 June	14 June	19 June

[a] Lakes were determined to have flooded by the river if shorelines and surrounding tundra were completely underwater and the lake was turbid, whereas lakes flooded by local runoff contained moats and were clear
[b] Qualitative assessment based on whether or not the site was above water and contained a moat so loons could access the site
[c] Nest detected during aerial nesting survey after camera malfunctioned
[d] Nest was found at the territory but was not in camera view
[e] Nest site was not in camera view but was assumed accessible on 11 June when water levels in camera view stabilized
[f] Territory surveyed by helicopter on 21 June and no nest was seen; nest with 1 egg was found 22 June during visit to retrieve the camera deployed during May

nesting lakes by helicopter to deploy cameras. Researchers were at nests an average of 35 min (SE = 2.6 min, range = 16–55 min, n = 13 nests). At 12 of 13 nests, an adult was incubating upon our arrival; the remaining nest had been monitored with a camera deployed in May and was visited after it had already failed. All 12 loons that were incubating left the nest during camera setup: 5 swam away from their nests as researchers approached the camera setup location, 4 left as the helicopter landed, 2 left as researchers exited the helicopter, and 1 left as the helicopter circled the nest prior to landing.

All 12 loons that left their nests during camera installation returned to incubate after installation. One returned before we departed in the helicopter, whereas the remaining 11 returned an average of 33 min (SE = 12 min, range = 1–140 min) after we departed in the helicopter. Loons were absent from nests an average of 68 min during camera installation (SE = 13 min, range = 21–173 min, n = 12 nests).

Cameras successfully recorded daily nest survival at 11 of 13 nests. The camera malfunctioned at 1 nest, 31 d after it was deployed; that nest eventually failed. At the other nest, wind-blown ice was driven onshore, bumping the camera so that the nest was no longer in view. That nest hatched 15 d later. We were able to use camera images to identify the day of hatch or failure at all 11 of the cameras that functioned for the entire period (Table 16). Of the 13 camera-monitored nests, 4 hatched and 9 failed for an apparent nesting success of 31%. At camera-monitored nests where nest initiation was not observed, the median date that incubation started was 17 June (range = 16–20 June, n = 8). That date was the same as the median start of incubation observed on camera images at 4 nests. The median hatch date was 15 July (range = 14–17 July, n = 4). That hatch

Table 16. Nest history and incubation activity of Yellow-billed Loon nests monitored by time-lapse digital cameras, Colville Delta study area, Alaska, 2013.

Territory	Fate[a]	Incubation Start Date[b]	Predator	No. Eggs[c]	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)
13	S	18 June		2	23 June	16 July	22.4	91.0	0.8	3.7	35.7
19	S	17 June		2	23 June	15 July[h]	7.1	94.2	1.0	4.9	16.6
20	S	16 June		2	23 June	14 July	19.5	95.6	0.7	4.4	13.7
26	S	19 June[e]		2	29 May	17 July[i]	13.4	90.5	1.7	5.2	27.0
Median/Average		17 June			–	15 July	–	92.8	1.1	4.6	23.3
SE		–			–	–	–	1.2	0.2	0.3	5.0
2	F	17 June	Brown Bear	2	22 June	1 July	8.9	95.7	1.8	2.9	87.2
6	F	19 June	Glaucous Gull	1	22 June	27 June	4.8	96.0	1.0	4.2	21.5
8	F	16 June[e]	Glaucous Gull	–	27 May	20 June	4.1	83.2	1.5	7.3	100.0
11	F	20 June	Brown Bear	2	22 June	27 June	4.4	97.9	2.7	2.0	23.6
14	F	22 June[f]	Parasitic Jaeger	1	22 June	25 June	2.6	65.3	0.8	5.3	204.7
15	F	17 June	Red Fox	2	23 June	27 June	3.6	93.2	0.6	5.6	90.1
17	F	–[g]	none, eggs nonviable	–	22 June	–	26.4	91.5	1.0	2.5	50.7
18	F	15 June[e]	none, nest abandoned	2	29 May	26 June	11.2	86.4	1.2	4.9	38.1
22	F	17 June	Glaucous Gull	2	26 June	4 July	8.0	75.8	0.1	5.3	84.1
Median/Average		17 June			–	27 June	–	87.2	1.2	4.4	77.8
SE		–			–	–	–	3.6	0.3	0.6	18.7

[a] S = successfully hatched, F = failed to hatch
[b] Incubation start dates for successful nests estimated by subtracting 28 d from date chick first observed on camera images; for failed nests, nest age estimated using egg flotation (see Methods: Loon Surveys)
[c] As known from aerial surveys, on day of camera setup, or maximum number of eggs seen on camera images
[d] Summarized from time loon returns to nest after camera installation to day before hatch, or to time of nest failure; excludes period of time when photo images could not be interpreted because of poor weather conditions
[e] Start of incubation documented by camera images
[f] Nest was not active during the nesting survey on 21 June but was found the next day during camera retrieval
[g] Eggs not floated; start of incubation unknown
[h] Hatch date estimated using egg flotation
[i] Pipped egg found in nest on 17 July

date agrees with the peak period of hatch determined from monitoring surveys, which indicated that most nests hatched between visits on 10 and 17 July (Table 12).

Incubation constancy by loons in the Colville Delta study area was much lower in 2013 (Table 16) than in previous years (Appendix G). During camera monitoring in 2008–2012, loons spent a high proportion of their time incubating (96.3 ± 0.6%, *n* = 78 nests). In 2013, however, loons at both hatched and failed nests exhibited fairly low nest attendance, respectively spending an average of 92.8% (SE = 1.2, *n* = 4) and 87.2% (SE = 3.6, *n* = 9) of the time incubating.

Since camera monitoring began in 2008, predation of 1 or both eggs has been documented at 43 of 99 nests, including 7 nests where predators were not captured on images (Figure 15). The majority (49%) of identified predators were Glaucous Gulls and Parasitic Jaegers, which take advantage of unattended nests. Of the 9 nests that failed to hatch in 2013, 3 failures were attributed to predation by Glaucous Gulls, 2 to a brown bear, 1 to a pair of Parasitic Jaegers, and 1 to a red fox. The remaining 2 nests did not fail due to predation; 1 contained nonviable eggs and the other was abandoned (Table 16). All 4 nests lost to avian predation were unattended at the time of predation. At 2 of these nests, images showed the incubating loon left the nest to interact with an intruding Yellow-billed Loon in the nesting lake. At the first nest, a gull arrived within 33 min of the loon's departure. The gull was at the nest for ~2 min before the loon chased it away and removed a

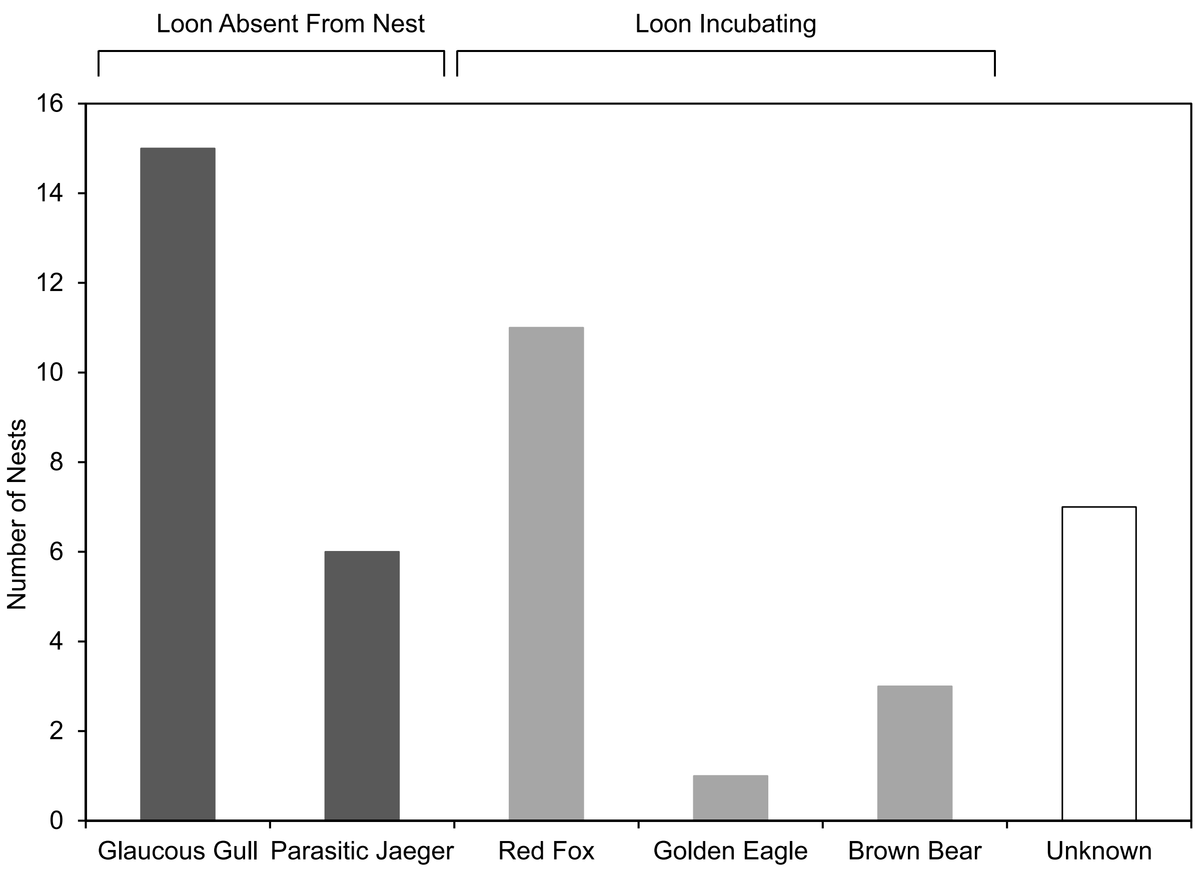


Figure 15. Predators seen taking eggs at camera-monitored Yellow-billed Loon nests (*n* = 99 nests), Colville Delta study area, Alaska, 2008–2013. Loons left nests 6–15 min prior to brown bear predation but showed signs of disturbance, which suggests that they were flushed into the water by the bears.

broken egg. The loon did not resume incubation. At the other nest, a pair of Parasitic Jaegers arrived within 12 min and remained at the nest for ~51 min, while 3 loons aggressively interacted nearby. No loons made an attempt to displace the jaegers and a loon returned only briefly to the nest nearly 3 h after the predation event. At the other 2 nests that suffered avian predation, the incubating loon exhibited decreased nest attendance prior to predation, likely in response to warm weather (>15°C) on the day of predation. During these warm temperatures, incubating loons were seen gular fluttering (a primary means of evaporative cooling in birds) and rubbing their heads on their backs, presumably in response to mosquito harassment. Loons may be attempting to increase heat dissipation by leaving their nests and entering the water. One loon left its nest while the ambient temperature was ~21 °C, as indicated by a sensor inside the time-lapse camera. That nest was unattended for ~27 min (within the range of normal recess length for successful nests) before gull predation occurred. The gull was present for ~2 min before a loon chased it away and removed ≥ 1 broken egg; the loon did not resume incubation. The ambient temperature at the other nest was ~18 °C when the loon left. The nest was unattended for >8 h before suffering gull predation. No loons attempted to defend that nest.

In contrast, incubating loons were likely flushed at the 1 nest taken by a red fox and the 2 nests taken by bears. A loon was incubating but quickly left the nest <4 min before the appearance of the fox in the camera image. At 1 nest taken by a bear, the loon entered the water and swam next to the nest for ~12 min before it left camera view; the bear appeared at the nest ~5 min later. The other loon was absent from its nest ~11 min before the bear approached the nest. That loon left its nest by swimming low in the water. The behaviors seen prior to bear predation are behaviors that we also see during researcher disturbance, suggesting that the bears' presence caused the loons to flush. The fox visited the nest twice, with the total encounter lasting ~1 min. Both of the bears were at nests for ~30 sec. Loons did not defend nests against either the fox or the bears.

One nest failure occurred at a nest that may have contained nonviable eggs. The nest was monitored for 34 d before the camera malfunctioned. According to monitoring surveys, the pair incubated for 36 to 42 d before nest failure occurred, which is longer than the 27–28 day incubation period reported for Yellow-billed Loons (North 1994). Extended incubation for infertile eggs has been observed in Common Loons (Sutcliffe 1982). Reasons for nonviable eggs are unknown but Suttcliffe (1982) suggests that loons may remain faithful to unhatched eggs to provide a wide safety margin for eggs taking longer to hatch. Since the camera was not working on the day of nest failure, it is not known whether the loons eventually abandoned the nest or suffered predation during an incubation recess.

The final nest failure occurred when a pair of loons abandoned their nest after 12 d of incubation. On the day of abandonment and for 3 d prior, the pair exhibited a low incubation constancy that ranged from 47 to 81%. An intruding loon was seen on 3 of those 4 d and the incubating loon left the nest during each encounter, suggesting that the presence of the intruder contributed to the low nest attendance by the nesting pair. Aggressive behaviors were observed including physical contact, splashing, and fencing (loon rises nearly straight up on its feet and treads water with its bill held towards its breast; see Sjölander and Ågren 1976 for descriptions). Whether or not the presence of the intruding loon contributed to nest abandonment is unknown. On the day of abandonment, a loon was incubating normally and did not display any disturbance-related behaviors as it left the nest. The nest contained 2 eggs that were eventually rolled out of the nest by geese. No predators took the eggs, which persisted at least until camera retrieval on 24 July.

As mentioned above, cameras often recorded other Yellow-billed Loons intruding into occupied territories. Intruders were identified by the presence of >2 adults or by aggressive interactions between 2 Yellow-billed Loons. In most cases, the appearance of an intruding loon elicited defensive behaviors among the birds such as fencing, rushing, and physical contact (for descriptions see Sjölander and Ågren 1976). In 2013, intruders were seen at 54% of camera-monitored nests on the Colville Delta (n = 13 nests). In all cases, the incubating loon left the nest to interact with the intruder. The proportion of monitored nests with intruders on camera images in 2013 was similar to the mean detected since 2010 (mean = 56% ± 6.7, *n* = 4 years) but camera images likely under represent the frequency of occurrence of intruders since such interactions may occur out of camera view. These interactions may reflect attempts at territorial takeover by the intruders. Territorial fights and subsequent takeovers have been observed in Common Loons (Piper et al. 2000) but it is unknown whether this behavior also plays an important role in the establishment of Yellow-billed Loon territories (North 1994).

Brood Fate

During monitoring surveys following hatch, we observed 2 chicks with 2 of 7 (29%) Yellow-billed Loon pairs that hatched young, and a single chick with 4 (57%) pairs (Table 14). The remaining pair had 1 chick but its brood was not detected until August so brood size at hatch was not known. We saw chicks during aerial surveys at all nests that contained evidence of hatch and did not detect additional chicks on camera images. We recorded 15 nests in the Colville Delta study area during the nesting, monitoring, and brood-rearing surveys in 2013, including a nest that was inferred from the presence of a brood. A minimum of 9 chicks were produced at 15 nests (0.60 chicks/nest; Table 13). Images from cameras deployed in May confirmed the presence of 2 additional nests that failed prior to monitoring surveys. Based on all available sources of data (camera, eggshell evidence, and aerial surveys), a minimum of 9 chicks were produced by 17 nests (0.53 chicks/nest).

On the second to last survey on 18 September, ~9- and ~10-week old chicks at 2 different territories were observed flying. Both achieved flight by orienting into a ~15-knot wind while running across the water and wing flapping; each chick flew 500–1,000 m over their brood-rearing lake before landing back on it. The length of time from hatch to fledging is not reported for Yellow-billed Loons but may be similar to Common Loons (North 1994). At ~8 weeks of age, Common Loons begin to exercise their wings by orienting into the wind and attempting to take off; however, flight is not usually achieved until ~11 weeks of age (McIntyre and Barr 1997). The relatively young Yellow-billed Loon chicks observed flying in this study may have been aided significantly by the strong winds. Common Loon chicks appear to exercise more often during windy weather than during calm conditions (McIntyre and Barr 1997). During periods of prolonged, calm weather, flight of Common Loon chicks can be delayed until week 12 or 13. Barr (1997) theorized that Yellow-billed Loons may become flight-capable sooner than Common Loons because Yellow-billed Loons have longer daylight periods during which to feed and that might allow them to grow faster than Common Loon chicks. In addition, Yellow-billed Loons are subject to persistent windy conditions, allowing them to exercise often and possibly fly earlier. On the final Yellow-billed Loon survey on 24 September, most loon chicks were ~11 weeks old (Table 14). Although we did not see chicks flying during that survey, 2 broods had left their natal lakes. Both lakes were 95% covered by thin ice which may have forced the adults and young to disperse. We assume that these loons fledged but do not know where they went since the river channels near those territories also were covered with thin ice.

One goal of brood monitoring was to estimate juvenile recruitment, or how many chicks survived to fledging. Assuming that 2 chicks fledged, all Yellow-billed Loon pairs that hatched at least 1 egg retained a chick on the final monitoring survey on 24 September; 1 pair retained both chicks (Table 14). According to the nesting, monitoring, and brood-rearing surveys, 8 chicks from 15 nests (0.53 chicks/nest) survived until the last survey on 24 September (Tables 13 and 14). Including the 2 nests detected only on camera images, 8 chicks from 17 nests (0.47 chicks/nest) survived. We detected almost 50% fewer nests in 2013 compared to the long-term mean and observed low nesting success, both of which contributed to produce the fewest chicks at hatch since nest monitoring surveys began in 2005 (Table 13). The number of chicks on the final survey in mid-September was also 50% fewer than the long-term mean; however, the number of chicks/nest was near average, indicating fairly high chick survival relative to previous years.

NE NPR-A

Distribution and Abundance

During the nesting survey, we counted 39 Yellow-billed Loons and 12 nests in the 3 subareas surveyed: Alpine West, Fish Creek Delta, and the eastern part of the Fish and Judy Creek Corridor (Figure 13, Table 9). Two additional nests were found during monitoring surveys on 26 June. Of the 14 nests found in the NE NPR-A study area in 2013, 1 nest was located in the Alpine West subarea, 7 nests in the Fish Creek Delta subarea, and 6 nests in the Fish and Judy Creek Corridor subarea (Appendix E). All 14 Yellow-billed Loon nests recorded in the NE NPR-A study area in 2013 were on lakes where Yellow-billed Loons have nested previously (Figure 13) (Johnson et al. 2007b, 2010, 2011, 2012, 2013a). Eleven of the 14 nests were located at the same nest sites used in 2012, and 3 were at or very close to nest sites used in years prior to 2012.

The density of Yellow-billed Loon adults in the NE NPR-A study area during the nesting survey in 2013 was slightly above average at 0.16 birds/km², whereas the density of nests was average at 0.06 nests/km² (Appendix E and F). The density of loons and nests in the Alpine West subarea and the Fish Creek Delta subarea in 2013 were similar to the long-term means (0.02 ± 0.003 birds/km² and 0.01 ± 0.002 nests/km² [2002–2006 and 2008–2013] and 0.13 ± 0.008 birds/km² and 0.05 ± 0.004 nests/km² [2005–2006 and 2008–2013], respectively). No more than 1 Yellow-billed Loon nest has been recorded in the Alpine West subarea during 11 years of surveys there.

We surveyed 21 territories in NE NPR-A in 2013 and found 14 nests resulting in a nest occupancy of 67%, which was only slightly higher than the long-term mean (64.2 ± 2.3%, *n* = 12 years; Table 9). Nesting surveys for Yellow-billed Loons in the NE NPR-A were most extensive in 2008–2010, when 51 territories were surveyed. During those 3 years, the highest number of Yellow-billed Loons recorded during nesting surveys was 82 adults in 2008 and the highest number of nests was 29 in 2010 (Table 9). The range of Yellow-billed Loon nest occupancy was 57–71% during 2008–2010.

During the brood-rearing survey on 21–22 August 2013, 21 adult Yellow-billed Loons (0.08 birds/km²) and no broods were observed in the NE NPR-A study area (Table 10); however, 1 nest hatched during weekly monitoring surveys, but its brood did not survive until the brood survey was conducted (Figure 13, Table 14). The density of adults was well below densities detected in 2011 and 2012 (0.12 loons/km^2 and 0.17 loons/km^2, respectively) when the study area was the same as its current size. More importantly, 2013 was the first year where no broods were observed during the brood-rearing survey (see *Brood Fate*, below).

In the Alpine West subarea, only 1 Yellow-billed Loon territory has been identified so the densities of adults and broods during aerial surveys in 2013 (0.03 birds/km² and 0 broods/km²; Appendix E) were similar to the 11-year means (0.02 ± 0.005 birds/km² and 0.01 ± 0.003 broods/km²; 2002–2006 and 2008–2013). The densities of adults and broods in the Fish Creek Delta subarea (0.07 birds/km² and 0 broods/km²; Appendix E) were well below the 8-year means for that area (0.10 ± 0.008 birds/km² and 0.02 ± 0.005 broods/km²; 2005–2006 and 2008–2013). Densities of adults and broods (0.24 birds/km² and 0.02 broods/ km²) in the eastern portion of the Fish and Judy Creek Corridor also were lower than in 2011 and 2012 when the same area was surveyed (Appendix E).

In 2013, we surveyed 21 territories containing 1 brood, resulting in 5% brood occupancy, which was the lowest occupancy recorded for the NE NPR-A (28.2 ± 4.2%, *n* = 12 years; Table 10). Territory occupancy is standardized by the number of territories surveyed so the metric can be used to compare years with different survey areas; however, comparisons should be made cautiously because territory quality could vary among areas. During our most extensive brood-rearing surveys for Yellow-billed Loons in 2008–2010, 49–51 territories were surveyed each year and territory occupancy by broods was 29–38% (Table 10). The highest territory occupancy by broods was recorded in 2012 (57%) in the same study area surveyed in 2013.

Habitat Use

Habitat selection was evaluated for nesting and brood-rearing Yellow-billed Loons in the 3 subareas of the NE NPR-A surveyed for loons in 2008–2013 (Alpine West, Fish Creek Delta, and Fish and Judy Creek Corridor subareas). Yellow-billed Loon nests were found in 12 of 26 available habitats in the NE NPR-A study area (Table 17). Four habitats were preferred for nesting (Tapped Lake with High-water Connection, Deep

Table 17. Habitat selection by nesting and brood-rearing Yellow-billed Loons, NE NPR-A study area, Alaska, 2008–2013.

SEASON Habitat	No. of Nests or Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	6.4	avoid	
Brackish Water	0	0	2.7	ns	low
Tapped Lake with Low-water Connection	0	0	1.8	ns	low
Tapped Lake with High-water Connection	18	14.8	1.4	prefer	low
Salt Marsh	0	0	4.9	avoid	
Tidal Flat Barrens	0	0	4.9	avoid	
Salt-killed Tundra	0	0	1.9	ns	low
Deep Open Water without Islands	4	3.3	5.6	ns	
Deep Open Water with Islands or Polygonized Margins	44	36.1	6.2	prefer	
Shallow Open Water without Islands	0	0	0.7	ns	low
Shallow Open Water with Islands or Polygonized Margins	4	3.3	1.5	ns	low
River or Stream	0	0	2.2	ns	low
Sedge Marsh	12	9.8	1.5	prefer	low
Deep Polygon Complex	3	2.5	0.1	prefer	low
Grass Marsh	2	1.6	0.4	ns	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	0	0	4.1	avoid	low
Riverine Complex	0	0	0.1	ns	low
Dune Complex	3	2.5	1.6	ns	low
Nonpatterned Wet Meadow	5	4.1	3.2	ns	low
Patterned Wet Meadow	20	16.4	11.8	ns	
Moist Sedge-Shrub Meadow	6	4.9	15.5	avoid	
Moist Tussock Tundra	1	0.8	15.0	avoid	
Tall, Low, or Dwarf Shrub	0	0	4.1	avoid	low
Barrens	0	0	2.0	ns	low
Human Modified	0	0	0	ns	
Total	122	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	6.4	ns	low
Brackish Water	0	0	2.7	ns	low
Tapped Lake with Low-water Connection	0	0	1.8	ns	low
Tapped Lake with High-water Connection	10	18.5	1.4	prefer	low
Salt Marsh	0	0	4.9	ns	low
Tidal Flat Barrens	0	0	4.9	ns	low
Salt-killed Tundra	0	0	1.9	ns	low
Deep Open Water without Islands	4	7.4	5.6	ns	low
Deep Open Water with Islands or Polygonized Margins	40	74.1	6.2	prefer	low
Shallow Open Water without Islands	0	0	0.7	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	4.1	ns	low
Riverine Complex	0	0	0.1	ns	low
Dune Complex	0	0	1.6	ns	low
Nonpatterned Wet Meadow	0	0	3.2	ns	low
Patterned Wet Meadow	0	0	11.8	avoid	
Moist Sedge-Shrub Meadow	0	0	15.5	avoid	
Moist Tussock Tundra	0	0	15.0	avoid	
Tall, Low, or Dwarf Shrub	0	0	4.1	ns	low
Barrens	0	0	2.0	ns	low
Human Modified	0	0	0	ns	
Total	54	100	100		

[a] use = (groups / total groups) x 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

Open Water with Islands or Polygonized Margins, Sedge Marsh, and Deep Polygon Complex), altogether supporting 77 of 122 (63%) total nests. Within these areas, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. Although all nests were on islands or shorelines of lakes, 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 (36% of all nests; Table 17). Nesting Yellow-billed Loons avoided 7 habitats composing 55% of the loon survey area in the NE NPR-A.

Fifty-four Yellow-billed Loon broods were found in 3 habitats in the NE NPR-A study area, 2 of which were preferred: Tapped Lake with High-water Connection and Deep Open Water with Islands or Polygonized Margins (Table 17). Deep Open Water with Islands or Polygonized Margins also was the most frequently used habitat for brood-rearing (74% of all broods). No shallow-water habitats were used during brood-rearing. The selection analyses for loons in the NE NPR-A, like those conducted for the Colville Delta, highlight the reliance on large, deep waterbodies by breeding Yellow-billed Loons.

Nest Monitoring and Nest Fate

We found 14 Yellow-billed Loon nests during nesting and monitoring surveys in the NE NPR-A study area in 2013, which was similar to the mean (13.7 ± 0.92 nests) found during 6 years of surveys on lakes within the same survey area. Apparent nesting success, however, was the lowest observed since monitoring surveys began in 2008 (Table 13). Only 1 of 14 (7.1%) nests hatched and that nest hatched by 24 July (Table 18).

Thirteen of 14 Yellow-billed Loon nests in the NE NPR-A study area failed to hatch (Table 18). Ten nests (71%) failed by 3 July, 1 by 10 July and 1 by 24 July. The remaining nest failed by 31 August and was active for 35 to 42 days, which is longer

Table 18. Weekly status and fate of Yellow-billed Loon nests monitored by aerial surveys, NE NPR-A study area, Alaska, 2013. Status (A = active, I = inactive) determined from camera-monitored nests is presented in parentheses where it differed from status determined from aerial surveys.

	June		July					
Territory	19–21	26	3[a]	10	17	24	31	Fate/Total
51	A	I	–	–	–	–	–	Failed
53	A	I	–	–	–	–	–	Failed
55[b]	A	A[a]	I	–	–	–	–	Failed
56[b]	A	I[a]	–	–	–	–	–	Failed
57	A	A	I	–	–	–	–	Failed
58[b]	A	A	I	–	–	–	–	Failed
59[b]	I	A	A	A	A	I	–	Hatched
88[b]	A	A[a]	I	–	–	–	–	Failed
91	A	A	A	A	A	A	I	Failed
92[b]	A	A	A	A	A	I	–	Failed
93[b]	A	A	A	I	–	–	–	Failed
94[b]	A	A (I[c])	I	–	–	–	–	Failed
96[b]	A	A	I	–	–	–	–	Failed
97	I	A	I	–	–	–	–	Failed
No. Active	12	11 (10)	4	3	3	1	0	14
No. Hatched	0	0	0	0	0	1	0	1
No. Failed	0	3 (4)	7	1	0	1	1	13

[a] Camera-monitored nest(s) was not surveyed by helicopter; nest status determined from camera images
[b] Nest monitored by camera
[c] Camera images show brown bear predation occurred at the nest after the aerial survey on 26 June

than the 28-day incubation period reported for Yellow-billed Loons. We found 2 smashed and yolky eggs next to the nest during the fate visit, suggesting that the pair was incubating non-viable eggs. Extended incubation for infertile eggs has been observed in Common Loons (Sutcliffe 1982; see *Time-lapse Cameras* under Colville Delta, above).

The contents of 13 Yellow-billed Loon nests were examined after nests were no longer active. One was classified as successful based on the presence of eggshell fragments in the nest and a brood. That nest contained 2 membranes and ~125 small eggshell fragments within 5 m of the nest. Approximately 65% of the fragments were ≤10 mm in length. Twelve failed nests were examined for fate evidence. Four nests were empty. Seven nests had 1–7 pieces of eggshell in or near the nest; 3 of those nests also contained a few pieces of thickened membrane loosely attached to egg fragments. The presence of membrane pieces alone are not necessarily indicative of hatch because nests that fail close to hatching may contain some membrane pieces (Johnson et al. 2013a). The remaining failed nest had 2 crushed and yolk-covered eggs sitting next to the nest bowl.

Time-lapse Cameras

We monitored 9 of 14 Yellow-billed Loon nests in the NE NPR-A study area with time-lapse cameras in 2013 (Table 19). Eight-power telephoto cameras were placed 53–87 m from nests (70 ± 17.0 m, *n* = 2 nests) and 2× and 2.5× telephoto cameras were placed 31–58 m from nests (43 ± 3.8 m, *n* = 7 nests). Two researchers were transported to and from nesting areas by helicopter for camera setup and were at nests an average of 26 min (range = 18–36 min, *n* = 9 nests). All 9 loons left their nest during camera setup (4 swam away as the helicopter landed, 4 left as researchers exited the helicopter, and 1 left as the helicopter circled the nest to land).

All 9 loons returned to incubate after camera installation, returning to their nests an average of 23 min after we departed in the helicopter (SE = 9 min, range = 2–71 min, *n* = 9 nests). Loons were absent from nests during camera installation for a mean of 49 min (SE = 9 min, range = 22–101 min, *n* = 9 nests).

Cameras successfully recorded daily nest survival, and we were able to use images to identify the day of hatch or failure at all 9 camera-monitored nests. One nest hatched and 8 failed for an apparent nesting success of 13%. The median initiation date of camera-monitored nests was 17 June (range = 9–23 June, *n* = 8) and the only nest to hatch did so on 21 July (Table 19). Five of the 8 failed nests suffered predation between 25 and 29 June. During camera monitoring in 2010–2012, loons spent a high proportion of their time incubating (mean = 96.8%, SE = 0.4, *n* = 25 nests; Appendix G). In 2013, however, the pair at the hatched nest and those at failed nests exhibited fairly low incubation constancy, spending 94.0% (*n* = 1) and 93.2% (SE = 0.9, *n* = 7) of the time incubating, respectively (Table 19).

Since camera monitoring began in 2010 in the NE NPR-A study area, we have identified predators at 22 of 36 (61%) monitored nests. Except for brown bears, Bald Eagles, and Golden Eagles, all predators took eggs while nests where unattended (Figure 16). Over half (54%) of the 22 events occurred while loons were absent from nests. Predators were not captured on images at 4 nests and the timing of predation could not be determined with certainty. In 2013, 2 failures were attributed to Glaucous Gulls, 1 to a Parasitic Jaeger, 1 to a Bald Eagle, and 2 to brown bears; the predators at 2 nests were unknown. All 3 of the nests that failed due to gull or jaeger predation were unattended at the time of predation. Two nests suffered predation while the incubating loon was interacting with an intruding loon. Both loons concealed on their nest prior to the arrival of the intruder but both eventually left their nest to interact, displaying aggressive behaviors such as fencing and rushing. A gull arrived at 1 nest ~2 min after the incubating loon departed camera view. The gull was at the nest for ~2 min before a loon flew towards the nest and displaced the gull. The loon incubated for ~7 min before leaving again to interact with the intruder. A gull returned to the nest for ~30 sec and left with an egg in its bill. About 12 min later, the loon came back to the nest and incubated for several hours before ending nest attendance. At the other nest, a jaeger appeared ~7 min after the incubating loon left to interact with an intruder. The jaeger was at the nest for ~13 min.

Table 19. Nest history and incubation activity at Yellow-billed Loon nests monitored by time-lapse digital cameras, NE NPR-A study area, Alaska, 2013.

Territory	Fate[a]	Incubation Start Date[b]	Predator	No. Eggs[c]	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)
59	S	23 June		2	26 June	21 July	24.4	94.0	1.4	4.0	16.4
55	F	17 June	Glaucous Gull	2	23 June	28 June	5.2	93.1	1.0	3.3	127.4
56	F	9 June	Glaucous Gull	2	23 June	25 June	1.8	94.1	1.7	2.2	40.3
58	F	12 June	Brown Bear	2	26 June	2 July	5.9	94.8	1.2	3.9	19.4
88	F	23 June	Unknown	1	23 June	29 June	5.0	92.6	1.0	3.6	20.7
92	F	–[e]	Unknown	–	26 June	18 July	16.3	93.8	1.4	4.8	21.3
93	F	18 June	Bald Eagle	1	26 June	8 July	11.8	95.8	1.1	3.6	19.7
94	F	19 June	Brown Bear	2	26 June	26 June	0.2	–	–	–	–
96	F	17 June	Parasitic Jaeger	1	26 June	29 June	2.8	88.3	0.7	3.9	161.7
Median/Average		17 June			–	29 June	–	93.2	1.2	3.6	58.6
SE		–			–	–	–	0.9	0.1	0.3	22.7

[a] S = successfully hatched, F = failed to hatch
[b] Incubation start dates for successful nests estimated by subtracting 28 d from date chick first observed on camera images; for failed nests, nest age estimated using egg flotation (see Methods: Loon Surveys)
[c] As known from aerial surveys, on day of camera setup, or maximum seen on camera images
[d] Summarized from time loon returns to nest after camera installation to day before hatch, or to time of nest failure; excludes period of time when photo images could not be interpreted because of poor weather conditions
[e] Eggs not floated; start of incubation is unknown

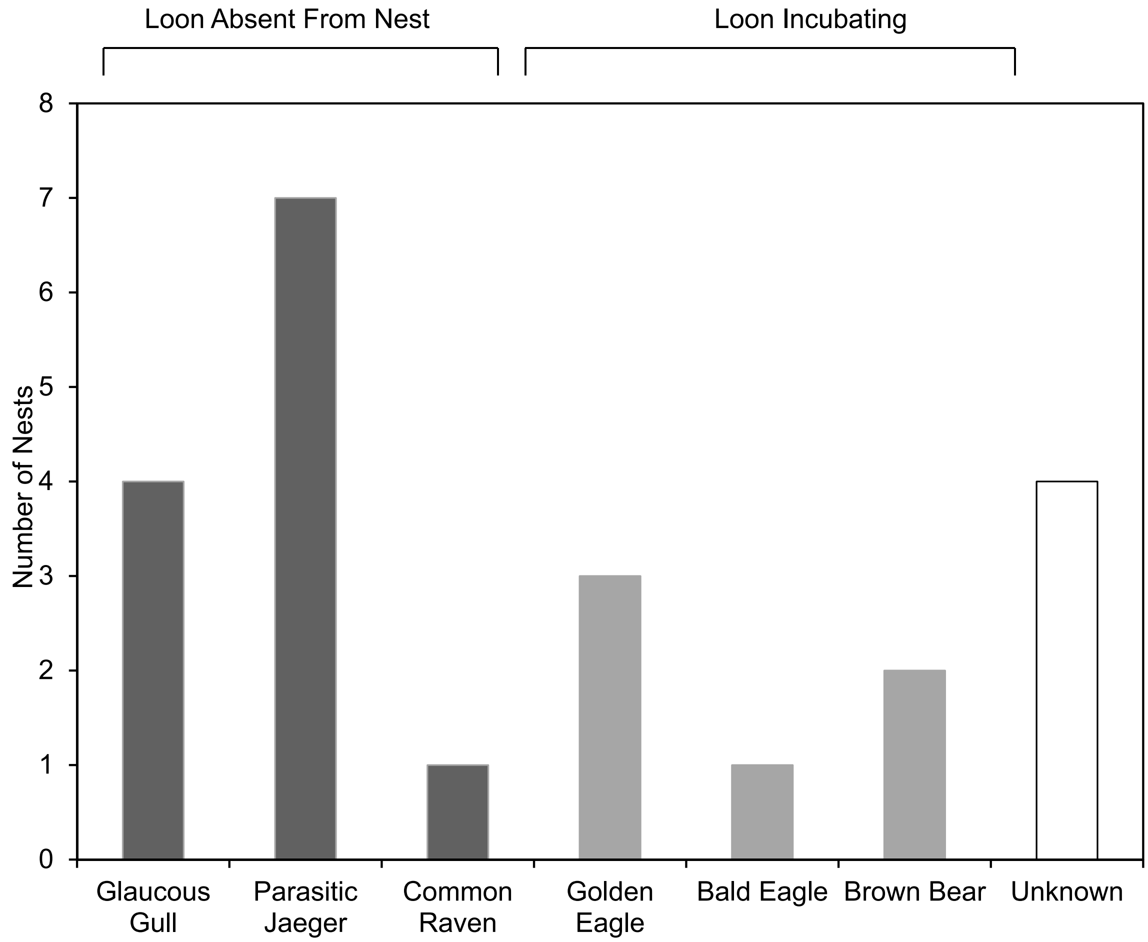


Figure 16. Predators seen taking eggs at camera-monitored Yellow-billed Loon nests (*n* = 36 nests), NE NPR-A study area, Alaska, 2010–2013. Loons left nests 3–33 min prior to brown bear predation but showed signs of disturbance, which suggests that they were flushed into the water by the bears.

During the predation event, a loon was seen chasing another loon ~250 m from the nest. A pair of loons eventually returned to the nest but did not attempt to incubate. The third nest that was unattended at the time of predation failed while the incubating loon took a recess during hot weather (18 °C). A pair of gulls arrived 1 h 19 min after the loon left but may have been chased away by a loon ~30 sec later. The loon did not resume incubation and the gulls returned after ~20 min and remained at the nest for ~8 min. The loon returned to the nest ~42 min later and removed at least 1 broken egg before ending nest attendance.

The loons at the nests taken by the Bald Eagle and the bears likely were incubating and flushed by those predators. A loon was incubating in concealed posture for ~1 min prior to leaving its nest and quickly swimming out of camera view. An eagle appeared ~5 min later and made 3 separate visits to the unattended nest over the course of ~12 min. After predation, the eagle spent ~20 min preening near the nest. The loon returned within 5 min of the eagle's departure and attempted to incubate for almost 30 min before ending incubation. At 1 nest depredated by a bear, the loon was incubating 3 min prior to the bear's arrival at the nest. At the other nest, however, the loon left its nest ~33 min before a sow and its cub appeared at the nest. That loon left its nest fairly quickly by swimming with its body low in the water, which is the same behavior we see when loons flush from nests into the water during researcher disturbance.

Although not known with certainty, the loon likely detected the bears approach, prompting it to leave its nest. During both encounters, the bears were at nests for ~30 sec. Loons at both nests returned within 30 min of the bears' departure but neither attempted to incubate.

In 2010 and 2011, we observed intruding loons on images at 50–80% of camera-monitored territories in NPR-A (*n* = 10 and 6 nests, respectively). In 2012, however, we did not observe intruders on images at any of the 11 camera-monitored nests in NPR-A. In 2013, we saw intruders at 56% of camera-monitored nests in NPR-A (*n* = 9 nests), a proportion similar to that observed in the Colville Delta study area (see *Time-lapse Cameras* under Colville Delta, above).

Brood Fate

Only 1 Yellow-billed Loon pair hatched young in 2013, producing 2 young seen on the monitoring survey following hatch (Table 14). No additional chicks were inferred from eggshell evidence or detected on camera images. Chick production at the 14 nests found in the NE NPR-A in 2013 (0.14 chicks/nest) was the lowest since brood monitoring began in 2008 (Table 13). Furthermore, those chicks died by late July so that no chicks survived until the final monitoring survey on 24 September.

PACIFIC AND RED-THROATED LOONS

Colville Delta

We counted 180 Pacific Loons and 13 nests, and 19 Red-throated Loons in the Colville Delta study area during the nesting survey for Yellow-billed Loons in 2013 (Figure 17, Appendix E). During the brood-rearing survey, we recorded 123 adult Pacific Loons and 21 broods, and 4 adult Red-throated Loons and 2 broods (Figure 17, Appendix E). Because these counts of Pacific and Red-throated loons were recorded incidentally during Yellow-billed Loon surveys, they reflect the general distribution of these species on the Colville Delta but are not accurate estimates of the abundance of these species. Nests of Red-throated Loons are not easily detected from the air and are found on small ponds, which were not surveyed systematically in this study. Pacific Loons breed on small and large lakes and were clearly the most abundant loon on the delta in 2013 and in previous years. 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.

NE NPR-A

Pacific Loons also were the most abundant and widespread loon species breeding in the NE NPR-A study area in 2013. On the loon nesting survey, we recorded 152 adult Pacific Loons and 8 nests, and 10 Red-throated Loons with no nests (Figure 17, Appendix E). During the brood-rearing survey, 135 adult Pacific Loons and 21 broods were found (Figure 17, Appendix E). One Red-throated Loon was found in the NE NPR-A study area during the brood-rearing survey.

DISCUSSION

The numbers of Yellow-billed Loon adults, nests, and young detected during the nesting and brood-rearing surveys in the Colville Delta study area generally appear to be stable to increasing although there are several years with very low numbers (Figure 14). We have too little comparable data to make similar evaluations in the NE NPR-A. Reasons for the annual variation on the Colville Delta are largely unknown but the extent of flooding during spring breakup appears to be highly influential. Since we began using the helicopter for surveys in 2000, 3 of the 4 years with the lowest numbers of nests and broods occurred during years when the Colville River flooded substantial portions of the delta during spring breakup (2000, 2001, and 2013). The arrival of loons on territories is closely associated with the formation of moats around thawing ice on lakes (North 1986), but pairs also must wait until water levels on lakes drop to allow use of nest sites (this study). Water levels on lakes during spring may rise in response to local runoff from snowmelt or from the Colville River spilling over its banks. During years with high water levels, nesting may be delayed or prohibited at some territories, either of which could affect production of young (Johnson et al. 2013a). When flood and non-flood years (2000–2013) are included in regressions, the growth rate of adults is positive (1.018) but not significantly different from equilibrium (Table 20). When the 3 most extreme flood years are excluded,

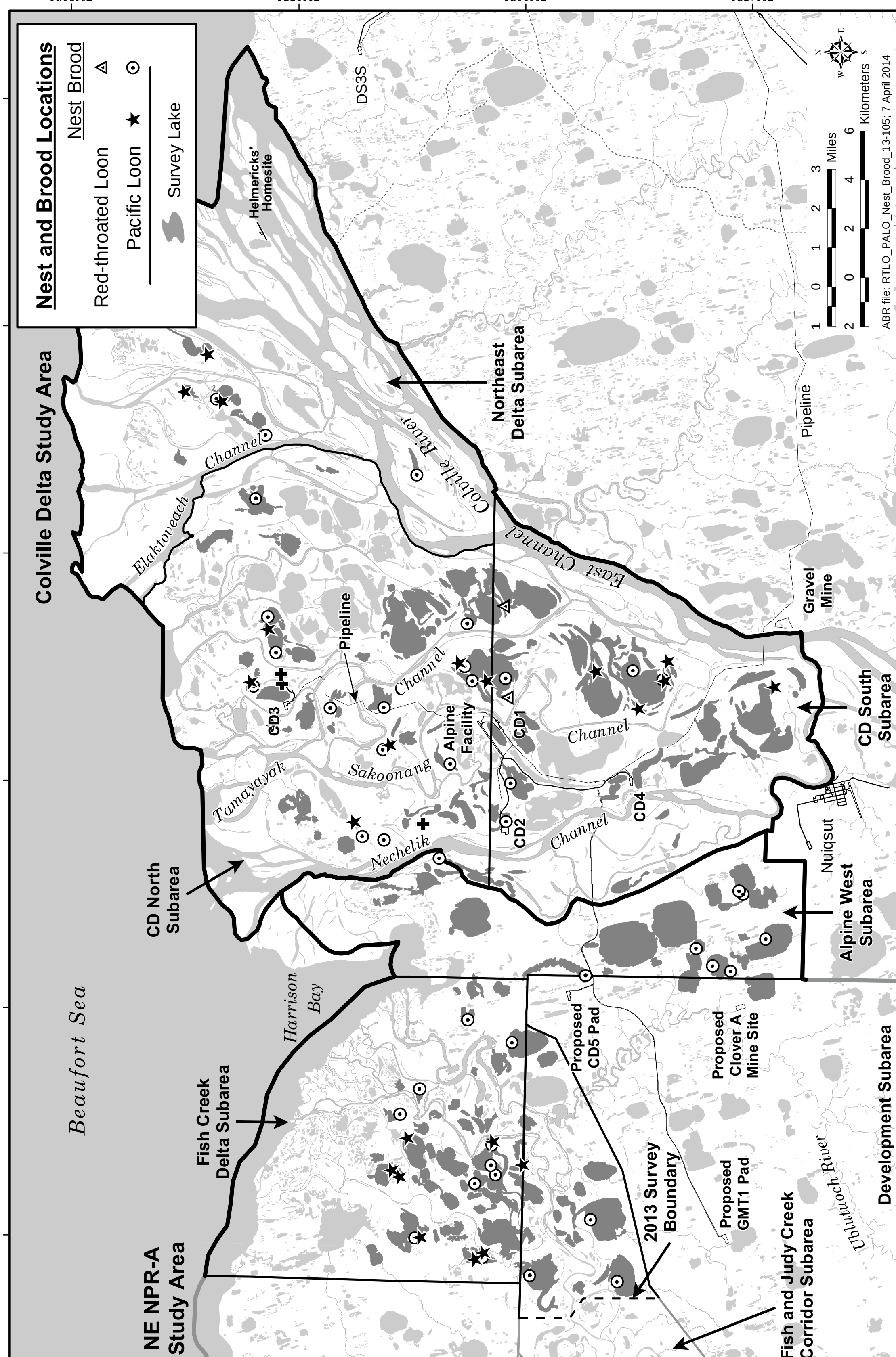


Figure 17. Pacific Loon nests and broods, Colville Delta and NE NPR-A study areas, Alaska, 2013.

Table 20. Population growth rate regressions of Yellow-billed Loon adults, nests, and young, Colville Delta study area, Alaska. Separate regressions run with data from all years (2000–2013) and with flood years excluded (non-flood years = 2002–2012).

VARIABLE Time Period	Growth Rate	90% CI	R^2	*P*-value	Regression
ADULTS					
All Years	1.018	1.002–1.034	0.259	0.06	In(y) = 0.018x – 33.40
Non-flood Years	1.034	1.010–1.057	0.437	0.03	ln(y) = 0.034x – 63.33
NESTS					
All Years	0.995	0.963–1.026	0.008	0.76	In(y) = -0.005x + 14.19
Non-flood Years	1.007	0.978–1.035	0.019	0.69	ln(y) = 0.007x – 9.80
YOUNG					
All Years	1.091	1.020–1.162	0.245	0.04	In(y) = 0.091x – 179.72
Non-flood Years	1.040	0.987–1.093	0.175	0.20	In(y) = 0.040x –77.68

the number of adults exhibits a significantly increasing growth rate of 1.034, which is similar to that estimated across the ACP during the last 10 years (1.050, 90% CI = 1.006–1.096; Stehn et al. 2013). The number of nests is more variable and shows no significant trend with or without flood years. Flood years, however, have a large effect on the trend for the number of young. When all years are included, young exhibit a significantly positive growth rate (1.091); however, when flood years are excluded, the growth rate decreases to 1.040 and is not significantly different from equilibrium. Our data do not suggest that nest or chick survival have increased, so in the absence of growth in nest numbers, the population of young likely is fairly stable. Regressions are highly influenced by low or high values at the beginning and end of a series, which is when floods occurred in our study; thus, population growth rates probably are most representative of the overall trends when extreme flood years are excluded from population growth regressions for Yellow-billed Loons.

The positive growth rate for adult Yellow-billed Loons and the variability in nest numbers indicates that adults arrive on the Colville Delta in slowly growing numbers each year but productivity (as measured by total nests and young) have not kept pace. Factors other than the lack of returning adults influence how many nests occur in the study area. Since 2000, an average of 87% (SE = 2.1, range = 73–100%, *n* = 14 years) of breeding territories have been occupied by ≥1 adult during the nesting survey whereas occupancy by nests has been more variable, ranging from 40 to 90% (mean = 65 ± 3.8%, *n* = 14 years). The positive growth in number of adults and relative unchanging number of nests and young also suggest a population that is habitat-limited for nesting. Yellow-billed Loons show clear preferences for habitats that are not uniformly distributed across the Colville Delta. Further, time-lapse cameras have documented intense physical interactions between territory holders and intruding loons. These interactions may be an attempt by intruders to usurp occupied territories. Territorial fights also have been observed in Common and Pacific loons and appear to be a high-risk activity that may result in injury, such as sternal punctures, or death caused by drowning or internal organ damage (McIntyre and Barr 1997, Sjolander 1978). Territory takeover through usurpation has been documented in Common Loons and, along with opportunistic occupation of territories left vacant by a previous resident, is thought to be an important means of territory acquisition (McIntyre and Barr 1997, Piper et al. 2000). The high frequency of aggressive interactions we have observed in the last 4 years (some leading to nest failure when loons left their nests unattended) in concert with an increasing adult population in the breeding area and static productivity suggest a possible density-dependent effect on reproduction. We have no data on suitable habitat for Yellow-billed Loons outside the Colville Delta and our NE NPR-A study area, but within these study areas, we suspect breeding habitat has become limiting.

As mentioned above, the timing of nest initiation and the number of nests occurring in the Colville Delta study area appear to be largely influenced by the extent of flooding during breakup and by climatic conditions in mid-May to mid-June (Earnst 2004, this study). Widespread flooding occurred on the Colville Delta in 2013 due to ice jams in the Niġliq and East channels (Michael Baker Jr. Inc. 2013a). Images from time-lapse cameras deployed at 9 Yellow-billed Loon territories showed that the Colville River flooded those territories between 1 and 4 June. Prior to that time, the territories and surrounding tundra were 100% covered by snow and ice. Two other camera-monitored territories formed moats and flooded from local runoff. Most loons at these camera-monitored lakes were seen on images within 3 d of their territory flooding, although nest sites were still submerged. Nesting was observed 6 to 16 d (median = 9 days, *n* = 4 nests) after loons arrived at territories. North (1986) conducted a study in 1983 and 1984 in a portion of our Colville Delta study area and observed that the first Yellow-billed Loons occupied territories shortly after moat formation on ~2–4 June in 1983, but in 1984 the first loons occupied territories on 11 June when moat formation was delayed. During both years, the first nests were observed 7 to 9 d after adults arrived on territories, a timeframe similar to this study. Yonge (1981) suggests that the delay between arrival and egg laying is related to gonadal cycles, which is ~2 weeks in loons. He also suggests that reproductive expediency is vital in northern populations where the breeding season is short. Since the incubation and chick-rearing periods are lengthy in loons (total ≈ 15 weeks), the only way to compress the breeding season is to arrive as early as water is available on nesting lakes and accelerate the laying cycle by shortening the pre-nesting period. Pacific Loons and Common Loons nesting at northern latitudes typically occupy territories within a day of moat formation; little courtship is observed by that time because loons arrive at territories already paired (Sjölander 1978, Sjölander and Ågren 1972, Yonge 1981). In addition, Common Loons nesting at northern latitudes have a shorter period between arrival and laying compared to their southern counterparts (Yonge 1981). The ability to access territories as soon as conditions allow and to lay eggs quickly after arrival is likely important to Yellow-billed Loons as well.

Despite the flooding on the Colville River Delta during early June in 2013, the median start date of incubation for camera-monitored loons (17 June, range = 15–22 June, *n* = 12) was only 2 days later than the median since 2008, when camera-monitoring began (range = 8–24 June, *n* = 85 nests). Other Yellow-billed Loon studies on the Colville Delta prior to 2000 also suggest that nesting in 2013 occurred in a fairly typical timeframe; in those studies, loons began incubation between 14 and 23 June (Earnst 2004, North 1986). Because we float eggs and estimate nest age only from a sample of nests that are active during the nesting survey (third week of June), the median start date in our study areas serves only as an index for comparing timing among years as some nests may start and fail before the nest survey and others may start after that survey. Despite a fairly typical nesting phenology in 2013, we found ~40% fewer nests compared to the 19-year mean. The paucity of nests suggests that the largest effect of the flooding was that it prevented nesting altogether at many territories, rather than delaying nesting. Of the nest sites monitored by time-lapse cameras, 1 was submerged for 19 days. Although loons occupied that territory by 7 June, the nest site was submerged until at least 23 June and nesting was not observed at that territory. The rate at which water subsided varied among territories and may have been an important factor in whether or not a given pair nested in 2013.

In contrast to the Colville Delta, the NE NPR-A study area had an average number of Yellow-billed Loons nests in 2013, yet nesting success was extremely poor. Only 1 nest hatched, resulting in record low chick production. Peak discharge along the Ublutuoch River occurred 1 day later than the historical average (4 June, *n* = 10 years; Michael Baker Jr. 2013b), suggesting that breakup in our NE NPR-A study area resembled a typical year. Flooding did occur along the Ublutuoch, and water levels were decreasing by 10 June. The median start of incubation at camera-monitored nests in the NE NPR-A (17 June) was the same as that in the Colville Delta. However, incubation began at camera-monitored nests over a longer period in the NE NPR-A (range = 9–23 June) compared to the Colville Delta (range = 15–22 June). The only brood produced in the NPR-A study area survived <1 week.

A preliminary comparison of incubation constancy between successful and failed nests in both study areas shows that Yellow-billed Loons at successful nests spent a higher percentage of time on nests (mean = 97.4%) than those at failed nests (mean = 92.6%; Mann-Whitney U test, n = 124, P < 0.001). This behavioral difference appears to be important given the fairly high rate of egg loss that occurs when nests are unattended. Further, in 2013 the incubation constancy of loons at hatched (93.1%, n = 5) and failed nests (89.8%, n = 16) was much lower than in previous years. We suspect that more time off nest and lower incubation constancy in 2013 resulted in low nesting success; only 30% of camera-monitored nests hatched in 2013, compared with 52–79% that hatched during 2008–2012. Each year, we have observed predation while resident loons were off nests during periods of warm weather (i.e. >15 °C; this study, unpublished data). The number of days between 20 June and 20 July with maximum temperatures >15 °C at Colville Village shows considerable annual variation (this study, unpublished data). Since 2008, much of that variation has occurred between 20 June and 30 June, which, at least for 2013, was the timeframe most camera-monitored nests failed. We also observed predation while loons were off nests fighting with intruding loons. Warm weather and territorial fighting appear to be highly influential on incubation constancy in both the Colville Delta and NE NPR-A study areas and likely are detrimental to Yellow-billed Loon productivity.

We began monitoring a sample of Yellow-billed Loon nests with cameras in the Colville Delta and NE NPR-A study areas in 2008 and 2010, respectively. Predators took 1 or both eggs from 48% of 135 camera-monitored nests. Glaucous Gulls and Parasitic Jaegers were the most commonly recorded nest predators, taking eggs at 49% of the nests that lost eggs (n = 65 nests). Those avian predators, along with Common Ravens, preyed exclusively on unattended nests. Eagles were the only avian taxa that flushed Yellow-billed Loons from nests to take eggs. Although avian predation was the most common reason for egg loss in both study areas, the predatory species differed between areas. Glaucous Gulls most frequently caused predation in the Colville Delta study area, whereas Parasitic Jaegers caused most predation in the NE NPR-A study area. After gulls and jaegers, red foxes were the most commonly identified predator. When taking eggs, red foxes always flushed loons from attended nests; however, red foxes were seen preying on nests only in the Colville Delta, not in the NE NPR-A study area.

A study conducted in 1983 and 1984 in a portion of our Colville Delta study area found that Yellow-billed Loons had high reproductive success compared to other loon species, as a result of low egg loss and high chick survival (North 1986). In both 1983 and 1984, apparent nesting success was 94% and only 1 nest failed each year. One nest was crushed by shifting ice and the other nest failed from avian predation. We observed a much higher rate of nest predation on the delta than did North (1986). During our study, apparent nesting success averaged 57% (n = 9 years). Data from camera-monitored nests indicated that predation was the main cause of nest failure, with Glaucous Gulls and red foxes being the primary predators on the Colville Delta. The high nesting success that North (1986) observed was reflected in chick productivity of 1.29 and 0.94 chicks/nest in 1983 and 1984, respectively (North 1986). Because we observed more nest failures, chick production at hatch was lower, ranging from 0.47 to 1.16 chicks/nest (mean = 0.83 chicks/nests, n = 9 years). In our study, chick survival seems fairly high, but we are unaware of comparable data for Yellow-billed Loons (for reviews see North 1986, North 1994, Earnst 2004).

An increase in the number of Glaucous Gulls and red foxes on the Colville Delta may be partly responsible for the increase in nest predation rates since the studies by North in 1983 and 1984 (1986). In our Colville Delta study area, gulls took eggs in 34% of the predation events and always took eggs at unattended nests. Although loons in North's (1986) study had an incubation constancy (95.3%, n = 12 nests) similar to the loons across 6 years of our study (mean = 95.2 ± 0.67%, n = 91 nests), nest predation in 1983 and 1984 was almost nonexistent. Gull numbers across the Arctic Coastal Plain have been variable and fairly stable over the last 21 years, but data from the last 10 years suggest that numbers have increased (Stehn et al. 2013). Since 2002, the number of gull nests seen in the Colville Delta study area also has increased (see GLAUCOUS AND SABINE'S GULLS, below). An increase in gull abundance could reduce nest or chick survival, because gulls prey on eggs as well as young loon chicks (Johnson et al. 2010).

The number of red foxes probably has increased on the Colville Delta since the 1980s. In our Colville Delta study area, red foxes caused nest failure in 25% of the predation events since camera monitoring began in 2008 (n = 44 events). North (1986) did not observe predation by red foxes and only mentions that they were uncommon on the delta. Although we lack survey data, anecdotal evidence collected during our avian studies suggests that red foxes have become more common on the delta. During the Alpine Avian Monitoring Program (1998–2001), arctic foxes were seen almost daily, whereas red foxes were uncommon and first observed in 1999 (Johnson et al. 2003a). During that study, video cameras were deployed to monitor swan and goose nests (1998–2001); 72% of foxes seen on camera were identified as arctic foxes, only 16% were red foxes, and 12% were unidentified. The proportion of red foxes on the Colville Delta increased in 2010–2013 to 57% of the foxes seen on cameras monitoring loon nests (n = 63 fox occurrences). An increase in the number of red foxes would likely have a negative effect on nest productivity because red foxes appear to be more effective predators of Yellow-billed Loon nests than arctic foxes. Camera images from this study have shown arctic foxes passing by Yellow-billed Loon nests and, less frequently, trying (unsuccessfully) to flush loons from nests, but they have not been documented taking eggs. In contrast, red foxes frequently have flushed loons from nests to steal eggs.

We also observed an increase in predation of loon nests by brown bears in 2013. Previously, we had observed brown bears on images from camera-monitored nests 2 times in 2009; 1 was of a bear taking a nest and the other was in the background at another nest. In 2013, we observed 4 cases of nest predation on camera images from which we could identify 3 different bear groups (1 adult with a collar, 1 adult without a collar, and 1 female with a 1- or 2-year-old cub). We saw bears at 6 different camera-monitored nests, but could only distinguish 4 different groups (2 females with cubs and 2 adults) based on age of cubs and whether the adults had collars. One more sighting of a female with 2 cubs of the year was made from a helicopter while deploying cameras at nests, which tallies to a minimum of 5 different bear groups or possibly as many as 7 (assuming each observation was a different group). Although other observers in the area reported the usual number of bear sightings in 2013 (Alex Prichard, ABR, pers. comm., and Sandy Hamilton, Arctic Air Alaska, pers. comm.), it is clear that bears caused more predation at loon nests than in any previous year we have used cameras to monitor nests in both the Colville Delta and NE NPR-A study areas.

TUNDRA SWAN

COLVILLE DELTA

Distribution and Abundance

Tundra Swan abundance matched long-term mean values on the Colville Delta study area in 2013; however, productivity was the lowest since we began surveys in 1992. During the swan nesting survey, 306 swans, including 88 pairs, were counted in the Colville Delta study area (Figure 18). The total swan count in 2013 was somewhat less than the 20-year mean of 380 swans found in the study area, but well within the range of counts previously recorded (range = 208–749, SE = 159). Thirty-nine swan nests were found in the Colville Delta study area in 2013 (Table 21), a slightly greater number than the annual mean of 35 nests (range = 14–55, SE = 2.2, n = 20 years). Twenty-two nests were located in the CD North subarea, 9 were in the CD South subarea, and 8 were in the Northeast Delta subarea. Six additional swan nests were discovered during helicopter-based loon surveys of portions of the Colville Delta study area and are not included in the swan survey total (Table 21) for consistency with data presentations from previous years; however, all swan nests are displayed in Figure 18.

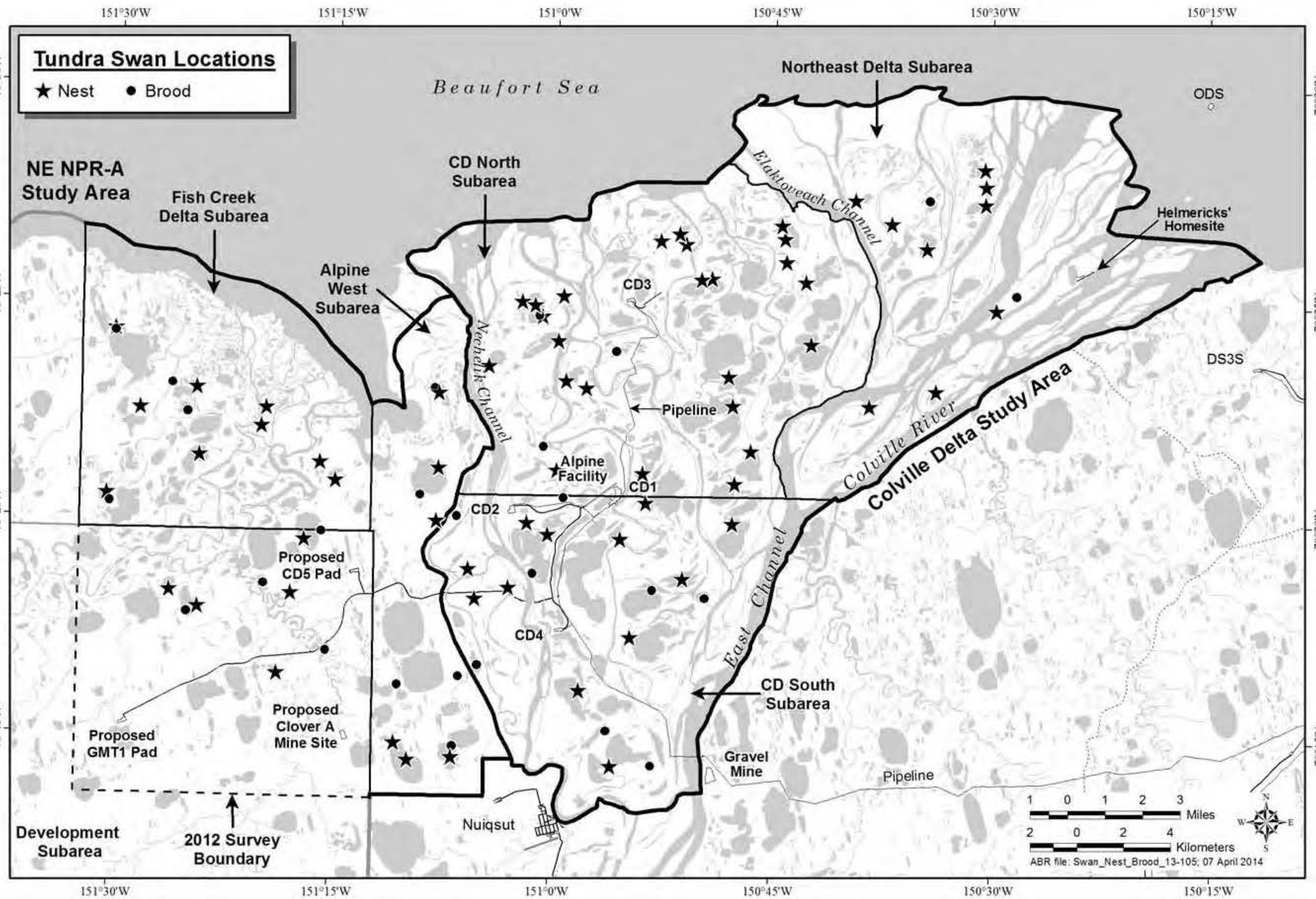


Figure 18. Tundra Swan nests and broods, Colville Delta and NE NPR-A study areas, Alaska, 2013.

Table 21. Number and density of Tundra Swan nests and broods during aerial surveys, Colville Delta study area, Alaska, 1992–2013.

Year	No. Nests	Density (nests/km²)[a]	No. Broods	Density (broods/km²)[a]	Mean Brood Size	Nesting Success (%)
1992	14	0.03	15	0.03	2.5	100
1993	17	0.04	14	0.03	2.6	82
1995	38	0.07	25	0.05	3.7	66
1996	45	0.08	32	0.06	3.4	71
1997	32	0.06	24	0.04	2.5	75
1998	31	0.06	22	0.04	2.4	71
2000	32	0.06	20	0.04	1.9	63
2001	27	0.05	22	0.04	1.7	81
2002	55	0.10	17	0.03	3.2	31
2003	43	0.08	27	0.05	2.4	63
2004	37	0.07	42	0.08	2.1	100
2005	35	0.06	36	0.07	2.3	100
2006	29	0.05	35	0.06	2.0	100
2007	42	0.08	33	0.06	2.6	79
2008	36	0.07	23	0.04	2.5	64
2009	40	0.07	17	0.03	2.8	43
2010	25	0.04	15	0.03	2.5	60
2011	35	0.06	29	0.05	2.8	83
2012	40	0.07	23	0.04	2.2	58
2013	39	0.07	13	0.02	1.8	33
Mean	35	0.06	24	0.04	2.5	71
SE	2.2	<0.01	1.8	<0.01	0.1	4.4

[a] Area surveyed = 552.2 km²

During the brood-rearing survey, only 13 Tundra Swan broods were observed in the Colville Delta study area, far fewer than the 20-year mean of 25 broods, and the smallest number of broods we have encountered. Apparent nesting success was 33% (13 broods/39 nests), in contrast to the 20-year mean of 71% (Table 21). Nesting success in the adjacent Kuparuk Oilfield during 2013 (54%, 72 broods/134 nests) also was lower than the 25-year mean for that study area (78%; Stickney et al. 2014). Furthermore, the mean brood size on the Colville Delta of 1.8 young/brood in 2013 was less than the 20-year mean of 2.5, and the total of 23 young counted on the delta was far less than the 20-year mean of 60 young per year. In contrast, the mean brood size in the Kuparuk study area of 2.4 young/brood was similar to the 25-year mean (2.3 young/brood).

Habitat Use

Habitat selection was evaluated for 694 Tundra Swan nests recorded on the Colville Delta since 1992 (Table 22). 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 were 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 1986,

Table 22. Habitat selection by nesting and brood-rearing Tundra Swans, Colville Delta study area, Alaska, 1992, 1993, 1995–1998, and 2000–2013.

SEASON Habitat	No. of Nests/Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	1.8	avoid	
Brackish Water	9	1.3	1.2	ns	
Tapped Lake with Low-water Connection	2	0.3	4.0	avoid	
Tapped Lake with High-water Connection	7	1.0	3.8	avoid	
Salt Marsh	41	5.9	3.0	prefer	
Tidal Flat Barrens	6	0.9	10.6	avoid	
Salt-killed Tundra	73	10.5	4.6	prefer	
Deep Open Water without Islands	19	2.7	3.3	ns	
Deep Open Water with Islands or Polygonized Margins	44	6.3	1.8	prefer	
Shallow Open Water without Islands	4	0.6	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	0.3	0.1	ns	low
River or Stream	1	0.1	15.0	avoid	
Sedge Marsh	2	0.3	<0.1	prefer	low
Deep Polygon Complex	94	13.5	2.4	prefer	
Grass Marsh	14	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	53	7.6	7.5	ns	
Patterned Wet Meadow	254	36.6	18.6	prefer	
Moist Sedge-Shrub Meadow	33	4.8	2.2	prefer	
Moist Tussock Tundra	9	1.3	0.6	prefer	low
Tall, Low, or Dwarf Shrub	11	1.6	5.0	avoid	
Barrens	16	2.3	13.8	avoid	
Human Modified	0	0	0.1	ns	low
Total	694	100	100		
BROOD-REARING					
Open Nearshore Water	1	0.2	1.8	avoid	
Brackish Water	28	5.8	1.2	prefer	
Tapped Lake with Low-water Connection	67	13.8	4.0	prefer	
Tapped Lake with High-water Connection	54	11.2	3.8	prefer	
Salt Marsh	31	6.4	3.0	prefer	
Tidal Flat Barrens	4	0.8	10.6	avoid	
Salt-killed Tundra	35	7.2	4.6	prefer	
Deep Open Water without Islands	40	8.3	3.3	prefer	
Deep Open Water with Islands or Polygonized Margins	16	3.3	1.8	prefer	
Shallow Open Water without Islands	6	1.2	0.4	prefer	low
Shallow Open Water with Islands or Polygonized Margins	2	0.4	0.1	ns	low
River or Stream	27	5.6	15.0	avoid	
Sedge Marsh	0	0	<0.1	ns	low
Deep Polygon Complex	14	2.9	2.4	ns	
Grass Marsh	12	2.5	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	28	5.8	7.5	ns	
Patterned Wet Meadow	63	13.0	18.6	avoid	
Moist Sedge-Shrub Meadow	7	1.4	2.2	ns	
Moist Tussock Tundra	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	8	1.7	5.0	avoid	
Barrens	40	8.3	13.8	avoid	
Human Modified	0	0	0.1	ns	low
Total	484	100	100		

[a] Use = (groups / total groups) x 100

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

[c] Expected number < 5

Monda et al. 1994) and that nest sites reused from previous years were slightly more successful than new nest sites (Monda et al. 1994). Therefore, deletion of multi-year nest sites from selection analysis could bias the results towards habitats used by less experienced or less successful pairs. Instead, we have chosen to include all nest sites, while recognizing that all locations may not be annually independent.

Tundra Swans on the Colville Delta used a wide range of habitats for nesting. Over 20 years of surveys, Tundra Swans nested in 20 of 24 available habitats, of which 9 habitats were preferred and 7 were avoided (Table 22). Eighty-one percent of the nests were found in the 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 also was evaluated for 484 Tundra Swan broods recorded on the Colville Delta since 1992 (Table 22). 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), 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 approximately 34% of all swan broods on the delta were in salt-affected habitats, compared with only 19% of all nests (Table 22). Similar patterns have been reported by previous investigators (Spindler and Hall 1991, Monda et al. 1994).

NE NPR-A

Distribution and Abundance

Productivity was higher in the NE NPR-A study area than the Colville Delta study area in 2013. During the 2013 nesting survey, 199 swans were counted in the NE NPR-A study area, including 54 pairs, of which 15 pairs were nesting (Table 23). An additional 5 nests were discovered during helicopter-based loon surveys of limited portions of the NE NPR-A study area. Apparent nesting success in 2013 was 87% (13 broods/15 nests), dramatically higher than on the Colville Delta study area (33%) and in the Kuparuk area in 2013 (54%, Stickney et al. 2014). Mean brood size in NE NPR-A in 2013 was 1.9 young, approximately the same as the mean brood size in the Colville Delta study area. Both these study areas produced much smaller brood sizes than in Kuparuk (mean = 2.4 young/brood).

Habitat Use

We evaluated habitat selection for 333 Tundra Swan nests recorded in the NE NPR-A study area since 2001 (Table 24). Tundra Swans nested in 21 of 26 available habitats, but preferred only 5 habitats—Salt Marsh, Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, Grass Marsh, and Young Basin Wetland Complex—in which 73 nests were located.

Swan broods in NE NPR-A were attracted to large, deep water bodies, similar to the habitats where swan broods were found on the Colville Delta. Habitat selection was evaluated for 210 Tundra Swan broods recorded in the NE NPR-A study area since 2001 (Table 24). Tundra Swan broods used 22 of 26 available habitats. We recorded 123 broods (61%) in the 5 preferred habitats: Tapped Lake with Low-water Connection, both types of Deep Open Water, River or Stream, and Grass Marsh.

DISCUSSION

Since we began aerial surveys for Tundra Swans on the Colville Delta in 1992, counts of pairs, nests, and brood numbers have shown a fair degree of variability, but the overall trend has been one of slow increase. The lowest count of nests was 14 in 1992, the first year of surveys and the highest count of nests was 55 in 2002, producing a growth rate of 1.021, which was not quite significantly different from 1.0 ($\ln(y) = 0.021x - 38.00$, $R^2 = 0.171$, $P = 0.078$, $n = 20$). The total number of pairs counted during nesting surveys has increased more strongly, from a low of 42 in 1992

Table 23. Number and density of Tundra Swan nests and broods during aerial surveys, NE NPR-A study area, Alaska, 2001–2013.

	Nests		Broods			
Year[a]	No.	Density (nests/km²)	No.	Density (broods/km²)	Mean Brood Size	Nesting Success (%)
2001	32	0.03	21	0.02	2.5	66
2002	43	0.04	27	0.02	2.0	63
2003	43	0.04	18	0.02	2.3	42
2004	63	0.06	37	0.03	2.1	59
2005	48	0.03	37	0.02	2.1	77
2006	72	0.05	50	0.03	2.0	69
2008	69	0.04	34	0.02	2.6	49
2009	73	0.05	52	0.03	2.3	71
2011	12	0.04	10	0.03	1.9	83
2012	19	0.06	12	0.04	2.0	63
2013	15	0.05	13	0.04	1.9	87

[a] Survey area differed among years: 2001–2003 = 1091.6 km², 2004–2009, 1571.1 km², and 2011–2013 = 322.1 km²

to a high of 118 pairs in 2011. The number of pairs has grown significantly at an annual rate of 1.033 (ln(y) = 0.033x – 61.358, $R^2 = 0.539$, $P < 0.001$, $n = 20$). The trends for numbers of adults, broods, and young also have increased at low rates, but none have grown significantly ($P \geq 0.306$), probably because of high annual variation in the number of non-breeding adults on the Colville Delta and in reproductive success in the cases of broods and young. The increase in Tundra Swans appears to be widespread; the growth observed on the Colville Delta generally matches the growth seen to the east in the Kuparuk Oilfield (Stickney et al. 2013). Moreover, the growth rate for adult Tundra Swans across the Arctic Coastal Plain (1.046) also is statistically significant (Stehn et al. 2013). The trend in these several areas probably tracks the population status of Tundra Swans wintering on the East Coast of the United States, which is where swans from the Arctic Coastal Plain return after breeding and where long-term growth has been recorded from 1955 to 2000 (Serie and Bartonek. 1991, Serie et al. 2002).

Aerial surveys for nesting and brood-rearing Tundra Swans in NE NPR-A have been flown during 12 years since 2001; no surveys were flown in 2007 or 2010. The area surveyed has varied widely during that period. Out of the 5 subareas of NE NPR-A, only Alpine West has been flown every survey year (Appendix H). Swan surveys in 2011–2013 were flown over a much smaller area than in previous years (Appendix H). Thus, comparisons of nest and brood counts in NE NPR-A among years are not very meaningful because of differing survey areas that support varying densities of breeding swans.

The low productivity of swans on the Colville Delta in 2013 was in contrast to that observed in NE NPR-A and the Kuparuk Oilfield. Poor nesting success and low brood sizes produced the smallest number of young ever recorded on the Colville Delta. Direct evidence of the cause of nest failures is lacking, but extensive flooding on the Colville Delta may have affected swans by delaying access to some tundra nest sites. Higher predation rates on the Colville Delta could also produce the geographic differences observed among study areas in 2013. Red foxes are more common on large river systems (Jones and Theberge 1982) such as the Colville Delta than in NE NPR-A. The frequency of red foxes on camera images from Yellow-billed Loon nests was >6 times the frequency at nests in the NE NPR-A (ABR, unpubl. data). The density of identified red fox

Table 24. Habitat selection by nesting and brood-rearing Tundra Swans, NE NPR-A study area, Alaska, 2001–2006, 2008, 2009, 2011–2013.

SEASON Habitat	No. of Nests/Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	1.0	ns	low
Brackish Water	8	2.4	1.1	ns	low
Tapped Lake with Low-water Connection	1	0.3	0.8	ns	low
Tapped Lake with High-water Connection	2	0.6	0.6	ns	low
Salt Marsh	13	3.9	2.0	prefer	
Tidal Flat Barrens	1	0.3	1.4	ns	low
Salt-killed Tundra	3	0.9	0.7	ns	low
Deep Open Water without Islands	13	3.9	6.5	ns	
Deep Open Water with Islands or Polygonized Margins	29	8.7	5.2	prefer	
Shallow Open Water without Islands	3	0.9	1.0	ns	low
Shallow Open Water with Islands or Polygonized Margins	18	5.4	1.7	prefer	
River or Stream	0	0	1.2	avoid	low
Sedge Marsh	6	1.8	1.7	ns	
Deep Polygon Complex	0	0	0.1	ns	low
Grass Marsh	6	1.8	0.3	prefer	low
Young Basin Wetland Complex	7	2.1	0.3	prefer	low
Old Basin Wetland Complex	26	7.8	8.0	ns	
Riverine Complex	1	0.3	0.3	ns	low
Dune Complex	1	0.3	1.0	ns	low
Nonpatterned Wet Meadow	15	4.5	3.0	ns	
Patterned Wet Meadow	40	12.0	11.3	ns	
Moist Sedge-Shrub Meadow	55	16.5	21.5	avoid	
Moist Tussock Tundra	80	24.0	25.1	ns	
Tall, Low, or Dwarf Shrub	5	1.5	3.1	ns	
Barrens	0	0	1.1	avoid	low
Human Modified	0	0	0.0	ns	
Total	333	100	100		
BROOD-REARING					
Open Nearshore Water	1	0.5	1.0	ns	low
Brackish Water	6	2.9	1.1	ns	low
Tapped Lake with Low-water Connection	7	3.3	0.8	prefer	low
Tapped Lake with High-water Connection	0	0	0.6	ns	low
Salt Marsh	2	1.0	2.0	ns	low
Tidal Flat Barrens	1	0.5	1.4	ns	low
Salt-killed Tundra	0	0	0.7	ns	low
Deep Open Water without Islands	55	26.2	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	45	21.4	5.2	prefer	
Shallow Open Water without Islands	2	1.0	1.0	ns	low
Shallow Open Water with Islands or Polygonized Margins	3	1.4	1.7	ns	low
River or Stream	17	8.1	1.2	prefer	low
Sedge Marsh	3	1.4	1.7	ns	low
Deep Polygon Complex	0	0	0.1	ns	low
Grass Marsh	5	2.4	0.3	prefer	low
Young Basin Wetland Complex	1	0.5	0.3	ns	low
Old Basin Wetland Complex	7	3.3	8.0	avoid	
Riverine Complex	1	0.5	0.3	ns	low
Dune Complex	1	0.5	1.0	ns	low
Nonpatterned Wet Meadow	10	4.8	3.0	ns	
Patterned Wet Meadow	11	5.2	11.3	avoid	
Moist Sedge-Shrub Meadow	20	9.5	21.5	avoid	
Moist Tussock Tundra	6	2.9	25.1	avoid	
Tall, Low, or Dwarf Shrub	5	2.4	3.1	ns	
Barrens	1	0.5	1.1	ns	low
Human Modified	0	0	0.0	ns	
Total	210	100	100		

[a] Use = (groups / total groups) x 100

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

[c] Expected number < 5

dens on the Colville Delta is >5 times higher (1 den/61 km²) than in the NE NPR-A study area (1 den/340 km²; Johnson et al. 2005). Brown bears are known to take eggs and nestlings (Hechtel 1985) and tend to frequent riparian areas (Shideler and Hechtel 2000), which are extensive on the Colville Delta but also abundant along Fish and Judy creeks and the Ublutuoch River in NE NPR-A. Brown bears and red foxes depredated Yellow-billed Loon nests in 2013, and both are likely predators of swan nests. Brown bears took 2 camera-monitored Yellow-billed Loon nests on the Colville Delta and 2 in NE NPR-A in 2013 (compared with only 1 camera-monitored nest taken by brown bears in either study area prior to 2013) and may have taken a number of swan nests as well. However, we lack observations of swan nest predation or nest failures, so we can only speculate on causes of low productivity on the Colville Delta in 2013.

GEESE

NESTING GEESE

Distribution and Abundance

Three species of geese nested on the 40 10-ha plots in the CD5 area in 2013, and their combined nests accounted for 84% of all nests recorded (Figure 19, Table 25). White-fronted Geese were the most abundant nesting waterfowl (21.8 nests/km^2), followed by Cackling/Canada Geese (1.5 nests/km^2). One Brant nest was recorded and 1 of the 122 goose nests found during nest searching could not be identified to species. White-fronted Goose nests were widely distributed among the plots, whereas Cackling/Canada Goose nests were clustered in the southern plots and adjacent to Oil Lake (Figure 19). We found the greatest number of White-fronted Goose nests on plot 22 (8 nests) and plot 35 (6 nests; Table 26). These plots are adjacent each other and are located in the drier, northern portion of the CD5 area (Figure 19). We found 4 White-fronted Goose nests on 4 plots, but on 85% of the plots we found 3 or fewer nests (Table 26).

Habitat Use

Geese nested in 7 of the 14 habitats found in the 2013 search area (Table 27). White-fronted Geese nested in 5 of the available habitats, though 76% of these nests were in 3 habitats: Old Basin Wetland Complex, Patterned Wet Meadow, and Moist Sedge–Shrub Meadow. White-fronted Goose nests were the only nests for which sample size was adequate to test for habitat selection. No habitats were preferred by White-fronted Geese; Shallow Open Water with Islands or Polygonized Margins was avoided but all other habitats were used in proportion to their availability (Table 28). Cackling/Canada Geese nested in 4 available habitats, and in 2 of these habitats (Deep Open Water with Islands or Polygonized Margins, and Shallow Open Water with Islands or Polygonized Margins) we found no White-fronted Goose nests (Table 27).

Nest Initiation and Incubation

We floated eggs from 106 White-fronted Goose nests and 6 Cackling/Canada Goose nests to estimate nest age and the start of incubation. The average date of nest initiation (first egg laid) for White-fronted Geese was 9 June (range = 2–14 June, SE = 0.22), although the greatest number of nests (24) were initiated on 11 June. By the time we began nest-searching on 12 June, 86% of the White-fronted Geese had initiated nesting. Average clutch size for nests with complete clutches (eggs > 3 d old) was 3.8 eggs (n = 55 nests). For Cackling/Canada Geese, the dates of nest initiation ranged from 5 to 10 June, and the average date was 8 June (SE = 0.75, n = 6). Average clutch size for nests with complete clutches was 3.0 eggs (n = 4 nests). The average start date of incubation for White-fronted Geese was 13 June (range = 6–18 June, SE = 0.22) and for Cackling/Canada Geese it was 12 June (range = 9–14 June, SE = 0.75; Figure 20).

Of the 38 thermistors installed in White-fronted Goose nests, 2 were removed from nests, probably by predators or adult geese, and 2 failed to collect useful data (Table 29). A total 18 temperature-monitored nests failed and 4 of these nests failed the same day the nest was found and the thermistor installed. In each case, normal incubation was not resumed by the goose following installation of the thermistor. The extra time we spent at these nests, floating eggs and installing temperature sensors, might have alerted predators to the vicinity of the nests, despite our efforts to conceal eggs and nests with vegetation. But it is also possible that our visit to the nest resulted in

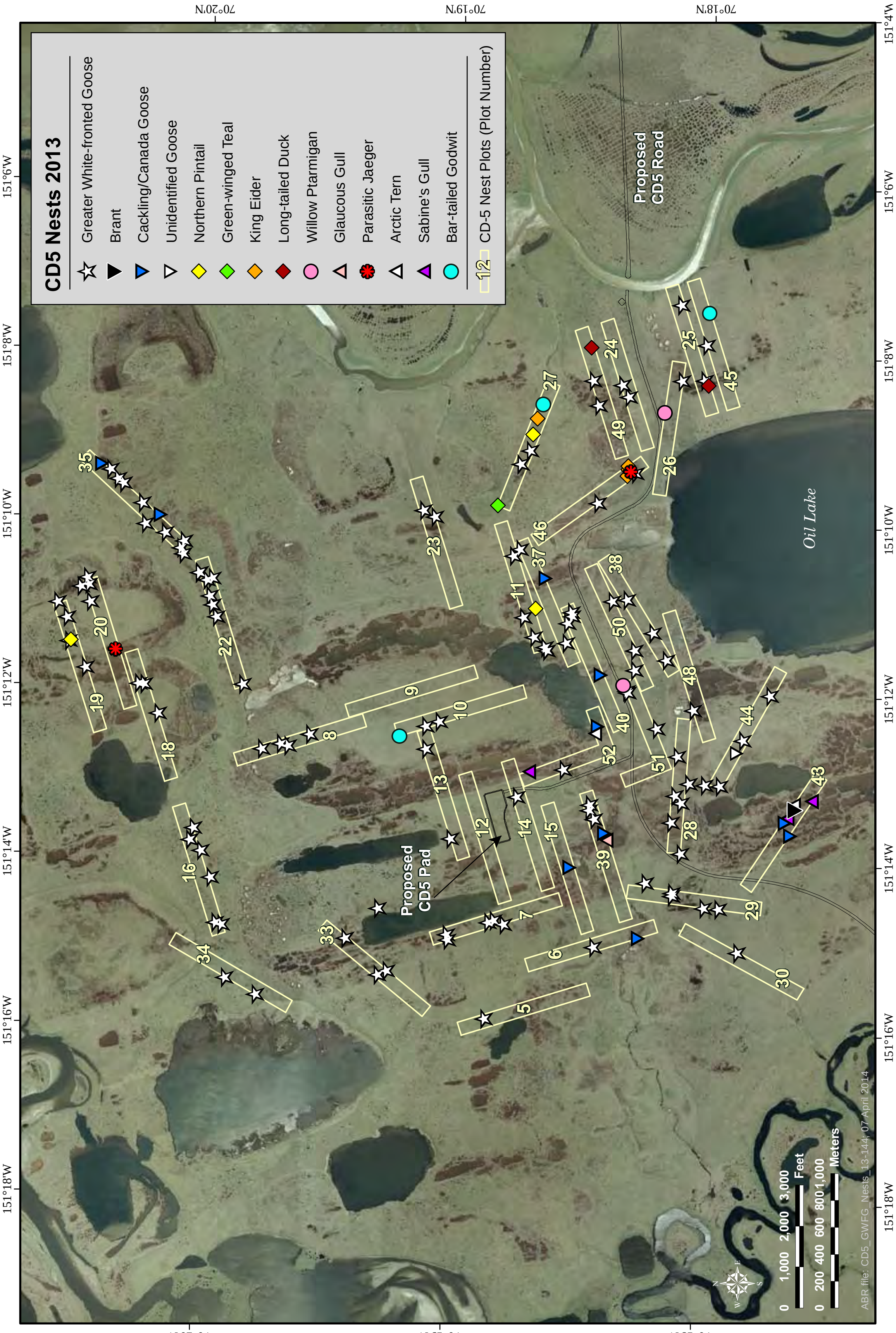


Figure 19. Nest locations on nest plots at CD5, NE NPR-A study area, Alaska, 2013.

Table 25. Number, density, and apparent nesting success of nests on plots at CD5, NE NPR-A study area, Alaska, 2013.

	Number of Nests						
Species	Total	Successful	Failed	Unknown	Success[a] (%)	Nests on Plot[b]	Density[c] (nests/km²)
Greater White-fronted Goose[d]	110	58	51	1	53	87	21.8
Brant[d]	1	1	0	0	100	1	0.3
Cackling/Canada Goose[e]	10	4	5	1	44	6	1.5
Unidentified goose	1	0	1	0	0	1	0.3
Northern Pintail	3	0	3	0	0	2	0.5
Green-winged Teal	1	0	1	0	0	1	0.3
King Eider[d]	4	0	4	0	0	4	1.0
Long-tailed Duck	2	0	2	0	0	2	0.5
Willow Ptarmigan	2	1	0	1		2	0.5
Glaucous Gull	1	1	0	0		1	0.3
Parasitic Jaeger	2	0	0	2		2	0.5
Arctic Tern	2	0	0	2		2	0.5
Sabine's Gull	3	0	0	3		3	0.8
Bar-tailed Godwit	3	0	1	2		3	0.8
Total	145	65	68	12	48	117	29.3

[a] Estimates are provided only for waterfowl; apparent nest success = (no. successful / (no. successful + no. failed)) × 100
[b] Number of nests within plots, some nests monitored were just outside plot boundaries
[c] Density calculations include nests on plots based on a total search area of 4.0 km²
[d] Includes nests identified to species from down and feather characteristics in nest
[e.] Nest belonging to either Cackling or Canada goose

abandonment of the nest or a long absence of adult geese that left the nest vulnerable to predation. Apparent nesting success at instrumented nests (53%) was nearly the same as for those nests without thermistors (54%), which suggests there was little effect from instrumenting the nests. We intended to measure incubation behavior (i.e., nest attendance, recesses, and breaks) of White-fronted Geese using temperature data, but for reasons we discuss later, data-loggers provided temperature graphs that were not interpretable for estimating incubation recesses.

Nesting Success

In 2013, we found 98% of the 110 White-fronted Goose nests active during the nest search and the apparent nesting success (the percentage of nests hatching ≥1 egg) was 53% (Table 25). Of the 38 White-fronted Geese monitored by temperature sensors, 53% were judged successful based on post-hatch evidence at the nest site. The DSR for monitored nests was 0.969 ± 0.008 with an estimated nesting success of 0.391 ± 0.095 assuming constant DSR over the 31 d nesting period that we observed nests. The estimated success for a 24-d incubation period was 0.472 (0.969^{24}). Among the other geese nesting in the CD5 nest search area in 2013, 44% of Cackling/Canada Goose nests hatched (4 nests), and the single Brant nest was successful.

OTHER NESTING BIRDS

Distribution and Abundance

We found a total of 145 nests belonging to 13 identified species of birds on nest plots in 2013 (Figure 19; Table 25). Sixteen percent of these nests belonged to species other than geese and their nests were more frequent in the plots closest to the proposed CD5 road and to Oil Lake (Figure 19). Among the large waterbirds nesting in the search area, we found 4 nests of King Eiders, 3 nests of

Table 26. Number of nests and apparent nesting success of Greater White-fronted Geese by nest plot at CD5, NE NPR-A study area, 2013.

	Number of Nests				Success[a]
Plot	Total	Successful	Failed	Unknown	(%)
5	1	0	1	0	0
6	1	0	1	0	0
7	4	0	4	0	0
8	4	1	3	0	25
9	0	0	0	0	–
10	2	1	1	0	50
11	4	4	0	0	100
12	0	0	0	0	–
13	1	0	1	0	0
14	1	0	1	0	0
15	0	0	0	0	–
16	4	1	3	0	25
18	2	2	0	0	100
19	3	0	3	0	0
20	1	1	0	0	100
22	8	5	3	0	63
23	2	1	1	0	50
24	2	0	2	0	0
25	2	2	0	0	100
26	1	1	0	0	100
27	2	2	0	0	100
28	4	3	1	0	75
29	3	2	1	0	67
30	1	1	0	0	100
33	3	0	3	0	0
34	1	1	0	0	100
35	6	3	3	0	50
37	2	1	1	0	50
38	3	2	1	0	67
39	3	2	1	0	67
40	3	0	3	0	0
43	0	0	0	0	–
44	3	2	1	0	67
45	0	0	0	0	–
46	2	0	1	1	0
48	1	0	1	0	0
49	1	1	0	0	100
50	3	2	1	0	67
51	2	1	1	0	50
52	1	1	0	0	100

[a] Estimates are provided only for waterfowl; apparent nesting success = (no. successful / (no. successful + no. failed)) × 100; dashes for plots with no Greater White-fronted Geese

Table 27. Habitat use (%) by nesting birds on nest plots at CD5, NE NPR-A study area, Alaska, 2013.

Habitat	Greater White-fronted Goose[a]	Brant	Cackling/Canada Goose[b]	Unidentified Goose	Northern Pintail	Green-winged Teal	King Eider[a]	Long-tailed Duck	Willow Ptarmigan	Glaucous Gull	Parasitic Jaeger	Arctic Tern	Sabine's Gull	Bar-tailed Godwit	All Species
Deep Open Water with Islands or Polygonized Margins	0	0	50	0	0	0	0	0	0	100	0	0	100	0	6
Shallow Open Water with Islands or Polygonized Margins	0	0	17	0	0	0	0	0	0	0	0	50	0	0	2
Sedge Marsh	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Old Basin Wetland Complex	30	100	17	0	0	0	75	50	0	0	100	50	0	0	30
Patterned Wet Meadow	30	0	17	100	0	0	25	0	0	0	0	0	0	67	26
Moist Sedge–Shrub Meadow	28	0	0	0	50	0	0	50	50	0	0	0	0	0	23
Moist Tussock Tundra	11	0	0	0	50	100	0	0	50	0	0	0	0	33	12
Total nests	87	1	6	1	2	1	4	2	2	1	2	2	3	3	117

[a] Includes nests identified to species from feather and down samples
[b] Nest belonging to either Cackling or Canada goose

Table 28. Habitat selection by nesting Greater White-fronted Geese on nest plots at CD5, NE NPR-A study area, 2013.

Habitat	No. of Nests	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
Deep Open Water without Islands	0	0	0.2	ns	low
Deep Open Water with Islands or Polygonized Margins	0	0	0.5	ns	low
Shallow Open Water without Islands	0	0	0.7	ns	low
Shallow Open Water with Islands or Polygonized Margins	0	0	5.3	avoid	low
River or Stream	0	0	<0.1	ns	low
Sedge Marsh	1	1.1	2.0	ns	low
Grass Marsh	0	0	<0.1	ns	low
Old Basin Wetland Complex	26	29.9	23.5	ns	
Riverine Complex	0	0	0.1	ns	low
Nonpatterned Wet Meadow	0	0	0.2	ns	low
Patterned Wet Meadow	26	29.9	28.3	ns	
Moist Sedge-Shrub Meadow	24	27.6	25.7	ns	
Moist Tussock Tundra	10	11.5	13.3	ns	
Moist Dwarf Shrub	0	0	0.1	ns	low
Total	87		100		

[a] Use (%) = (nests / total nests) × 100
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, and avoid = significantly less use than availability
[c] Expected number <5

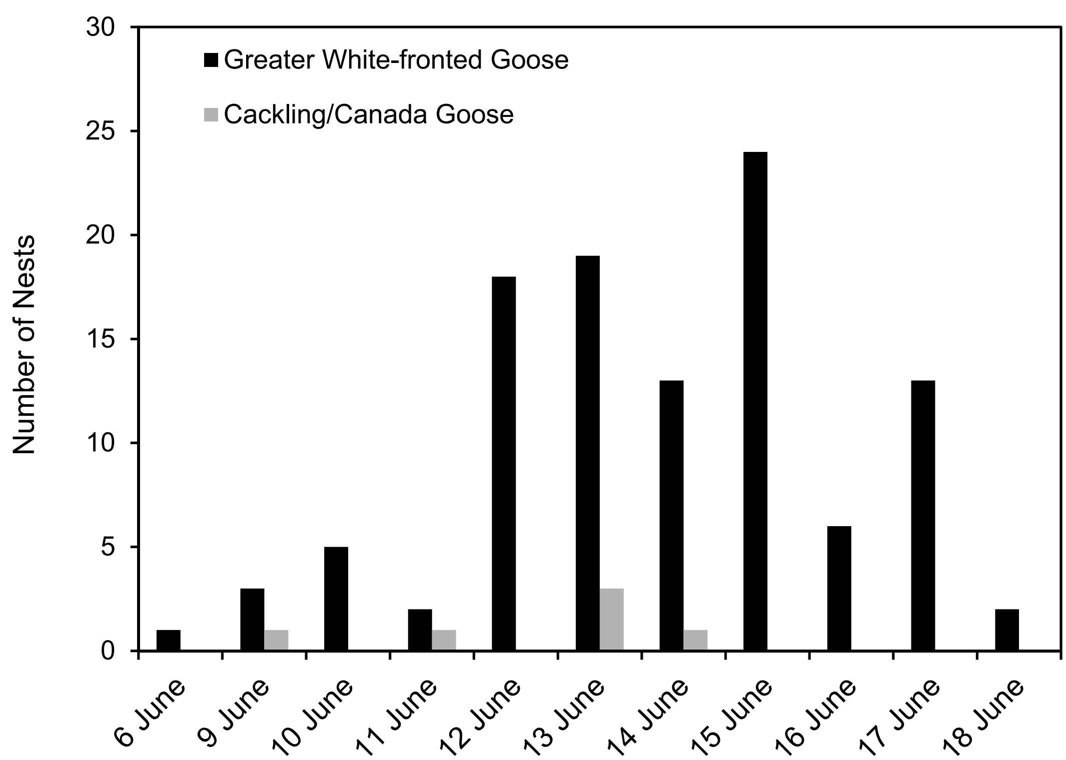


Figure 20. Incubation start dates for White-fronted (n = 106 nests) and Cackling/Canada (n = 6 nests) Geese estimated by egg-flotation at CD5, NE NPR-A study area, 2013.

Table 29. Nest histories of Greater White-fronted Geese, monitored by temperature thermistors on nest plots at CD5, NE NPR-A study area, Alaska, 2013.

Nest	Plot	Fate[a]	Incubation Start Date[b]	No. Eggs[c]	Date Hobo Installed	Date of Hatch or Failure[d]	No. Days Monitored
104	22	S	9 June	6	13 June	6 July	24
109	52	S	10 June	4	14 June	4 July	21
114	30	S	11 June	7	15 June	6 July	22
116	33	F	14 June	2	15 June	2 July	17
120	11	S	16 June	6	17 June	10 July	24
123	46	F	13 June	4	17 June	17 June	0
127	29	F	12 June	4	18 June	20 June	2
130	19	F	15 June	2	19 June	19 June	0
133	20	S	18 June	3	19 June	12 July	24
135	16	F	13 June	5	19 June	3 July	14
140	25	S	14 June	2	20 June	6 July	17
141	26	S	14 June	4	20 June	6 July	17
142	24	F	14 June	4	20 June	21 June	1
203	8	S	12 June	2	13 June	5 July	23
205	14	F	10 June	5	14 June	29 June	15
206	40	F	13 June	2	14 June		–[f]
207	51	F	10 June	3	14 June	29 June	15
208	13	S	15 June	6	16 June	9 July	24
209	13	F	15 June	7	16 June	4 July	18
212	11	S	16 June	1	17 June	8 July	22
215	39	S	17 June	2	18 June	7 July	20
218	20	S	15 June	3	19 June	19 June	0[f]
300	45	S	11 June	3	12 June	12 June	1[f]
306	6	F	14 June	4	15 June	2 July	17
307	10	F	15 June	2	16 June		–[f]
308	23	S	15 June	2	16 June	8 July	23
312	7	F	17 June	1	18 June	2 July	14
315	29	S	17 June	2	18 June	11 July	–[f]
319	25	S	16 June[e]	2	20 June	10 July	24
402	35	S	12 June	4	13 June	4 July	22
412	50	S	13 June	5	14 June	8 July	25
418	5	F	14 June	1	15 June		–[f]
422	23	F	15 June	2	16 June	16 June	0
423	27	S	13 June	2	17 June	7 July	21
426	37	F	16 June	4	17 June	28 June	11
428	7	F	17 June	7	18 June	2 July	14
436	19	F	15 June	5	19 June	19 June	0
439	18	S	15 June	2	19 June	30 June	12

[a] S= hatched, F= failed
[b] Dates estimated using egg-float data
[c] As known on day thermistor was installed in nest
[d] Hatch dates for successful nests are 1 d before the thermistor tracks ambient temperatures. The date of nest failure is the same day the thermistor tracks ambient temperature
[e] No float data available. Incubation estimated by subtracting 25 (median no. days calculated for incubation) from the hatch date +1
[f] Thermistor failed or was missing upon retrieval

Northern Pintails, 2 nests of Long-tailed Ducks, and 1 nest of a Green-winged Teal. Other species nesting in the search area included Glaucous Gull (1 nest), Sabine's Gull (3 nests), Arctic Tern (2 nests), Parasitic Jaeger (2 nests), Willow Ptarmigan (2 nests), and Bar-tailed Godwit (3 nests).

King Eider (1.0 nests/km²) was the only species of eider and the third most common large waterbird nesting in the search area (Figure 19; Table 25). All eider nests failed prior to hatching young. Several Red-throated Loons were observed in lakes near study plots but we did not locate any nests for this species. No Yellow-billed Loons or Spectacled Eider nests were seen in or near study plots.

Habitat Use

Nests of the non-goose species were located in the same 7 habitats that were used by geese (Table 27). Most King Eider nests (75%) were found in Old Basin Wetland complex, as was the only Brant nest. The greatest species diversity was found in Old Basin Wetland Complex where we found nests of 7 species.

NEST PREDATORS

Jaegers and gulls were the most abundant and widespread nest predators observed during predator scans and incidental observations at nest plots. Potential nest predators seen on plots during predator scans included Long-tailed, Parasitic, and Pomarine jaegers (57% of 97 sightings), Glaucous Gulls (39%), raptors (1%; Short-eared Owl and Northern Harrier), and Common Ravens (3%; Appendix I). The same predators listed above were seen incidentally during nest searches and the species composition during nest searches was similar to that recorded during the predator scans, with jaegers being the most common predators (63% of 38 sightings), followed by Glaucous Gulls (29%; Appendix I). Avian predators were most often seen flying over plots and only occasionally landed on plot. During predator scans and incidental observations, similar proportions of the same predators were observed outside plots, but we generally observed fewer individuals of each species group. During predator scans, jaegers were seen on 31 of 40 plots and Glaucous Gulls were seen on 29 of 40 plots (Appendix I). Notably absent were mammalian predators; arctic foxes and brown bears occur in the area, whereas red foxes were observed on the nearby Colville Delta (Figures 15 and 16). Mammalian predators are likely less abundant than avian predators, but some species such as arctic foxes may have been more active at night, when we were not at the nesting plots, or they avoided humans. In either case, biases against observing mammalian predators during predator scans can lead to underestimating the mammalian component of nest predators in the CD5 area.

Fewer predators were seen incidentally than during predator scans. Observers during timed counts were focused on detecting predators unlike during incidental counts when observers were focused on other activities. Despite the differences in methods, we recorded a similar species composition of predators on scans and incidental observations (Appendix I).

BROOD-REARING GEESE

Colville Delta

Distribution and Abundance

Brant and Snow Goose production on the Colville Delta, as measured by numbers of adults and young on brood surveys, was low in 2013. During the goose brood-rearing aerial survey in 2013, we counted 795 Brant (439 adults and 356 young) in 9 groups in the Colville Delta study area (Figure 21, Table 30). All Brant groups included broods, and goslings comprised 45% of the total number of birds. Surveys producing comparable data on the total number of Brant (adults + goslings) have been conducted in the area for 17 years (this study, Bayha et al. 1992) and the total count in 2013 was well below the long-term mean of combined adults and goslings (1,261 ± 264 [mean ± SE]) (Table 30). The percentage of goslings in 2013 was near average, but the total count of goslings was the fourth lowest in 14 years that goslings were recorded (Table 30). Eight groups containing 764 Brant (423 adults and 341 goslings) were located in the Northeast Delta subarea, and 1 group of 31 Brant (16 adults and 15 goslings) was located in the CD North subarea.

Snow Geese had similarly low productivity in 2013, compared with the prior 2 years. In 2013, a total of 2,454 Snow Geese (1,568 adults and 886 goslings) were counted in 31 groups in the Colville

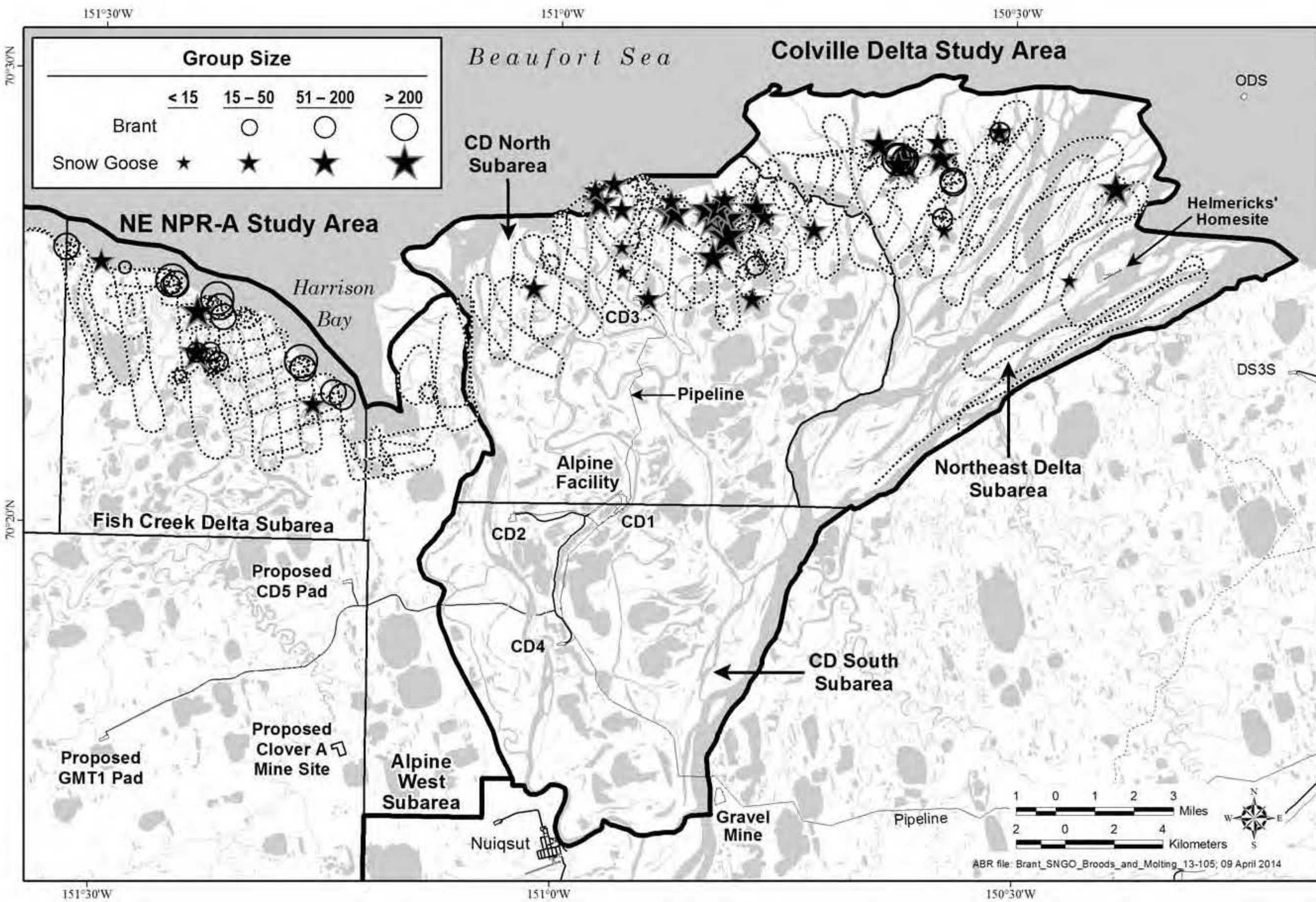


Figure 21. Brant and Snow Goose brood-rearing and molting groups, Colville Delta and NE NPR-A study areas, Alaska, 2013.

Table 30. Number of Brant adults and goslings during aerial surveys, Colville Delta study area, Alaska, 1998–2013. Data for 1988–1991 are from Bayha et al. 1992; subsequent data are from this study.

Year	Total Birds	Adults	Goslings	% Goslings	No. Groups	Survey Date(s)
1988[a]	no data[b]	173[b]	no data[b]	no data[b]	no data	25, 26 July
1989[a]	197[c,d]	no data[c,d]	no data[c,d]	no data[c,d]	no data	12, 13 August
1990[a]	628[c]	no data[c]	no data[c]	no data[c]	no data	2, 9 August
1991[a]	460[c,d]	no data[c,d]	no data[c,d]	no data[c,d]	no data	1, 7 August
1992	0	0	0	-	0	27 July
1993	720	347	373	51	5	27 July
1995	1,480	768	712	48	6	4 August
1996	993	478	515	52	7	25 July
1998	1,974	836	1,138	58	13	27 July
2005	3,847	2,360	1,487	39	16	30 July
2006	438	296	142	32	4	29 July
2007	980	446	534	54	6	30 July
2008	3,637	1,839	1,798	49	22	29 July
2009	679	501	178	26	6	29 July
2010	1,474	746	728	49	11	28 July
2011	1,986	1,221	765	39	10	28 July
2012	1,145	776	369	32	7	26 July
2013	795	439	356	45	9	26 July
Mean	1,261	748	650	44.2	8.7	
SE	264	163	138	2.7	1.5	

[a] Data are from an average of 2 surveys (Bayha et al. 1992)
[b] Only adults were counted. Goslings were observed but were not enumerated
[c] Adults and goslings were not differentiated by the observer
[d] Includes birds in flight (90 on 12 August 1989, and 50 on 7 August 1991)

Delta study area, which was a sharp decline from the numbers counted in 2012 (Figure 21, Table 31). Twenty-seven groups (87%) contained broods, but goslings comprised only 36% of the total number of birds, which was the second lowest gosling percentage since Snow Geese were added to the survey in 2005. Twenty-two groups (1,021 adults and 668 goslings) were found in the CD North subarea, and 9 groups (547 adults and 218 goslings) were found in the Northeast Delta subarea.

Habitat Use

Brant brood groups primarily occupied coastal salt-affected habitats in the Colville Delta study area (Table 32). Eight of 9 Brant groups recorded during aerial surveys were found in 4 salt-affected habitats: Salt Marsh (4 groups), Brackish Water (2 groups), Tapped Lake with Low-water Connection (1 group; this habitat typically has brackish water and salt marsh vegetation along the shoreline; Appendix B) and Salt-killed Tundra (1 group). The ninth group was found in Barrens.

Snow Geese were found in a wider range of habitats than Brant, but they also favored coastal salt-affected habitats for brood-rearing and molting in the Colville Delta (Table 32). Of 31 Snow Goose groups observed, 23 groups (74%) were found in salt-affected habitats, including Salt-killed Tundra (8 groups), Brackish Water (4 groups), Tidal Flat

Table 31. Number of Snow Goose adults and goslings during aerial surveys, Colville Delta study area, Alaska, 2005–2013.

Year	Total Birds	Adults	Goslings	% Goslings	No. Groups	Survey Date(s)
2005	972	412	560	58	11	30 July
2006	997	421	576	58	9	29 July
2007	1,154	596	558	48	13	30 July
2008	1,967	834	1,133	58	22	29 July
2009	678	463	215	32	15	29 July
2010	1,873	883	990	53	19	28 July
2011	4,023	1,745	2,278	57	36	28 July
2012	4,035	2,009	2,026	50	57	26 July
2013	2,454	1,568	886	36	31	26 July
Mean	2,017	992	1,025	50	23.7	
SE	425	206	233	3.3	5.1	

Table 32. Habitat use by brood-rearing/molting Brant and Snow Geese, Colville Delta and NE NPR-A study areas, Alaska, 2013.

	Colville Delta				NE 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	2	6.5	7	46.7	1	25.0
Brackish Water	2	22.2	4	12.9	0	0	0	0
Tapped Lake with Low-water Connection	1	11.1	2	6.5	0	0	0	0
Tapped Lake with High-water Connection	0	0	1	3.2	0	0	0	0
Salt Marsh	4	44.4	3	9.7	4	26.7	1	25.0
Tidal Flat Barrens	0	0	4	12.9	4	26.7	0	0
Salt-killed Tundra	1	11.1	8	25.8	0	0	0	0
Deep Open Water with Islands or Polygonized Margins	0	0	1	3.2	0	0	0	0
River or Stream	0	0	1	3.2	0	0	0	0
Nonpatterned Wet Meadow	0	0	1	3.2	0	0	0	0
Patterned Wet Meadow	0	0	2	6.5	0	0	0	0
Moist Sedge–Shrub Meadow	0	0	0	0	0	0	1	25.0
Moist Tussock Tundra	0	0	1	3.2	0	0	0	0
Dry Dwarf Shrub	0	0	0	0	0	0	1	25.0
Barrens	1	11.1	1	3.2	0	0	0	0
Total	9	100	31	100	15	100	4	100

Barrens (4 groups), Salt Marsh (3 groups), Open Nearshore Water (2 groups), and Tapped Lake with Low-water Connection (2 groups). The 8 Snow Goose groups not found in salt-affected sites were distributed among 7 different habitats (Table 32).

NE NPR-A

Distribution and Abundance

Brant did slightly better in the NE NPR-A study area than on the Colville Delta in 2013. During the aerial brood-rearing survey in 2013, we counted 1,749 Brant (1,346 adults and 403 goslings) in 15 groups in the NE NPR-A study area (Figure 21, Table 33). Total numbers (adults plus goslings) were similar to counts from the previous 3 years (Table 33). The number of adults was near the 8-year mean (1,450 ± 190 adults) but the number of goslings was somewhat below the mean. Five of 15 Brant groups contained only adults, and goslings comprised 23% of the total

Table 33. Numbers of Brant and Snow Goose adults and goslings during aerial surveys, NE NPR-A study area, Alaska, 2005–2013.

SPECIES Year	Total Birds	Adults	Goslings	% Goslings	No. of Groups
BRANT					
2005	1,634	1,003	631	39	11
2006	2,235	1,350	885	40	17
2007[a]	1,512	1,185	327	22	8
2008	4,012	2,617	1,395	35	36
2009	2,628	2,161	467	18	12
2010[a]	1,565	1,073	492	31	8
2011	1,756	906	850	48	14
2012	1,684	1,410	274	16	15
2013	1,749	1,346	403	23	15
Mean	2,086	1,450	636	30.2	15.1
SE	269	190	119	3.7	2.8
SNOW GEESE					
2005	32	13	19	59	1
2006	713	270	443	62	9
2007[a]	145	78	67	46	5
2008	234	107	127	54	5
2009	102	60	42	41	4
2010[a]	105	85	20	19	3
2011	388	142	246	63	8
2012	626	289	337	54	12
2013	312	182	130	42	4
Mean	295	136	159	48.9	5.7
SE	80	31	50	4.6	1.1

[a] Surveys in 2007 and 2010 were conducted by ABR for the North Slope Borough Department of Wildlife Management (Ritchie et al. 2008, Appendix H; Burgess et al. 2011, Appendix G)

number of birds in all groups, indicating below-average productivity for Brant in 2013 (Table 33). All 15 Brant brood-rearing and molting groups were located in the Fish Creek Delta subarea.

As was the case for the Colville Delta, productivity of Snow Geese in the NE NPR-A was low in 2013. In the NE NPR-A study area during 2013, 182 adult Snow Geese and 130 goslings were counted in 4 groups (Figure 21, Table 33), which was about half the total observed in 2012. The total for goslings was less than half the number observed in 2012, and the percentage of goslings was below the 9-year mean (Table 33). In contrast, the number of adults was above average. Three of 4 groups included broods, and goslings comprised 42% of the total number of birds in all groups. As with Brant, all 4 Snow Goose groups were located in the Fish Creek Delta subarea.

Habitat Use

As on the Colville Delta, Brant and Snow Goose brood groups primarily used salt-affected habitats in the NE NPR-A study area (Table 32). All 15 Brant brood groups were found in 3 salt-affected habitats: Open Nearshore Water (7 groups), Salt Marsh (4 groups) and Tidal Flat Barrens (4 groups). Snow Geese were found in a wider range of habitats than Brant: 2 Snow Goose groups occupied salt-affected habitats (Open Nearshore Water and Salt Marsh) and 2 groups occupied non-saline sites (Moist Sedge–Shrub Meadow and Dry Dwarf Shrub).

DISCUSSION

Nesting

The cold temperatures and higher than average snow depth observed in mid-May (see CONDITIONS IN THE STUDY AREAS) did not appear to hinder the nesting effort of White-fronted Geese in the NE NPR-A study area. Nest densities, nest initiation dates, and clutch sizes appeared to be normal, although nesting success was probably lower than average. In fact, the CD5 search area had one of the highest densities (21.8 nests/km^2) of White-fronted Goose nests reported in the vicinity in recent years. The density at CD5 might be slightly inflated due to our process of plot selection which excluded plots with water covering >25% of the area, reducing the proportion of habitats that White-fronted Geese would avoid for nesting (i.e., open water), while increasing the proportion of preferred nesting habitat (i.e., Patterned Wet Meadow and Old Basin Wetland Complex [Johnson et al. 2004]). For comparison, densities of White-fronted Geese on the northern Colville Delta ranged from 9.8 to 18.0 nests/km^2 (Johnson et al. 2003a, 2004, 2005), the central Colville Delta ranged from 2.4 to 5.0 nests/km^2 (Johnson et al. 2003a), and the east channel of the Colville River was 14.8 nests/km^2 (Burgess et al. 2012a). Combined search areas in the NE NPR-A ranged from 0.9 to 17.9 nests/km^2 annually (Murphy and Stickney 2000, Burgess et al. 2002b, Burgess et al. 2003b, Johnson et al. 2004, 2005, 2010), with higher densities in isolated areas near the Colville Delta. In 2013, the average nest initiation date of White-fronted Geese fell within a range of previously reported dates, and only 1 day later than observed for this species in 2012, near the east channel of the Colville River (Burgess et al. 2012a). Earliest dates of nest initiation for White-fronted Geese on the Colville Delta, ranged from 26 May to 10 June, with the peak of initiation ranging from 3 June to 10 June (Simpson et al. 1982, Renken et al. 1983, Burgess et al. 2012a, Hupp et al. 2012).

The average clutch size of the White-fronted Goose nests (3.8 eggs/nest) was comparable to what has been observed in previous years in the NE NPR-A. Mean clutch sizes in the NE NPR-A annually ranged from 3.6 to 4.1 eggs/nest (n = 331 nests, years = 2001–2004, 2009; ABR unpublished data). The clutch sizes reported in previous years may underestimate the number of eggs because some clutches may not have been complete. Other researchers who recorded complete clutches reported slightly higher clutch sizes averaging 4.2 eggs/nest on the Colville Delta (Simpson et al. 1982, Rothe et al. 1983, Hupp et al. 2012).

We were unable to examine nest attendance for White-fronted Geese in this study due to the erratic nature of our temperature graphs. We suspect the problem with the temperature recording was a result of using a “bare” thermistor in the goose nests rather than embedding it in an artificial egg. In previous applications, we constructed artificial eggs around the thermistor. This required additional preparation time and expense and these artificial eggs were fragile and difficult to carry, limiting the number that could be deployed each day. However, the artificial egg provides some thermal mass and air space around the thermistor, which probably dampens the thermistor response to temperature changes outside the egg. Fortunately, we had no difficulty determining from temperature records whether a nest was active and when a nest hatched or failed (used in survival analysis).

The apparent nesting success of White-fronted Geese (58%) in our study area was low by comparison with annual success rates calculated over multiple sites in NE NPR-A 2002–2005 (66–81%) (Burgess et al. 2002b, 2003b; Johnson et al. 2004, 2005). In 2012, apparent nesting success of White-fronted Geese on the East Channel of the Colville River was 77% (*n* = 112 nests; Burgess et al. 2012a). High annual variability in nesting success in White-fronted Geese is not uncommon and has been observed in many areas in Alaska (Johnson et. al. 2013b).

The mean daily survival rate of White-fronted Goose nests in 2013 (0.969 ± 0.008) was higher than reported for this species on plots in the NE NPR-A during 2003 and 2004 (0.946 ± 0.014, *n* = 12 nests and 0.917 ± 0.031 *n* = 10 nests, respectively; Johnson et al. 2004, Johnson et al. 2005) but was lower than the daily survival rate of nests on the east side of the Colville River in 2012 (0.984 ± 0.011, *n* = 7 nests, Burgess et. al. 2012a). Nesting success estimated for a 24-day incubation period was 47% (0.969^{24}), compared to the respective estimates of nesting success of 26% and 12% for the 2-year study above and 68% on the east side of the Colville River in 2012.

Jaegers and Glaucous Gulls were the most commonly observed predators observed during predator scans of the CD5 area. Time-lapse cameras in NE NPR-A recorded a similar predator composition but also included brown bears and foxes, which were not seen during predator scans. During 10 days of nest-searching in the CD5 area, we did not observe a single fox (arctic or red) in or near our nest plots. Liebezeit et al. (2009) used a similar method of sampling predators and concluded they also underestimated the occurrence of arctic and red foxes. It is possible that predator scans (2 10-min scans per plot) are too brief and limited (to line of sight) to have much opportunity for recording animals that occur in low densities. Foxes and bears both may avoid people on tundra, particularly in areas where they can be hunted. Both species of foxes are nocturnal (Ables 1969, Garrott 1980, Eberhardt et al. 1982), which biased our daytime predator scans against detecting their occurrence. We encountered 2 fox dens within the study area, but neither showed any sign of current activity, and both of which were previously mapped (Burgess et al. 2003b). Evidence that foxes did occur in the area in 2013 came from fox scat and scent found at 25 waterbird nests during nest fate checks in July. For whatever reason, predator scans tend to underestimate the occurrence of mammalian predators, which are present in the nest search area, albeit at low densities.

Brood-rearing

Nest success in large Brant colonies is variable, and tends to be either high or very low (see Sedinger and Stickney 2000). The presence of predators in a breeding colony during nest initiation can result in very low nesting effort, as was seen in 1991 and 1992 when arctic foxes disrupted breeding on Howe Island in the Sagavanirktok Delta (Stickney and Ritchie 1996). During incubation, predators such as brown bears and arctic foxes can remove substantial numbers of nests (Smith et al. 1993). Furthermore, unfavorable weather conditions such as persistent snow and ice or cool temperatures can limit availability of nesting habitat or reduce nesting effort and success in some years (Barry 1962, Stickney and Ritchie 1996).

Low productivity for Brant and Snow Geese in 2013 may have resulted in part from predation by brown bears. In early June, Snow Goose nests were observed in large numbers throughout the Colville Delta, including on islands in the Northeast Delta subarea, where nests of both Snow Geese and Brant were numerous and densely distributed. On 19 June, 4 brown bears (a sow with 3 large cubs) were observed near the east bank of the Colville River, in the Kuparuk study area, about a mile from the easternmost of these islands. Observations in early June and on 19 June indicate that Snow Goose nests in the vicinity of the bears were likely depredated (Stickney et al. 2014). Low numbers of brood-rearing Brant and Snow Geese in the Colville Delta in July suggest that the bears may have crossed the narrow channel from the

Kuparuk study area and depredated goose nests on islands in the Northeast Delta subarea on or after 19 June 2013. As reported in the section on Yellow-billed Loons, brown bears took 4 times as many camera-monitored Yellow-billed Loon nests in 2013 as in 2009, the only other year we observed brown bear predation of loon nests. Bears were observed at 6 different camera-monitored nests compared with 2 nests in 2009. These observations suggest brown bears, if not more numerous in the ASDP study areas in 2013, were more active in the area and possibly caused more nest losses among multiple species of waterbirds than in previous years.

It is unknown what effect weather conditions may have had on nesting effort, nesting success, or gosling survival of Brant and Snow Geese in 2013. Aerial observers noted that nests of both species were numerous in the Colville Delta in mid-June, but large flocks of non-nesting Snow Geese (roughly similar to the number of nesting Snow Geese) were also observed, suggesting that many Snow Geese either did not initiate nests, or failed early during the nesting season. The same pattern was not apparent for Brant, but in addition to being less conspicuous than Snow Geese (thus more likely to be overlooked by aerial observers), non- and failed-breeding Brant often molt outside the Colville Delta.

The number of adult Brant present in the Colville Delta during the brood-rearing period is not a reliable measure of the size of the local breeding population. Failed nesters typically depart the Colville Delta prior to the brood-rearing period and molt in other areas on the ACP, including the large molting area northeast of Teshekpuk Lake (Lewis et al. 2009). Additionally, some successful breeders from the Colville Delta rear their broods on coastal salt marshes outside the delta, at least as far east as Kavearak Point in the Kuparuk Oilfield (Sedinger and Stickney 2000) and likely to the west in the adjacent Fish Creek delta. Snow Geese are comparatively new breeders to the Colville Delta, and less is known about their movements after nest failure or hatch. Regardless, relatively few brood-rearing Brant or Snow Geese were observed between the Colville Delta and Kavearak Point in 2013 (Stickney et al. 2014) further suggesting that productivity was low for goose colonies in the Northeast Delta subarea in 2013.

Results from our surveys show the number of adult Brant on the Colville Delta during the brood-rearing period has been growing at a rate of 1.105 (10.5% annually) since 1988 (Figure 22), but that rate is not quite significant ($\ln(y) = 0.105x - 205.1$, $R^2 = 0.237$, $P = 0.066$, $n = 15$ years). Numbers vary widely from year to year, probably due to factors discussed above, including variation in nesting effort and nesting success, and variable movements of broods out of the Colville Delta prior to our survey. These factors may make trends difficult to detect or interpret.

On the ACP, Brant can be found in large breeding colonies on deltaic islands, such as those on the Sagavanirktok, Colville, and Kuparuk river deltas, and in numerous smaller colonies in basin-wetland complexes primarily between the Sagavanirktok River and Barrow. Broad regional surveys conducted during early to mid-June show a statistically significant annual growth rate of 1.095 for Brant on the ACP since 1986 ($n = 27$ years; Stehn et al. 2013); however, this trend may have resulted in part from an influx of early failed breeders from other breeding areas, such as the Yukon-Kuskokwim Delta where numbers of nesting Brant have been decreasing in some colonies in recent years (Wilson 2013). Trends are not uniform across the ACP. Nest numbers have dropped substantially since 1993 on the Sagavanirktok River delta (A. Stickney, ABR, pers. comm.). In contrast, numbers of Brant nests appear to have remained stable or increased since 1995 in 23 small colonies between Fish Creek and Barrow (Ritchie et al. 2013). Data from Larned et al. (2012) suggest that Brant may have begun expanding their range inland from the coast in parts of the ACP.

Snow Goose nests have been found in small numbers on the Colville Delta at least as far back as 1994, and brood-rearing Snow Geese have been observed in small numbers at least as far back as 1996 (Johnson et al. 2003b). Numbers of brood-rearing Snow Geese have steadily increased in recent years, reaching record numbers in 2012 before declining in 2013. Similarly, numbers have increased sharply on the Ikpikpuk River delta (to the west of the Colville River) since surveys began there in 1994 (Ritchie et al. 2013). That colony suffered near-total nest failure due to brown bear

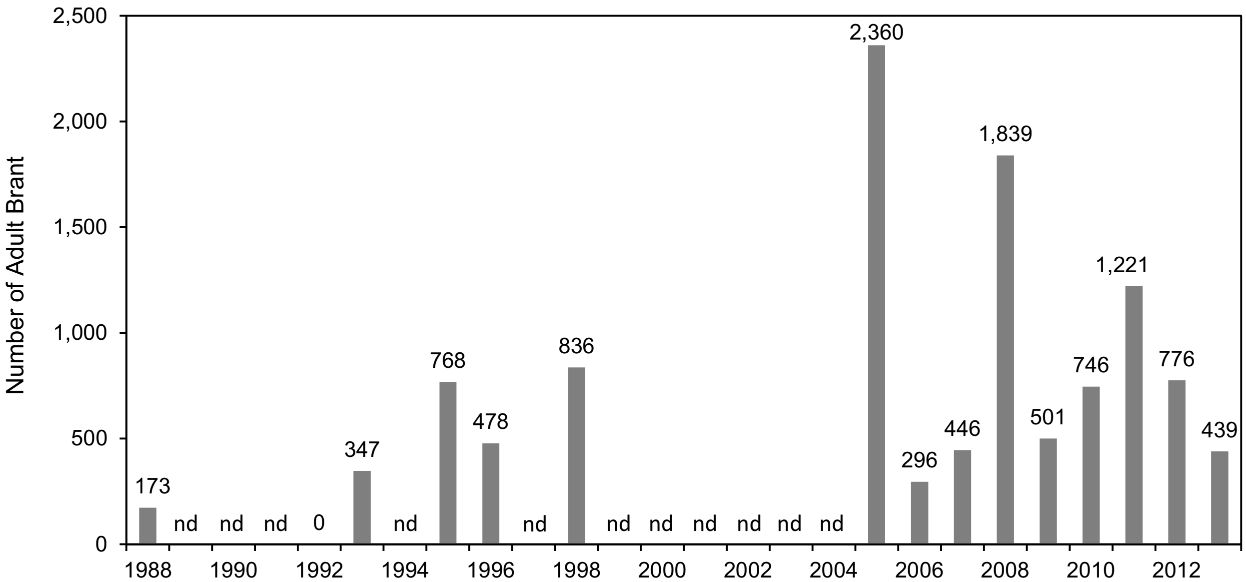


Figure 22. Number of adult Brant during the brood-rearing period, Colville Delta study area, Alaska, 1988–2013. Data for 1988–1991 are from Bayha et al. 1992; subsequent data are from this study.

predation in 2009 and 2010 (Burgess et al. 2011, Ritchie et al. 2010).

Snow Goose breeding populations have been expanding in North America since at least the 1960s (Kerbes 1983, Kerbes et al. 1983, McCormick and Poston 1988, Alisauskas and Boyd 1994) perhaps due to increased availability of agricultural resources in wintering areas (Davis et al. 1989). Snow Geese forage by grubbing for roots and rhizomes during spring prior to emergence of above-ground vegetation (Kerbes et al. 1990). This behavior, coupled with high fidelity to breeding areas (Ganter and Cooke 1998) has resulted in long-term degradation of some nesting areas and arctic coastal salt marshes used for brood-rearing (Kerbes et al. 1990, Ganter et al. 1995, Srivastava and Jefferies 1996). Over-population of breeding colonies has led to decreased growth and survival of goslings (Cooch et al. 1991, Burgess et al. 1993, Gadallah and Jefferies 1995), and eventual dispersal of young breeders to higher quality breeding areas (Ganter and Cooke 1998). In the long term, one might predict a negative impact on Brant from a substantial increase in Snow Goose numbers due to degradation of salt marsh habitats used by both species during brood-rearing. Intense grazing by Brant, focusing exclusively on above-ground biomass, appears to have no lasting deleterious effects on salt marsh grazing lawns (Person et al. 1998). Snow Geese, however, can cause long-term declines of these plant communities in the vicinity of nesting colonies (e.g., Kerbes et al. 1990, Abraham and Jefferies 1997).

GLAUCOUS AND SABINE'S GULLS

COLVILLE DELTA

Distribution and Abundance

Glaucous Gull nests were abundant on the Colville Delta study area in 2013. We recorded 67 Glaucous Gull nests during the aerial survey for nesting loons in 2013 (Figure 23, Table 34). Thirty-eight of those nests were in the CD South subarea, 26 in the CD North subarea, and 3 in the Northeast Delta subarea. We found gulls in 3 colonies and at 35 single nest locations. The largest colony in the Colville Delta survey area is a site in the CD South subarea ~5 km southeast of Alpine (Figure 23). Twenty-three nests were found at this colony in 2013, the highest nest count recorded in the last 12 years (16 ± 1.2 nests, $n = 12$; Table 35). The other two colonies are smaller and developed within the last 10 years. One colony in the

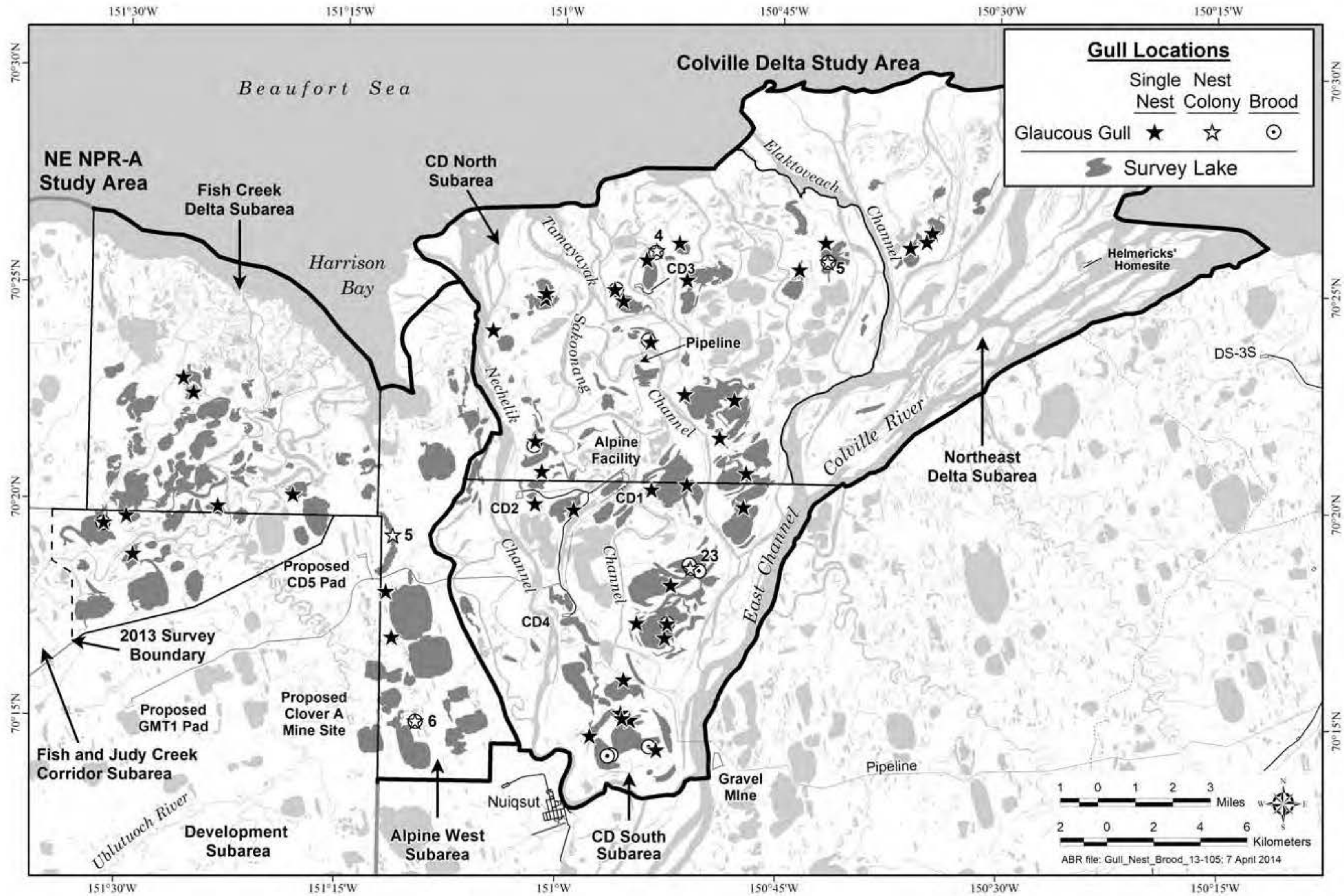


Figure 23. Glaucous and Sabine's gull nests and broods, Colville Delta and NE NPR-A study areas, Alaska, 2013. Numbers of nests are listed for colony locations.

Table 34. Number of Glaucous Gull nests observed during aerial surveys for nesting loons, Colville Delta and NE NPR-A study areas, Alaska, 2013.

STUDY AREA Subarea	Nests
COLVILLE DELTA	
CD North	26
CD South	38
Northeast Delta	3
Total	67
NE NPR-A	
Alpine West	13
Fish Creek Delta	4
Fish and Judy Creek Corridor	3
Total	20

northeastern part of the CD North subarea grew from ≤2 nests in 2002–2003 to 4–7 nests thereafter; in 2013 it supported 5 nests. The third and most recently formed colony is on a lake ~1.7 km north of the CD3 drill pad. This site was stable with 1–2 nests until 2012– 2013, when it grew to 4–5 nests.

Since 2002, 50 index lakes in the Colville Delta study area have been monitored for the presence of Glaucous Gull nests during the aerial survey for nesting loons. In 2013, 57 nests were found on 44% (22 of 50 lakes; Table 35). During the last 12 years, counts of Glaucous Gulls nests at the index lakes grew from 28 nests in 2003 to 62 nests in 2012. The number of lakes occupied by nesting gulls grew at a similar rate, doubling from 14 lakes in 2003 (28% of all lakes) to 28 lakes in 2012 (56% of all lakes).

Twelve groups of Glaucous Gulls with young were recorded incidentally in 2013 in the Colville Delta study area during the survey for brood-rearing loons (Figure 23). Twenty-three adults and 48 young were recorded, of which 8 adults and 9 young were in the CD North subarea and 15 adults and 39 young were in the CD South subarea. No Glaucous Gull broods were observed in the Northeast Delta subarea. Four young were observed at the colony site in the northeastern part of the CD North subarea, 1 young at the colony site north of the CD3 drill pad, and 27 young at the colony site in the CD South subarea. Young from some nests were flight capable at the time of the loon survey, and consequently we may have undercounted their numbers.

No nests belonging to Sabine’s Gulls were observed in 2013 in the Colville Delta study area during the aerial survey for nesting loons; however, foraging flocks of Sabine’s Gulls were observed. Some areas of the Colville Delta were still flooded by high water levels at the time of the survey, particularly island or shoreline habitats of lakes where Sabine’s Gulls frequently nest, and some gulls probably had not yet initiated nesting. Sabine’s Gull nests, particularly single nests, are difficult to detect during aerial surveys, which would cause us to underestimate their abundance. Sabine's Gull colonies or single nests were recorded during aerial surveys in the Colville Delta study area in only 4 of 12 survey years (2002–2013) and the distribution of these nests was limited to a couple of lakes in the northwestern portion of the delta. In years when nests were detected, the number of Sabine’s Gull nests ranged from 1 to 16 nests. Sabine’s Gulls did nest on the Colville Delta in 2013, however, as was documented later during ground-based nest searches conducted in late June (Seiser and Johnson 2014).

Habitat Use

Glaucous Gull nests and colonies were found in 9 different habitats in the Colville Delta study area (Table 36). Most nests (37%) were in Patterned Wet Meadow. The largest Glaucous Gull colony (23 nests) was located on a large island classified as Pattern Wet Meadow. Another 25% of the nests were found in Deep Open Water with Islands or Polygonized Margins and 18% were in Tapped Lakes with High-water Connection. The remaining 20% of nests were found on islands or complex shorelines of 6 other habitats. Glaucous Gull broods observed during aerial surveys were located near nests and in the same habitats as were the nests.

NE NPR-A

Distribution and Abundance

The number of Glaucous Gull nests in the portion of the NE NPR-A study area surveyed during 2013 was near the middle of the range

Table 35. Number of Glaucous Gull nests recorded during aerial surveys for nesting loons on 50 index lakes, Colville Delta study area, Alaska, 2002–2013.

Year	Number of Nests: CD North Subarea[a]	CD South Subarea[b]	Northeast Delta Subarea	Total	No. of Lakes with Nests[c]
2002	11 (2, 1)	24 (18)	1	36	15
2003	11 (1, 1)	17 (14)	0	28	14
2004	19 (7, 1)	17 (13)	0	36	16
2005	18 (5, 1)	22 (15)	0	40	19
2006	15 (4, 1)	21 (16)	1	37	19
2007	16 (5, 1)	21 (13)	2	39	19
2008	19 (5, 1)	26 (18)	2	47	22
2009	17 (6, 1)	27 (19)	2	46	21
2010	17 (5, 2)	16 (6)	2	35	21
2011	17 (5, 2)	36 (17)	2	55	24
2012	26 (7, 5)	34 (17)	2	62	28
2013	19 (5, 4)	35 (23)	3	57	22
Mean	17.1 (4.8, 1.8)	24.7 (15.8)	1.4	43.2	20.0
SE	1.1 (0.5, 0.4)	2.1 (1.2)	0.3	3.0	1.1

[a] First number in parenthesis is the number of nests at the colony site in the northeastern part of the CD North subarea and second number is the number of nests at the site north of the CD3 drill pad (see Figure 20)

[b] Number in parenthesis is the number of nests at the colony site in the CD South subarea (see Figure 20)

[c] Of 50 lakes monitored annually for the presence of Glaucous Gull nests, 2 occur in the Northeast Delta subarea, 20 in the CD South subarea, and 28 in the CD North subarea

Table 36. Habitat use by nesting Glaucous Gulls, Colville Delta and NE NPR-A study areas, Alaska, 2013.

Habitat	Colville Delta: Nests	Colville Delta: Use (%)	NE NPR-A: Nests	NE NPR-A: Use (%)
Brackish Water	2	3.0	1	5.0
Tapped Lake with High-water Connection	12	17.9	1	5.0
Deep Open Water without Islands	3	4.5	1	5.0
Deep Open Water with Islands or Polygonized Margins	17	25.4	2	10.0
Shallow Open Water with Islands or Polygonized Margins	1	1.5	12	60.0
Deep Polygon Complex	3	4.5	1	5.0
Grass Marsh	1	1.5	1	5.0
Nonpatterned Wet Meadow	3	4.5	–	–
Patterned Wet Meadow	25	37.3	1	5.0
Total	67	100	20	100

previously recorded. We counted 20 nests during aerial surveys for loons (Figure 23, Table 34). We recorded 13 nests in the Alpine West subarea, 4 in the Fish Creek Delta subarea, and 3 in the Fish and Judy Creek Corridor subarea. Two colonies accounted for 11 Glaucous Gull nests and 9 were solitary nests. Both colony sites are in the Alpine West subarea; one near the proposed CD5 pad site had 5 nests in 2013 and the other in the southern part of Alpine West had 6 nests (Figure 23, Table 37). Annual counts have ranged from 0 to 7 nests at the CD5 colony and from 4 to 11 nests at the other colony site (Table 37). We have collected data on Glaucous Gull nests in the Alpine West and Fish Creek Delta subareas over 8 years, more consistently than in other subareas, during which counts of nests have been highly variable. The lowest count of 12 nests in 2009 was attributed partly to the predation by a grizzly bear of all nests at the CD5 colony (Johnson et al. 2010). In most years, Glaucous Gulls probably initiate nesting in the study area by mid-June and some nests may fail prior to the time of the loon survey.

During the loon brood-rearing survey in 2013, 2 Glaucous Gull brood-rearing groups were observed in the NE NPR-A study area (Figure 23). One group was an adult with 1 young in the Fish and Judy Creek Corridor subarea and the second brood group consisted of 10 adults and 13 young at the colony site in the southern part of the Alpine West subarea. Young from some nests probably were flight capable at the time of the brood-rearing survey, and consequently may have been missed if they were no longer near their nest sites.

No Sabine's Gull nests were found in the NE NPR-A study area in 2013 during the loon nesting survey, but flocks of adult gulls were observed foraging in the study area during the survey. Nest counts for Sabine's Gulls have ranged from 3–29 nests in the combined Alpine West and Fish Creek Delta subareas during 8 years of surveys. Sabine's Gull nests were observed in 2013 during ground-based nest searches on June 14 in the Alpine West subarea (see OTHER NESTING BIRDS, above), and therefore the timing of the aerial survey on 19–21 June was appropriate. At the time of the loon nesting survey in 2013, water levels were high on some large lakes in the NE NPR-A study area, which may have delayed nesting at colony sites in marshy areas on islands or along the shorelines of large lakes. The highest count of Sabine's Gull nests in the NE NPR-A study area occurred in 2008, which was characterized by an early spring breakup and relatively low flood levels.

Table 37. Number of Glaucous Gull nests recorded during aerial surveys for nesting loons in the Alpine West and Fish Creek Delta sub-areas, NE NPR-A study area, Alaska, 2002–2013.

Year	Alpine West Subarea[a]	Fish Creek Delta Subarea[b]	Total
2002	13 (4, –)	–	–
2003	16 (4, 7)	–	–
2004	15 (5, 6)	–	–
2005	13 (5, 6)	4	17
2006	17 (7, 6)	11	28
2008	19 (7, 6)	7	26
2009	9 (0, 5)	3	12
2010	12 (5, 4)	2	14
2011	19 (5, 11)	4	23
2012	17 (5, 9)	5	22
2013	13 (5, 6)	4	17

[a] First number in parenthesis is the number of nests at the colony site near the proposed CD5 Pad and second number is the number of nests at the site in the southern part of the subarea (see Figure 20). The colony in southern part of the subarea was discovered in 2003 and the count of nests at that location was unknown for 2002.

[b] The Fish Creek Delta Subarea was not surveyed in 2002–2004

Habitat Use

Glaucous Gulls nested in 8 different habitats in the NE NPR-A study area (Table 36). We recorded 60% of the 20 nests in Shallow Open Water with Islands or Polygonized Margins. The remaining 40% were found on islands or complex shorelines of 5 other aquatic habitats and 2 terrestrial habitats. Glaucous Gull broods were found in aquatic and terrestrial habitats near nest locations, often in the same habitat as the nest.

DISCUSSION

The number of Glaucous Gull nests in the Colville Delta study area has steadily increased from 2002 to 2013. Over this 12-year period, we have recorded the occurrence of nesting gulls at 50 index lakes and found a significant annual growth rate in the number of Glaucous Gull nests of 1.054 (In(y) = 0.054x – 103.9, R^2 = 0.645, *P* = 0.001, *n* = 12). Glaucous Gulls have been increasing on the ACP over the last 21 years (annual growth rate = 1.20, 90% CI = 1.007–1.033) and during the last 10 years the rate was equivalent to the growth in number of nests on the Colville Delta (annual growth rate = 1.058, 90% CI = 1.023–1.095; Stehn et al. 2013). The increase on the Colville Delta occurred both in the number of nests associated with colonies and the number of solitary nests. The number of colonies (where ≥3 nests occur in proximity) in the 50 index lakes increased from 1 to 3 over 12 years. Once colonies were established, nest numbers at each site varied annually but the increase in the number of colony nests appears to be largely because of the establishment of new colonies. The colonies contribute a large proportion to the total nests, comprising 37–58% of the nests found each year. The number of solitary nests at the index lakes doubled over 12 years and most of the new nest locations occurred on lakes where nesting by gulls had not been previously documented during our surveys on the delta. The percentage of the index lakes occupied by solitary nesting gulls increased from 22% in 2003 to 50% in 2012.

The trend for Glaucous Gulls nests in the NE NPR-A study area is less clear because survey coverage was less consistent and because numbers were more variable among years. Since 2005, only the Alpine West and Fish Creek Delta subareas of the NE NPR-A study area have been consistently surveyed each year. Between 2005 and 2013, we found no trend in number of nests in the combined Alpine West and Fish Creek Delta subareas (*P* = 0.674, *n* = 8 years).

Sabine's Gulls are found as solitary nesting birds or in loose nesting colonies. Single nests are difficult to detect during loon surveys and nesting colonies are more easily detected because some birds are flying near the colony. Single nesting birds are likely under-recorded. The number of Sabine's Gulls nests observed during surveys for nesting loons has been variable during the 12 years of surveys on the Colville Delta study area and 8 years of surveys in the NE NPR-A study area. This variation may be because spring conditions have a large influence on nesting effort or because nests are missed, either for the reason that nests are hard to detect during aerial surveys or the timing of the loon nesting survey is not always appropriate for Sabine's Gulls. Although Sabine's Gulls do appear to be increasing across the ACP (annual growth rate = 1.044, 90% CI = 1.026–1.062; Stehn et al. 2013), we are unable to confirm the same trends in the ASDP study areas.

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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		
Snow Goose	Kaŋuq	*Chen caerulescens*
Brant	Niġlinġaq	*Branta bernicla*
Cackling Goose/Canada Goose	Iqsraġutilik	*Branta hutchinsii/B. canadensis*
Greater White-fronted Goose	Niġliviq	*Anser albifrons*
Tundra Swan	Qugruk	*Cygnus columbianus*
Northern Pintail	Kurugaq	*Anas Acuta*
Green-winged Teal	Qaiŋŋiq	*Anas crecca*
Steller's Eider	Igniqauqtuq	*Polysticta stelleri*
Spectacled Eider	Qavaasuk	*Somateria fischeri*
King Eider	Qiŋalik	*Somateria spectabilis*
Common Eider	Amauligruaq	*Somateria mollissima*
Willow Ptarmigan	Aqargiq, Nasaullik	*Lagopus lagopus*
Red-throated Loon	Qaqsrauq	*Gavia stellata*
Pacific Loon	Malġi	*Gavia pacifica*
Yellow-billed Loon	Tuullik	*Gavia adamsii*
Common Loon		*Gavia immer*
Bald Eagle	Tiŋmiaqpak	*Haliaeetus leucocephalus*
Northern Harrier	Papiktuuq	*Circus cyaneus*
Golden Eagle	Tiŋmiaqpak	*Aquila chrysaetos*
Glaucous Gull	Nauyavasrugruk	*Larus hyperboreus*
Bar-tailed Godwit	Turraaturaq	*Limosa lapponica*
Sabine's Gull	Iqirgagiak	*Xema sabini*
Arctic Tern	Mitqutailaq	*Sterna paradisaea*
Pomarine Jaeger	Isuŋŋaġluk	*Stercorarius pomarinus*
Parasitic Jaeger	Migiaqsaayuk	*Stercorarius parasiticus*
Long-tailed Jaeger	Isuŋŋaq	*Stercorarius longicaudus*
Short-eared Owl	Nipailuktaq	*Asio flammeus*
Common Raven	Tulugaq	*Corvus corax*
MAMMALS		
Arctic Fox	Tiġiganniaq	*Vulpes lagopus*
Red Fox	Kayuqtuq	*Vulpes vulpes*
Brown (Grizzly) Bear	Akłaq	*Ursus arctos*
Caribou	Tuttu	*Rangifer tarandus*

Appendix B. Classification and descriptions of wildlife habitat types found in the Colville Delta or NE NPR-A study areas, Alaska, 2012. Species associations of some habitats vary between the Colville Delta and the NE NPR-A study areas.

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).

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.

Appendix C. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2013.

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	30	22	52	22	60	0.25	0.29
In flight	5	2	7	2	–	0.03	–
All birds	35	24	59	24	–	0.29	–
Northeast Delta							
On ground	1	0	1	0	2	0.01	0.01
In flight	0	0	0	0	–	0.00	–
All birds	1	0	1	0	–	0.01	–
CD South							
On ground	2	1	3	1	4	0.02	0.03
In flight	0	0	0	0	–	0.00	–
All birds	2	1	3	1	–	0.02	–
Total (subareas combined)							
On ground	33	23	56	23	66	0.11	0.13
In flight	5	2	7	2	–	0.01	–
All birds	38	25	63	25	–	0.13	–
KING EIDER							
CD North							
On ground	8	8	16	8	16	0.08	0.08
In flight	2	1	3	1	–	0.01	–
All birds	10	9	19	9	–	0.09	–
Northeast Delta							
On ground	1	1	2	1	2	0.01	0.01
In flight	3	1	4	1	–	0.03	–
All birds	4	2	6	2	–	0.04	–
CD South							
On ground	3	3	6	3	6	0.04	0.04
In flight	6	1	7	1	0	0.05	–
All birds	9	4	13	4	–	0.09	–
Total (subareas combined)							
On ground	12	12	24	12	24	0.05	0.05
In flight	11	3	14	3	–	0.03	–
All birds	23	15	38	15	–	0.08	–

[a] Indicated total 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 not corrected for sightability

Appendix D. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, NE NPR-A study area, Alaska, 2013.

SPECIES Subarea Location	Observed Males	 Females	 Total	 Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
SPECTACLED EIDER							
Development							
On ground	2	2	4	2	4	0.05	0.05
In flight	0	0	0	0	–	0.00	–
All birds	2	2	4	2	–	0.05	–
Alpine West							
On ground	1	1	2	1	2	0.05	0.05
In flight	1	1	2	1	–	0.05	–
All birds	2	2	4	2	–	0.10	–
Fish Creek Delta							
On ground	4	3	7	3	8	0.12	0.14
In flight	1	1	2	1	–	0.03	–
All birds	5	4	9	4	–	0.16	–
Total (subareas combined)							
On ground	7	6	13	6	14	0.08	0.08
In flight	2	2	4	2	–	0.02	–
All birds	9	8	17	8	–	0.10	–
KING EIDER							
Development							
On ground	10	8	18	8	20	0.25	0.27
In flight	2	2	4	2	–	0.05	–
All birds	12	10	22	10	–	0.30	–
Alpine West							
On ground	9	9	18	9	18	0.43	0.43
In flight	3	3	6	3	–	0.14	–
All birds	12	12	24	12	–	0.57	–
Fish Creek Delta							
On ground	29	28	57	25	58	0.99	1.01
In flight	8	7	15	7	–	0.26	–
All birds	37	35	72	32	–	1.26	–
Total (subareas combined)							
On ground	48	45	93	42	96	0.54	0.56
In flight	13	12	25	12	–	0.15	–
All birds	61	57	118	54	–	0.69	–

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

[b] Numbers not corrected for sightability. Surveys conducted at 50% coverage. Density based on area surveyed: Development subarea = 72.9 km², Alpine West = 41.8 km², Fish Creek Delta = 57.3 km², all subareas combined = 172.0 km². Fish Creek West, Exploration, and the western portion of the Development subareas were not surveyed in 2013 (see Figure 1)

Appendix E. Number and density of loons and their nests, broods, and young during aerial surveys, Colville Delta and NE NPR-A study areas, Alaska, 2013.

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	37	6[c]	–	0.18	0.03	104	5	–	9	0	–
Brood-rearing	19	3	3	0.09	0.01	65	13	15	2	0	0
CD South											
Nesting	28	9[d]	–	0.18	0.06	60	5	–	10	0	–
Brood-rearing	22	4	6	0.14	0.03	34	5	6	2	2	2
Northeast Delta[e]											
Nesting	2	1	–	–	–	16	3	–	0	0	–
Brood-rearing	1	0	0	–	–	24	3	3	0	0	0
Total (subareas combined)[f]											
Nesting	67	16[c, d]	–	0.18	0.04	180	13	–	19	0	–
Brood-rearing	42	7	9	0.11	0.02	123	21	24	4	2	2
NE NPR-A											
Alpine West											
Nesting	2	1	–	0.03	0.01	49	0	–	2	0	–
Brood-rearing	2	0	0	0.03	0	86	10	11	0	0	0
Fish Creek Delta											
Nesting	18	7[d]	–	0.14	0.05	89	8	–	4	0	–
Brood-rearing	9	0	0	0.07	0	38	8	11	1	0	0
Fish and Judy Creek Corridor											
Nesting	19	6[d]	–	0.46	0.15	14	0	–	4	0	–
Brood-rearing	10	1[g]	2	0.24	0.02	11	3	5	0	0	0
Total (subareas combined)[f]											
Nesting	39	14[d]	–	0.16	0.06	152	8	–	10	0	–
Brood-rearing	21	1[g]	2	0.08	<0.01	135	21	27	1	0	0

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and surveys did not include smaller lakes (<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; eastern portion of Fish and Judy Creek Corridor = 41.0 km²; see Figure 5

[c] Number includes 2 nests documented in the CD North subarea on camera images only

[d] Number includes nests found during weekly monitoring surveys: 2 nests in the CD South subarea of the Colville Delta study area, and 1 nest in both the Fish Creek Delta and the Fish and Judy Creek Corridor subareas of the NE NPR-A study area

[e] Densities were not calculated for the Northeast Delta subarea because only a portion of the subarea was surveyed

[f] 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 eastern part of Fish and Judy Creek Corridor for NE NPR-A (251.2 km² total)

[g] Number includes 1 brood found during weekly monitoring surveys in the Fish and Judy Creek Corridor subarea of the NE NPR-A study area

Appendix F. Annual density (number/km²) of Yellow-billed Loons, nests, and broods, Colville Delta (1993–2013) and NE NPR-A (2001–2013) study areas, Alaska.

STUDY AREA Year	Nesting Survey Adults	Nests[a]	Brood-rearing Survey Adults	Broods[b]
COLVILLE DELTA[c]				
1993	0.14	0.02	0.08	0.02
1995	0.11	0.03	0.14	0.02
1996	0.12	0.03 (0.05)	0.17	0.02
1997	0.13	0.03 (0.04)	0.18	0.01
1998	0.09	0.04 (0.06)	0.14	0.03
2000	0.15	0.04 (0.04)	0.04	0.01
2001	0.15	0.05 (0.05)	0.07	0.01
2002	0.13	0.05 (0.05)	0.18	0.02
2003	0.14	0.07	0.13	0.04
2004	0.11	0.07	0.14	0.03
2005	0.15	0.08	0.10	0.04 (0.05)
2006	0.17	0.06 (0.07)	0.18	0.03 (0.04)
2007	0.17	0.07 (0.08)	0.14	0.05 (0.06)
2008	0.18	0.09 (0.10)	0.15	0.06 (0.07)
2009	0.17	0.07 (0.08)	0.15	0.02 (0.03)
2010	0.18	0.06 (0.09)	0.16	0.04 (0.04)
2011	0.19	0.06 (0.07)	0.12	0.03 (0.04)
2012	0.15	0.06 (0.08)	0.14	0.03 (0.04)
2013	0.18	0.03 (0.04)	0.11	0.02 (0.02)
Mean	0.15	0.05 (0.08)[d]	0.13	0.03 (0.04)
SE	<0.01	<0.01 (<0.01)[d]	<0.01	<0.01 (<0.01)
NE NPR-A[e, f]				
2001	0.07	0.03	0.08	0.01
2002	0.07	0.03	0.05	0.01
2003	0.06	0.03	0.06	0.02
2004	0.07	0.03	0.08	0.01
2005	0.11	0.04	0.06	0.01
2006	0.11	0.04	0.07	0.01
2008	0.17	0.05 (0.06)	0.14	0.02 (0.04)
2009	0.13	0.05 (0.06)	0.16	0.03 (0.03)
2010	0.15	0.06 (0.06)	0.14	0.03 (0.03)
2011	0.12	0.03 (0.05)	0.12	0.02 (0.02)
2012	0.14	0.06 (0.07)	0.17	0.05 (0.05)
2013	0.16	0.05 (0.06)	0.08	0 (<0.01)

[a] Density of nests found on the nesting survey and, in parentheses, cumulative density including additional nests found during revisit (1996–2002) and monitoring (2006–2013) surveys

[b] Density of broods found on the brood-rearing survey and, in parentheses, cumulative density including additional broods found during monitoring surveys (2005–2013) that did not survive to the time of the brood-rearing survey

[c] Colville Delta study area = 362.6 km² and includes CD North and CD South subareas combined

[d] Mean density and SE includes only years when monitoring surveys were conducted: 2006–2013

[e] Survey area included 5 subareas: Development (617.8 km²) surveyed in 2001–2004, Exploration (260.4 km²) in 2002–2004, Alpine West (79.7 km²) in 2002–2006 and 2008–2013, Fish Creek Delta (130.5 km²) in 2005–2006 and 2008–2013, and the Fish and Judy Creek Corridor (255.9 km²) in 2008–2010. In 2011–2013, the eastern one-quarter of the Fish and Judy Creek Corridor subarea (41.0 km²) was surveyed

[f] Mean densities not calculated for NE NPR-A because the study area differed among years

Appendix G. Nest history and incubation activity of Yellow-billed Loon nests monitored by time-lapse digital cameras, Colville Delta and NE NPR-A study areas, Alaska, 2008–2013.

	Median				Average				
STUDY AREA/ Year/ Fate	Start of Incubation	*n*	Hatch or Failure	*n*	Incubation Constancy[d] (%)	Exchange Frequency[a] (no/d)	Recess Frequency[a] (no/d)	Recess Length[a] (min/recess)	*n*
COLVILLE DELTA									
2008									
Hatched	10 June	10	8 July	9	97.1 ± 0.7	1.1 ± 0.1	2.1 ± 0.3	17.1 ± 2.2	9
Failed	11 June	3	29 June	3	98.5 ± 1.0	2.1 ± 0.2	1.4 ± 0.4	13.0 ± 6.5	3
2009									
Hatched	11 June	9	9 July	9	98.2 ± 0.4	1.5 ± 0.2	1.7 ± 0.4	12.6 ± 1.6	9
Failed	10 June	6	29 June	7	95.7 ± 2.2	1.5 ± 0.5	2.5 ± 1.0	14.6 ± 5.9	4
2010									
Hatched	19 June	9	16 July	7	98.0 ± 0.2	1.8 ± 0.1	2.6 ± 0.2	10.0 ± 0.8	9
Failed	22 June	10	6 July	9	89.8 ± 3.9	1.6 ± 0.3	5.0 ± 0.7	34.9 ± 17.1	9
2011									
Hatched	15 June	13	13 July	13	98.0 ± 0.3	1.5 ± 0.1	2.6 ± 0.3	10.2 ± 1.0	13
Failed	19 June	7	4 July	7	93.1 ± 2.2	1.3 ± 0.2	5.0 ± 1.0	24.0 ± 8.1	6
2012									
Hatched	14 June	10	12 July	9	97.6 ± 0.5	1.6 ± 0.2	2.8 ± 0.3	10.6 ± 1.2	10
Failed	14 June	8	29 June	8	95.9 ± 1.8	1.7 ± 0.4	4.5 ± 1.6	12.0 ± 1.9	6
2013									
Hatched	17 June	4	16 July	3	92.8 ± 1.2	1.0 ± 0.2	4.5 ± 0.3	23.3 ± 5.0	4
Failed	17 June	8	27 June	8	87.2 ± 3.6	1.2 ± 0.3	4.4 ± 0.6	77.8 ± 18.7	9
Total									
Hatched	14 June[b]	6	12 July[b]	6	97.4 ± 0.3	1.5 ± 0.1	2.5 ± 0.1	12.8 ± 0.8	54
Failed	15 June[b]	6	29 June[b]	6	92.0 ± 1.5	1.5 ± 0.1	4.2 ± 0.4	35.9 ± 7.4	37

Appendix G. Continued.

STUDY AREA/ Year/ Fate	Median				Average				
	Start of Incubation	*n*	Hatch or Failure	*n*	Incubation Constancy[d] (%)	Exchange Frequency[a] (no/d)	Recess Frequency[a] (no/d)	Recess Length[a] (min/recess)	*n*
NE NPRA									
2010									
Hatched	19 June	6	18 July	5	97.2 ± 0.5	1.2 ± 0.2	3.5 ± 0.2	11.0 ± 1.3	6
Failed	18 June	2	5 July	4	94.4 ± 1.8	1.4 ± 0.2	3.6 ± 0.5	30.9 ± 9.6	4
2011									
Hatched	14 June	2	12 July	2	98.4 ± 0.2	1.3 ± 0.5	1.8 ± 0.1	12.4 ± 1.8	2
Failed	19 June	4	25 June	3	95.2 ± 0.4	1.6 ± 0.4	4.9 ± 0.4	20.5 ± 5.6	2
2012									
Hatched	14 June	9	12 July	8	97.9 ± 0.4	1.4 ± 0.2	2.4 ± 0.3	11.2 ± 1.2	9
Failed	16 June	2	4 July	2	95.8 ± 0.8	0.9 ± 0.9	4.0 ± 0.4	16.8 ± 1.8	2
2013									
Hatched	23 June	1	21 July	1	94.0	1.4	4.0	16.4	1
Failed	17 June	7	29 June	8	93.2 ± 0.9	1.1 ± 0.1	3.6 ± 0.3	58.6 ± 22.7	7
Total									
Hatched	16 June[b]	4	15 July[b]	4	97.5 ± 0.3	1.3 ± 0.1	2.8 ± 0.2	11.5 ± 0.8	18
Failed	17 June[b]	4	1 July[b]	4	94.1 ± 0.7	1.2 ± 0.1	3.8 ± 0.2	40.6 ± 11.4	15

[a] Summarized from time loon returns to nest after camera installation to day before hatch, or to time of nest failure; excludes period of time when photo images could not be interpreted because of poor weather conditions

[b] Overall median calculated across yearly medians

Appendix H. Annual number of Tundra Swan nests and broods during aerial surveys, NE NPR-A study area, Alaska, 2001–2013.

SEASON Year	Alpine West	Development	Exploration	Fish Creek Delta	Fish Creek West
NESTS					
2001	1	20	11	–	–
2002	2	24	17	–	–
2003	3	27	13	–	–
2004	2	33	15	13	–
2005	3	25	9	4	7
2006	5	36	11	4	16
2008	5	32	18	4	10
2009	5	27	13	12	16
2011	4	1	–	7	–
2012	4	9	–	6	–
2013	3	5	–	7	–
BROODS					
2001	2	16	5	–	–
2002	1	15	10	–	–
2003	3	12	5	–	–
2004	2	16	13	–	–
2005	2	18	6	3	8
2006	1	17	11	6	14
2008	2	16	4	4	9
2009	0	28	8	6	8
2011	0	5	–	5	–
2012	3	5	–	4	–
2013	5	4	–	4	–

[a] Alpine West = 79.7 km², Development = 615.8 km², Exploration = 404.7 km², Fish Creek Delta = 130.5 km², Fish Creek West = 340.4 km². In 2011–2013, only a small portion (130.9 km²) of the Development Subarea was surveyed

Appendix I. Number of predators observed in and outside 40 10-ha breeding-bird plots in the CD5 area, NE NPR-A study area, Alaska, 2013. Predators include Long-tailed, Parasitic, and Pomarine jaegers (jaeger); Glaucous Gull (gull); Short-eared Owl and Northern Harrier (raptor); and Common Raven (raven). No mammalian predators were observed.

	Predator Scans [a]										Incidental Observations [a]									
	On Plot					Outside Plot [b]					On Plot					Outside Plot [b]				
Plot	Jaeger	Gull	Raptor	Raven	Total	Jaeger	Gull	Raptor	Raven	Total	Jaeger	Gull	Raptor	Raven	Total	Jaeger	Gull	Raptor	Raven	Total
5	5	2	0	0	7	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1
6	3	0	0	0	3	0	0	1	0	1	1	1	0	0	2	0	0	0	0	0
7	0	1	0	0	1	1	2	0	0	3	1	0	0	0	1	0	1	0	0	1
8	2	1	0	0	3	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
9	1	2	0	0	3	0	1	0	0	1	1	1	0	0	2	0	0	0	0	0
10	2	0	0	0	2	2	1	0	0	3	0	0	0	0	0	1	1	0	0	2
11	2	0	0	0	2	0	1	0	0	1	0	0	0	0	0	1	1	0	0	2
12	1	1	0	0	2	2	0	0	0	2	2	0	0	0	2	0	0	0	0	0
13	2	0	0	0	2	1	0	0	0	1	1	1	0	0	2	0	0	0	0	0
14	1	1	1	0	3	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2
15	1	1	0	0	2	0	1	0	0	1	1	1	0	0	2	1	0	0	0	1
16	2	0	0	0	2	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
18	1	2	0	0	3	0	1	0	0	1	1	1	0	0	2	0	0	0	0	0
19	1	2	0	0	3	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
20	2	2	0	0	4	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
22	1	2	0	0	3	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
23	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
24	2	1	0	0	3	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0
25	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	2	0	0	0	2	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
27	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
28	3	2	0	0	5	0	1	0	0	1	2	0	0	0	2	0	0	0	0	0
29	0	1	0	1	2	1	2	0	1	4	0	0	0	0	0	0	0	0	0	0
30	2	0	0	0	2	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
33	1	1	0	0	2	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0
34	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
37	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	2
38	1	2	0	0	3	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1
39	1	1	0	0	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
40	0	1	0	0	1	0	0	0	0	0	1	0	1	0	2	0	0	0	0	0
43	2	1	0	0	3	1	1	0	0	2	1	1	0	0	2	0	0	0	0	0
44	2	1	0	0	3	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
45	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	2	1	0	0	3	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0

Appendix I. Continued.

Plot	Predator Scans [a]										Incidental Observations [a]									
	On Plot					Outside Plot [b]					On Plot					Outside Plot [b]				
	Jaeger	Gull	Raptor	Raven	Total	Jaeger	Gull	Raptor	Raven	Total	Jaeger	Gull	Raptor	Raven	Total	Jaeger	Gull	Raptor	Raven	Total
48	3	1	0	0	4	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1
49	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2	1	0	0	3
50	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
52	2	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	55	38	1	3	97	13	14	1	1	29	24	11	1	2	38	7	8	0	2	17
Mean	0.70	0.48	0.01	0.04	1.28	0.16	0.18	0.03	0.01	0.38	0.60	0.28	0.03	0.05	0.95	0.18	0.20	0.00	0.05	0.43
SE	0.07	0.06	0.01	0.02	0.10	0.04	0.04	0.02	0.01	0.07	0.10	0.07	0.03	0.03	0.14	0.07	0.06	0.00	0.03	0.12
n [c]	79	79	79	79	79	79	79	79	79	79	40	40	40	40	40	40	40	40	40	40

[a] Predator scans included 2, 10-min scans per plot except plot 45 (3 scans), and plots 23 and 25 (1 scan each); incidental observations were made during nest-searching
[b] Predators observed outside but ≤300 m from plot
[c] *n* = total number of 10-min scans for predators (predator scans) on plots and *n*= number of plots visited for incidental observations