AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2011

NINTH ANNUAL REPORT

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ABR, INC.–ENVIRONMENTAL RESEARCH & SERVICES
FAIRBANKS, ALASKA

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EXECUTIVE SUMMARY

Avian aerial surveys were conducted in the Colville Delta and in the northeastern National Petroleum Reserve–Alaska (NE NPRA) in 2011 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 NPRA. 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 for development impacts. Monitoring a collection of focal species with differing habitat requirements provides both in-depth data on species trends and responses to a changing environment and a general view of ecosystem health. Aerial surveys for eiders, swans, and geese were conducted from fixed-wing airplanes. 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 (CD-1 and CD-2) began oil production on the Colville Delta in 2000. Two ASDP satellite drill sites were built in the winter of 2005: CD-3 was built as a roadless drill site to reduce its gravel footprint in Spectacled Eider (a federally listed threatened species) breeding habitat on the outer delta, and CD-4 was connected by a road on the south side of the Alpine Facility. The CD-3 site began producing oil in August 2006, and CD-4 began producing in November 2006. The NE NPRA study area (reduced in size to 174 km² in 2011) abuts the western edge of the Colville Delta and encompasses 2 proposed development sites that are part of the ASDP: drill site CD-5 and the Clover A gravel mine site.

Most years, open houses were held in Nuiqsut to allow residents to visit with CPAI biologists and other scientists to discuss information and concerns about resources in the Colville Delta and NE NPRA areas. In October 2010, CPAI staff attended a science fair at the local school during the day, followed by a community meeting in the evening where they presented findings of recent monitoring efforts. During the summer field season in 2011, CPAI sent weekly updates to the Department of Wildlife of the North Slope Borough, various state and federal agencies, several environmental organizations, and key representatives of the Kuukpik Subsistence Oversight Panel (KSOP) and Kuukpik Corporation for distribution in Nuiqsut. The updates reported on surveys conducted the previous week (for example, type of aircraft used, altitude of aircraft, and species enumerated) and the schedule of surveys for the upcoming week. Chris Long, a Nuiqsut resident flew along on several aerial surveys in 2011, providing assistance to our wildlife biologists and serving as a liaison between wildlife studies and the local community. CPAI also attends Kuukpik Corporation board meetings annually. The open houses, board meetings, subsistence representatives, and weekly updates keep local residents informed on the progress and results of studies conducted by CPAI in the area near Nuiqsut.

Results of aerial surveys in the Colville Delta study area indicated that 2011 was an above-average year in terms of abundance for Spectacled and King Eiders, Yellow-billed Loons, Brant, and Snow Geese, Glaucous Gulls, and an average year for Tundra Swans. Productivity in the Colville Delta study area was generally high for geese, gulls, and loons, and average for swans. In the NE NPRA study area, 2011 was an above-average year in terms of abundance for Spectacled and King eiders and Snow Geese, an average year for Yellow-billed Loons and Tundra Swans, and possibly below average for Brant. Surveys were conducted in a more restricted portion the NE NPRA study area in 2011 when compared with previous years.

Spring conditions began with warmer than average temperatures in the last half of May and ended with colder than average temperatures in the first half of June. The mean monthly temperature for May 2011 on the Colville Delta was only 0.3° C below the 15-year mean temperature and June was 1.3° C colder than the long-term mean. Cumulative thawing degree-days (an index to days with temperatures above freezing) for the last half of May (11 thawing degree-days) were higher than

the long-term mean (7 days). However, by 15 June, only 17 thawing degree-days had accumulated, compared to the long-term mean of 38 thawing degree-days by the same date. Peak water levels in the Colville River occurred on 28 May, about 3 days earlier than the mean date. Snow disappeared from the tundra on 3 June. Ice was gone from all lakes by 4 July, 9 days earlier than in 2010.

The indicated number of pre-nesting Spectacled Eiders on the Colville Delta in 2011 was the highest recorded in 18 years. As in previous years, Spectacled Eiders were found primarily in the CD North subarea. Some of the highest counts of Spectacled Eiders have been recorded on the Colville Delta study area over the last 5 years, reversing the depressed numbers recorded in the early 2000s. Nonetheless, the long-term trend for Spectacled Eiders on the Colville Delta is similar to the long-term trend observed on the Arctic Coastal Plain, which is slightly negative but not significantly different from a slope of 0, indicating a stable population. During 2011, Spectacled Eiders in the NE NPRA were also at near record numbers, but as is typical, they occurred at about 25% of the density found on the Colville Delta study area, with the highest densities of eiders in NE NPRA occurring in the Alpine West subarea. Spectacled Eiders preferred 7 habitats on the Colville Delta study area: 3 coastal salt-affected habitats, 3 aquatic habitats, and 1 terrestrial habitat. Spectacled Eiders in the NE NPRA preferred 4 habitats, of which 3 were the same as those preferred on the Colville Delta.

During pre-nesting on the Colville Delta in 2011, King Eiders were more numerous than Spectacled Eiders and most of the King Eiders were in the Northeast Delta subarea. The density of King Eiders on the Colville Delta study area in 2011 was well above the long-term average. 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 surmise that King Eiders primarily use the Colville Delta as a stopover while moving to breeding areas to the east. In contrast, King Eiders breed in high numbers in the NE NPRA study area, and in 2011 they occurred at about twice the density on pre-nesting surveys in NE NPRA compared with the density in the Colville Delta study area.

Seventy-two Yellow-billed Loons were observed during the nesting survey in the Colville Delta study area in 2011, which was the highest number recorded during 17 years of surveys. A total of 29 Yellow-billed Loon nests were found in 2011. Six of the 29 nests were found during a survey that was conducted on 13 June, 1 week before the nesting survey. The number of nests found only during the nesting and monitoring surveys in 2011 (25 nests) was the fewest recorded during the last 7 years when both surveys were conducted.

In the NE NPRA study area, we counted 13 Yellow-billed Loon nests, 1 of which was found on the 13 June survey. The number of nests found in the Alpine West and Fish Creek Delta subareas was similar to previous survey years. In both the NE NPRA and Colville Delta study areas, high water levels on many lakes during the last half of June caused the flooding of some traditional nest sites. Of the Yellow-billed Loons affected by flooding, some nested late, after water levels had dropped, while other loons failed to nest.

Most Yellow-billed Loon nests hatched between surveys on 11 and 18 July, which is similar to the timing of hatch of most previous years when nest monitoring occurred. In the Colville Delta study area, 15 of the 25 nests found during the nesting and monitoring surveys hatched young for an apparent nesting success of 60%, which was similar to the 7-year mean (59.4%) . In the NE NPRA study area, 4 of 12 nests found during the nesting and monitoring surveys hatched young for an apparent nesting success of 33%, which was the lowest since nest monitoring surveys began in that area in 2008.

Despite low nest numbers on the Colville Delta in 2011, chick survival was high, producing a higher than average number of chicks at the end of monitoring. During the monitoring surveys immediately post-hatch in 2011, 15 Yellow-billed Loon pairs and 24 chicks (0.83 chicks/nest) were observed in the Colville Delta study area. In the NE NPRA study area, 4 pairs and 6 chicks were observed (0.46 chicks/nest). On the last brood monitoring survey on 12 September, 7 pairs in the Colville Delta study area each had 2 chicks and 5 pairs each had 1 chick (0.66 chicks/nest). In the NE NPRA study area, 1 pair retained 2 chicks and 3 pairs had 1 chick each (0.38 chicks/nest). Loon chicks in both study areas were 8–9 weeks old during the last monitoring survey and none were observed flying.

Twenty Yellow-billed Loon nests on the Colville Delta were monitored with time-lapse cameras. Nineteen loons left nests during camera installation. Six nests were monitored with cameras in the NE NPRA study area and 5 loons left nests during camera installation. All but 1 loon returned to their nests after camera installation and that loon lost its eggs to a Parasitic Jaeger while interacting with intruding loons on its lake. Apparent nesting success for camera-monitored nests on the Colville Delta and NE NPRA was 65% and 33%, respectively. Of the 7 nests that failed in the Colville Delta study area, 3 failures were attributed to predation by Glaucous Gulls, 1 to a Parasitic Jaeger, and 3 to red foxes. Of the 4 nests that failed in the NE NPRA study area, 2 were attributed to a Parasitic Jaeger and 1 to a Glaucous Gull; the predator at the remaining nest was not captured on camera images. Yellow-billed Loons at hatched nests exhibited slightly higher nest attendance than those at failed nests, spending 97.8% and 95.0% of monitored time on nests, respectively. Similar nest attendance was recorded at hatched and failed nests in the NE NPRA study area (98.3% and 94.8%, respectively). The cameras also documented partial predation at 1 nest and verified that chicks were present at another nest where no chicks were seen during weekly monitoring surveys.

Fifteen nests and 10 broods of Pacific Loons were counted incidentally during Yellow-billed Loon surveys in the Colville Delta study area in 2011. One nest and 1 brood of Red-throated Loons were seen during the same aerial surveys. In the NE NPRA study area, we counted 13 nests and 11 broods of Pacific Loons, but no Red-throated Loon nests or broods.

Swan productivity was average in 2011. Thirty-five Tundra Swan nests were found in the Colville Delta study area, which is close to the 18-year mean of 34 nests/year. The count of 29 swan broods in the Colville Delta study area in 2011 was a little higher than the long-term average of 25 broods. Apparent nesting success was 83%. The mean brood size of 2.8 young in 2011 was above average, and the 63 swan young counted on the delta approximated the long-term average production of 62 young/year. In the NE NPRA study area, 12 Tundra Swan nests were found in June and 10 broods were seen in August, for a success rate of 83%. Brood size averaged 1.9 young.

Brant and Snow Goose productivity was high in the Colville Delta study area in 2011. The total count for Brant during brood-rearing (1,986) was well above average, and the gosling count (765) was the fourth highest ever recorded along the survey route. Record numbers of Snow Geese were counted in the Colville Delta. The total count of Snow Geese (4,023) and the number of goslings (2,278) were each twice the previous records set in 2008. In the NE NPRA study area, 1,756 Brant (906 adults and 850 goslings) were recorded, representing a decline from the previous 2 surveys in 2008 and 2009. However, goslings comprised 48% of all Brant recorded, indicating good survival of goslings in 2011. A record 388 Snow Geese (142 adults and 246 goslings) were counted in the NE NPRA study area in 2011, well above the previous record in 2008. Brant and Snow Geese favored coastal salt-affected habitats for brood-rearing and molting in the Colville Delta and NE NPRA study areas.

The number of Glaucous Gull nests and broods in the Colville Delta study area in 2011 was the highest in 12 years of records. Sixty-four Glaucous Gull nests and at least 22 broods were counted incidentally during loon aerial surveys in the Colville Delta study area in 2011. More solitary nests were recorded in 2011 than in previous years while the number of gull nests at colony locations remained similar to previous years. Based on 50 lakes monitored annually in the Colville River study area, the number of Glaucous Gull nests increased significantly during the 10 years between 2002 and 2011.

In the NE NPRA study area, we found 24 Glaucous Gull nests and 7 broods in 2011. Nineteen of the 24 nests were in the Alpine West subarea, 16 of which were at 2 colony locations. Three Sabine's Gull colonies with a total of 24 nests were found in the NE NPRA study area during the loon nesting survey. No Sabine's Gull nests were found in the Colville Delta study area.

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INTRODUCTION

During 2011, ABR, Inc., conducted wildlife surveys for selected birds and mammals in the Colville River delta and Northeast Planning Area of the National Petroleum Reserve–Alaska (NE NPRA) in support of the Alpine Satellite Development Project (ASDP) of ConocoPhillips Alaska, Inc., (CPAI) and Anadarko Petroleum Corporation (APC). The wildlife studies in 2011 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; Burgess et al. 2000, 2002a, 2003a) and in the NE NPRA in 1999 (Anderson and Johnson 1999; Murphy and Stickney 2000; Johnson and Stickney 2001; Burgess et al. 2002b, 2003b; Johnson et al. 2004, 2005, 2006b, 2007b, 2009, 2010, 2011). Avian surveys in the NE NPRA were interrupted in 2007 due to delays in permitting for the CD-5 drill site. Permits for CD-5 still were unapproved in 2010; consequently, surveys were conducted in NE NPRA 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 Yellow-billed Loons, but those surveys were conducted only in the eastern portion of the 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. 2012, Lawhead and Prichard 2012). 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 in 2000 with the development of the CD-1 and CD-2 drill sites. Production was augmented in 2006 with construction of the CD-3 and CD-4 drill sites. CPAI has proposed additional oil and gas development sites in NE NPRA as part of the Alpine Satellite Development Project (BLM 2004) at CD-5 (Alpine West) (Figure 1). Readers are directed to prior reports for wildlife information from previous years.

We report here the results of avian surveys in 2011 that were conducted in the Colville River delta and NE NPRA. Surveys in 2011 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. Monitoring a collection of focal species provides in-depth data on individual species trends and responses to a changing environment, as well as a general overview of ecosystem health. Data collection for a suite of indicator species with diverse life histories and habitat needs is an efficient way to monitor a multi-species system without studying all species that breed in the study area. Ground-based surveys for nesting birds were conducted in select areas on the Colville River delta in 2011 as part of other studies (Seiser and Johnson 2011b). Required state and federal permits were obtained for authorized survey activities, including a Scientific or Educational Permit (Permit No. 11-009) from the State of Alaska and a Federal Fish and Wildlife Permit—Threatened and Endangered Species [Permit No. TE012155-0 issued under Section 10(a)(1)(A) of the Endangered Species Act (58 FR 27474-27480)]. Similar avian species were monitored in the Kuparuk Oilfield on the eastern border of the Colville River delta in 2011 (Stickney et al. 2012). CPAI supported other avian research on the Arctic Coastal Plain in 2011 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 NPRA areas. CPAI attends Kuukpik Corporation board meetings annually to share information on activities on the Colville River Delta and in NE NPRA. 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. In 2009, CPAI flew the late Joeb Woods, Sr., and Lydia Sovalik, 2 elders from Nuiqsut, and James Taallak as facilitator, to meet with biologists in the study site near Fiord West on 3 July. 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. During the summer field season in 2011, CPAI emailed weekly updates to the Department of Wildlife of the North Slope Borough, various state and federal agencies, several environmental organizations, and key representatives of the Kuukpik Subsistence Oversight Panel (KSOP) and 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. The open house meetings and weekly updates kept local residents informed on the progress and results of studies conducted by CPAI in the area near Nuiqsut.

STUDY AREA

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

COLVILLE DELTA

The Colville River delta (henceforth, Colville Delta) is one of the most prominent and important landscape features on the 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 full-production facility including a processing

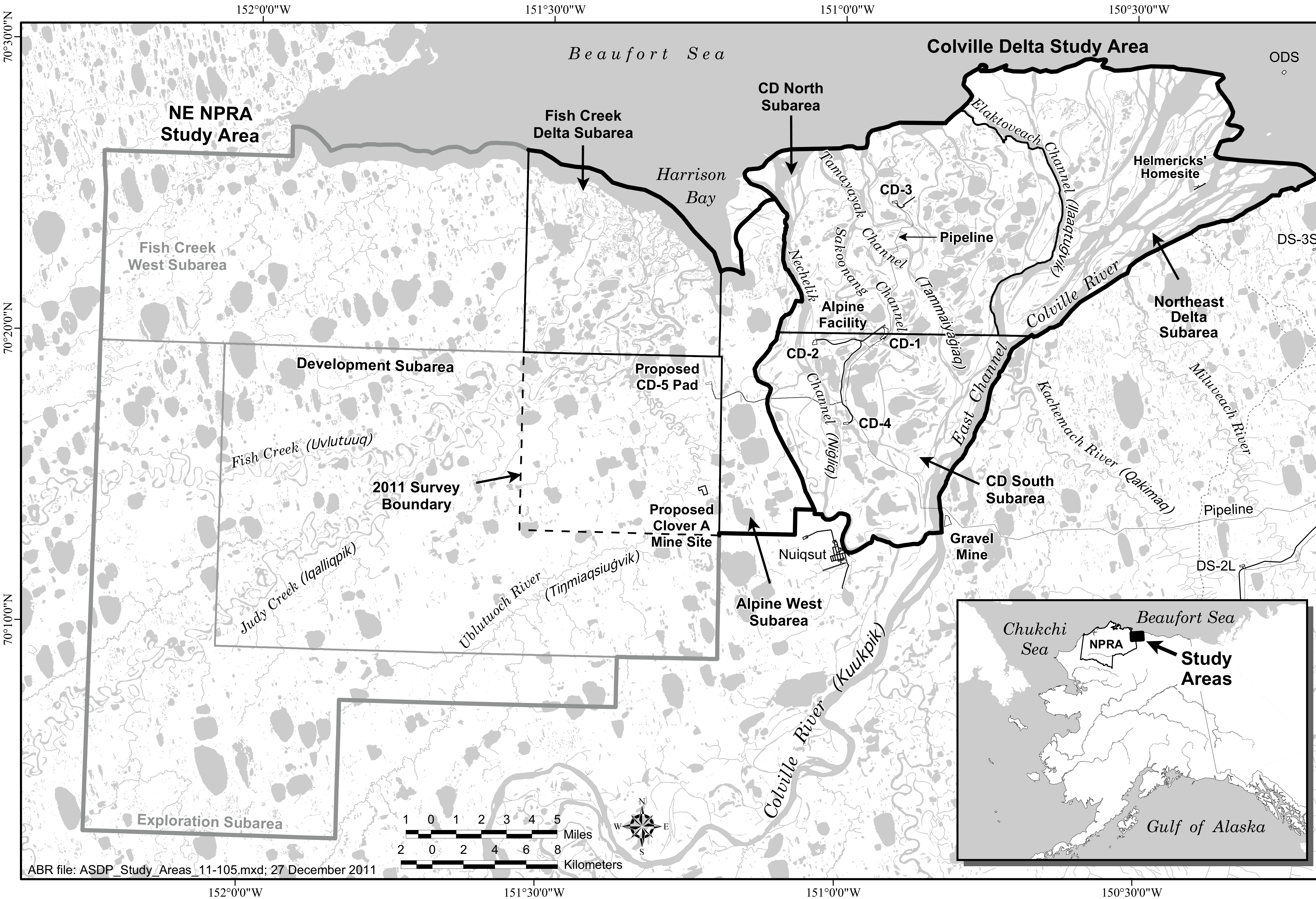

Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2011.

plant, camp, airstrip, and the CD-1 and CD-2 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 CD-3 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 CD-4 satellite is connected to Alpine by an all-season road. Both the CD-3 and CD-4 drill sites began producing oil in 2006.

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

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 comprise 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) are unique to the delta environment and also are important to the physical and biological diversity of the delta, although they occupy slightly less than 8% of the total area. Other important habitats for birds are those that contain emergent aquatic vegetation (Deep Polygon Complex, Grass Marsh, and Sedge Marsh) and waterbodies with islands 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 <5% of the delta. Wildlife habitat types are described 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, Patterned Wet Meadow, Moist Sedge–Shrub Meadow, and the non-halophytic shrub types are more prevalent away from the coast. These patterns of habitat distribution have strong effects on the distribution and abundance of various wildlife species in the delta.

As mentioned above, lakes and ponds are dominant physical features of the Colville Delta. The most abundant waterbodies on the delta are polygon ponds, which generally are shallow (i.e., ≤2 m deep), freeze to the bottom during winter, and thaw by June. Deep ponds and lakes (>2 m deep) with steep, vertical sides are more common on the delta than in adjacent areas of the 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 until the first half of July (Walker 1978). Several other types of lakes occur on the delta, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, thaw lakes, and tapped lakes (Walker 1983). Tapped lakes are connected to the river by narrow channels that result from 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 staging habitat for migrating waterfowl in that season (Rothe et al. 1983).

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

Table 1. Habitat availability in the Colville Delta and the NE NPRA study areas, Alaska, 2011.

Habitat	Colville Delta		NE NPRA[a]	
	Area (km²)	Availability (%)	Area (km²)	Availability (%)
Open Nearshore Water	10.12	1.8	22.49	2.7
Brackish Water	6.55	1.2	9.50	1.1
Tapped Lake with Low-water Connection	22.28	4.0	6.20	0.7
Tapped Lake with High-water Connection	20.77	3.8	4.87	0.6
Salt Marsh	16.31	3.0	16.51	2.0
Moist Halophytic Dwarf Shrub	0.14	<0.1	0.44	0.1
Dry Halophytic Meadow	0	0	0.21	<0.1
Tidal Flat Barrens	58.42	10.6	16.63	2.0
Salt-killed Tundra	25.63	4.6	6.49	0.8
Deep Open Water without Islands	18.42	3.3	50.71	6.1
Deep Open Water with Islands or Polygonized Margins	9.55	1.7	42.49	5.1
Shallow Open Water without Islands	2.01	0.4	7.77	0.9
Shallow Open Water with Islands or Polygonized Margins	0.54	0.1	13.37	1.6
River or Stream	82.79	15.0	10.28	1.2
Sedge Marsh	0.13	<0.1	13.64	1.6
Deep Polygon Complex	13.17	2.4	0.35	<0.1
Grass Marsh	1.44	0.3	2.38	0.3
Young Basin Wetland Complex	<0.01	<0.1	2.67	0.3
Old Basin Wetland Complex	0.14	<0.1	64.76	7.8
Riverine Complex	0	0	2.81	0.3
Dune Complex	0	0	8.07	1.0
Nonpatterned Wet Meadow	41.50	7.5	24.33	2.9
Patterned Wet Meadow	102.45	18.6	90.44	10.9
Moist Sedge–Shrub Meadow	12.25	2.2	173.74	20.9
Moist Tussock Tundra	3.24	0.6	205.17	24.7
Moist Tall Shrub	0	0	1.02	0.1
Moist Low Shrub	27.10	4.9	10.68	1.3
Moist Dwarf Shrub	0	0	4.83	0.6
Dry Tall Shrub	0	0	1.71	0.2
Dry Dwarf Shrub	0.47	0.1	7.25	0.9
Barrens	76.11	13.8	8.66	1.0
Human Modified	0.66	0.1	0	0
Subtotal (total mapped area)	552.19	100	830.50	100.0
Unknown (unmapped areas)	0		740.65	
Total	552.19		1,571.15	

[a] Habitat availability of the entire NE NPRA study area. See species tables for habitat availabilities in the areas surveyed in 2011.

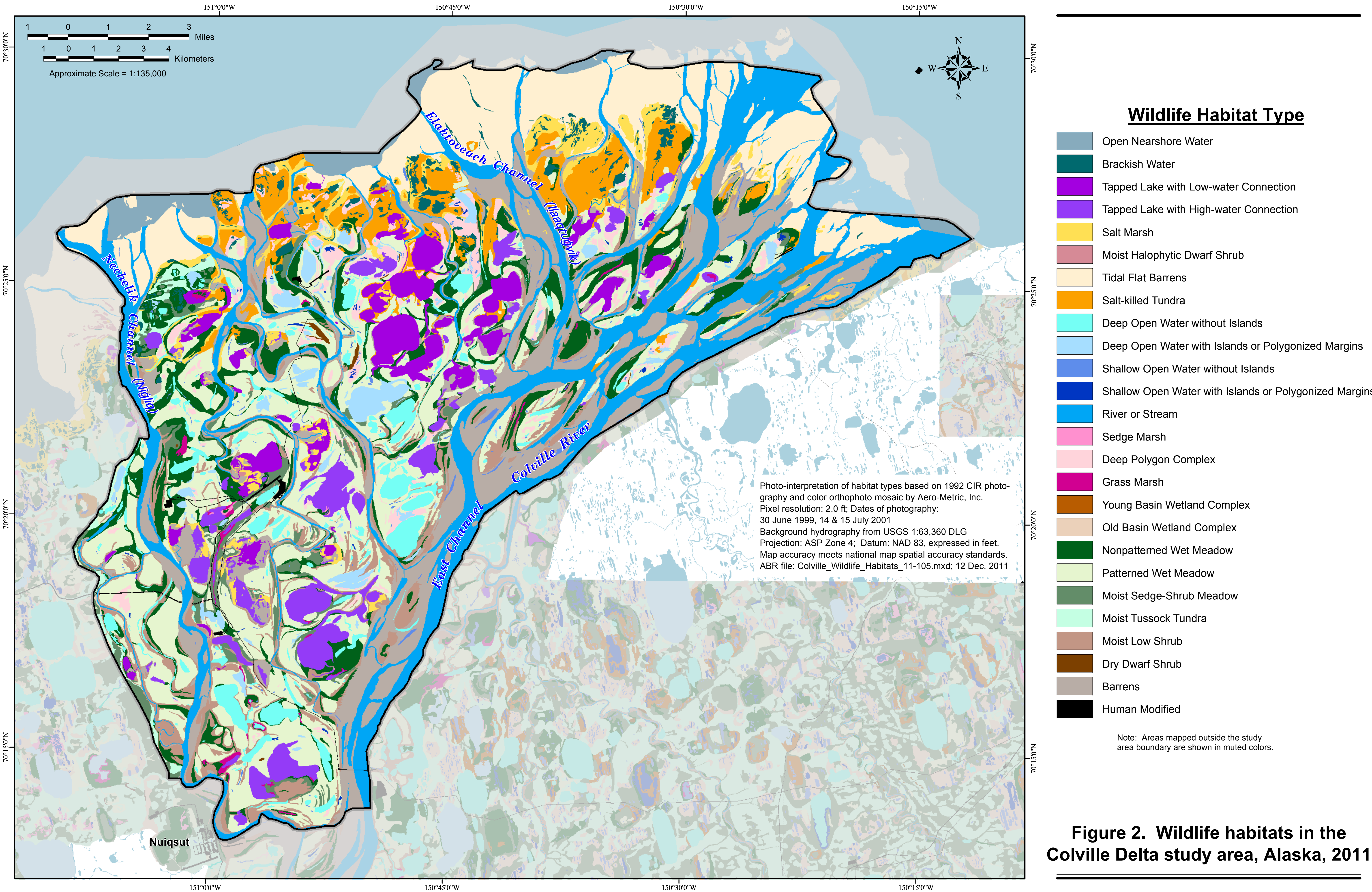

Figure 2. Wildlife habitats in the Colville Delta study area, Alaska, 2011

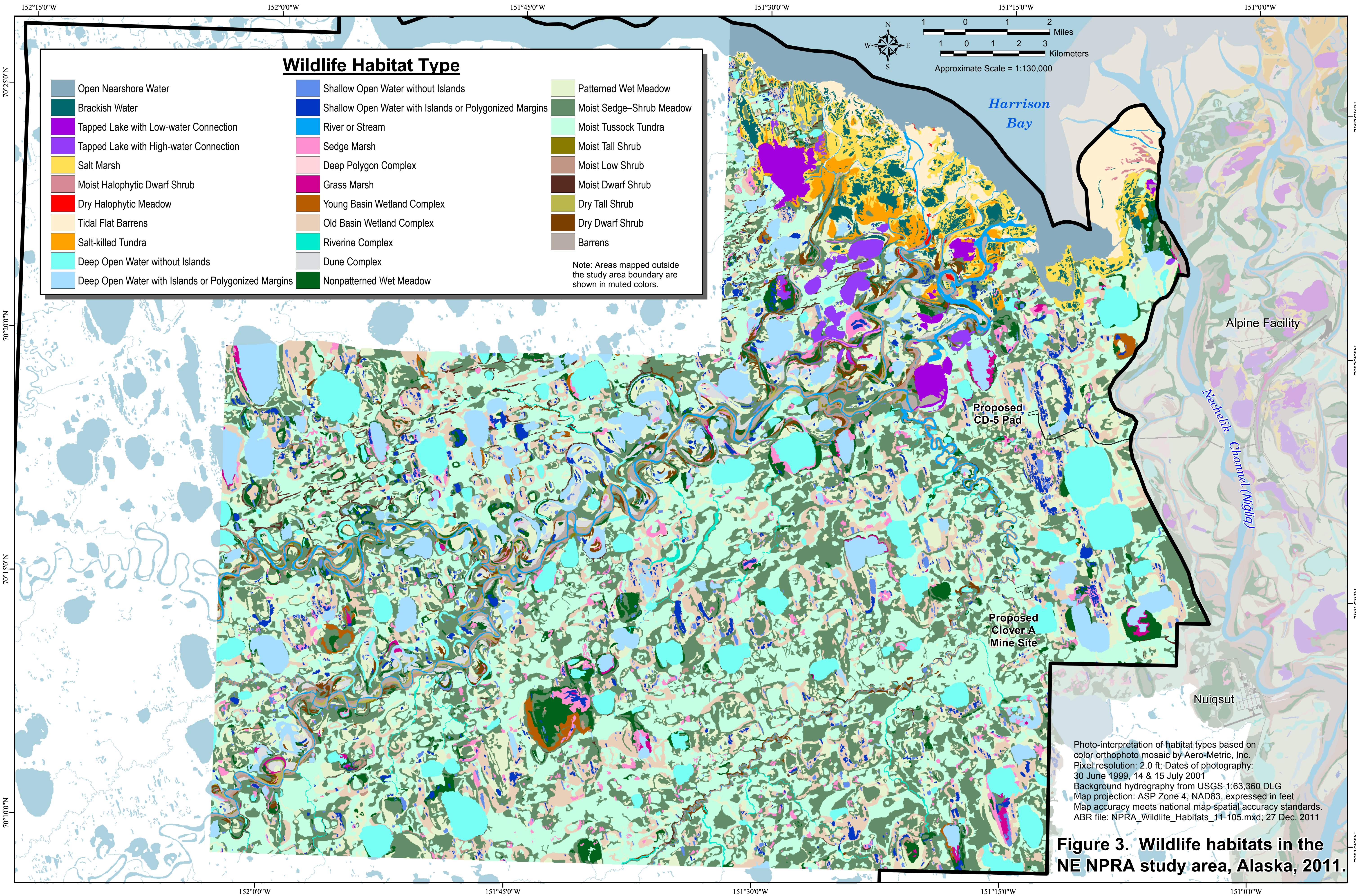

Figure 3. Wildlife habitats in the NE NPRA study area, Alaska, 2011.

the westernmost distributary of the Nechelik (Niġliq) Channel and inland to the juncture of these channels.

NE NPRA

The NE NPRA study area (1,571 km²) abuts the western edge of the Colville Delta and comprises 5 subareas, which are useful subdivisions for comparisons with past years: the Development, Exploration, Alpine West, Fish Creek Delta, and Fish Creek West subareas (Figure 1). The NE NPRA study area is located 6–39 km west of the village of Nuiqsut and 1–43 km west of the Alpine Facility. The NE NPRA study area encompasses 2 proposed development sites (CD-5 and the Clover A mine site) and exploration sites that may be proposed for development in the future. The CD-5 pad will connect to the Alpine Facility near CD-4 by an all-season gravel road and a bridge across the Nigliq channel (Figure 1). In 2011, avian surveys were conducted in the eastern portions of the NE NPRA study area; the Fish Creek Delta and Alpine West subareas were surveyed in their entirety, whereas only the northeast corner was surveyed in the Development subarea. Neither the Fish Creek West nor the Exploration subareas were included in the avian studies in 2011.

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

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

Six of the 31 wildlife habitats identified in the NE NPRA study area are not present on the Colville Delta study area (Figure 3, Table 1). Three habitats dominate the NE NPRA landscape: Moist Tussock Tundra (25% of area), Moist Sedge–Shrub Meadow (21%), and Patterned Wet Meadow (11%; Table 1). Aquatic habitats comprise 29% of the study area. Although the NE NPRA study area includes some coastal habitats in the Fish Creek Delta, they are much less abundant than in the adjacent Colville Delta (Table 1). Riparian habitats also are much less common in the NE NPRA than they are on the Colville Delta.

Like the Colville Delta, the NE NPRA is an important area for wildlife and for subsistence harvest activities. The NE NPRA supports a wide array of wildlife, providing breeding habitat for geese, swans, passerines, shorebirds, gulls, and predatory birds, such as jaegers and owls. The Fish Creek and Judy Creek drainages in the NE NPRA 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, Johnson et al. 2009, 2010, 2011).

METHODS

Aerial surveys are the primary means for collecting data on bird species using the Colville Delta and NE NPRA because of the large size of the study areas and the short periods of time that each species is at the optimal stage for data collection. In 2011, 4 aerial surveys were conducted using fixed-wing aircraft: 1 for Spectacled Eiders (pre-nesting), 2 for Tundra Swans (nesting and brood-rearing), and 1 for geese (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). Fourteen aerial surveys (1 per week) for loons were conducted from a helicopter, targeting specific

Table 2. Avian surveys conducted in the Colville Delta and the NE NPRA study areas, Alaska, 2011.

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	10, 13, 14 June	C185	0.4	0.4	30–35	100% coverage
NE NPRA	1	10, 11, 13–15 June	C185	0.4	0.8	30–35	50% coverage
Yellow-billed Loon surveys[b]							
Nesting	2	13 June and 20–22 June	206L	–	–	60-75	All lakes ≥5 ha and adjacent lakes
Brood-rearing	1	15 Aug.	206L	–	–	60–90	Yellow-billed Loon territory lakes
Nest and brood monitoring	12 (1/week)	27 June–12 Sept.	206L	–	–	60–90	Lakes with active nests and broods
Tundra Swan surveys							
Nesting	1	22–25 June	C185	1.6	1.6	150	100% coverage
Brood-rearing	1	16–17 Aug.	C185	1.6	1.6	150	100% coverage
Goose surveys							
Brood-rearing	1	28 July	PA-18	–	–	75–150	Coastal and lake-to-lake pattern

[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

lakes suitable to Yellow-billed Loons. The NE NPRA study area was surveyed in 2011 for eiders, loons, swans and geese, but the area surveyed was reduced from that in 2010 to the Alpine West and Fish Creek Delta subareas and the northeastern corner of the Development subarea (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. 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 taken in 2004–2010 (Colville Delta and Alpine West subarea in NE NPRA, by AeroMetric, Inc.), 2-ft resolution natural color imagery taken in 1999–2004 (Development Area and Fish Creek Delta subareas in NE NPRA, by AeroMetric, Inc.), or 8.2-ft resolution color infrared imagery taken in 2002 (Fish Creek West and Exploration subareas in NE NPRA, by USGS). Plotted bird locations 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.

EIDER SURVEYS

Regional abundance, distribution, and habitat selection of Spectacled and King eiders (other eider species are seen infrequently), were evaluated with data collected on 1 aerial survey flown during the pre-nesting period (Table 2), when male eiders (the more visible of the 2 sexes in breeding plumage) were still present on the breeding grounds. The pre-nesting survey in 2011 covered the same areas surveyed in 2010 and prior years in the Colville Delta. In the NE NPRA study area, the survey area was contracted eastward from the survey boundary in 2010 (Figure 4). The pre-nesting survey was conducted 10–15 June using the same methods that were used on the Colville Delta in 1993–1998 and 2000–2010 and in the NE NPRA study area in 1999–2006, 2008, and 2010, 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; 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. A Global Positioning System (GPS) receiver was used to navigate pre-determined east–west transect lines that were spaced 800 m apart (50% coverage) in the NE NPRA study area and 400 m apart (100% coverage) over the Colville Delta study area (Figure 4). The lower coverage in the NE NPRA is intended to sample the larger area with its lower densities of Spectacled Eiders relative to the Colville Delta study area. An observer (in addition to the pilot) counted eiders in a 200-m-wide transect on each side of the airplane. 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), an ~1.6-km-radius circle around the Helmericks' homesite, and the extreme southern 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 tape 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).

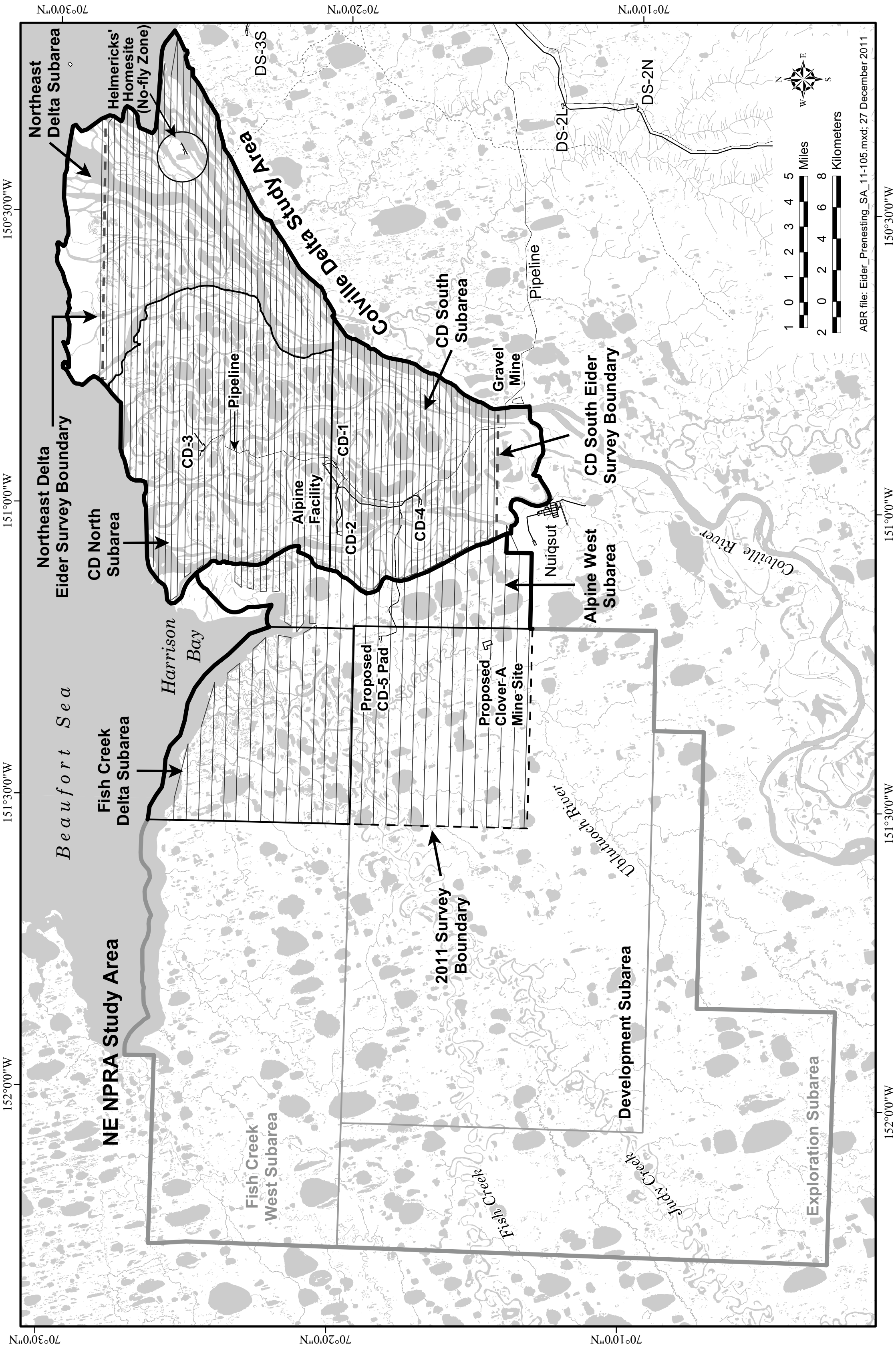

Figure 4. Transect lines for aerial surveys of pre-nesting eiders, Colville Delta and NE NPRA study areas, Alaska, 2011.

LOON SURVEYS

One aerial survey for nesting Yellow-billed Loons and 1 for brood-rearing loons have been conducted on the Colville Delta for 17 years since 1993, including 2011. Surveys were not conducted in 1994 and 1999. The CD North and CD South subareas were surveyed in each of the 17 survey years and part of the Northeast Delta subarea was surveyed in all survey years except 2000. The number of lakes surveyed increased between 1993 and 2011 because of a small expansion in the study area in 2002 to include the lakes between the NPRA eastern boundary and the Nechelik Channel, and because the minimum size of lakes surveyed in 2008 was reduced from 10 ha to 5 ha. In 2011, a total of 169 lakes were surveyed on 20–22 June and 15 August on the Colville Delta for nesting and brood-rearing Yellow-billed Loons (Figure 5, Table 2).

Surveys for nesting and brood-rearing Yellow-billed Loons in the NE NPRA began in 2001 and have occurred in all years since then except for 2007. During 10 years of surveys, 5 different subareas have been surveyed for loons in the NE NPRA study area: the Development subarea was surveyed in 2001–2004, the Exploration subarea in 2002–2004, the Alpine West subarea in 2002–2006 and 2008–2011, and the Fish Creek Delta subarea in 2005–2006 and 2008–2011 (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. In 2008–2010, the entire Fish and Judy Creek Corridor subarea was surveyed along with 4 Yellow-billed Loon territories identified during surveys in previous years in the Development and Exploration subareas. In 2011, just the eastern quarter of the Fish and Judy Creek Corridor subarea was surveyed for Yellow-billed Loons, along with the Alpine West and Fish Creek Delta subareas (Figure 5).

Each year the nesting survey was conducted during 20–30 June and the brood-rearing survey during 15–27 August. In 2011, an additional survey for nests was conducted on 13 June, 1 week prior to the nesting survey, to document early nesting phenology and nest survival. During the 13 June survey in 2011, only lakes where Yellow-billed Loons 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 2000–2011. 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 2008–2011. We reduced the minimum survey lake size to 5 ha and larger 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 a larger lake that is 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).

Incidental observations of Pacific (Malbi) and Red-throated loons (Qaqsrauq) were recorded 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 2003–2011. In 2005–2011, Yellow-billed Loon nest locations also were marked on high resolution color images of nest site areas (~1:1,500). Each year, all loon locations were digitized into a GIS database.

The total numbers of adults, nests, broods, and young counted on aerial surveys were summarized for each species of loon. Densities of adults, nests, 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. The number and density of Yellow-billed Loon adults, young, nests, and broods recorded during surveys from previous years were

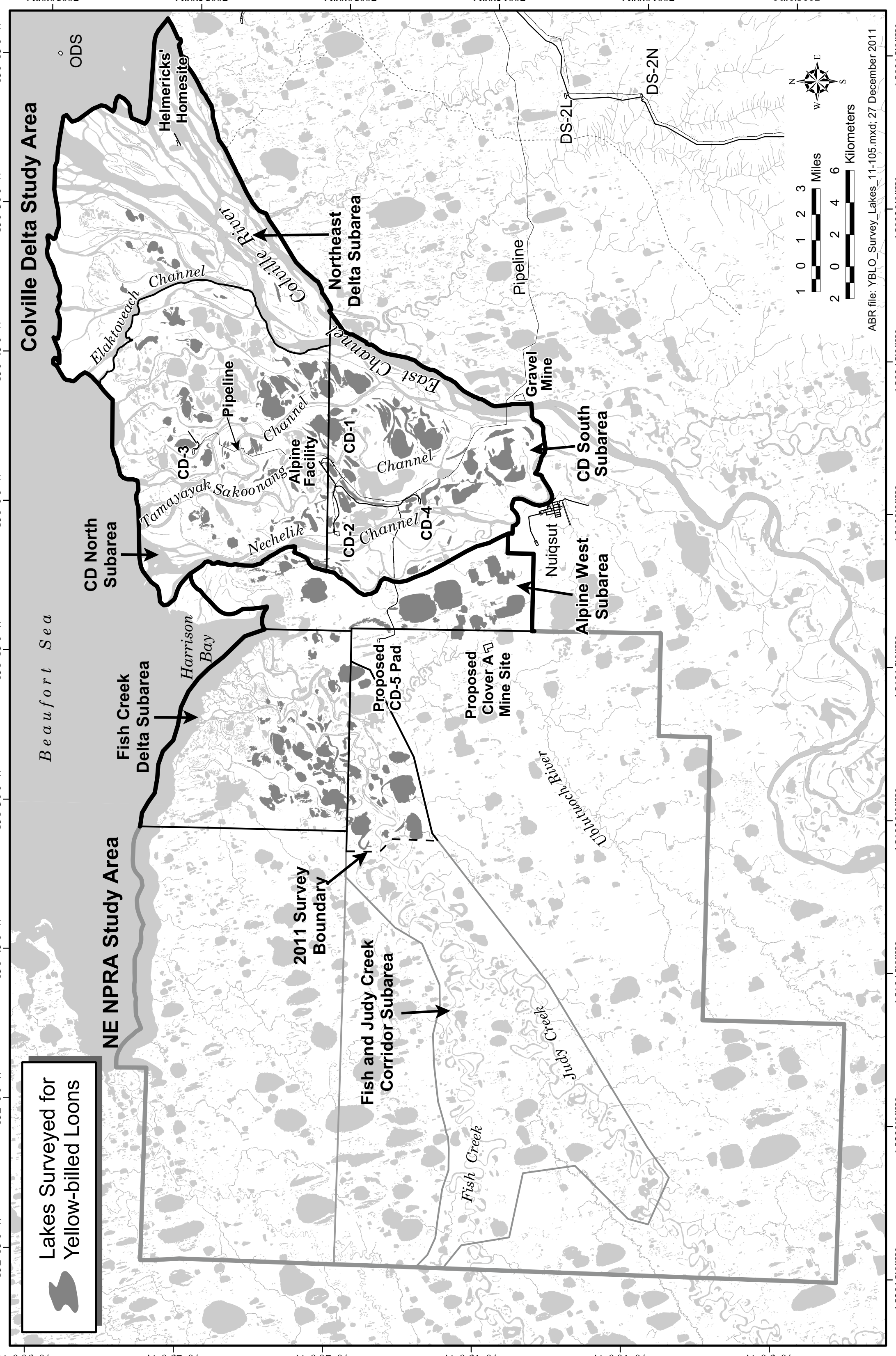

Figure 5. Lakes included in aerial surveys for Yellow-billed Loons, Colville Delta and NE NPRA study areas, Alaska, 2011.

summarized to compare annual differences. Counts of adults, young, nests, and broods are presented from nesting and brood-rearing surveys, and additionally, from nests and broods that were found during ground, revisit, and monitoring surveys. Ground surveys mostly occurred near drill sites and facility areas and were conducted in 1992–2007 in the Colville Delta study area and 1999–2004 and 2009 in the NE NPRA study area. Revisit and monitoring aerial surveys occurred after the nesting survey, and these surveys typically included all lakes used for breeding in the current or past years. Revisit surveys were conducted in 1996–1998 and 2000–2002 and consisted of 1 or more surveys that took place anywhere from 3to 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 and other lakes where Yellow-billed Loons were observed during the nesting survey were surveyed weekly for 2 weeks after the nesting survey to find nests that were initiated later or were missed on previous surveys. To make annual comparisons among years when different numbers of territories were sampled, territory occupancy was calculated by dividing the number of territories with nests, adults, or broods by the total number of territories surveyed. Additionally, to adjust counts of adults, nests, and young for the number of territories surveyed, counts were divided by the number of territories surveyed and multiplied by 43, the number territories surveyed for the last 3 years. Annual growth rates for adults, nests, and young were calculated with linear regression on adjusted counts with natural logarithm transformations for the period from 2000–2011, when helicopters were used for all surveys.

NEST MONITORING AND NEST FATE

Weekly monitoring surveys were conducted in the Colville Delta and NE NPRA study areas in 2005–2011 to monitor 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 lakes 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. Nests were assumed inactive when adults were no longer incubating and eggs were absent from the nest. When a nest appeared inactive, the nesting lake was immediately searched for a brood by scanning 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 camera images on survey dates were used to determine nest status each week. The weekly status of camera-monitored nests was determined from the camera images taken at 14:00 on the day of the monitoring survey. That time 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 egg floatation data.

Inactive nests were visited on the ground to inspect their contents and to confirm nest fate. The nest and the surrounding area within 5 m, including the water adjacent to the nest, were examined closely for the presence of 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. 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. Egg fragments were used in addition to the presence of broods to classify nest fate because some broods may not survive the period between hatch and the following monitoring survey. If egg fragments were found, they were counted and, based on the length of their longest side, placed into 3 approximate size categories: 1–10, 11–20, and 21–30 mm. Egg membranes or pieces of membranes also were counted and measured.

TIME-LAPSE CAMERAS

We deployed digital time-lapse cameras at 20 Yellow-billed Loon nests in the Colville Delta study area and 6 in the NE NPRA study area, primarily to monitor nest survival and, secondarily, to summarize nest attendance patterns and identify causes of nest failures. We used 3 models of Silent Image® Professional cameras: 8 PM35 cameras with custom 8× telephoto lens and 640 × 480 pixel photos, and 9 each of PC85 and PC800 cameras with custom 2.5× and 2× telephoto lens and 3.1 megapixel photos (Reconyx, Lacrosse, WI). We attempted to install cameras at all of the nests that were active 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. Cameras were installed within 1–12 d of nest discovery. 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 picture every 60 sec. The PC85 and PC800 cameras were equipped with 32-GB memory cards and programmed to take 1 picture every 30 sec. All cameras were run on 12V external sealed lead acid batteries. Settings, memory cards, and power were chosen so that we could take the maximum number of photos possible for 23–27 d without requiring maintenance (e.g., battery or memory card changes). Cameras were removed when nests were no longer active.

We reviewed digital images on personal computers with Irfanview software (version 4.2.0). Loon activity was classified into 4 major classes of activity: incubation, break, incubation exchange, 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), preening on the nest, 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, sitting beside the nest, standing over the nest, and rolling eggs. Recess activities were absences from the nest and those activities immediately preceding and following the recess, including egg moving, swimming beside the nest, flying, and gone from view. We identified predators in camera views to species, estimated their distance from the nest, and described their behavior.

Nest images were reviewed from the day of camera set-up through nest failure or when the loons and their young were observed leaving the nest. Day of hatch was defined as occurring when the first chick was seen at the nest. The day of nest failure was the last date on which adults were observed attending a nest at which chicks were not seen.

Nest initiation dates were estimated for successful nests by subtracting 28 d from the day of hatch. Twenty-eight days is the reported incubation period for Yellow-billed Loons (North 1994), which begins with laying of the first egg. For failed nests, we estimated nest initiation dates using an egg-floatation schedule that we developed from known-age Yellow-billed Loon nests in 2008–2011 (using a method developed for Semipalmated Sandpipers by Mabee et al. [2006]). During visits to Yellow-billed Loon nests to set up cameras in 2008–2011, we floated eggs in water and recorded the position of the egg in the water column (on the bottom [all eggs in 2011], suspended in the water column, or on the surface), measured the angle between the central axis of the egg and the water surface (from 0° when egg is first laid to a maximum of 90° when the egg is upright in the water column), and estimated the percent volume of the egg above the surface (none in this study). For nests that were observed hatching on camera images in 2008–2011 (known-age nests; n = 31 nests), the clutch age on the day of egg floating was determined by backdating from hatch date to the day the eggs were floated. The relationship between the float angle and clutch age was plotted, and the correlation provided an egg-floatation schedule that could be used to estimate nest initiation date ± 2 days. For nests with 2 eggs, an average of the float angle or position of the 2 eggs was used for dating.

The number of days monitored and incubation statistics (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

Weekly brood monitoring surveys were conducted after hatch in the Colville Delta (2008–2011) and NE NPRA (2009–2011) study areas to estimate chick survival and document juvenile recruitment of Yellow-billed Loons. Brood-monitoring surveys were flown in a manner similar to the brood-rearing survey described above. We surveyed all lakes known to have pairs with nests or broods by flying above the shoreline and scanning for loons on the water. If no young were seen, 2–3 additional flights were conducted around the lakes, and for some large lakes, a flight 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 also are likely to hide in shoreline vegetation. When these conditions occurred, brood detection was reduced, and any lake with such conditions was resurveyed the following week, regardless of the lake's observation history. Brood locations were hand-mapped and the number of adults and young was recorded.

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 added half of the interval between the date of first observation and the previous monitoring survey. Similarly, to account for the number of days the brood was alive after its last observation, we added one-half of the interval between the date of its last observation and the subsequent monitoring survey. In the case of a typical 7-day interval between surveys, each chick was assumed to be 4 days old when first observed, and the date of death was assumed to be 4 days 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 photos often revealed additional chicks at hatching that were not subsequently 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

One aerial survey for nesting Tundra Swans was flown 22–25 June and 1 aerial survey for brood-rearing Tundra Swans was flown 16–17 August 2011 (Table 2). With the exception of an area within an approximately 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 NPRA study areas (Figure 6). The surveys were conducted in accordance with USFWS protocols (USFWS 1987b, 1991). East–west transects spaced 1.6 km apart were flown in a Cessna 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%

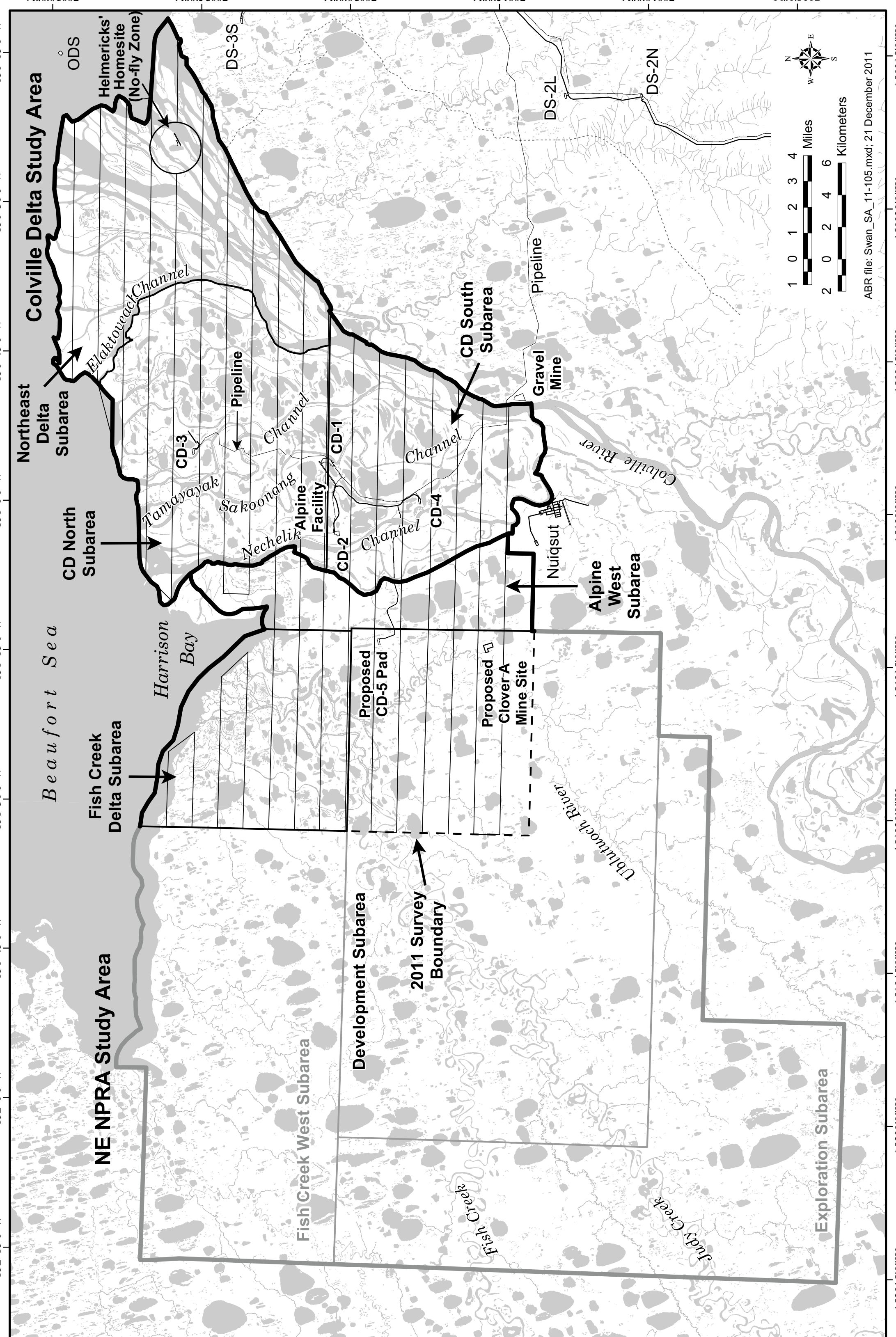

Figure 6. Transect lines for aerial surveys of nesting and brood-rearing Tundra Swans, Colville Delta and NE NPRA study areas, Alaska, 2011.

coverage of the surveyed area. Locations and counts of swans and their nests were recorded on color photomosaics (1:63,360-scale). Each nest on the Colville Delta was photographed 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 each subarea. Apparent nesting success was estimated from the ratio of broods to nests counted during aerial surveys only. The accuracy of these estimates can be affected by differential detection, predation, and movements of broods; therefore, the calculated estimates of nesting success should be considered relative indices.

GOOSE SURVEYS

One survey for brood-rearing and molting Brant and Snow Geese was conducted on 28 July 2011 in the coastal zone of the Colville Delta and NE NPRA study areas (Table 2). 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 7). One pilot and 1 observer searched appropriate habitats along the coast, rivers, channels, and lakes. The numbers of adults and young Brant and Snow Geese were recorded and their locations were saved on a GPS receiver. Geese in small groups (<50) were counted visually from the airplane, whereas larger groups were counted on photographs taken with a Canon EOS 40D digital SLR camera (10.1 megapixel) equipped with a 17–85 mm image-stabilizing lens.

GULL SURVEYS

Glaucous Gulls were recorded during the nesting and brood surveys conducted for Yellow-billed Loons in the Colville Delta and NE NPRA study areas in 2011 (see Loon Surveys, above, for methods). Nests and broods were recorded incidentally as they were encountered and traditional nest locations within the study areas, including colony sites, were checked for activity. We considered a collection of 3 or more Glaucous Gulls nests occurring in close 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 small size compared to Glaucous Gulls; therefore, the number of Sabine’s Gulls nesting in the study areas is underestimated, because colony locations rather than single nesting pairs comprise most of the observations. At colonies, nest counts were estimated by dividing the number of Sabine’s Gulls by 2. 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.

Fifty lakes surveyed annually since 2002 during the nesting survey for Yellow-billed Loons in the Colville Delta study area were chosen 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 for the 10 years during 2002–2011 and serves as an index of 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 its coordinates on the wildlife habitat maps (Figures 2 and 3). Several habitats were merged, based on similar composition or physiography and low areal coverage, to reduce the number of classes. For example, Moist Halophytic Dwarf Shrub (≤0.1% of both study areas; Table 1) was merged into Salt Marsh, Dry Halophytic Meadow (<0.1% of NE NPRA) 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 species, habitat use (% of all observations in each identified habitat type) was determined separately for various seasons (e.g.,

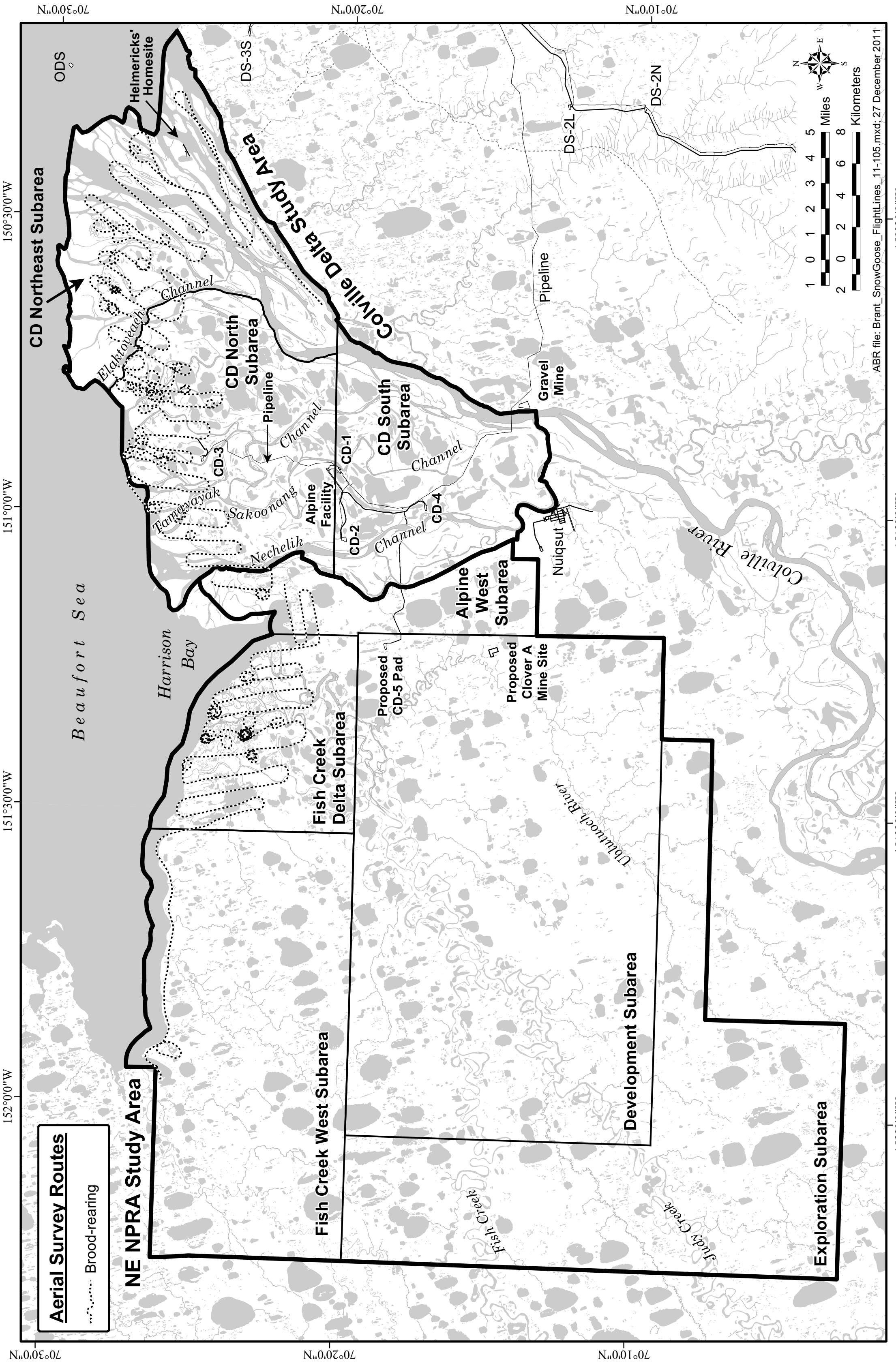

Figure 7. Flight lines for aerial surveys of brood-rearing Brant and Snow Geese, Colville Delta and NE NPRA study areas, Alaska, 2011.

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 could not be assumed to have independent location, habitat use, or habitat selection (i.e., a few large groups could bias results).

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

Habitat selection was evaluated for the following species and seasons:

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

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

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

DATA MANAGEMENT

All data collected during surveys for CPAI were compiled into a centralized database following CPAI's GPS/GIS Data Management Protocols, North Slope, Alaska, Version 7.4 (CPAI 2011). 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

During the period of waterfowl arrival and peak nest initiation (15 May–15 June) birds returning to the Colville Delta and NE NPRA experienced warm conditions in late May followed by cooler weather in June. Spring temperatures started warm but then cooled in early June. Between mid-May and mid-June 2011 only 17 thawing degree-days were accumulated, far below the 15-year mean of 38 cumulative thawing degree-days. Most of the thawing degree days in 2011were accumulated from 15–31 May (11 thawing degree-days), and the total was more than the long-term mean (7 thawing degree-days) for this period (Figure 8). The mean temperature in May 2011 (–5.9 ± 1.2° C [mean ± SE]) was similar to the 15-year mean (–5.6 ± 0.6° C), but the mean temperature in June 2011 (2.1 ± 0.7° C) was colder than the 15-year mean (3.4 ± 0.4° C).

The snowmelt volume the Colville River received from the Brooks Range was average but warm temperatures caused increased runoff in late May (National Weather Service, http://aprfc.arh.noaa.gov/data/breakup.php). The 25 cm of snow present at Colville Village on 15 May melted away by 3 June 2011, 2 days before the mean snow-free date (5 June ± 2 days [mean ± SE]). Peak water level of the Colville River occurred on 28 May 2011, 3 days ahead of the mean date of peak water level (24-year mean, Michael Baker, Jr. Inc. 2011). Peak discharge rate in 2011 (590,000 cfs) was the highest recorded in the last 20 years, but this level was not sustained once ice jams released (Michael Baker, Jr., Inc. 2011). River ice at Colville Village began to move on 29 May and the river was clear of ice by 1 June , when water levels dropped (National Weather Service, http://aprfc.arh.noaa.gov/data/breakup.php).

During the eider pre-nesting surveys on 10 June 2011, ice cover in polygon ponds and small shallow lakes was variable and patchy, while deep lakes were mostly ice-covered. Deep lakes in the Colville Delta and NE NPRA study areas dropped from ~90% ice cover on 13 June, to ~65% ice cover on 22 June, to ~20% ice cover on 27 June. All lakes were ice-free by 4 July. Observers on the Yellow-bill Loon nest surveys noted lake water levels were relatively high and many traditional nest sites were unavailable during 20–22 June. High numbers of mosquitos were first noticed on 27 June.

EIDERS

Four species of eiders may occur in the ASDP study areas, 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 NPRA study areas, the Spectacled Eider has received the most attention because it was listed as "threatened" in 1993 (58 FR 27474) 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,

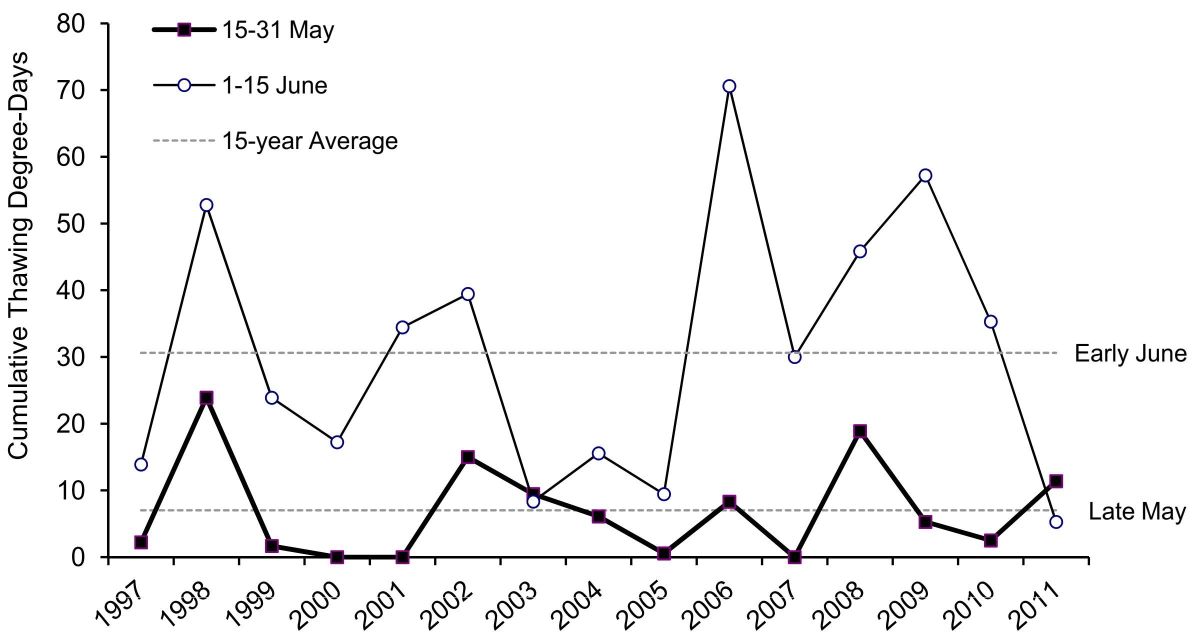

Figure 8. Cumulative number of thawing degree-days recorded 15 May–15 June at Colville Village, Colville Delta, Alaska, 1997–2011.

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 NPRA study area (Burgess et al. 2003a, 2003b; Johnson et al. 2004, 2005). The King Eider is more widespread and generally more numerous than the Spectacled Eider, although their relative abundance varies geographically. Steller's Eiders (also a threatened species, listed in 1997) are rare on the Colville Delta and NE NPRA study areas as these areas are outside their current range. Both study areas are within the range of Common Eiders, but they nest primarily on barrier islands and coastlines and are seen rarely on surveys of the Colville Delta and NE NPRA study areas.

SPECTACLED EIDER

Colville Delta

Distribution and Abundance

The indicated total of Spectacled Eiders recorded during pre-nesting aerial surveys in 2011 was the highest recorded on the Colville Delta and second highest recorded in the CD North subarea in 18 years (Figure 9, Table 3). In 2011, we recorded 99 Spectacled Eiders on the Colville Delta, of which 76 were on the ground and 23 were in flight (Table 4). All but 1 sighting of Spectacled Eiders in the Colville Delta study area during the pre-nesting survey in 2011 were in small groups of 1–4 birds, and nearly 80% of those counted were found in the CD North subarea, where Spectacled Eiders traditionally have been most concentrated (Figure 10, Appendix C). The density of observed birds in the CD North subarea was 0.35 birds/km² (birds on ground and in flight), and the density of indicated birds (USFWS 1987a) was 0.36 birds/km². The density of Spectacled Eiders in the entire Colville Delta study area was lower: 0.20 observed birds/km² and 0.19 indicated birds/km². This was the second year of high densities for both areas with at least double the density seen in 2009.

Habitat Use

Pre-nesting Spectacled Eiders used 17 of 24 available habitats during 18 years of aerial surveys on the Colville Delta study area (Table 5). Seven 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), 3 aquatic habitats (Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, and

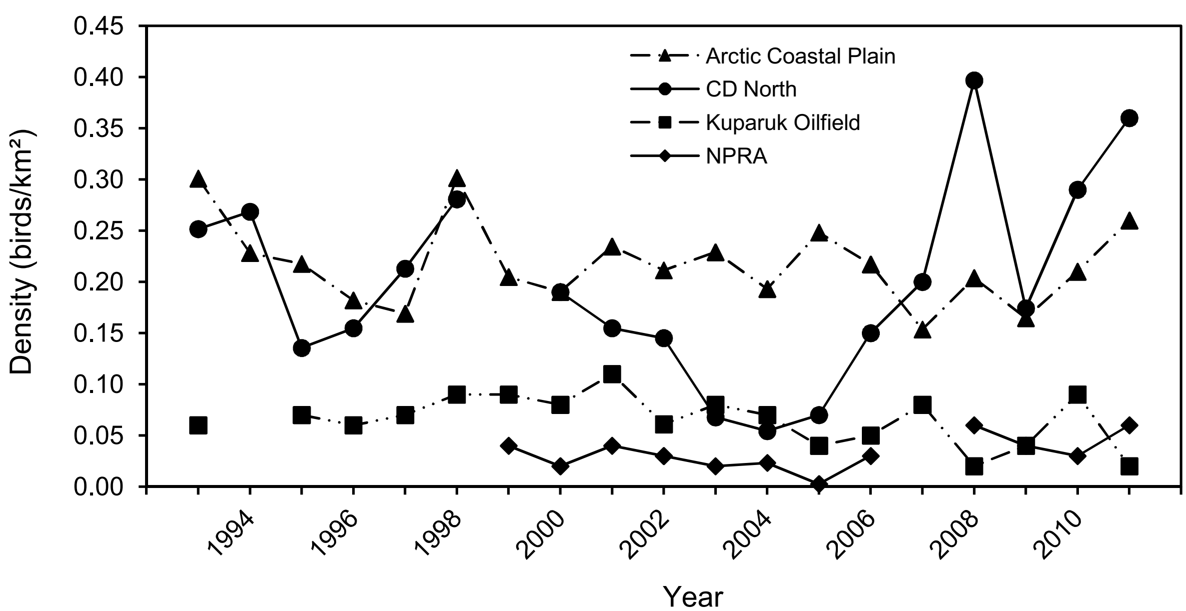

Figure 9. Density of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2011. Arctic Coastal Plain data from Larned et al. 2011, Kuparuk data from Stickney et al. 2012, and CD North and NE NPRA data from this study.

Table 3. Annual number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 1993–2011.

		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
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

Table 4. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2011.

SPECIES	Observed				Indicated	Observed	Indicated
Location	Males	Females	Total	Pairs	Total[a]	Density[b]	Density[a, b]
SPECTACLED EIDER							
On ground	49	27	76	25	95	0.15	0.19
In flight	14	9	23	7	–	0.05	–
All birds	63	36	99	32	–	0.20	–
KING EIDER							
On ground	62	55	117	13	129	0.23	0.26
In flight	11	5	16	5	–	0.03	–
All birds	73	60	133	18	–	0.27	–

[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

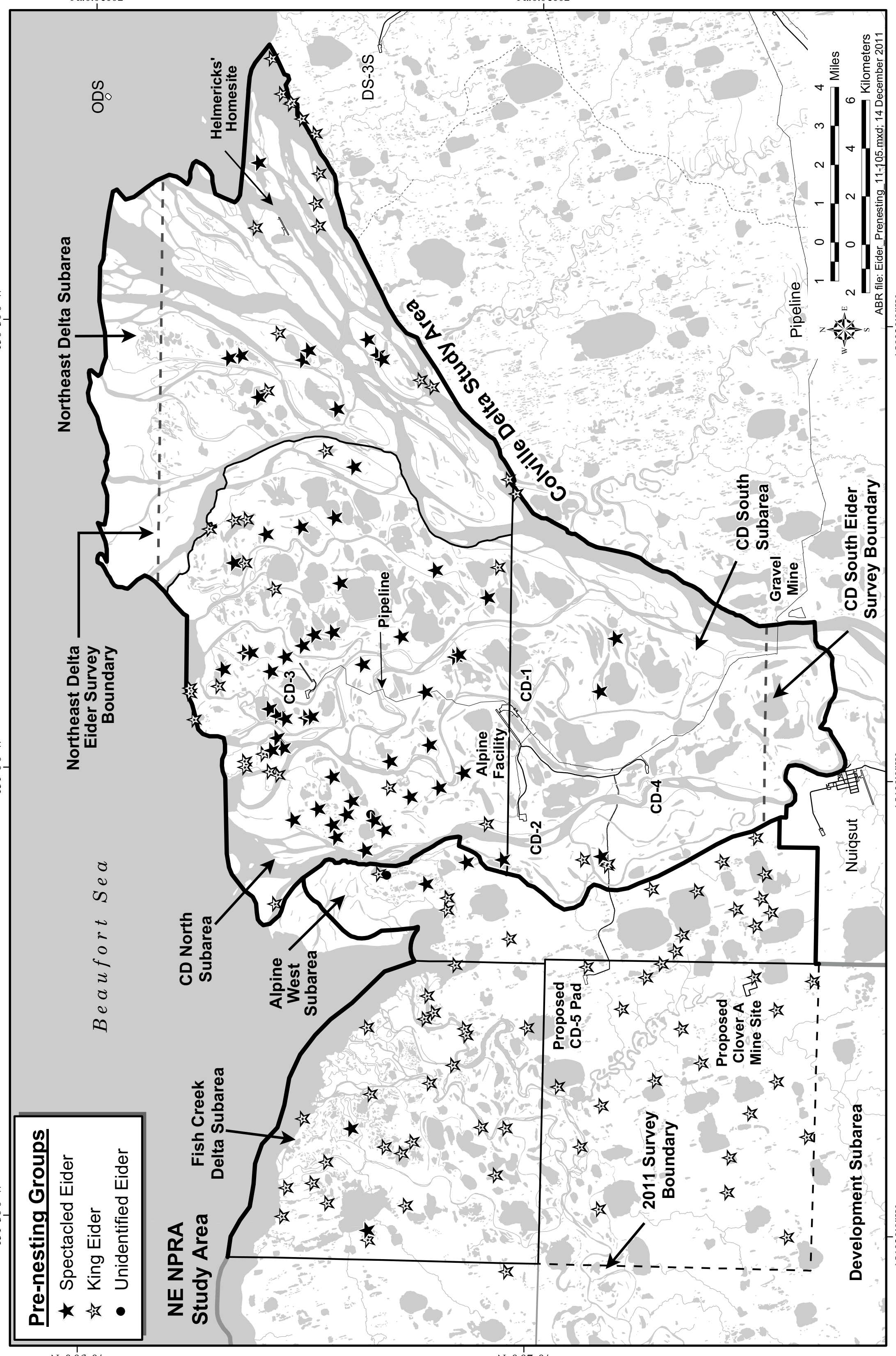

Figure 10. Spectacled and King eider groups during pre-nesting, Colville Delta and NE NPRA study areas, Alaska, 2011.

Table 5. Habitat selection by Spectacled and King eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998 and 2000–2011.

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	73	32	8.6	1.3	prefer	low
Tapped Lake with Low-water Connection	29	12	3.2	4.5	ns	
Tapped Lake with High-water Connection	17	10	2.7	3.7	ns	
Salt Marsh	48	27	7.3	3.2	prefer	
Tidal Flat Barrens	2	1	0.3	7.0	avoid	
Salt-killed Tundra	62	34	9.1	5.1	prefer	
Deep Open Water without Islands	29	18	4.8	3.5	ns	
Deep Open Water with Islands or Polygonized Margins	29	15	4.0	2.1	prefer	
Shallow Open Water without Islands	5	3	0.8	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	6	5	1.3	0.1	prefer	low
River or Stream	20	10	2.7	14.4	avoid	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	173	99	26.6	2.7	prefer	
Grass Marsh	8	5	1.3	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	69	35	9.4	8.2	ns	
Patterned Wet Meadow	122	64	17.2	19.5	ns	
Moist Sedge-Shrub Meadow	0	0	0	2.3	avoid	
Moist Tussock Tundra	1	1	0.3	0.6	ns	low
Tall, Low, or Dwarf Shrub	0	0	0	4.9	avoid	
Barrens	2	1	0.3	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	695	372	100	100		
KING EIDER						
Open Nearshore Water	11	3	1.3	1.6	ns	low
Brackish Water	29	16	6.8	1.3	prefer	low
Tapped Lake with Low-water Connection	25	12	5.1	4.5	ns	
Tapped Lake with High-water Connection	8	3	1.3	3.7	avoid	
Salt Marsh	23	11	4.7	3.2	ns	
Tidal Flat Barrens	4	2	0.9	7.0	avoid	
Salt-killed Tundra	45	24	10.2	5.1	prefer	
Deep Open Water without Islands	20	9	3.8	3.5	ns	
Deep Open Water with Islands or Polygonized Margins	11	5	2.1	2.1	ns	low
Shallow Open Water without Islands	4	2	0.9	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	1	0.4	0.1	ns	low
River or Stream	317	89	37.9	14.4	prefer	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	36	20	8.5	2.7	prefer	
Grass Marsh	8	3	1.3	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	8	6	2.6	8.2	avoid	
Patterned Wet Meadow	37	22	9.4	19.5	avoid	
Moist Sedge-Shrub Meadow	2	1	0.4	2.3	ns	
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	2.1	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	605	235	100	100		

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

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

[c] Expected number < 5

Grass Marsh), and 1 terrestrial habitat (Deep Polygon Complex). Deep Polygon Complex, which consists of a mosaic of small, deep, polygon ponds with relatively narrow vegetated rims and sometimes with islets, is notable because its disproportionate use; it was used by 27% of the Spectacled Eider groups yet was available on only 2.7 % of the delta. Patterned Wet Meadow also had high use (17% of Spectacled Eider groups) but was not preferred because of its higher availability (20%). All other habitats were avoided or used in proportion to their availabilities.

NE NPRA

Distribution and Abundance

Relative to the Colville Delta, the reduced study area for the NE NPRA in 2011 had low numbers and low densities of Spectacled Eiders, a geographic difference that has been consistent during all years both areas have been surveyed (Figure 10, Table 6). However, similar to the annual trend on the Colville Delta, NE NPRA had near record densities in 2011. Over the entire NE NPRA study area, we counted 9 observed (on ground and in flight) and 10 indicated Spectacled Eiders resulting in a density of 0.05 observed birds/km² and 0.06 indicated birds/km², about 25% of the density on the Colville Delta study area in 2011 (Table 7). The highest number and density of Spectacled Eiders in 2011 were found in the Alpine West subarea (0.14 indicated birds/km²), followed by the Fish Creek Delta subarea (0.05 indicated birds/km²). No Spectacled Eiders were seen in the portion of the Development subarea surveyed in 2011 (Appendix D).

Habitat Use

Pre-nesting Spectacled Eiders used 12 of 26 available habitats in the NE NPRA study area over 10 years of aerial surveys (Table 8). Spectacled Eiders preferred 4 habitats in NE NPRA, 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. However, the sample size is low (47 groups total) resulting in low power in the selection analysis, so we expect that additional habitats will be indicated as preferred with increases in the sample size in the future.

OTHER EIDERS

Colville Delta

Distribution and Abundance

A record number of King Eiders was recorded on the Colville Delta in 2011 (Figure 11). The indicated density of King Eiders (0.26 birds/km²) in 2011 was about 3 times higher than the 18-year mean (Table 3). King Eiders (129 indicated birds) also were more numerous than Spectacled Eiders (95 indicated birds) during the 2011 pre-nesting period (Table 3). Seventy-seven of these King Eiders were in 3 large flocks of at least 20 birds on river channels. Most King Eiders (73% of indicated birds) were seen in the Northeast Delta subarea, which is typical for King Eiders on the delta (Figure 10, Appendix C). 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 2011. Steller's Eiders rarely are seen in the vicinity of the Colville Delta, but a flying male Steller's Eider was seen on the Colville Delta in 2007 (Johnson et al. 2008b), and several sightings of single males or pairs were reported in the Colville Delta and the NE NPRA during 2001 (Johnson and Stickney 2001), and in the Kuparuk Oilfield during 1995, 2000, 2001, and 2007 (not all sightings in the Kuparuk Oilfield were confirmed; see Anderson et al. 2008). Since 1992, nest searches have been conducted in multiple locations on the Colville Delta, in the Kuparuk Oilfield, and, during a subset of years, in NE NPRA; in almost 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 have been recorded during pre-nesting in 1992, 1998, and 2001, and a nest was found near the coastline in 1994 (Johnson 1995).

Table 6. Annual number and density (birds/km²) of eiders during pre-nesting aerial surveys, NE NPRA study area, Alaska, 1999–2011.

		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
Mean				0.03	0.03			0.44	0.36
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 NPRA study area, Alaska, 2011.

SPECIES	Observed				Indicated	Observed	Indicated
Location	Males	Females	Total	Pairs	Total[a]	Density[b]	Density[a, b]
SPECTACLED EIDER							
On ground	5	4	9	4	10	0.05	0.06
In flight	0	0	0	0	–	0	–
All birds	5	4	9	4	–	0.05	–
KING EIDER							
On ground	47	35	82	33	94	0.48	0.55
In flight	21	16	37	14	–	0.22	–
All birds	68	51	119	47	–	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 2011

Table 8. Habitat selection by Spectacled and King eider groups during pre-nesting, NE NPRA study area, Alaska, 2001–2006 and 2008–2011.

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	0.6	ns	low
Brackish Water	11	6	12.8	1.1	prefer	low
Tapped Lake with Low-water Connection	0	0	0	0.7	ns	low
Tapped Lake with High-water Connection	0	0	0	0.5	ns	low
Salt Marsh	6	3	6.4	2.1	ns	low
Tidal Flat Barrens	0	0	0	1.2	ns	low
Salt-killed Tundra	0	0	0	0.7	ns	low
Deep Open Water without Islands	4	2	4.3	6.5	ns	low
Deep Open Water with Islands or Polygonized Margins	10	5	10.6	5.3	ns	low
Shallow Open Water without Islands	5	4	8.5	1.0	prefer	low
Shallow Open Water with Islands or Polygonized Margins	15	7	14.9	1.6	prefer	low
River or Stream	1	1	2.1	1.2	ns	low
Sedge Marsh	1	1	2.1	1.7	ns	low
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	3	2	4.3	0.3	prefer	low
Young Basin Wetland Complex	0	0	0	0.3	ns	low
Old Basin Wetland Complex	13	8	17.0	8.2	ns	low
Riverine Complex	0	0	0	0.3	ns	low
Dune Complex	0	0	0	1.0	ns	low
Nonpatterned Wet Meadow	4	2	4.3	3.2	ns	low
Patterned Wet Meadow	14	6	12.8	11.1	ns	low
Moist Sedge-Shrub Meadow	0	0	0	21.6	avoid	
Moist Tussock Tundra	0	0	0	25.5	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	87	47	100	100		
KING EIDER						
Open Nearshore Water	6	3	0.6	0.6	ns	low
Brackish Water	52	26	4.9	1.1	prefer	
Tapped Lake with Low-water Connection	48	14	2.6	0.7	prefer	low
Tapped Lake with High-water Connection	1	1	0.2	0.5	ns	low
Salt Marsh	62	28	5.2	2.1	prefer	
Tidal Flat Barrens	10	4	0.7	1.2	ns	
Salt-killed Tundra	5	3	0.6	0.7	ns	low
Deep Open Water without Islands	177	60	11.2	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	133	54	10.1	5.3	prefer	
Shallow Open Water without Islands	94	48	9.0	1.0	prefer	
Shallow Open Water with Islands or Polygonized Margins	201	79	14.8	1.6	prefer	
River or Stream	86	34	6.4	1.2	prefer	
Sedge Marsh	50	23	4.3	1.7	prefer	
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	17	5	0.9	0.3	prefer	low
Young Basin Wetland Complex	0	0	0.0	0.3	ns	low
Old Basin Wetland Complex	185	89	16.6	8.2	prefer	
Riverine Complex	6	3	0.6	0.3	ns	low
Dune Complex	0	0	0	1.0	avoid	
Nonpatterned Wet Meadow	23	13	2.4	3.2	ns	
Patterned Wet Meadow	57	35	6.5	11.1	avoid	
Moist Sedge-Shrub Meadow	16	7	1.3	21.6	avoid	
Moist Tussock Tundra	9	5	0.9	25.5	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	1,239	535	100	100		

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

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

[c] Expected number < 5

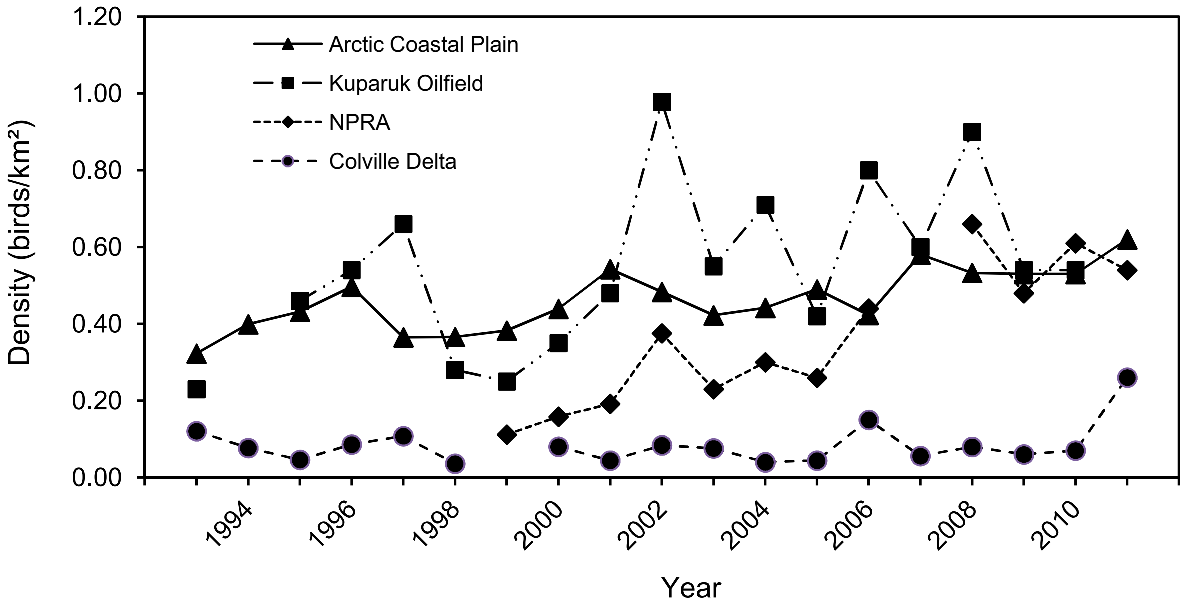

Figure 11. Density of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2011. Arctic Coastal Plain data from Larned et al. 2011, Kuparuk data from Stickney et al. 2012, and CD North and NE NPRA data from this study.

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 18 years of aerial surveys. King Eiders preferred 4 of the same habitats preferred by pre-nesting Spectacled Eiders on the Colville Delta: Brackish Water, Salt-killed Tundra, Deep Polygon Complex, and Grass Marsh (Table 5). King Eiders also preferred River or Stream, where the largest percentage (38%) of the groups was found. The high percentage use of River or Stream, which includes river channels, suggests that many King Eiders were in transit to breeding areas farther east, because River or Stream is not potential breeding habitat and because King Eiders are relatively scarce in suitable breeding habitats on the delta. In contrast, Spectacled Eiders, which occur in high numbers during pre-nesting and nest in relative concentrations on the Colville Delta (≤1 nest/km²) 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), affirming that most of the pre-nesting King Eiders seen on the delta are stopping over during migration.

NE NPRA

King Eiders also were abundant in the NE NPRA study area in 2011, as they were on the Colville Delta study area. The indicated total of King Eiders in the NE NPRA study area in 2011 was 94 birds, and the density was 0.55 indicated birds/km², the third highest density in 12 years of surveys (Figure 11, Table 6). King Eiders were 9 to 13 times more abundant than Spectacled Eiders in the NE NPRA study area in 2011 (Table 7), which is typical for these species in this area. The ratio of King Eiders to Spectacled Eiders (indicated birds) averages about 12:1 in the NE NPRA (Table 6). The highest number of King Eiders was seen in the Development subarea (44 indicated birds), but the densities were similar in the Development and Alpine West subareas (0.60 and 0.57 indicated birds/km², respectively; Figure 10, Appendix D).

Habitat Use

King Eiders used 21 of 26 available habitats and preferred 11 habitats over 10 years of pre-nesting surveys in the NE NPRA study area (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 18 years (Figure 9). The current breeding season (2011) was the fifth 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 2007–2011 (Figure 9). These fluctuations in abundance are unexplained, but the recent upswing in Spectacled Eiders is encouraging because numbers were quite low during 2003–2005. Nonetheless, the overall population trend remains slightly negative ($\ln(y) = -0.002x + 7.6$, $R^2 < 0.001$, $P = 0.94$, $n = 18$ years), which translates to an annual growth rate of 0.998. A similar slightly negative growth rate of 0.992 was calculated for Spectacled Eiders on the Arctic Coastal Plain (SE = 0.008, $n = 19$ years; Larned et al. in prep.). However, neither growth rate is significantly different from 1.0 (a growth rate of 1.0 equals 0% annual change), which suggests that the breeding population is stable.

The NE NPRA study area appears to be less important than the Colville Delta to breeding Spectacled Eiders. The density of Spectacled Eiders in the NE NPRA study area has been consistently low (mean = 0.03 birds/km², SE = 0.005, $n = 12$ years). The Spectacled Eider density in NE NPRA averages 40% ($n = 11$ years) of the density in the Colville Delta study area and 20% of the density in the CD North subarea. An evaluation of the regional distribution of Spectacled Eiders shows that significant concentrations of Spectacled Eiders on the ACP do not occur in the NE NPRA study area (Figure 17 in Larned et al. 2006, Figure 19 in Larned et al. 2011). The population trend for Spectacled Eiders in NE NPRA is slightly positive (1.08), but not significantly different from 1.0 ($\ln(y) = 0.076x - 150.2$, $R^2 = 0.089$, $P = 0.402$, $n = 10$ years).

Unlike Spectacled Eiders, King Eiders appear to be increasing on breeding pair surveys of the ACP, with a growth rate of 1.027, which is significantly different from 1.0 (SE = 0.006, $n = 19$ years; Larned et al. in prep.). In the NE NPRA study area, the growth rate for King Eiders (1.104) is also significantly positive ($\ln(y) = 0.104x - 202.1$, $R^2 = 0.708$, $P = 0.002$, $n = 10$ years). The growth rate on the Colville Delta (1.014), however, is not significant ($\ln(y) = 0.014x - 23.7$, $R^2 = 0.024$, $P = 0.539$, $n = 18$ years). The distribution of King Eiders in the 2 study areas is the reverse of that observed for Spectacled Eiders. NE NPRA supports high densities of King Eiders (mean = 0.36 indicated birds/km², SE = 0.05, $n = 12$ years), in contrast to low densities on the Colville Delta (mean = 0.08 indicated birds/km², SE = 0.01, $n = 18$ 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). Thus, the differences in densities of eider species observed on the Colville Delta and NE NPRA study areas are reflective of the regional patterns of distribution these 2 species exhibit on breeding pair surveys across the entire ACP.

LOONS

YELLOW-BILLED LOON

Colville Delta

Distribution and Abundance

In 2011, we conducted a survey on 13 June, 1 week earlier than the nesting survey to better document Yellow-billed Loons nesting phenology and to record nests that fail prior to the nesting survey normally conducted during the 3rd week of June. On the 13 June survey, we found 6 Yellow-billed Loon nests in the Colville Delta study area. Four of those 6 nests failed by the time the nesting survey was conducted on 20–22 June 2011, and therefore, would not have been recorded on that later survey. During the nesting survey, we counted 72 Yellow-billed Loons and 23 nests (Figure 12, Table 9). Two additional nests were found on the 27 June monitoring survey, 1 of which was an apparent renesting attempt, and the other was a late nesting attempt. Of the 29 nests found in the Colville Delta study area in 2011, 14 nests were located in the CD North subarea, 13 nests in the CD South subarea, and 2 nests in the Northeast Delta subarea (Figure 12, Appendix E). The count of 72 adults in 2011 on the nesting survey was the highest number recorded in the Colville Delta study area during 17 years of surveys, while the number of nests found during nesting and monitoring surveys in 2011 (25 nests, excluding 4 nests observed on 13 June that had failed by the time of the nesting survey) was the smallest recorded during the last 7 years, when both types of survey were conducted (Table 9).

The density of Yellow-billed Loon adults in the Colville Delta study area during the nesting survey in 2011 was 0.19 birds/km², which was higher than the 17-year mean (0.15 birds/km², SE = 0.007; Appendix F). The density of loons was higher in the CD North subarea (0.21 birds/km²) than the CD South subarea (0.17 birds/km²; Appendix E). However, the density of nests found in 2011 during nesting and monitoring surveys was similar in the CD North (0.07 nests/km²) and CD South subareas (0.08 nests/km²; Appendix E).

Twenty-eight of the 29 Yellow-billed Loon nests recorded in the Colville Delta study area in 2011 were on lakes where Yellow-billed Loons have nested previously (Figure 12) (Johnson et al. 2009, 2010, 2011). One nest was found on a lake where nesting had not been previously documented, but it was part of a previously identified territory consisting of 2 lakes; the only record of a nest in the territory occurred on the other lake. Of the other 28 nests, 9 were located at the same nest sites used in 2010, 13 were at or very close to nest sites used in years prior to 2010, and 6 were at new nest sites on lakes previously used for nesting. The water level at some lakes in the Colville Delta study area was higher during the nesting survey than during previous years so that traditional nest sites were not available during nest initiation, particularly at sites in emergent vegetation or on small islands. The high water may have caused some pairs to use alternate nest sites or to fail to nest.

During 17 years of nesting surveys in the Colville Delta study area, the lowest number of nests recorded was 10 nests in 1993 and 1997 and the highest was 33 nests in 2008 (Table 9). In most years, an additional 1–12 nests were found during ground, revisit, and/or monitoring surveys. With the addition of these nests, the counts of nests ranged from 15 in 1993 to 38 in 2008 (Table 9). These annual counts are not directly comparable because survey coverage varied among years from 37 to 43 territories. Territory occupancy by nests, calculated as the number of nests divided by the number of territories surveyed, is a better metric to compare among years because it is adjusted by the number of territories surveyed in each year. Territory occupancy by nests appears to have increased during the period we have surveyed for nests on the Colville Delta (Table 9). During the first 8 years of surveys, territory occupancy was 38–58%, while during the last 9 years of surveys territory occupancy was 63–90% (Table 9). Similarly, the numbers of Yellow-billed Loon adults and nests counted during nesting surveys, when adjusted for the number of territories surveyed, has increased since 2000, and possibly since earlier years (Figure 13).

During the brood-rearing survey on 15 August 2011, 45 Yellow-billed Loons, 12 broods, and 20 young were recorded in the Colville Delta study area (Figure 12, Table 10). Two additional broods were observed during the monitoring survey on 18–19 July and a third brood was documented on camera images, but these 3 broods did not survive

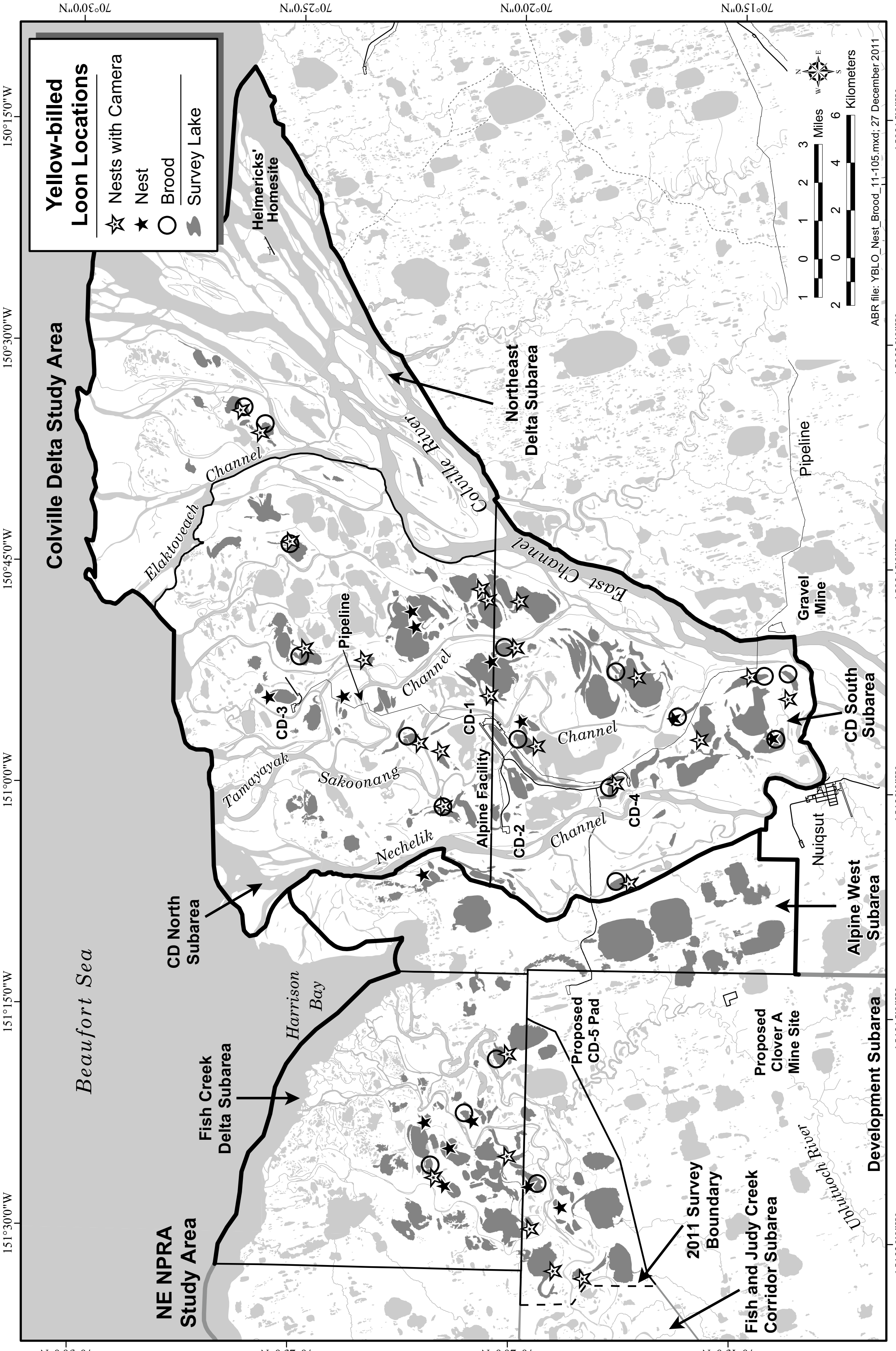

Figure 12. Yellow-billed Loon nests and broods, Colville Delta and NE NPRA study areas, Alaska, 2011.

Table 9. Annual number of Yellow-billed Loons, nests, and territory occupancy by nests, Colville Delta (1993–2011) and NE NPRA (2001–2011) study areas, Alaska.

STUDYAREA Year	Nesting Survey[a] No. Adults	Nesting Survey[a] No. Nests	All Surveys[b] No. Nests	No. Territories Surveyed	Territory Occupancy (%)[c]
COLVILLE DELTA[d]					
1993	50	10	15[e, f]	39	38
1995	39	12	21[e, f]	39	54
1996	45	12	21[e, f, g]	37	57
1997	48	10	18[e, g]	38	47
1998	36	17	23[e, g]	40	58
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	26[f]	41	63
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	74
2008	69	33	38[g]	42	90
2009	67	27	30[g]	43	70
2010	69	23	35[g]	43	81
2011	72	23	29[g]	43	67
Mean	54.8	20.6	25.3		62.3
SE	2.8	1.7	1.6		3.4
NE NPRA[h]					
2001	44	20	23[e]	36	64
2002	65	27	27	42	64
2003	53	26	27[e]	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
Mean[i]					62.1
SE					4.1

[a] Nesting survey was conducted sometime between 20–30 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
[d] In 2000, CD North and CD South subareas surveyed; in all other years, CD North, CD South, and Northeast Delta 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 (2006–2011), and early nesting (2011) surveys
[h] Survey area included 5 subareas: Development surveyed in 2001–2004, Exploration in 2002–2004, Alpine West in 2002–200 and 2008–2011, Fish Creek Delta in 2005–2006 and 2008–2011, 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, 11 Yellow-billed Loon territories in the eastern part of the Fish and Judy Creek Corridor were surveyed
[i] Mean numbers not calculated because survey area differed among years

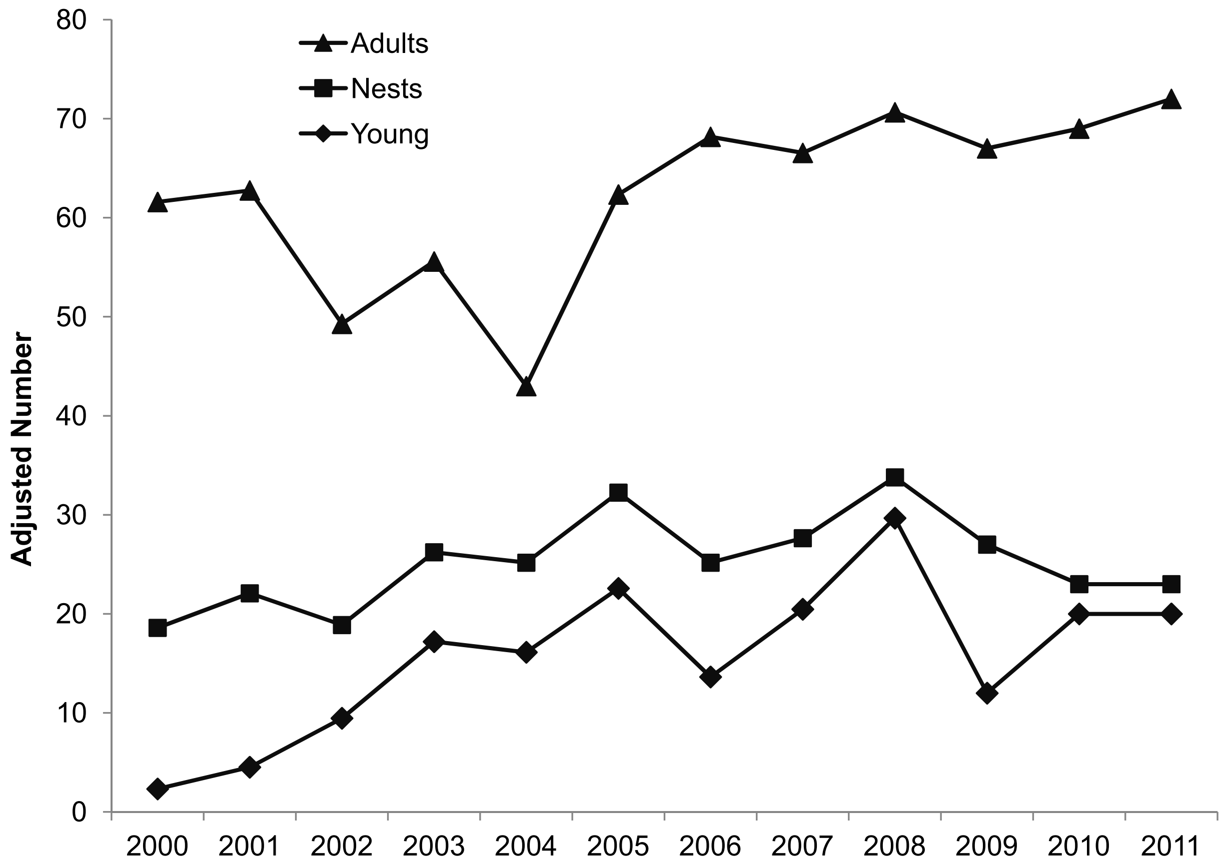

Figure 13. Annual numbers of Yellow-billed Loon adults and nests during the nesting survey and young during the brood-rearing survey, 2000–2011. Numbers are adjusted for the number of territories surveyed each year.

until the brood-rearing survey in August (see *Nest Fate*, below). Of the 15 broods recorded in the Colville Delta study area, 9 broods were found in the CD South subarea, 4 in the CD North subarea, and 2 in the Northeast Delta subarea (Appendix E). The count of 45 adults on the 2011 brood-rearing survey was slightly below the 17 year-mean of 49.9 adults (SE = 3.6), while the number of broods observed (12) was similar to the 17 yr- mean of 11.0 (SE = 1.3; Table 10).

The density of Yellow-billed Loon adults in the Colville Delta study area during the brood-rearing survey in 2011 was 0.12 birds/km², which was similar to the long-term mean (0.13 birds/km², SE = 0.010; Appendix F). The density of broods found in 2011 during brood-rearing and monitoring surveys in the Colville Delta study area was 0.04 broods/km², which was similar to the average of 7 years of surveys from 2005–2011 (0.05 broods/km, SE = 0.005; Appendix F), years in which monitoring surveys and nest fate checks documented the occurrence of broods.

During 17 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 evidence indicating that hatching occurred. With the addition of these broods, the range of brood counts was 3–27 between 1993 and 2011. These annual counts are not directly comparable because survey coverage varied annually from 34 to 43 territories and because nest fate visits in 2005–2011 recorded broods that disappeared before the brood-rearing survey (Table 10). We calculated territory occupancy by broods (the number of broods divided by the number of territories) to adjust brood counts by survey coverage and facilitate

Table 10. Annual number of Yellow-billed Loons, broods, and territory occupancy by broods, Colville Delta (1993–2011) and NE NPRA (2001–2011) study areas, Alaska.

STUDYAREA Year	Brood-rearing Survey[a] No. Adults	Brood-rearing Survey[a] No. Young	Brood-rearing Survey[a] No. Broods	All Surveys[b] No. Broods	No. Territories Surveyed	Territory 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	20	14	15[g, h]	43	35
2011	45	20	12	15[f, g, h]	43	35
Mean	49.9	13.6	11.0	13.0		32.1
SE	3.6	1.7	1.3	1.6		3.6
NE NPRA[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	17[g]	49	35
2011	31	5	4	4	21	19
Mean[j]						27.9
SE						3.1

[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 at nest indicating successful hatch
[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 2008–2011, Fish Creek Delta in 2005–2006 and 2008–2011, 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, 11 Yellow-billed Loon territories in the eastern part of the Fish and Judy Creek Corridor were surveyed
[j] Mean numbers not calculated because survey area differed among years

annual comparisons. The lowest territory occupancy by broods was 3% in 2000, whereas the highest occupancy values occurred in 4 consecutive years from 2005–2008 (range = 39–64%); all other years had ≤30% occupancy by broods.

Habitat Use

During 17 years of nesting aerial surveys in the CD North and CD South subareas, 381 Yellow-billed Loon nests were found in 11 of 24 available habitats on the Colville Delta (Table 11). Five habitats were preferred for nesting (Patterned Wet Meadow, Grass Marsh, Sedge Marsh, Deep Open Water with Islands or Polygonized Margins, and Deep Open Water without Islands), altogether supporting 290 of 381 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 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 10 habitats, which together occupied 49% of the CD North and CD South subareas.

All Yellow-billed Loon broods (186 broods over 17 years) were found in 4 habitats, 3 of which were preferred: Deep Open Water without Islands, Deep Open Water with Islands or Polygonized Margins, and Tapped Lake with High-water Connection (Table 11). 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

Overall, 15 of 29 Yellow-billed Loon nests hatched in the Colville Delta study area in 2011 for an apparent nesting success of 52% (Table 12). Six of the 29 nests were found on 13 June, but 4 of those nests failed by the time of the nesting survey 1 week later. In previous years, no surveys were conducted prior to the nesting survey and nesting success was calculated in those years based only on the nesting survey and subsequent monitoring surveys. For comparison with previous years, we calculated nesting success in 2011 for the 25 nests found on the nesting and monitoring surveys, which yielded an apparent nesting success of 60% (Table 13). Although, 25 nests were the fewest found since monitoring surveys began in 2005, nest success in 2011 was near the 7-year mean (59.4%; Table 13). In addition to finding nests that failed prior to the nesting survey, the 13 June survey provided evidence of a pair that failed and renested. The initial nest failed by 20 June; 1 week later a second nest was found 11 m from the first nest and ultimately hatched.

All of the 15 successful nests in 2011 hatched in July; 3 (20%) hatched by 11 July, 10 (67%) hatched between 11 July and 18 July, and the remaining 2 (13%) hatched by 25 July (Table 12). Young loons were observed during aerial surveys at all but 1 hatched nest (Table 14). At that nest, hatch was confirmed by eggshell fragments and by a chick seen on camera images, but the chick did not survive to the following monitoring survey 1 week later. Fourteen of 29 Yellow-billed Loon nests on the Colville Delta failed to hatch (Table 12). Nest failure occurred without an obvious peak in timing. Four of 29 nests (14%) failed by the time of the nesting survey on 20–22 June, and 2 more nests (7%) failed by 27 June. After that week, 2–4 nests failed each week until 18 July. Only 2 nests were active after 18 July, including the renesting attempt, and both hatched the following week.

The contents of all 29 Yellow-billed Loon nests were examined after nests were no longer active. Fifteen nests were classified as successful based on the presence of >20 eggshell fragments and at some nests, egg membranes. Fourteen nests were judged failed based on the absence of eggshell fragments, the presence of only a few fragments, or the presence of broken eggshells. Successful nests contained 60–110 eggshell fragments, and broods were observed at all of these nests, including 1 nest where a chick was seen only on camera images. Of >1,100 eggshell fragments found and measured within 5 m of successful nests, 77% were ≤10 mm in length. All but 1 nest contained pieces of membrane that were either separate or loosely attached to fragments. One nest contained an entire membrane covered in crushed shell. The majority of egg membranes and eggshell fragments were found in nest bowls; only 138

Table 11. Habitat selection by nesting (1993–1998 and 2000–2011) and brood-rearing (1995–1998 and 2000–2011) 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	22	5.8	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	33	8.7	4.9	prefer	
Deep Open Water with Islands or Polygonized Margins	109	28.6	2.5	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	1.3	<0.1	prefer	low
Deep Polygon Complex	18	4.7	2.8	ns	
Grass Marsh	5	1.3	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	42	11.0	8.7	ns	
Patterned Wet Meadow	138	36.2	24.6	prefer	
Moist Sedge–Shrub Meadow	5	1.3	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	ns	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	381	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	39	21.0	5.4	prefer	
Salt Marsh	0	0	2.6	avoid	low
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	85	45.7	4.9	prefer	
Deep Open Water with Islands or Polygonized Margins	61	32.8	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	186	100	100		

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

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

[c] Expected number < 5

Table 12. Weekly status and fate of Yellow-billed Loon nests monitored by aerial surveys, Colville Delta study area, Alaska, 2011. 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	13	20–22	27[a]	4[a]	11[a]	18–19	25	Fate/Total
1[b]	I	A	A	A	A	I	–	Hatched
2[b]	I	A	A	A	A	I	–	Hatched
4[b]	I	A	A	A	A	I	–	Hatched
6[b]	I	A	A	A	I[d]	–	–	Hatched
8	A	I	–	–	–	–	–	Failed
10	A	I	–	–	–	–	–	Failed
11[b]	I	A	A[c]	I	–	–	–	Failed
13[b]	I	A	A	A	I[d]	–	–	Hatched
14[b]	I	A	A	A	A	I	–	Failed
15[b]	I	A	A	A	A	I	–	Hatched
16	A	I	–	–	–	–	–	Failed
17[b]	I	A	A	A	A	A (I[d])	I	Hatched
18[e]	A	I	–	–	–	–	–	Failed
18[e]	–	–	A	A	A	A	I	Hatched
19[b]	I	A	A	A	I	–	–	Failed
20[b]	A	A	A	A	I[d]	–	–	Hatched
21	I	A	A	A	A	I	–	Hatched
22[b]	I	A	A	A	A	I	–	Hatched
26[b]	I	A	A	A	A	I	–	Hatched
28	I	I	A	A	I	–	–	Failed
29[b]	I	A	A	A	A	I	–	Failed
30[b]	I	A	A	I	–	–	–	Failed
31[b]	I	A	A	I	–	–	–	Failed
33[b]	A	A	I	–	–	–	–	Failed
36	I	A	I	–	–	–	–	Failed
37	I	A	A	I	–	–	–	Failed
43[b]	I	A	A	A	A	I	–	Hatched
45[b]	I	A	A	A	A	I	–	Hatched
46[b]	I	A	A	A	A	I	–	Hatched[f]
No. Active	6	23	23	19	14	2 (1)	0	29
No. Hatched	0	0	0	0	3	10 (11)	2 (1)	15
No. Failed	0	4	2	4	2	2	0	14

[a] Camera-monitored nests were not surveyed by helicopter; nest status determined from camera images
[b] Nest monitored by camera
[c] Camera images show this nest failed at 15:48 on day of survey
[d] Camera images show young were being brooded in nest during this survey
[e] Nest found 13 June failed by 20 June; pair renested 11 m from first nest by 27 June and second nest hatched
[f] No brood was seen but nest classified as hatched based on eggshell evidence at the nest and chicks detected on camera images

Table 13. Number of nests, apparent nesting success, and number of chicks of Yellow-billed Loons seen during aerial monitoring surveys, Colville Delta (2005–2011) and NE NPRA (2008–2011) study areas, Alaska.

STUDY AREA Year	No. Territories Surveyed	No. Nests	Nesting Success (%)	Post Hatch No. Chicks	Post 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	43	35	43	22	0.63	17	0.49
2011	43	25[b]	60	24	0.96	19	0.76
Mean		31.1	59.4	27.1	0.87	17.8	0.56
SE		1.6	4.8	3.7	0.10	2.7	0.08
NE NPRA							
2008	51	29	66	27	0.93	–	–
2009	51	29	52	24	0.83	15	0.52
2010	51	36	47	22	0.61	17	0.47
2011[c]	21	12[d]	33	6	0.50	5	0.42
Mean		31.3	55.0	24.3	0.79	16.0	0.50
SE		2.3	5.7	1.5	0.10	0.8	<0.01

[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] Data not included in mean and standard error calculations because the study area was different from previous years
[d] Total does not include 1 nest that was only seen prior to the nesting survey

fragments were found in the water or on shore adjacent to successful nests. Five of the 14 failed nests that were inspected had egg remains in the nest or nearby; 3 nests had eggs broken in half or eggs with holes in them within 5 m of the nest and 2 nests contained 7–18 egg fragments. The remaining 9 nests were empty.

Time-lapse Cameras

We monitored 20 of 29 Yellow-billed Loon nests in the Colville Delta study area with time-lapse cameras in 2011 (Table 15). Eight-power telephoto cameras were placed 35–126 m from nests (mean = 65 m, SE = 13.9 m, n = 6) and 2× and 2.5× telephoto cameras were placed 25–86 m from nests (mean = 47 m, SE = 4.3 m, n = 14). Two researchers were transported to and from nesting lakes by helicopter for camera setup and were at nests an average of 32 min (range = 20–57 min, n = 20 nests). One nesting lake was reached on foot from Alpine. At 17 of 20 nests, an adult was incubating upon our arrival in the helicopter and left the nest during camera setup: 8 swam away from the nest as the helicopter landed, 6 left as researchers exited the helicopter, and 3 left as researchers approached the camera setup location. One loon remained on its nest during camera setup. At the remaining 2 nests, loons were off their nests when researchers arrived. At 1 of these last 2 nests, a loon was swimming next to the nest upon our arrival and swam away as the helicopter approached. At the other nest, we walked to the nest from the CD-1 Pad and the attending adult probably left the nest after we came into view. An adult was seen on the nest lake about

Table 14. Number of Yellow-billed Loon chicks observed during weekly aerial surveys, Colville Delta study area, Alaska, 2011. Status and number of chicks determined by camera-monitoring presented in parentheses where it differed from counts determined during aerial surveys.

	July			August					September				
Territory	11 July[a]	18–19	25	1	8	15	24	29	5	12	No. Chicks Hatched	Age (d) When Last Seen	Brood Fate[b]
1[c]	Inc[d]	1[e, f]	1[e, g]	1	1	1	1	1	1	1	1	59.5	A
2[c]	Inc	2	2	2	2	2	2	2	2	2	2	59.5	A
4[c]	Inc	2	2	2	2	2	2	2	2	2	2	59.5	A
6[c]	1[e]	1[h]	0	0	–	–	–	–	–	–	1 (2)	13.5	F
13[c]	Inc	1	1	1	1	1	1	1	1	1	1	66.5	A
15[c]	Inc	1	1	1	1	1	1	1	1	1	1	59.5	A
17[c]	Inc	Inc (2[e])	2[g]	2	2	2	1	1[g]	1	1	2	52.5	A
18	Inc	Inc	2[e, g]	2	2	2	2	2	2	2	2	52.5	A
20[c]	2[e]	2	2	2	2	2	2	2	2	2	2	66.5	A
21	Inc	2	2[g]	2	2	2	2	2	2	2	2	59.5	A
22[c]	Inc	1	0	0	–	–	–	–	–	–	1	7.0	F
26[c]	Inc	2	1[g]	1	1[g]	1	1	1	1	1	2	59.0	A
43[c]	Inc	2	2[g]	2	2	2	2	2	2	2	2	59.0	A
45[c]	Inc	2	2	2	2	2	2	2	2	2	2	59.5	A
46[c]	Inc	0[i]	0	–	–	–	–	–	–	–	1	3.5	F
Totals													
Broods of 2	1	7 (8)	8	8	8	8	7	7	7	7	–	–	–
Broods of 1	1	5	4	4	4	4	5	5	5	5	–	–	–
Chick Loss	0	1 (2)	3	0	0	0	1	0	0	0	–	–	–

[a] Except for the nest at territory 20, camera monitored nests were not surveyed by helicopter; nest status determined from camera images
[b] A = active, young present on 12 September, F = failed
[c] Nest monitored by camera
[d] Inc = loon incubating at the time of the survey
[e] Adult brooding chick(s)
[f] No chick observed; camera images confirmed that 1 chick hatched on 16 July
[g] No chick(s) observed; chick(s) assumed present based on subsequent aerial surveys
[h] 1 chick observed; camera data confirm that a 2nd chick hatched 13 July but did not survive until 18 July
i Camera images confirm that 1 chick hatched on 12 July but did not survive until 18 July

Table 15. Nest history and incubation activity of Yellow-billed Loon nests monitored by time-lapse digital cameras, Colville Delta study area, Alaska, 2011.

Territory	Fate[a]	Nest Initiation 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)
1	S	18 June		2	23 June	16 July	22.6	99.2	2.2	1.3	7.7
2	S	16 June		2	23 June	14 July	20.6	98.6	2.1	2.2	8.4
4	S	15 June		2	23 June	13 July	18.8	98.3	1.4	2.0	11.1
6	S	12 June		2	23 June	10 July	16.5	99.3	1.8	1.5	5.6
11	F	19 June	Glaucous Gull	2	23 June	27 June	3.9	90.3	1.6	5.9	18.2
13	S	12 June		2	22 June	10 July	17.2	97.6	1.6	2.3	14.9
14	F	18 June	Red Fox	2	22 June	13 July	20.3	97.2	1.1	3.6	11.8
15	S	16 June		2	20 June	14 July	23.1	96.5	0.8	4.4	11.7
17	S	14 June		2	24 June	12 July	15.5	97.9	1.7	2.9	9.7
19	F	21 June	Red Fox	2	24 June	5 July	11.4	97.2	1.1	4.6	8.6
20	S	12 June		2	24 June	10 July	14.9	99.1	1.1	1.6	7.3
22	S	15 June		2	24 June	13 July[e]	18.5	98.4	1.3	3.7	6.1
26	S	18 June		2	23 June	16 July	22.3	95.6	1.2	3.1	18.8
29	F	20 June	Red Fox	2	23 June	15 July	21.0	99.0	2.3	1.2	11.8
30	F	12 June	Parasitic Jaeger	2	23 June	28 June	5.0	88.4	0.8	8.5	60.3
31	F	13 June	Glaucous Gull	2	23 June	4 July	11.1	86.3	0.7	6.3	33.0
33	F	14 June	Glaucous Gull	2	23 June	24 June	0.6	82.7	1.7	10.0	30.9
43	S	14 June		2	24 June	12 July	17.6	98.9	1.3	1.6	9.1
45	S	15 June		2	25 June	13 July	17.5	97.7	1.3	3.5	8.6
46	S	14 June		1	23 June	12 July	18.2	97.2	1.5	3.1	13.3

[a] S = successfully hatched, F = failed to hatch
[b] Nest initiation dates for successful nests estimated by subtracting 28 d from hatch date; for failed nests, nest age estimated using egg floatation (see Methods: Loon Surveys)
[c] As known on day of camera setup 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] Unable to detect chicks on camera; hatch date estimated by non-incubating adult's increased presence at the nest

200 m from the nest while researchers were setting up the camera.

All 19 loons that left nests during camera installation returned to incubate after installation. Five returned before we departed in the helicopter, whereas the remaining 14 returned an average of 23 min (median = 14 min, SE = 8 min, range = 2–121 min) after we departed in the helicopter. Excluding the 2 loons already off their nests when we arrived, loons were absent from nests an average of 41 min during camera installation (median = 42 min, SE = 3 min, range = 21–77 min, *n* = 17 nests).

Cameras successfully recorded daily nest survival, and we were able to identify the day of hatch or failure from 19 of 20 camera-monitored nests (Table 15). The day of hatch could not be judged at 1 nest because thick sedge growth around the nest prevented the detection of chicks on camera images. Of the 20 nests that were monitored, 13 hatched and 7 failed for an apparent nesting success of 65%. The median initiation date of camera-monitored nests was 15 June (range = 12–21 June, *n* = 20), and the median hatch date was 13 July (range = 10–16 July, *n* = 13). That hatch date agrees with the peak period of hatch determined from monitoring surveys, which indicated that most nests hatched between visits on 11 and 19 July. Loons at hatched and failed nests exhibited fairly high nest attendance, spending 98.0% (SE = 0.3, *n* = 13) and 93.1% (SE = 2.2, *n* = 6) of the time incubating, respectively.

Since camera monitoring began in 2008, predation of 1 or both eggs has been documented at 28 of 68 nests, including 4 nests where predators were not captured on images (Figure 14). The majority (50%) of identified predators were Glaucous Gulls and Parasitic Jaegers, which take advantage of unattended nests. Of the 7 nests that failed to hatch in 2011, 3 failures were attributed to

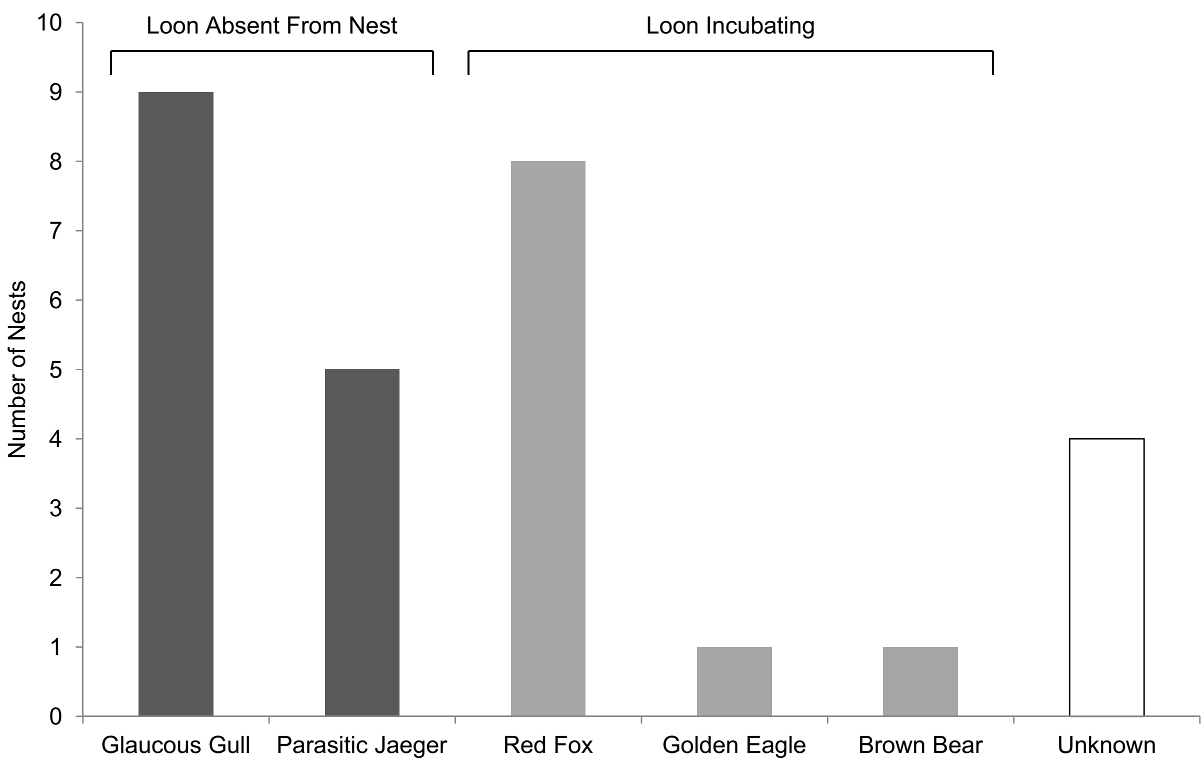

Figure 14. Predators seen taking eggs at camera-monitored Yellow-billed Loon nests (*n* = 68 nests), Colville Delta study area, Alaska, 2008–2011. Predation events divided into those that occurred when the loon was off the nest and those that occurred when the loon was incubating and flushed by the predator. Data include partial predation events at nests that later hatched 1 egg as well as events that caused nest failure.

predation by Glaucous Gulls, 1 to a Parasitic Jaeger, and 3 to red foxes (Table 15). All 4 nests that failed because of gull or jaeger predation were unattended at the time of predation. At 2 of these nests, an incubating loon left the nest to interact with an intruding Yellow-billed Loon in the nesting lake before avian predators attacked the nest and caused its failure. At a third nest, intruding loons may have been involved because the nesting pair was seen interacting with an intruding loon on camera images on more than a dozen occasions, but intruding loons were not in camera view when the incubating loon departed and the nest was depredated. At the fourth nest, the attending loon swam away from its nest and ~2 h later, a gull ate the eggs. Intruding loons do not always approach the nest or come into camera view, making their detection unpredictable. In contrast, at all 3 nests taken by red foxes, loons were incubating <1 min prior to the appearance of each fox in the camera view, suggesting that the foxes flushed the loons. During all 3 fox predation events, loons were recorded swimming near their nests after flushing. One of those nests was visited 2 times by a red fox. During the first encounter, the incubating loon spread its wings and stood between the fox and the nest. The fox returned <2 min later and the loon, which was swimming next to the nest, resumed incubation, faced the fox, and successfully defended the nest. Ultimately the nest was lost as a red fox approached the nest 9 d later, at which time the loon flushed from the nest and the fox took both eggs.

Yellow-billed Loon eggs hatch asynchronously. Adults brood and swim with the first hatched chick while the second egg is hatching, which can take 1–3 d. At 1 Yellow-billed Loon nest which hatched 1 egg, camera images suggest predation of the second egg. The second egg was visible in the nest when the adults and the first chick were swimming away from the nest and out of camera view. Shortly thereafter, the second egg was missing from the nest, but a predator was not observed, probably because the predation event occurred during the 30 sec interval between 2 successive photos.

As mentioned above in descriptions of predation events, cameras often recorded other Yellow-billed Loons intruding into occupied territories. Intruding loons were seen on images at 14 of 20 camera-monitored nests. Intruders were identified by the presence of >2 adults or, less frequently, by aggressive interactions between 2 Yellow-billed Loons. In nearly all cases, the incubating loon left the nest to interact with the intruder. Aggressive behaviors included fencing, rushing, and physical contact (for descriptions see Sjölander and Ågren 1976). Such interactions between territory holders and intruders may be an attempt by the intruder to usurp the territory. Territorial takeover through usurpation has been documented in Common Loons and, along with passive 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).

Brood Fate

During monitoring surveys following hatch, 5 of 15 (33%) Yellow-billed Loon pairs that hatched young were observed with a single chick, and 9 (60%) were observed with 2 chicks (Table 14). One additional pair hatched at least 1 chick based on camera images and the presence of eggshell fragments at the nest, but the chick did not survive to the following monitoring survey. We found 29 nests in the Colville Delta study area in 2011, including 4 nests that were active only on the 13 June survey, prior to the nesting survey. Based on monitoring surveys and eggshell evidence, a minimum of 24 chicks were produced at 29 nests (0.83 chicks/nest). Images from camera-monitoring confirmed the presence of 1 additional chick at 1 nest that was not seen on monitoring surveys. Based on all available sources of data (camera, eggshell evidence, and monitoring surveys), a minimum of 25 chicks were produced by 29 nests (0.86 chicks/nest). However, for comparisons with previous years, the 4 nests that were active only during the 13 June survey (only flown in 2011) were excluded, increasing the estimate to 0.96 chicks/nest (Table 13).

Twelve of 15 (80%) Yellow-billed Loon pairs that hatched at least 1 egg retained 1 chick on the final monitoring survey on 12 September (Table 14). Seven of those pairs retained both chicks. Three pairs suffered complete brood loss: 1 pair lost their chick within 6 d of hatch, and 2 pairs lost their broods within 7–14 d of hatch. One goal of brood monitoring was to estimate juvenile recruitment, or how many chicks survived to fledging. Nineteen chicks from 29 nests (0.66 chicks/nest), or from 25 nests (0.76 chicks/nest) excluding the 4 nests only found prior to the nesting survey, survived until the last survey on 12 September (Table 14). Despite finding the fewest nests in 2011 since nest monitoring surveys began in 2005, productivity (chicks/nest) measured in September was the highest observed since brood-monitoring began in 2008 (Table 13). The combination of average nesting success, a high proportion of 2-chick broods, and high chick survival contributed to a slightly above average chick count in September. On the final survey on 12 September, most loon chicks were 8–9 weeks old and none were observed flying (Table 14). The period from hatch to fledging is unknown in Yellow-billed Loons, but is assumed to be similar to Common Loons, which make their first flights at ~11 weeks (McIntyre and Barr 1997, North 1994). Chicks in this study were observed exercising their wings by mid-September but were likely 2–3 weeks from becoming flight capable.

NE NPRA

Distribution and Abundance

During the survey conducted on 13 June in 2011, we found 1 Yellow-billed Loon nest in the NE NPRA study area. That nest failed by the time the nesting survey was conducted on 21 June 2011. During the nesting survey, we counted 30 Yellow-billed Loons and 8 nests in the 3 subareas surveyed: Alpine West, Fish Creek Delta, and the eastern part of the Fish and Judy Creek Corridor (Figure 12, Table 9). Four additional nests were found during monitoring surveys, 1 nest on 27 June and 3 nests on 4 July. At 3 of these territories, pairs were observed near the eventual nest location during the nesting survey, but laying probably had not yet occurred. Of the 13 nests found in the NE NPRA study area in 2011, 1 nest was located in the Alpine West subarea, 7 nests in the Fish Creek Delta subarea, and 5 nests in the Fish and Judy Creek Corridor subarea (Appendix E).

All Yellow-billed Loon nests found in NE NPRA in 2011 were on lakes where nesting was recorded during surveys in previous years (Figure 12) (Johnson et al. 2007b, 2010, 2011). Of the 13 nests found, 2 were located at the same nest site used in 2010, 6 were at nest sites or very close to nest sites used in years prior to 2010, and 5 were at new nest sites on lakes where nesting had occurred in previous years. The water level of most lakes in the Fish Creek Delta subarea was higher during the nesting survey in 2011 than in previous years, and many traditional nest sites were underwater and not available to loons. The high water levels may have caused some loons to use alternate nest sites, while others either waited for water levels to drop and nested late or did not attempt to nest.

The density of Yellow-billed Loon adults and nests in the NE NPRA study area during the nesting survey in 2011 was average at 0.12 birds/km² and 0.05 nests/km² (Appendix E). The density of loons and nests in the Alpine West subarea in 2011 (0.03 birds/km² and 0.01 nests/km²) was the same as the 9-year mean (2002–2004 and 2006–2011); no more than 1 Yellow-billed Loon nest has been recorded in the Alpine West subarea during each survey year. The density of loons and nests in the Fish Creek Delta subarea in 2011 (0.12 birds/km² and 0.05 nests/km²) also was similar to the 6-year mean (0.13 birds/km² and 0.05 nests/km²) from 2005–2006 and 2008–2011.

In 2011, 21 territories were surveyed in NE NPRA and 13 nests were found for a 62% territory occupancy by nests, which was average (62.1%, SE = 1.4, n = 10 years; Table 9). Nesting surveys for Yellow-billed Loons in the NE NPRA 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). An additional 7 nests were found in 2010 during monitoring surveys. The range of Yellow-billed Loon territory occupancy by nests was 57%–71% during 2002–2004 and 2008–2010.

During the brood-rearing survey on 15 August 2011, 31 adult Yellow-billed Loons and 4 broods were observed in the NE NPRA study area (Figure 12, Table 10). Three broods were found in the Fish Creek Delta, 1 brood was found in the Fish and Judy Creek Corridor, and no broods were found in the Alpine West subarea (Appendix E). The density of adults and broods in the Fish Creek Delta during the brood-rearing survey in 2011 (0.10 birds/km² and 0.02 broods/km²; Appendix E) was the same as the 6-year mean for that area (2005–2006 and 2008–2011).

In 2011, we surveyed 21 territories containing only 4 broods for a 19% territory occupancy by broods, less than the 10-year mean (27.9%, SE = 3.1; Table 10). The highest territory occupancy by broods (48%) occurred in 2003 and the lowest occurred in 2006 (17%). During brood-rearing surveys for Yellow-billed Loons in 2008–2010, 49–51 territories were surveyed each year. The highest number of Yellow-billed Loons recorded during brood-rearing surveys in these 3 years was 85 adults in 2009 and the highest number of broods was 15 in 2010 (Table 10). Additional broods were recorded during monitoring surveys in 2008–2010, and with the inclusion of those broods, the highest number occurred in 2008, when 19 broods were found.

Habitat Use

Habitat selection was evaluated for nesting and brood-rearing Yellow-billed Loons in 2008–2011 in the 3 subareas surveyed for loons (Alpine West, Fish Creek Delta, and Fish and Judy Creek Corridor subareas) in the NE NPRA study area. Yellow-billed Loon nests were found in 12 of 26 available habitats in the NE NPRA study area (Table 16). Four habitats were preferred for nesting (Tapped Lake with High-water Connection, Deep Open Water with Islands or Polygonized Margins, Sedge Marsh, and Deep Polygon Complex), altogether supporting 57 of 90 total nests. Within these areas, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. All nests were on shorelines of lakes, but only nests on islands or in emergent vegetation were assigned to the aquatic habitat of the lake; otherwise nests were assigned to the terrestrial habitat on the lakeshore. Deep Open Water with Islands or Polygonized Margins was the most frequently used habitat for nesting (38% of all nests; Table 16). Nesting Yellow-billed Loons avoided 6 habitats (Open-Nearshore Water, Salt Marsh, Old Basin Wetland Complex, Moist Sedge–Shrub Meadow, Moist Tussock Tundra, and Tall, Low, or Dwarf Shrub), composing 48% of the loon survey area in the NE NPRA.

Forty-one Yellow-billed Loon broods were found in 3 habitats in the NE NPRA study area, 2 of which were preferred: Deep Open Water with Islands or Polygonized Margins and Tapped Lake with High-water Connection (Table 16). Deep Open Water with Islands or Polygonized Margins also was the most frequently used habitat for brood-rearing (78% of all broods). No shallow-water habitats were used during brood-rearing. The selection analyses for loon in the NE NPRA, like those conducted for the Colville Delta, highlight the reliance on large, deep waterbodies by breeding Yellow-billed Loons.

Nest Monitoring and Nest Fate

Overall, 4 of 13 Yellow-billed Loon nests hatched in the NE NPRA study area in 2011 for an apparent nesting success of 31%, which was the lowest observed since monitoring surveys began in 2008 (Tables 13 and 17). Within the 2011 study area, we found a similar number of nests in each of 3 previous years (2008–2010; 12–13 nests), but nesting success was higher in those years, ranging from 54 to 58% (mean = 57%, n = 3 years). Of the 4 successful nests in 2011, 3 (75%) hatched between visits on 11 and 18 July and the remaining nest, first discovered on 4 July, hatched by 8 August (Table 17).

Nine of thirteen Yellow-billed Loon nests in the NE NPRA study area failed to hatch (Table 17). One nest found on 13 June failed by the time of the nesting survey on 21 June. Three nests failed during the week after the nesting survey and 1 failed between 27 June and 4 July. An additional 3 nests failed between 11 and 18 July, including 1 nest that may have failed earlier but the date of failure was unknown due to a camera malfunction. The last nest failure occurred by 1 August.

The contents of 10 of 13 Yellow-billed Loon nests were examined after nests were no longer active. Three nests were classified as successful based on the presence of eggshell fragments in the nest and a brood; an additional nest was not examined but was associated with a brood. The 3 successful nests that were examined contained 40–80 small eggshell fragments within 5 m of the nest. Of >170 eggshell fragments found in successful nests, 73% were ≤10 mm in length. All 3 nests also contained pieces of thickened egg membrane. The majority of egg membranes and eggshell fragments were found in nest bowls and <10 fragments were found in the water or on shore adjacent to successful nests. Seven of 9 failed nests

Table 16. Habitat selection by nesting and brood-rearing Yellow-billed Loons, NE NPRA study area, Alaska, 2008–2011.

SEASON Habitat	No. of Nests or Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	8.9	avoid	
Brackish Water	0	0	3.8	ns	low
Tapped Lake with Low-water Connection	0	0	2.5	ns	low
Tapped Lake with High-water Connection	11	12.2	1.9	prefer	low
Salt Marsh	0	0	6.7	avoid	low
Tidal Flat Barrens	0	0	6.7	ns	low
Salt-killed Tundra	0	0	2.6	ns	low
Deep Open Water without Islands	3	3.3	6.0	ns	
Deep Open Water with Islands or Polygonized Margins	34	37.8	5.7	prefer	
Shallow Open Water without Islands	0	0	0.6	ns	low
Shallow Open Water with Islands or Polygonized Margins	4	4.4	1.5	ns	low
River or Stream	0	0	2.2	ns	low
Sedge Marsh	10	11.1	1.4	prefer	low
Deep Polygon Complex	2	2.2	0.1	prefer	low
Grass Marsh	2	2.2	0.4	ns	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	0	0	4.2	avoid	low
Riverine Complex	0	0	0.1	ns	low
Dune Complex	3	3.3	0.7	ns	low
Nonpatterned Wet Meadow	4	4.4	3.1	ns	low
Patterned Wet Meadow	12	13.3	10.6	ns	
Moist Sedge-Shrub Meadow	4	4.4	12.6	avoid	
Moist Tussock Tundra	1	1.1	12.6	avoid	
Tall, Low, or Dwarf Shrub	0	0	3.1	avoid	low
Barrens	0	0	1.7	ns	low
Human Modified	0	0	0	ns	
Total	90	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	8.9	ns	low
Brackish Water	0	0	3.8	ns	low
Tapped Lake with Low-water Connection	0	0	2.5	ns	low
Tapped Lake with High-water Connection	7	17.1	1.9	prefer	low
Salt Marsh	0	0	6.7	ns	low
Tidal Flat Barrens	0	0	6.7	ns	low
Salt-killed Tundra	0	0	2.6	ns	low
Deep Open Water without Islands	2	4.9	6.0	ns	low
Deep Open Water with Islands or Polygonized Margins	32	78.0	5.7	prefer	low
Shallow Open Water without Islands	0	0	0.6	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	1.4	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	4.2	ns	low
Riverine Complex	0	0	0.1	ns	low
Dune Complex	0	0	0.7	ns	low
Nonpatterned Wet Meadow	0	0	3.1	ns	low
Patterned Wet Meadow	0	0	10.6	avoid	low
Moist Sedge-Shrub Meadow	0	0	12.6	avoid	
Moist Tussock Tundra	0	0	12.6	avoid	
Tall, Low, or Dwarf Shrub	0	0	3.1	ns	low
Barrens	0	0	1.7	ns	low
Human Modified	0	0	0	ns	
Total	41	100	100		

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

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

[c] Expected number < 5

Table 17. Weekly status and fate of Yellow-billed Loon nests monitored by aerial surveys, NE NPRA study area, Alaska, 2011. 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				August		
Territory	13	21–22	27[a]	4[a]	11[a]	18	25	1	8	Fate/Total
51	A	I	–	–	–	–	–	–	–	Failed
53	I	A	A	A	A	I	–	–	–	Hatched
55	I	I	A	A	A	A	A	I	–	Failed
58[b]	I	A	A	I	–	–	–	–	–	Failed
59[b]	I	A	I	–	–	–	–	–	–	Failed
88[b]	I	A	A	A	A	I	–	–	–	Hatched
89	I	I	I	A	A	A	A	A	I	Hatched
90[b]	I	A	A	A[c]	A[c]	I[c]	–	–	–	Failed
91	I	A	I	–	–	–	–	–	–	Failed
92[b]	I	A	A	A	A	I	–	–	–	Hatched
93	I	I	I	A	A	I	–	–	–	Failed
96	I	I	I	A	A	I	–	–	–	Failed
100[b]	I	A	I	–	–	–	–	–	–	Failed
No. Active	1	8	6	8	8	2	2	1	0	13
No. Hatched	0	0	0	0	0	3	0	0	1	4
No. Failed	0	1	3	1	0	3	0	1	0	9

[a] Camera-monitored nests were not surveyed by helicopter; nest status determined from camera images
[b] Nest monitored by camera
[c] Camera bumped by animal on 29 June and after then was no longer focused on nest. Nest found inactive during aerial survey on 18 July; date of failure unknown but counted as failed on 18 July

were examined for fate evidence. The 2 nests not visited were on islands that were inaccessible; both nests failed within a week of discovery. Of the 7 nests examined, 2 were empty and 4 had 1–9 pieces of eggshell in or near the nest. Another nest was associated with 20 egg fragments, 17 of which were strewn into the water. The fragments from this nest had membranes that were both adhered and easily peeled. This nest was confirmed as failed because it was active for less than the incubation period (27–28 days; North 1994) for Yellow-billed Loons.

Time-lapse Cameras

We monitored 6 of 13 Yellow-billed Loon nests in the NE NPRA study area with time-lapse cameras in 2011 (Table 18). Eight-power telephoto cameras were placed 50–77 m from nests (mean = 64 m, SE = 13.5 m, n = 2) and 2× and 2.5× telephoto cameras were placed 38–95 m from nests (mean = 60 m, SE = 12.4 m, n = 4). Two researchers were transported to and from nesting areas by helicopter for camera setup and were at nests an average of 34 min (range = 23–42 min, n = 6 nests). One of 6 loons remained on its nest during camera setup and 5 left their nest (2 swam away as the helicopter landed, 2 left as researchers exited the helicopter, and 1 left as researchers approached the camera setup location).

Four of 5 loons that left their nests returned to incubate after camera installation; 1 loon did not return and that nest suffered predation by a Parasitic Jaeger (see below). Loons returned to their nests an average of 18 min after we departed in the helicopter (median = 18 min, SE = 3 min, range = 9–27 min, n = 4 nests). Loons were absent from nests during camera installation for a mean of 55 min (median = 54 min, SE = 3 min, range = 48–65 min, n = 4 nests).

We were able to identify the day of hatch or failure from 5 of 6 camera-monitored nests. At 1 nest, an unidentifiable animal disturbed the camera so that it was no longer focused on the nest. Of the 6 nests that were monitored, 2 hatched and 4 failed

Table 18. Nest history and incubation activity at Yellow-billed Loon nests monitored by time-lapse digital cameras, NE NPRA study area, Alaska, 2011.

Territory	Fate[a]	Nest Initiation 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)
58	F	19 June	Glaucous Gull	2	24 June	1 July	7.3	95.6	1.2	4.5	26.1
59	F	19 June	Parasitic Jaeger	2	24 June	25 June	0.4	0.1	0	2.7	888.0
88	S	14 June		2	25 June	12 July	15.8	98.2	0.8	1.7	14.1
90[e]	F	15 June	Unknown	2	25 June	29 June	4.2	94.7	1.9	5.3	14.9
92	S	15 June		2	25 June	13 July	16.9	98.5	1.7	1.8	10.6
100	F	–	Parasitic Jaeger	–[f]	24 June	25 June	0.9	96.1	2.1	3.2	19.3

[a] S = successfully hatched, F = failed to hatch

[b] Nest initiation dates for successful nests estimated by subtracting 28 d from hatch date; for failed nests, nest age estimated using egg floatation (see Methods: Loon Surveys)

[c] As known on day of camera setup 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] Camera bumped by animal on 29 June and after then was no longer focused on nest; date of failure unknown

[f] Eggs not floated

for an apparent nesting success of 33%. The median initiation date of camera-monitored nests was 15 June (range = 14–19 June, n = 5). The 2 successful nests hatched on 12 July and 13 July (Table 18). Hatch dates determined from camera images agree with the hatch dates determined from monitoring surveys, which indicate that most nests hatched between visits on 11 and 18 July (Table 17). Loons at hatched and failed nests exhibited high nest attendance, spending 98.4% (n = 2) and 95.2% (n = 2) of the time incubating, respectively (Table 18).

Since camera monitoring began in 2010 in the NE NPRA study area, predators have been identified at 9 of 16 monitored nests and all were avian predators that, except for Golden Eagles, took eggs while nests where unattended (Figure 15). In some cases, avian predation likely ensued when incubating birds left their nests to encounter intruding Yellow-billed Loons. When intruding loons were seen in camera images, the incubating loon almost always left its nest to interact with the intruders, often aggressively, which left the nest exposed to avian predators. In 2011, 4 of 6 nests monitored with cameras failed to hatch (Table 18). Two failures were attributed to Parasitic Jaegers and 1 to a Glaucous Gull. At the remaining nest, an animal disturbed the camera for ~6 min, after which the nest was no longer in the field of view. The cause of failure at that nest was unknown. All 3 nests that failed due to avian predation were unattended prior to the predation event. Researcher disturbance and/or intruding loons during camera installation likely contributed to the extended absence of 1 pair, resulting in nest predation attributed to Parasitic Jaegers. At that nest, 2 Yellow-billed Loons were at the opposite end of the nest lake; when the incubating loon left the nest

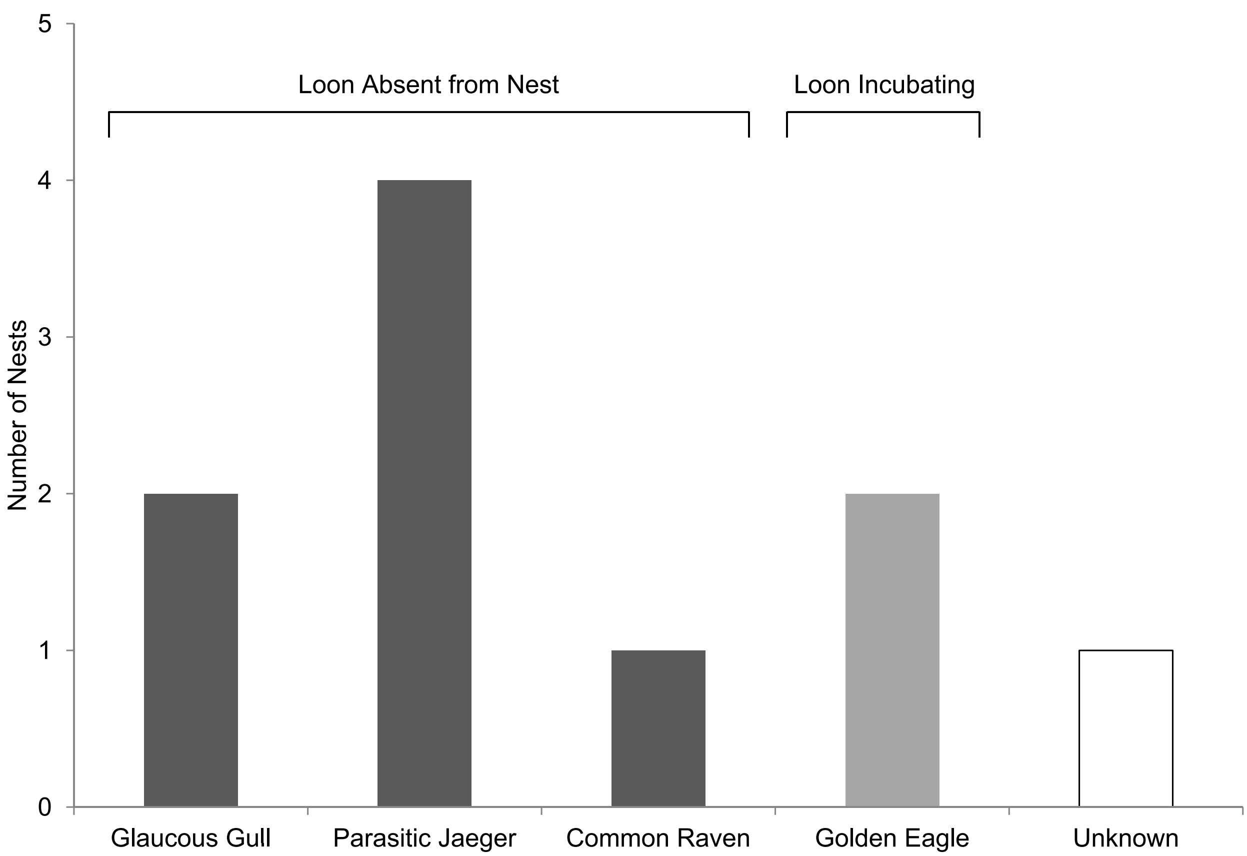

Figure 15. Predators seen taking eggs at camera-monitored Yellow-billed Loon nests (n = 16 nests), NE NPRA study area, Alaska, 2010–2011. Predation events divided between those that occurred when the loon was off the nest and those that occurred when the loon was incubating and flushed by the predator. Data include partial predation events at nests that later hatched 1 egg as well as events that caused nest failure.

during camera installation, it flew to join the intruding loons. In images taken after departure of the researchers, 3–4 loons were seen interacting ~350 m from the camera. Aggressive postures, such as fencing, were observed among the loons. Although a loon returned to the nest ~2.5 h after researchers left, it only incubated for 2 min before leaving again. A Parasitic Jaeger destroyed the unattended nest ~13 h after camera installation. The second failure attributed to Parasitic Jaegers occurred when a jaeger landed at a nest that had been unattended for 10 minutes. The loon returned after about 5 minutes and chased the jaeger but did not resume incubation. The reason that the loon left its nest prior to predation was unknown but 3 loons were observed swimming near the nest ~1.5 h after the predation. The third nest that failed due to avian predation was destroyed by a Glaucous Gull. The incubating loon was gone from the nest for ~22 min before a gull appeared and ate the eggs. The gull spent ~7 min at the nest eating eggs before leaving. A loon eventually returned and was observed swimming away from the nest with pieces of eggshell.

Intruding loons were seen on images at 3 of 6 camera-monitored territories. As reported above, intruding loons also were seen at nests in the Colville Delta study area and may reflect attempts at territorial takeover by the intruders. Territorial fights and subsequent takeovers have been observed in Common Loons but it is unknown whether this behavior also plays an important role in the establishment of Yellow-billed Loon territories (North 1994, Piper et al. 2000).

Brood Fate

During the monitoring survey following hatch, 2 of 4 successful Yellow-billed Loon pairs in the NE NPRA study area were observed with 2 chicks and 2 pairs had 1 chick (Table 19). Chicks were observed at all hatched nests during aerial surveys and all chicks seen on images at camera-monitored nests also were seen during monitoring surveys. Thirteen nests were found in the NE NPRA study area in 2011, including 1 that was active only on 13 June, prior to the nesting survey. Based on camera monitoring, eggshell evidence, and brood-monitoring, a minimum of 6 chicks were produced at 13 nests (0.46 chicks/nest). For the purposes of annual comparisons, we also calculated productivity excluding the nest that failed prior to the usual nesting survey, which resulted in the lowest estimate of post-hatch productivity in 4 years (0.50 chicks/nest; Table 13).

All 4 Yellow-billed Loon pairs that hatched eggs retained chicks through the final monitoring survey on 12 September. One pair retained both chicks. During the final survey, we recorded 5 chicks from 13 nests (0.38 chicks/nest). Excluding the nest that failed prior to the nesting survey, the final productivity estimate was 0.42 chicks/nest (Table 13). The number of chicks that survived to September in 2011 was below the mean of the previous 2 years (0.50 chicks/nest; Table 13). However, the sample size of nests in 2011 was much smaller than in previous years, making annual comparisons less reliable. Most loon chicks in 2011 were ~8 weeks old (range = 6–8 weeks) and none were observed flying by the time of the last survey in mid-September (Table 19). Assuming the fledging period is similar to that of Common Loons, which is ~11 weeks (McIntyre and Barr 1997, North 1994), the chicks in this study were 3–5 weeks from fledging.

PACIFIC AND RED-THROATED LOONS

Colville Delta

We counted 150 Pacific Loons and 15 nests, and 11 Red-throated Loons and 1 Red-throated Loon nest in the Colville Delta study area during the nesting survey for Yellow-billed Loons in 2011 (Figure 16, Appendix E). During the brood-rearing survey, we recorded 54 adult Pacific Loons and 10 broods and 3 adult Red-throated Loons and 1 brood (Figure 16, Appendix E). Because these counts of Pacific and Red-throated loons were made 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 relative abundance of these species (due to differences in species detectability). 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 2011 and in previous years. Because the survey focused on lakes larger than those typically occupied by

Table 19. Number of Yellow-billed Loon chicks observed during weekly aerial surveys, NE NPRA study area, Alaska, 2011.

	July		August					September		No. Chicks	Age (d) When	Brood
Territory	18	25	1	8	15	24	29	5	12	Hatched	Last Seen	Fate[a]
53	1[c]	1	1	1	1	1	1	1	1	1	59.5	A
88[d]	2	2	2	2[e]	2[e]	2	2	2	2	2	59.5	A
89	Inc	Inc	1[c, f]	1	1	1	1	1	1	1	45.5	A
92[d]	2	2	2	2	2	1	1	1	1	2	59.5	A
Totals												
Broods of 2	2	2	2	2	2	1	1	1	1	–	–	–
Broods of 1	1	1	2	2	2	3	3	3	3	–	–	–
Chick Loss	0	0	0	0	0	1	0	0	0	–	–	–

[a] A = active, young present on 12 September, F = failed
[b] Inc = loon incubating at the time of the survey
[c] No chick observed; 1 chick assumed present based on subsequent aerial surveys
[d] Nest monitored by camera
[e] Only 1 chick observed; 2 chicks assumed present based on subsequent aerial surveys
[f] Adult brooding chick

Pacific and Red-throated loons for nesting and brood-rearing, densities have not been calculated for these 2 species.

NE NPRA

Pacific Loons also were the most abundant and widespread loon species breeding in the NE NPRA study area in 2011. On the loon nesting survey, we recorded 137 adult Pacific Loons and 13 nests (Figure 16, Appendix E). During the brood-rearing survey, 72 adult Pacific Loons and 11 broods were found (Figure 16, Appendix E). Two adult Red-throated Loons were observed during the nesting survey and 1 adult during the brood-rearing survey (Figure 16, Appendix E). No nests or broods of Red-throated Loons were found in the NE NPRA study area.

DISCUSSION

The number of Yellow-billed Loon adults and nests recorded during nesting surveys in the Colville Delta study area has increased since aerial surveys began. During 17 years of nesting surveys in the Colville Delta study area, the lowest number of nests recorded was 10 nests in 1993 and 1997 and the highest was 33 nests in 2008 (Table 9). In most years, an additional 1–12 nests were found during ground, revisit, and/or monitoring surveys; with the addition of these nests, the counts of nests ranged from 15 in 1993 to 38 in 2008 (Table 9). Territory occupancy by nests increased from 38–58% over the first 8 years of surveys to 63–90% during the last 9 years of surveys (Table 9).

Prior to 2000, we conducted nesting surveys in a fixed-wing aircraft and the detection of adults and nests probably was lower than detection from a helicopter. When the numbers of adults and nests recorded from helicopters (2000–2011) are adjusted by the number of territories surveyed, the annual growth rate for adults is positive and significant at 1.026 ($\ln(y) = 0.026x - 47.2$, $R^2 = 0.348$, $P = 0.044$, $n = 12$), and positive but not significant at 1.023 for nests ($\ln(y) = 0.023x - 42.5$, $R^2 = 0.201$, $P = 0.14$, $n = 12$). The growth of the local population on the Colville Delta study area appears to fit into the slope-wide trend. The Colville growth rate is similar to the annual growth rate (1.019, SE = 0.009, $n = 19$ years) measured for Yellow-billed Loons on the entire Arctic Coastal Plain (Larned et al. 2011). The number of young produced on the Colville Delta study area also has increased; since 2000, the number of young counted during brood-rearing surveys has grown significantly at an annual rate of 1.146 ($\ln(y) = 0.146x - 289.7$, $R^2 = 0.468$, $P = 0.008$, $n = 12$).

Comparable data for estimating growth rates in Yellow-billed Loons in NE NPRA are unavailable. The survey area for loons in the NE NPRA study area has not been consistent for enough years to allow a meaningful evaluation. As a general observation, the number of adults and nests found in each subarea has varied but the population along the Fish and Judy creek corridor appears stable.

The increase in the numbers of adults is due in part to a higher annual occupation of territories and to an increase in the numbers of nests, but also represents an increase in the numbers of adult loons not associated with territories. The number of territories with >2 adults during nesting surveys has increased since 1993. The number of intruding loons has increased on camera images since cameras were first used in 2008. These visiting loons may be new or failed breeders and may be attempting to usurp loons in desirable territories. During 2005–2008, a total of 83 young were recorded during brood-rearing surveys in the Colville Delta study area; the survivors from these cohorts would be at breeding age (3–6 years, Barr 1997) in 2011. Assuming that young return to natal grounds for breeding, as has been documented in Common Loons (McIntyre and Barr 1997), the return of these cohorts of birds to the study area could account for the increase in adults observed.

The timing of nest initiation and the number of nests occurring in both the Colville Delta and NE NPRA study areas during the study years were influenced by the extent of flooding during breakup and by climatic conditions in mid-May to mid-June. In years when flooding resulted in high water levels on nesting lakes, some loons could not occupy traditional nest sites and either waited for water levels to drop before nesting, nested at an alternate site, or failed to nest. In 2011, water levels were high in the CD North and Fish Creek Delta subareas, and this is probably why the CD North subarea had the lowest number of nests found in the last 9 years. High water levels also may have caused late nesting at 3 territories in the Fish Creek

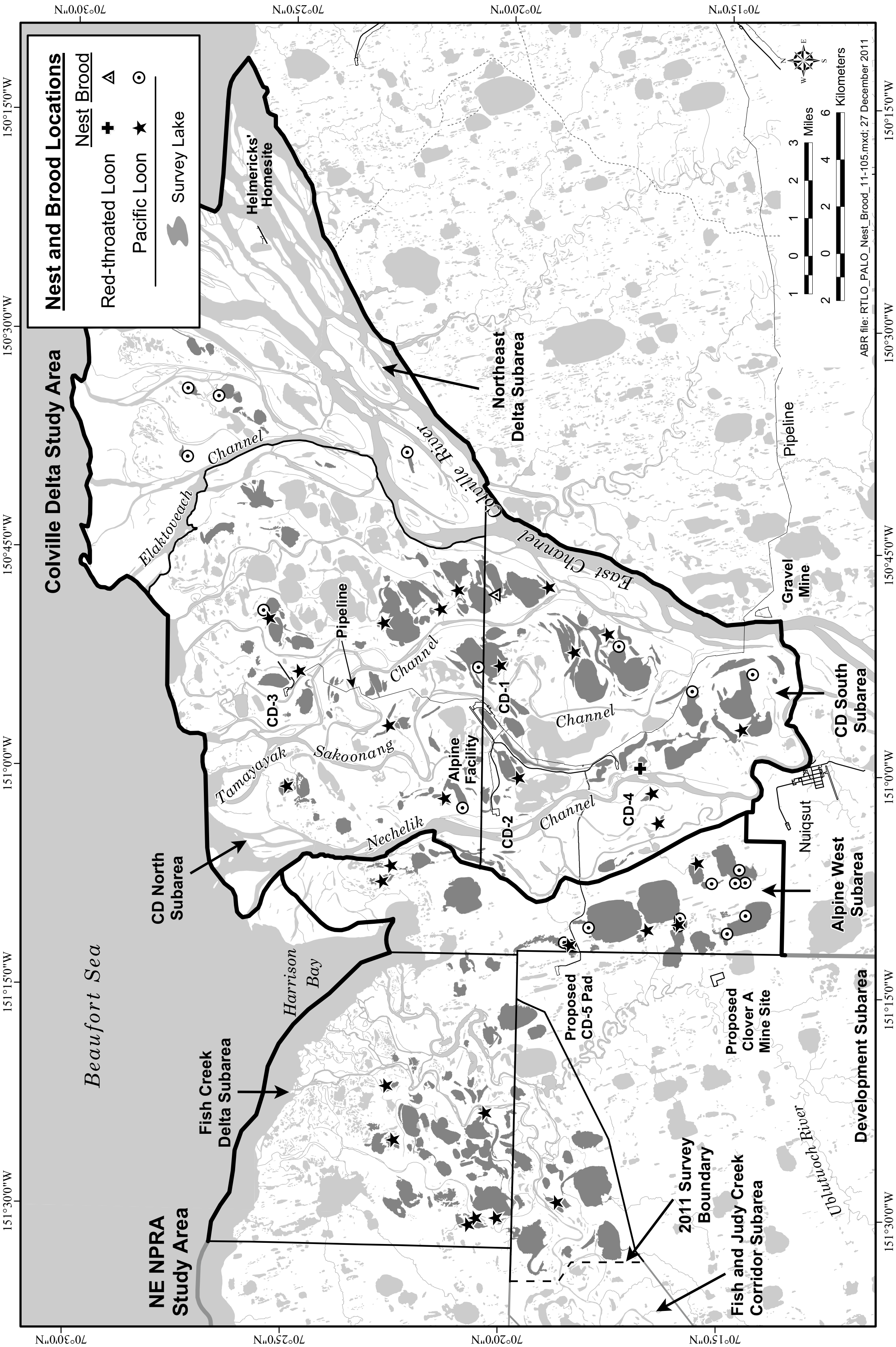

Figure 16. Pacific and Red-throated loon nests and broods, Colville Delta and NE NPRA study areas, Alaska, 2011.

Delta subarea, where nests were initiated 2 weeks after the nesting survey in 2011, when water levels had dropped. Late nesting phenology in 2010 on the Colville Delta was the result of delayed thaw and the late formation of moats around ice on nesting lakes (Johnson et al. 2011), which delayed access to lakes. In sharp contrast, Yellow-billed Loons initiated nesting early on the Colville Delta in 2008 (between 7–15 June) because May and June were warm and breakup on the Colville River was average (Johnson et al. 2009). Thirty-eight nests were found in the Colville Delta study area in 2008, the highest number recorded during 17 years of surveys (Table 9).

We conducted for the first time in 2011 a survey for nesting Yellow-billed Loons 1 week earlier than the nesting survey to document nests that fail prior to the nesting survey. Including nests from that survey in the nesting success calculation produced a lower estimate because most of those early nests failed. If this pattern is representative of most breeding years, previous nesting success reports based on a nest survey during the 3rd week of June overestimate actual hatch rates. We have conducted monitoring surveys of all known (active or inactive) territories in the Colville Delta study area for 6 years (2006–2011) and in the NE NPRA study area for 3 years (2009–2011). Together, the early survey and the monitoring surveys have increased the number of nests detected, improved estimates of nesting success, and have documented 2 renesting attempts. Although we have suspected in previous years that Yellow-billed Loons renest after an early nest failure, the data from weekly resurveys in 2011 have provided strong evidence that renesting occurs with this species.

We began monitoring a sample of Yellow-billed Loon nests with cameras in the Colville Delta and NE NPRA study areas in 2008 and 2010, respectively. From all the nests monitored with cameras, predators took 1 or both eggs from 45% of 84 nests. Glaucous Gulls and Parasitic Jaegers were the most commonly recorded nest predators, taking eggs at 53% of the nests that lost eggs (n = 38 nests). Those avian predators, along with Common Ravens, preyed exclusively on unattended nests. Golden Eagles were the only avian species that flushed Yellow-billed Loons from nests to take eggs. Red foxes were the second most commonly recorded predator on the Colville Delta and they also flushed loons to take eggs from attended nests. Red Foxes were not seen preying on nests in the NE NPRA study area. A preliminary comparison of incubation constancy between successful and failed nests shows that loons at successful nests spent a higher percentage of time on nests (mean = 97.7%) than those at failed nests (mean = 93.3%; Mann-Whitney U test, n = 76, $p<0.001$). This behavioral difference appears to be important given the fairly high rate of egg loss that occurs when nests are unattended. Reasons for poor attendance were unknown at many nests, but at other nests we observed predation when resident loons were off nests while interacting with intruding loons or during periods of warm weather (i.e. >60°F; this study, unpublished data).

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 59% (n = 7 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. 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, our post-hatch productivity was lower, ranging from 0.47–1.16 chicks/nest (mean = 0.87 chicks/nests, n = 7 years). Once chicks hatched, however, ~80% survived until mid-September; the only exception was in 2008 when nesting success was high but chick survival was low.

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 study by North (1986). In our Colville Delta study area, gulls took eggs in 32% of the predation events. Although gull numbers across the Arctic Coastal Plain have been variable and fairly stable over the last 19 years, data from the last 10 years suggest that numbers have increased (Larned et al. 2011). Since 2002, the number of gull nests seen in the Colville Delta study area also has increased (see Glaucous Gull section 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 29% of the predation events since camera monitoring began in 2008 (*n* = 28 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 fox, 16% as red fox, and 12% were unidentified. In 2010–2011, over half (58%) of the foxes seen on images from cameras monitoring loon nests were identified as red fox (*n* = 52 fox occurrences). An increase in the number of red foxes would likely have a negative effect on Yellow-billed Loon productivity because red foxes appear to be more effective predators of loon nests than arctic foxes. Camera images from this study have shown arctic fox passing by Yellow-billed Loon nests and, less frequently, trying to flush loons from nests, but they have not been documented taking eggs. In contrast, red foxes frequently have been successful at flushing loons from nests to steal eggs.

TUNDRA SWAN

COLVILLE DELTA

Distribution and Abundance

Tundra Swan abundance and productivity matched long-term mean values on the Colville Delta study area in 2011. During the swan nesting survey, 362 swans, including 118 pairs, were counted in the Colville Delta study area (Figure 17). The count of swans in 2011 was very close to the 18-year mean of 378 swans found in the study area (range 208–749, SE = 159). Thirty-five swan nests were found in the Colville Delta study area in 2011 (Table 20), approximating the annual mean of 34 nests. Twelve nests were located in the CD North subarea, 10 were in the CD South subarea, and 13 were in the Northeast Delta subarea. Twelve 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 20), for consistency with data presentations from previous years; however, all swan nests are displayed in Figure 17.

Productivity of Tundra Swans was average on the Colville Delta in 2011. During the brood-rearing survey, 29 Tundra Swan broods were observed in the Colville Delta study area, slightly more than the 18-year mean of 25 broods. Nesting success was 83%, which was higher than the 18-year mean of 74% (Table 20). Similarly, nesting success in the adjacent Kuparuk oilfield during 2011 (96%) was similarly higher than the 22-year mean (79%; Stickney et al. 2012). The mean brood size of 2.8 young in 2011 on the Colville Delta was only slightly greater than the 18-year mean of 2.6, and the total of 63 young counted on the delta was nearly equal to the 18-year mean of 62 young per year.

Habitat Use

Habitat selection was evaluated for 615 Tundra Swan nests recorded on the Colville Delta since 1992 (Table 21). 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, 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.

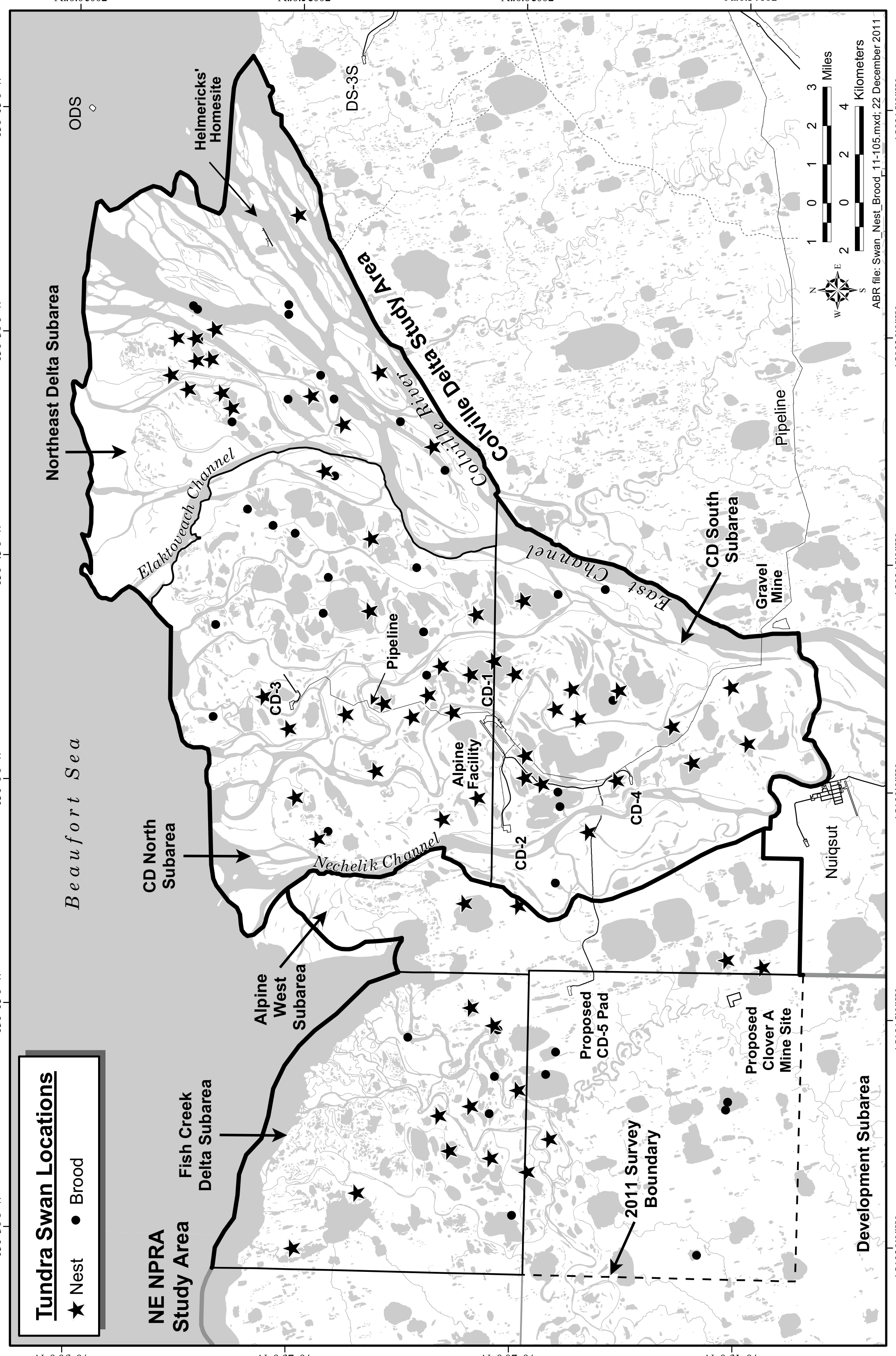

Figure 17. Tundra Swan nests and broods, Colville Delta and NE NPRA study areas, Alaska, 2011.

Table 20. Number and density (bird/km²) of Tundra Swan nests and broods during aerial surveys, Colville Delta study area, Alaska, 1992–2011.

Year	No. Nests	Density [a]	No. Broods	Density [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
Mean	34	0.06	25	0.05	2.6	74
SE	2.3	<0.01	1.9	<0.01	0.1	4.5

[a] Area surveyed = 552.2-km²

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 18 years of surveys, Tundra Swans nested in 19 of 24 available habitats, of which 8 habitats were preferred and 7 were avoided (Table 21). Eighty 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, Grass Marsh, Deep Polygon Complex, Patterned Wet Meadow, and Moist Sedge–Shrub Meadow. Nests occurred most frequently in Patterned Wet Meadow (38% of all nests), Deep Polygon Complex (13%), and Salt-killed Tundra (10%).

Habitat selection also was evaluated for 448 Tundra Swan broods recorded on the Colville Delta since 1992 (Table 21). 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 35% of all swan broods on the delta were in salt-affected habitats, compared with only 20% of all nests (Table 21). Similar patterns have been reported by previous investigations (Spindler and Hall 1991, Monda et al. 1994).

Table 21. Habitat selection by nesting and brood-rearing Tundra Swans, Colville Delta study area, Alaska, 1992, 1993, 1995–1998, and 2000–2011.

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	8	1.3	1.2	ns	
Tapped Lake with Low-water Connection	2	0.3	3.9	avoid	
Tapped Lake with High-water Connection	5	0.8	3.8	avoid	
Salt Marsh	40	6.5	3.0	prefer	
Tidal Flat Barrens	5	0.8	10.6	avoid	
Salt-killed Tundra	64	10.4	4.6	prefer	
Deep Open Water without Islands	16	2.6	3.3	ns	
Deep Open Water with Islands or Polygonized Margins	38	6.2	1.8	prefer	
Shallow Open Water without Islands	3	0.5	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	0.3	0.1	ns	low
River or Stream	0	0	15.0	avoid	
Sedge Marsh	2	0.3	<0.1	prefer	low
Deep Polygon Complex	81	13.2	2.4	prefer	
Grass Marsh	12	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	47	7.6	7.5	ns	
Patterned Wet Meadow	231	37.6	18.6	prefer	
Moist Sedge-Shrub Meadow	27	4.4	2.2	prefer	
Moist Tussock Tundra	8	1.3	0.6	ns	low
Tall, Low, or Dwarf Shrub	10	1.6	5.0	avoid	
Barrens	14	2.3	13.8	avoid	
Human Modified	0	0	0.1	ns	low
Total	615	100	100		
BROOD-REARING					
Open Nearshore Water	1	0.2	1.8	avoid	
Brackish Water	28	6.3	1.2	prefer	low
Tapped Lake with Low-water Connection	64	14.3	3.9	prefer	
Tapped Lake with High-water Connection	49	10.9	3.8	prefer	
Salt Marsh	30	6.7	3.0	prefer	
Tidal Flat Barrens	3	0.7	10.6	avoid	
Salt-killed Tundra	32	7.1	4.6	prefer	
Deep Open Water without Islands	38	8.5	3.3	prefer	
Deep Open Water with Islands or Polygonized Margins	16	3.6	1.8	prefer	
Shallow Open Water without Islands	6	1.3	0.4	prefer	low
Shallow Open Water with Islands or Polygonized Margins	2	0.4	0.1	ns	low
River or Stream	24	5.4	15.0	avoid	
Sedge Marsh	0	0	<0.1	ns	low
Deep Polygon Complex	13	2.9	2.4	ns	
Grass Marsh	10	2.2	0.3	prefer	low
Young Basin Wetland Complex	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	25	5.6	7.5	ns	
Patterned Wet Meadow	57	12.7	18.6	avoid	
Moist Sedge-Shrub Meadow	7	1.6	2.2	ns	
Moist Tussock Tundra	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	8	1.8	5.0	avoid	
Barrens	34	7.6	13.8	avoid	
Human Modified	0	0	0.1	ns	low
Total	448	100	100		

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

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

[c] Expected number < 5

NE NPRA

Distribution and Abundance

During the 2011 nesting survey, 148 swans were counted in the NE NPRA study area, including 52 pairs, of which 12 pairs were nesting (Table 22). An additional 3 nests were discovered during helicopter-based loon surveys of limited portions of the NE NPRA study area. Apparent nesting success in 2011 was 83% (12 nests, 10 broods). The high nest success in the NE NPRA study area mirrored the high success rate of nests in the adjacent, much larger Colville Delta study area. Mean brood size was 1.9 young, less than the mean of 2.8 young/brood produced in the Colville Delta study area.

Habitat Use

Habitat selection was calculated for 299 Tundra Swan nests recorded in the NE NPRA study area since 2001 (Table 23). 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 65 nests were located.

Swan broods in NE NPRA 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 185 Tundra Swan broods recorded in the NE NPRA study area since 2001 (Table 23). Tundra Swan broods used 21 of 26 available habitats. One hundred and nineteen broods (40%) were located in the 6 preferred habitats: Brackish Water, Tapped Lake with Low-water Connection, both types of Deep Open Water, River or Stream, and Grass Marsh.

DISCUSSION

Since we began aerial surveys for Tundra Swans on the Colville Delta, 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. The 18-year mean is 34 nests. The trend in numbers of nests has been increasing but not at a significant rate; the annual growth rate on the Colville Delta study area was 1.021 ($\ln(y) = 0.021x - 38.24$, $R^2 = 0.153$, $P = 0.108$). However, the total number of pairs counted during the nesting surveys has increased more strongly, from a low of 42 in 1992 to a high of 118 pairs in 2011 (mean = 76). The number of pairs has grown significantly at an annual rate of 1.031 ($\ln(y) = 0.031x - 56.80$, $R^2 = 0.476$, $P = 0.002$, $n = 18$). 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. Moreover, the growth rate for Tundra Swans across the Arctic Coastal Plain (1.038) also is statistically significant (Larned et al.

Table 22. Number and density (bird/km²) of Tundra Swan nests and broods during aerial surveys, NPRA study area, Alaska, 2001–2011.

Year[a]	No. Nests	Density	No. Broods	Density	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

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

Table 23. Habitat selection by nesting and brood-rearing Tundra Swans, NE NPRA study area, Alaska, 2001–2006, 2008, 2009, and 2011.

SEASON Habitat	No. of Adults	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	0.8	ns	low
Brackish Water	4	1.3	0.9	ns	low
Tapped Lake with Low-water Connection	1	0.3	0.7	ns	low
Tapped Lake with High-water Connection	2	0.7	0.5	ns	low
Salt Marsh	13	4.3	1.7	prefer	
Tidal Flat Barrens	1	0.3	1.2	ns	low
Salt-killed Tundra	2	0.7	0.6	ns	low
Deep Open Water without Islands	12	4.0	6.5	ns	
Deep Open Water with Islands or Polygonized Margins	24	8.0	5.2	prefer	
Shallow Open Water without Islands	3	1.0	1.0	ns	low
Shallow Open Water with Islands or Polygonized Margins	17	5.7	1.6	prefer	low
River or Stream	0	0	1.2	avoid	low
Sedge Marsh	6	2.0	1.7	ns	
Deep Polygon Complex	0	0	<0.1	ns	low
Grass Marsh	6	2.0	0.3	prefer	low
Young Basin Wetland Complex	5	1.7	0.3	prefer	low
Old Basin Wetland Complex	25	8.4	8.2	ns	
Riverine Complex	1	0.3	0.4	ns	low
Dune Complex	1	0.3	1.0	ns	low
Nonpatterned Wet Meadow	14	4.7	3.0	ns	
Patterned Wet Meadow	37	12.4	11.2	ns	
Moist Sedge-Shrub Meadow	50	16.7	21.9	avoid	
Moist Tussock Tundra	71	23.7	25.8	ns	
Tall, Low, or Dwarf Shrub	4	1.3	3.1	ns	
Barrens	0	0	1.1	ns	low
Human Modified	0	0	0	ns	
Total	299	100	100		
BROOD-REARING					
Open Nearshore Water	1	0.5	0.8	ns	low
Brackish Water	5	2.7	0.9	prefer	low
Tapped Lake with Low-water Connection	7	3.8	0.7	prefer	low
Tapped Lake with High-water Connection	0	0	0.5	ns	low
Salt Marsh	2	1.1	1.7	ns	low
Tidal Flat Barrens	0	0	1.2	ns	low
Salt-killed Tundra	0	0	0.6	ns	low
Deep Open Water without Islands	51	27.6	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	41	22.2	5.2	prefer	
Shallow Open Water without Islands	2	1.1	1.0	ns	low
Shallow Open Water with Islands or Polygonized Margins	3	1.6	1.6	ns	low
River or Stream	11	5.9	1.2	prefer	low
Sedge Marsh	3	1.6	1.7	ns	low
Deep Polygon Complex	0	0	<0.1	ns	low
Grass Marsh	4	2.2	0.3	prefer	low
Young Basin Wetland Complex	1	0.5	0.3	ns	low
Old Basin Wetland Complex	7	3.8	8.2	avoid	
Riverine Complex	1	0.5	0.4	ns	low
Dune Complex	1	0.5	1.0	ns	low
Nonpatterned Wet Meadow	8	4.3	3.0	ns	
Patterned Wet Meadow	9	4.9	11.2	avoid	
Moist Sedge-Shrub Meadow	17	9.2	21.9	avoid	
Moist Tussock Tundra	5	2.7	25.8	avoid	
Tall, Low, or Dwarf Shrub	5	2.7	3.1	ns	
Barrens	1	0.5	1.1	ns	low
Human Modified	0	0	0	ns	
Total	185	100	100		

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

2011). 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). Brood counts on the Colville Delta have fluctuated considerably over the years, ranging from a low of 14 in 1993 to a high of 42 in 2004. The 2011 count of 29 broods was above average, and although the long-term growth rate was positive (1.015), it was not significant ($\ln(y) = 0.015x - 27.63$, $R^2 = 0.075$, $P = 0.27$).

Aerial surveys for nesting and brood-rearing Tundra Swans in NE NPRA have been flown since 2001; however the area surveyed has varied widely during that period. Out of the 5 sub-areas of NE NPRA, only Alpine West has been flown every year since 2001 (Appendix G). Swan surveys in 2011 were flown over a much smaller area than in previous years (Appendix G). Thus, comparisons of nest and brood counts in NE NPRA among years are not very meaningful because of different survey areas.

GEESE

COLVILLE DELTA

Distribution and Abundance

During the goose brood-rearing aerial survey in 2011, we counted 1,986 Brant (1,221 adults and 765 young) in 10 groups in the Colville Delta study area (Figure 18, Table 24). All Brant groups included broods, and goslings comprised 39% 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 15 years and the total count in 2011 was well above the long-term mean of 1,300 Brant (Table 25; Bayha et al. 1992; Johnson et al. 1999a, 2006b, 2008b, 2009, 2010, 2011). The percentage of goslings was near average, but the total count of goslings was the fourth highest in 12 years that goslings were recorded (Table 25). Total Brant numbers were similar between the CD North and Northeast Delta subareas; 1,055 Brant (647 adults and 408 goslings) were counted in 7 groups in the CD North subarea, and 931 Brant (574 adults and 357 goslings) were counted in 3 groups in the Northeast Delta subarea.

In 2011, a record 4,023 Snow Geese (1,745 adults and 2,278 goslings) were counted in 36 groups in the Colville Delta study area (Figure 18, Table 24), representing a sharp increase from the 1,873 Snow Geese (883 adults and 990 goslings) counted in 2010, and more than double the previous record of 1,967 Snow Geese (834 adults and 1,133 goslings) counted in 2008 (Johnson et al. 2006b, 2007b, 2008b, 2009, 2010, 2011). Thirty-five groups (97%) contained broods, and goslings comprised 57% of the total number of birds, indicating that 2011 was a highly productive year for Snow Geese on the Colville Delta. Twenty-one groups (1,020 adults and 1,368 goslings) were found in the CD North subarea, and 15 groups (725 adults and 910 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 26). Eight of 10 Brant brood groups were found in 4 salt-affected habitats: Salt-killed Tundra (3 groups), Brackish Water (2 groups), Salt Marsh (2 groups) and Tapped Lake with Low-water Connection (1 group; this habitat typically has brackish water and salt marsh vegetation along the shoreline; Appendix B). Brant brood groups were also found in Shallow Open Water without Islands (1 group) and Barrens (1 group).

Snow Geese favored similar habitats as Brant for brood-rearing and molting in the Colville Delta. Of 36 Snow Goose groups observed, 25 groups (69%) were found in coastal salt-affected habitats, including Brackish Water (7 groups), Salt-killed Tundra (5 groups), Tapped Lake with Low-water Connection (4 groups), Tidal Flat Barrens (4 groups), Salt Marsh (3 groups) and Open Nearshore Water (2 groups). Snow Geese were also found in River or Stream (4 groups), Patterned Wet Meadow (3 groups), Barrens (3 groups) and Nonpatterned Wet Meadow (1 group).

NE NPRA

Distribution and Abundance

During the aerial brood-rearing survey in 2011, we counted 1,756 Brant (906 adults and 850

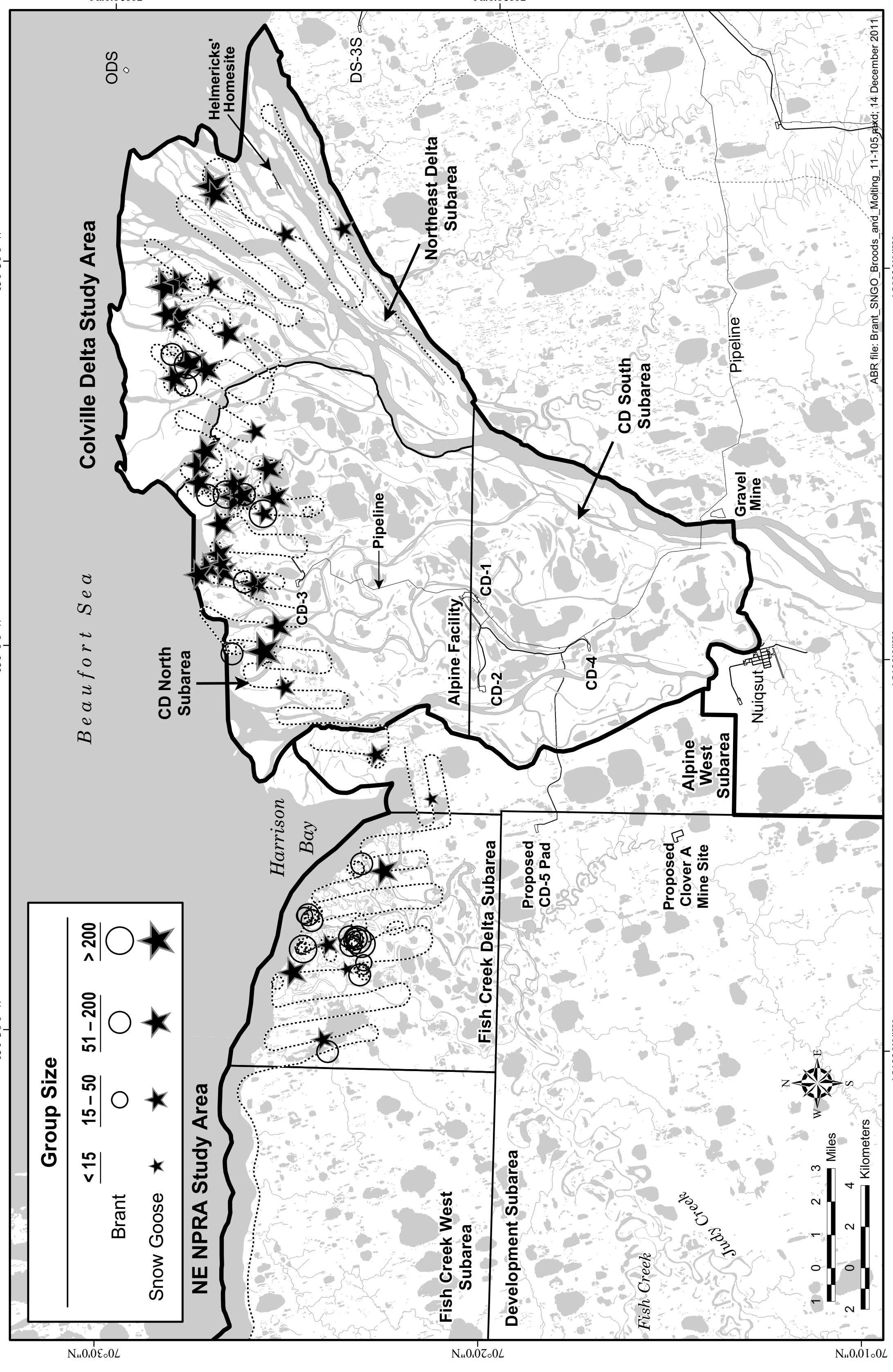

Figure 18. Brant and Snow Goose brood-rearing groups, Colville Delta and NE NPRA study areas, Alaska, 2011.

Table 24. Numbers of Brant and Snow Goose adults and young during brood-rearing aerial surveys, Colville Delta and NE NPRA study areas, Alaska, 2011.

SPECIES Study Area	Total Birds	Adults	Young	% Young	No. of Groups
BRANT					
Colville Delta[a]	1,986	1,221	765	39	10
NE NPRA[b]	1,756	906	850	48	14
SNOW GEESE					
Colville Delta[a]	4,023	1,745	2,278	57	36
NE NPRA[b]	388	142	246	63	8

[a] Only the CD North and Northeast Delta subareas were surveyed
[b] Only the Fish Creek Delta, Fish Creek West, and Alpine West subareas were surveyed

Table 25. Number of Brant adults and goslings during aerial surveys, Colville Delta study area, Alaska, 1998–2011. Data for 1988–1991 are from Bayha et al. 1992; subsequent data are from this study.

Year	No. Groups	Adults	Goslings	Total Birds	% Goslings	Survey Date(s)
1988[a]	no data	173[b]	no data	no data	no data	25, 26 July
1989[a]	no data	no data	no data	197[c,d]	no data	12, 13 August
1990[a]	no data	no data	no data	628[c]	no data	2, 9 August
1991[a]	no data	no data	no data	460[c,d]	no data	1, 7 August
1992	0	0	0	0	-	27 July
1993	5	347	373	720	51	27 July
1995	6	768	712	1,480	48	4 August
1996	7	478	515	993	52	25 July
1998	13	836	1,138	1,974	58	27 July
2005	16	2,360	1,487	3,847	39	30 July
2006	4	296	142	438	32	29 July
2007	6	446	534	980	54	30 July
2008	22	1,839	1,798	3,637	49	29 July
2009	6	501	178	679	26	29 July
2010	11	746	728	1,474	49	28 July
2011	10	1,221	765	1,986	39	28 July
Mean	8.8	770	698	1,300	45.3	
SE	1.7	188	157	298	3.0	

[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)

Table 26. Habitat use by brood-rearing/molting Brant and Snow Geese, Colville Delta and NE NPRA study areas, Alaska, 2011.

	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	5.6	3	21.4	0	0
Brackish Water	2	20.0	7	19.4	4	28.6	1	14.3
Tapped Lake with Low-water Connection	1	10.0	4	11.1	0	0	0	0
Salt Marsh	2	20.0	3	8.3	6	42.9	1	14.3
Tidal Flat Barrens	0	0	4	11.1	0	0	2	28.6
Salt-killed Tundra	3	30.0	5	13.9	0	0	2	28.6
Shallow Open Water without Islands	1	10.0	0	0	0	0	0	0
River or Stream	0	0	4	11.1	0	0	0	0
Old Basin Wetland Complex	0	0	0	0	1	7.1	0	0
Nonpatterned Wet Meadow	0	0	1	2.8	0	0	0	0
Patterned Wet Meadow	0	0	3	8.3	0	0	0	0
Moist Sedge–Shrub Meadow	0	0	0	0	0	0	1	14.3
Barrens	1	10.0	3	8.3	0	0	0	0
Total	10	100	36	100	14	100	7[a]	100

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

goslings) in 14 groups in the NE NPRA study area (Figure 18, Table 24), down from 2,628 Brant (2,161 adults and 467 goslings) in 2009 (the last year surveys were conducted in the NE NPRA study area) and well below the 4,012 total Brant (2,617 adults and 1,395 goslings) counted in 2008. All 14 Brant groups included broods, and goslings comprised 48% of the total number of birds in all groups, indicating good survival for goslings in 2011. All 14 Brant brood-rearing and molting groups were located in the Fish Creek Delta subarea.

In 2011, a record 388 Snow Geese (142 adults and 246 goslings) were counted in 8 groups in the NE NPRA study area (Figure 18, Table 24), up from 102 Snow Geese (60 adults and 42 goslings) in 2009 (the last year surveys were conducted in the NE NPRA study area) and higher than the previous record of 234 Snow Geese (107 adults and 127 goslings) counted in 2008. Seven of 8 groups included broods, and goslings comprised 63% of the total number of birds in all groups, indicating good survival for Snow Goose goslings in 2011. Five Snow Goose groups were located in the Fish Creek Delta subarea, 2 groups were in the Alpine West subarea, and 1 group was in the Fish Creek West subarea.

Habitat Use

As on the Colville Delta, Brant and Snow Goose brood groups primarily used salt-affected habitats in the NE NPRA study area (Table 26). Thirteen of 14 Brant brood groups (93%) were found in 3 salt-affected habitats: Salt Marsh (6 groups), Brackish Water (4 groups), and Open Nearshore Water (3 groups). Six of 7 Snow Goose brood-rearing and molting groups were located in coastal salt-affected habitats: Tidal Flat Barrens (2 groups), Salt-killed Tundra (2 groups), Salt Marsh (1 group) and Brackish Water (1 group).

DISCUSSION

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. 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 oil field (Sedinger and Stickney 2000) and likely to the west in the adjacent Fish Creek Delta. Additionally, 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). Nest success in large Brant colonies is highly 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 nest success in some years (Barry 1962, Stickney and Ritchie 1996).

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 1.125 since 1988 (Figure 19), but that rate is not quite significant ($\ln(y) = 0.125x - 245.2$, $R^2 = 0.264$, $P = 0.072$, $n = 13$ years). Numbers vary widely from year to year, probably due to factors discussed above, including variation in nesting success and nesting effort, and movements of variable numbers 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 since 1992 show a statistically significant annual growth rate of 1.101 for Brant on the ACP over the past 2 decades (SE = 0.014, n = 19 years; Larned et al. 2011), 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 2011). 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

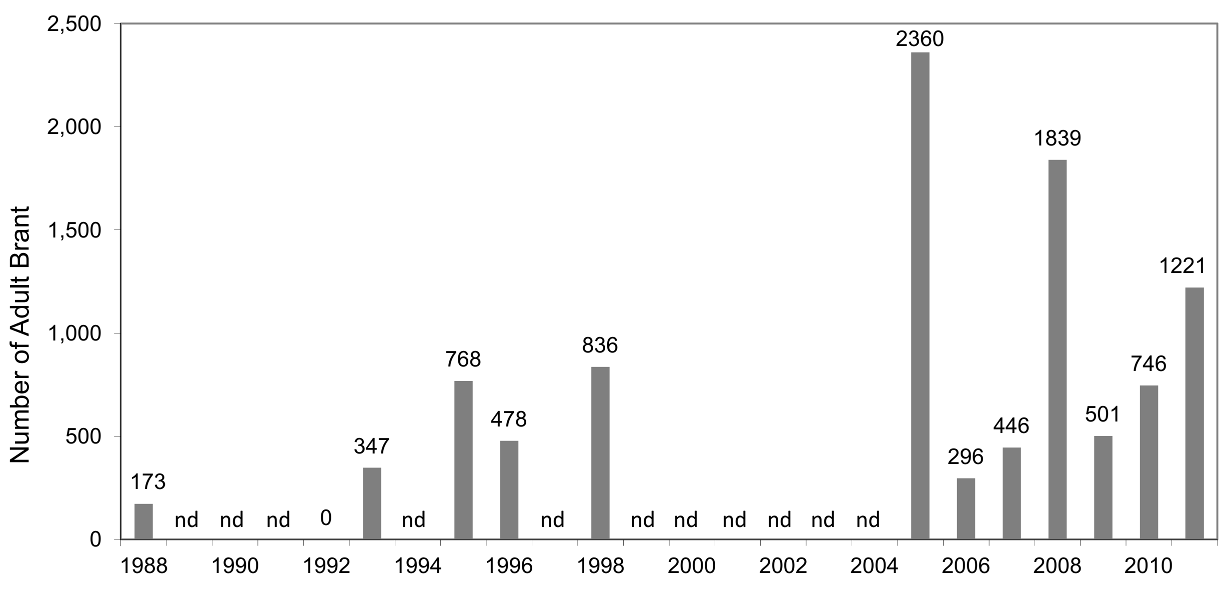

Figure 19. Number of adult Brant during the brood-rearing period, Colville Delta study area, Alaska, 1988–2011. Data for 1988–1991 are from Bayha et al. 1992; subsequent data are from this study.

of Brant nests appear to have remained stable or increased since 1995 in 23 small colonies between Fish Creek and Barrow (Burgess et al. 2012). Data from Larned et al. (2011) 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 2003 (Johnson et al. 2003b). Numbers of brood rearing Snow Geese have steadily increased in recent years, reaching record numbers in 2011. Similarly, numbers have increased sharply on the Ikpikpuk River delta (to the west of the Colville) since surveys began there in 1994 (Burgess et al. 2012).

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, Williams 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. Although 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 remove rhizomes and meristematic tissue by grubbing in the spring, which can result in 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

Sixty-four Glaucous Gull nests were observed in the Colville Delta study area during the aerial survey for nesting loons in 2011, the highest number of nests found in the study area since counts began in 2000 (Figure 20, Table 27). Thirty-seven of those nests were in the CD South subarea, 25 in the CD North subarea, and 2 in the Northeastern Delta. Glaucous Gulls nest singly or in colonial groups. The largest colony on the Colville Delta is a site in the CD South subarea, located ~5 km southeast of Alpine (Figure 20); this colony supported 17 nests in 2011, but has ranged from 6 to 19 nests (mean = 15 nests, SE = 1.0, n = 13 years). Another colony site in the northeastern part of the CD North subarea, supported 5 nests in 2011, slightly more than the mean number of nests at that site since 2000 (mean = 3.9 nests, SE = 0.6, n =12 years).

The count of 64 Glaucous Gull nests in 2011 includes nests from traditional nest locations that are checked annually and any other nests encountered incidentally during the loon surveys. To compare annual trends in the number of nests in the Colville Delta study area, we tallied the number of nests recorded on 50 lakes that were surveyed annually since 2002. The number of nests has ranged from a low of 27 nests in 2003 to a high of 53 nests in 2011 (Table 28). Glaucous Gull nests were found at about a quarter of the 50 monitored lakes in 2002–2004, but in recent years almost half of the monitoring lakes supported 1 or more nests (Table 28). The size of gull colonies monitored over 10 years did not appear to increase as much as the number of solitary nest sites has grown.

Thirteen groups of Glaucous Gulls with young were recorded in 2011 incidentally during the survey for brood-rearing loons on 15 August (Figure 20). Twenty-five adults and 56 young were recorded in the Colville Delta study area, of which 12 adults and 27 young were in the CD North subarea and 13 adults and 29 young were in the CD South subarea. No Glaucous Gull broods were observed in the Northeast Delta subarea. Nine

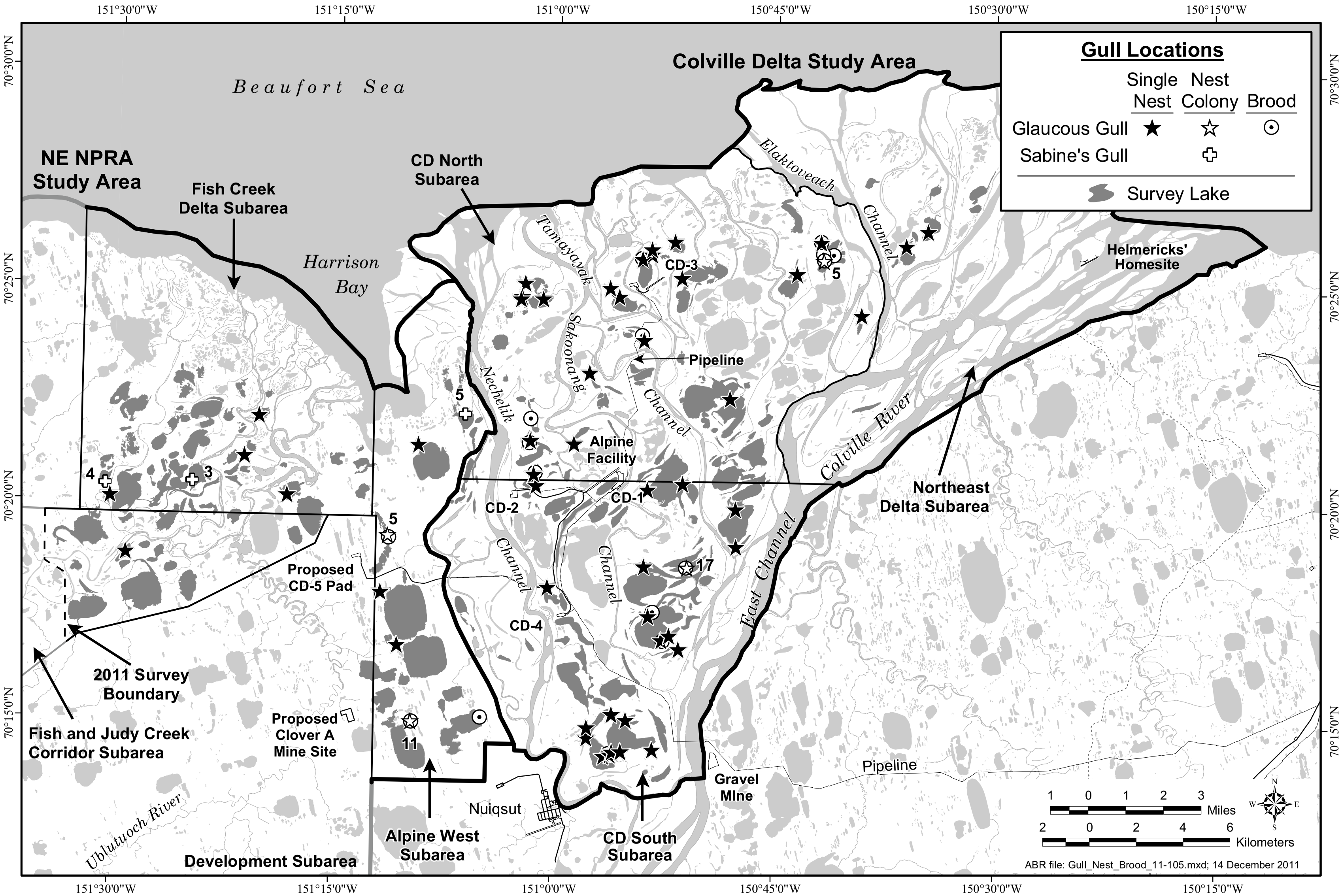

Figure 20. Glaucous and Sabine's gull nests and broods, Colville Delta and NE NPRA study areas, Alaska, 2011. Numbers of nests are listed for colony locations.

Table 27. Number of Glaucous and Sabine's gull nests, Colville Delta and NE NPRA study areas, Alaska, 2011.

STUDY AREA[a] Subarea	Sabine's Gull	Glaucous Gull
COLVILLE DELTA		
CD North	0	25
CD South	0	37
Northeast Delta	0	2
Total	0	64
NE NPRA		
Alpine West	5	19
Fish Creek Delta	7	4
Fish and Judy Creek Corridor	0	1
Total	12	24

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

Table 28. Annual number of Glaucous Gull nests and their occurrence on 50 monitored lakes, Colville Delta study area, Alaska, 2002–2011.

	Number of Nests[a]				
Year	CD North Subarea[b]	CD South Subarea[b]	Northeast Delta Subarea	Total	No. of Lakes with Nests[c]
2002	11 (2)	23 (18)	1	35	14
2003	11 (1)	16 (14)	0	27	13
2004	19 (7)	16 (13)	0	35	15
2005	18 (5)	21 (15)	0	39	18
2006	15 (4)	20 (16)	1	36	18
2007	17 (5)	20 (13)	2	39	19
2008	19 (5)	25 (18)	2	46	20
2009	18 (6)	25 (19)	2	45	20
2010	19 (5)	14 (6)	2	35	21
2011	18 (5)	33 (17)	2	53	23

[a] Data was collected during aerial surveys for nesting Yellow-billed Loons
[b] Number in parenthesis is number of nests within total that were found in nesting colony
[c] Of 50 lakes monitored annually for the presence of Glaucous Gull nests, 2 occur in the Northeast Delta subarea, 2
South subarea, and 28 in the CD North subarea

young were counted at the colony site in the CD North subarea and 22 young were recorded at the colony site in the CD South subarea. Young from some nests were flight capable at the time of the loon brood-rearing survey, and consequently some young may have been missed because they were no longer near their nest site.

No Sabine's Gull nests were observed in the Colville Delta study area during the aerial survey for nesting loons in 2011. The number of Sabine's Gull nests ranged from 1 to 16 nests during the years 2003–2010.

Habitat Use

Glaucous Gull nests were found in 9 different habitats in the Colville Delta study area in 2011 (Table 29). Twenty of the 64 Glaucous Gull nests (31%) were in Patterned Wet Meadow, most of which were part the colony in the CD South subarea that is located on a large island within a lake classified as Deep Open Water with Islands or Polygonized Margins. Fourteen nests (22%) were found on small islands in Deep Open Water with Islands or Polygonized Margins and another 9 nests (14%) were on islands in Tapped Lake with High-water Connection. The remaining 21 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 NPRA

Distribution and Abundance

Twenty-four Glaucous Gull nests were counted in the NE NPRA study area in 2011 during aerial surveys for loons (Figure 20, Table 27). Nineteen nests were counted in the Alpine West subarea, 4 in the Fish Creek Delta subarea, and 1 in the Fish and Judy Creek Corridor subarea. Of the 19 nests found in the Alpine West subarea, 16 nests were in 2 colonies—1 colony of 5 nests was found near the proposed CD-5 Pad and another colony of 11 nests was located in the southern part of the subarea (Figure 20). During 10 previous years of surveys, the annual count of nests at each colony has ranged from 4 to 7 nests. All other Glaucous Gull nests found in the NE NPRA study area in 2011 were solitary nest locations. Incidental counts of Glaucous Gull nests in the Alpine West and Fish Creek Delta subareas in 2005–2006 and 2008–2011 have been highly variable (Appendix H). The lowest count of nests was 12 nests in 2009, when a grizzly bear took all nests in the colony near the proposed CD-5 pad prior to our surveys (Johnson et al. 2010). The highest count of 28 nests occurred in 2006 (Appendix H). Because Glaucous Gulls were counted on aerial surveys designed to survey loons, some nests undoubtedly were missed.

At the time of the loon brood-rearing aerial survey in 2011, the 2 colonies in Alpine West were

Table 29. Habitat use by nesting Glaucous Gulls, Colville Delta and NE NPRA study areas, Alaska, 2011.

	Colville Delta		NE NPRA	
Habitat	Nests	Use (%)	Nests	Use (%)
Brackish Water	3	4.7	1	4.2
Tapped Lake with High-water Connection	9	14.1	1	4.2
Deep Open Water without Islands	5	7.8	0	0
Deep Open Water with Islands or Polygonized Margins	14	21.9	2	8.3
Shallow Open Water with Islands or Polygonized Margins	0	0	18	75.0
Deep Polygon Complex	3	4.7	0	0
Grass Marsh	5	7.8	1	4.2
Nonpatterned Wet Meadow	3	4.7	0	0
Patterned Wet Meadow	20	31.3	1	4.2
Moist Sedge-Shrub Meadow	2	3.1	0	0
Total	64	100	24	100

occupied by 6 Glaucous Gull adults and 8 young. Young from some nests were flight capable at the time of the loon brood-rearing survey, and consequently some young may have been missed because they were no longer near their nest site.

Twelve Sabine's Gull nests were found in the NE NPRA study area during the loon nesting survey in 2011 (Table 27). Five nests were found in 1 colony in the Alpine West subarea, and 2 colonies in the Fish Creek Delta subarea contained 3 and 4 nests each (Figure 20). No nests were found in the Fish and Judy Creek Corridor subarea. Sabine's Gull densities were not calculated for the NE NPRA study area because sightings were incidental and not comprehensive for that area. The distribution and number of Sabine's Gull nests found each year during loon surveys is highly variable. The highest number of Sabine's Gull nests recorded on loon nesting surveys in the NE NPRA study area was 53 nests in 2008 (Johnson et al. 2009).

Habitat Use

Glaucous Gulls nested in 6 different habitats in the NE NPRA study area (Table 29). Eighteen of the 24 nests were located on islands in Shallow Open Water with Islands or Polygonized Margins (75% of all nests). The remaining 5 nests were found on islands or complex shorelines of 4 other aquatic habitats and 1 terrestrial habitat. Glaucous Gull broods were found in aquatic and terrestrial habitats near nest locations, often in the same habitat as the nest. Two Sabine's Gull colonies were on islands in Deep Open Water with Islands or Polygonized Margins and the other Sabine's Gull colony was in Sedge Marsh.

DISCUSSION

Glaucous Gull nests have increased over the last 10 years in the Colville Delta study area. The highest numbers of Glaucous Gull nests (64) and broods (22) were recorded in the Colville Delta study area in 2011. Increases in nests are evident from counts that have been made consistently at 50 lakes monitored for Yellow-billed Loons since 2002. The number of Glaucous Gull nests on the monitored lakes has grown significantly at an annual rate of 1.045 ($\ln(y) = 0.045x - 86.1$, $R^2 = 0.463$, $P = 0.018$, $n = 10$). The large increase in the number of Glaucous Gull nests in the Colville Delta study area in 2011 compared with previous years was not due to a large increase in the number of nests at colony sites, but instead was from an increase in the number of solitary nests found at locations where nesting gulls have not been recorded in previous years.

The trend for Glaucous Gulls in the NE NPRA study area is less clear. Glaucous Gulls nests have been recorded in the NE NPRA study area when Yellow-billed Loon nesting surveys were conducted in 2001–2006 and 2008–2011, but survey areas were not the same more than 3 years in a row, so a trend is not discernible. Total counts have ranged from 17 nests when the survey area included only the Alpine West and Fish Creek Delta subareas to 93 nests when it was more expansive comprising the Development, Exploration, and Alpine West subareas.

Sabine's Gulls are found as solitary nesting birds or in loose nesting colonies. Single nests are hard to detect during loon surveys and nesting colonies are usually only detected because some birds are flying near the colony site. Recorded observations are most often colony sites and single nesting birds are likely under reported. Counts of Sabine's Gull nests have varied annually in both the Colville Delta and NE NPRA survey areas largely because of the variability in detection rates but also possibly because of the timing of their nesting relative to the loon survey. In 2011, only 3 small colony locations of Sabine's Gulls were observed in the NE NPRA survey area. Water levels at some lakes in both study areas appeared high at the time of the loon survey and, as a result, some nest sites traditionally used by Sabine's Gulls may have been unavailable for nesting.

LITERATURE CITED

Abraham, K. F., and R. L. Jefferies. 1997. High goose populations: causes, impacts and complications. Pages 7–72 *in* B. D. J. Batt, ed. Arctic Ecosystems in Peril: Report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120 pp.

Alisauskas, R. T., and H. Boyd. 1994. Previously unrecorded colonies of Ross' and Lesser Snow Geese in the Queen Maud Gulf Bird Sanctuary. Arctic 47: 69–73.

Anderson, B. A., and B. A. Cooper. 1994. Distribution and abundance of Spectacled Eiders in the Kuparuk and Milne Point oilfields, Alaska, 1993. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 71 pp.

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

Anderson, B. A., A. A. Stickney, T. Obritschkewitsch, and J. E. Shook. 2008. Avian studies in the Kuparuk Oilfield, Alaska, 2007. Data Summary Report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Barr, J. F. 1997. Status report on the Yellow-billed Loon *Gavia adamsii* in arctic Canada. Report to Committee on Status of Endangered Wildlife in Canada. Guelph, Ontario, Canada.

Barry, T. W. 1962. Effect of late seasons on Atlantic Brant reproduction. Journal of Wildlife Management 26:19–26.

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

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

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

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

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

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

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

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

Burgess, R. M., T. Obritschkewitsch, R. J. Ritchie, J. E. Shook, and L. B. Attanas. 2012. Surveys for nesting and brood-rearing Brant and Lesser Snow Geese, Barrow to Fish Creek delta, Alaska, 2011. Draft Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 89 pp.

ConocoPhillips Alaska, Inc. 2011. Data Management Protocols, North Slope and Chukchi Sea Field Surveys,Version 7.4.

Cooch, E. G., D. B. Lank, R. F. Rockwell, and F. Cooke. 1991. Long-term decline in body size in a Snow Goose population: evidence of environmental degradation? Journal of Animal Ecology 60: 483–496.

Davis, S. E., E. E. Klaas, and K. J. Koehler. 1989. Diurnal time-activity budgets and habitat use of Lesser Snow Geese *Anser caerulescens* in the middle Missouri River Valley during winter and spring. Wildfowl 40: 45–54.

Gadallah, F. L., and R. L. Jefferies. 1995. Forage quality in brood rearing areas of the Lesser Snow Goose and the growth of captive goslings. Journal of Applied Ecology 32: 276–287.

Ganter, B., and F. Cooke. 1998. Colonial nesters in deteriorating habitat: site fidelity and colony dynamics of Lesser Snow Geese. Auk 115: 642–652.

Ganter, B., F. Cooke, and P. Mineau. 1995. Long-term vegetation changes in a Snow Goose nesting habitat. Canadian Journal of Zoology 74: 965–969.

Hawkins, L.L. 1986. Nesting behaviour of male and female Whistling Swans and implications of male incubation. Wildfowl 37: 5–27.

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

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

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

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

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

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

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

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

Johnson, C. B., R. M. Burgess, A. M. Wildman, A. A. Stickney, P. E. Seiser, B. E. Lawhead, T. J. Mabee, J. R. Rose, and J. E. Shook. 2004. Wildlife studies for the Alpine Satellite

Development Project, 2003. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 155 pp.

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

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

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

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

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

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

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

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

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

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

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

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

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, and T. Obritschkewitsch. 2010. Avian studies for the Alpine Satellite Development Project, 2009. Seventh annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 71 pp.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, T. Obritschkewitsch, and P.E. Seiser. 2011. Avian studies for the Alpine Satellite Development Project, 2010. Eighth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 69 pp.

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

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, T. Obritschkewitsch, and A. A. Stickney. 2009. Avian studies for the Alpine Satellite Development Project, 2008. Sixth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

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

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

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

Kerbes, R. H. 1983. Lesser Snow Goose colonies in the western Canadian Arctic. Journal of Wildlife Management 47: 523–526.

Kerbes, R. H., M. R. McLandress, G. E. J. Smith, G. W. Beyersbergen, and B. Godwin. 1983. Ross' Goose and Lesser Snow Goose colonies in the central Canadian Arctic. Canadian Journal of Zoology 61: 168–173.

Kerbes, R. H., P. M. Kotanen, and R. L. Jefferies. 1990. Destruction of wetland habitats by Lesser Snow Geese: a keystone species on the west coast of Hudson Bay. Journal of Applied Ecology 27: 242–258.

Larned, W., R. Stehn, and R. Platte. 2006. Eider breeding population survey, Arctic Coastal Plain, Alaska, 2006. U.S. Fish and Wildlife Service, Migratory Bird Management–Waterfowl Management Branch, Soldotna, AK. 53 pp.

Larned, W., R. Stehn, and R. Platte. 2010. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2008. Unpublished report, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK.

Larned, W., R. Stehn, and R. Platte. 2011. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2010. Unpublished report, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK.

Lawhead, B. E., and A. K. Prichard. 2012. Mammal surveys in the Greater Kuparuk Area, Northern Alaska, 2011. Report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks.

Lewis, T. L., P. L. Flint, J. A. Schmutz, and D. V. Derksen. 2009. Temporal distributions and patterns of habitat use by Black Brant molting in the Teshekpuk Lake Special Area, Alaska. Interagency Report by U. S. Geological Survey, Alaska Science Center, Anchorage, AK. 113 pp.

Mabee, T. J., A. M. Wildman, and C. B. Johnson. 2006. Using egg flotation and eggshell evidence to determine age and fate of arctic shorebird nests. Journal of Field Ornithology 77: 163–172.

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

McCormick, K. J., and B. Poston. 1988. Lesser Snow Geese, *Anser c. caerulescens*, nesting on Jenny Lind Island, Northwest Territories. Canadian Field-Naturalist 102: 530–532.

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

Michael Baker Jr. Inc. 2011. Colville River Delta Spring Breakup 2011 Hydrologic Assessment. Draft. Report for ConocoPhillips Alaska, Inc., by Michael Baker, Jr., Inc. Anchorage, AK.

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

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

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

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

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

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

Piper, W. H., K. B. Tischler, M. Klich. 2000. Territory acquisition in loons: the importance of take-over. Animal Behaviour 59: 385–394.

Person, B. T., C. A. Babcock, and R. W. Ruess. 1998. Forage variation in brood-rearing areas used by Pacific Black Brant geese on the Yukon-Kuskokwim Delta, Alaska. Journal of Ecology 86: 243–259.

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

Sedinger, J. S., and A. A. Stickney. 2000. Black Brant. Pages 221–232 *in* J. C. Truett and S. R. Johnson, eds. The Natural History of an Arctic Oil Field: Development and the Biota. Academic Press, 422 pp.

Seiser, P. E. and C. B. Johnson. 2010. Eider nest searches at the CD-3 Pad, ice road, and spill-response sites on the Colville Delta, 2009. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Seiser. P.E. and C. B. Johnson. 2011a. Eider nest searches at the CD-3 Pad, ice road, spill-response sites, and pipeline bridges on the Colville River Delta, 2010. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Seiser. P.E. and C. B. Johnson. 2011b. Eider nest searches at the CD-3 Pad, ice road, and spill-response sites on the Colville River Delta, 2011. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 14 pp.

Serie, J. R, and J. C. Bartonek. 1991. Population status and productivity of tundra swans *Cyngus columbianus columbianus* in North America. pp 172-177 *in* Proceedings of the Third International Swan Symposium, Oxford 1989 (J. Sears and P. J. Bacon, Eds.). Wildfowl, Supplement No. 1.

Serie, J. R., D. Luszcz and R. V. Raftovich. 2002. Population trends, productivity and harvest of eastern population tundra swans. pp 32-36 *in* Proceedings of the Fourth International Swan Symposium, 2001 (E. C. Rees, S. L. Earnst and J. Coulson, Eds.) Waterbirds 25, special publication 1.

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

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

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

Spindler. M. A. and K. F. Hall. 1991. Local movements and habitat use of Tundra or Whistilng Swans *Cygnus columbianus* in the Kobuk-Selawik Lowlands of northwest Alaska. Wildfowl 42: 17–32.

Srivastava, D. S., and R. L. Jefferies. 1996. A positive feedback: herbivory, plant growth, salinity and the desertification of an Arctic salt-marsh. Journal of Ecology 84: 31–42.

Stickney, A. A., and R. J. Ritchie. 1996. Distribution and abundance of Brant (*Branta bernicla*) on the Central Arctic Coastal Plain of Alaska. Arctic 49:44–52.

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

Stickney, A. A., L. Attanas, and T. Obritschkewitsch. 2012. Avian studies in the Kuparuk Oilfield, 2011. Report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Stickney, A. A., T. Obritschkewitsch, L. Attanas, and P. E. Seiser. 2012. Avian studies in the Kuparuk Oilfield, 2011. Report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 18 pp.

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

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

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

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

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

Williams, T. D., E. G. Cooch, R. L. Jefferies, and F. Cooke. 1993. Environmental degradation, food limitation and reproductive output: juvenile survival in Lesser Snow Geese. Journal of Animal Ecology 62: 766–777.

Wilson, H. M. 2011. Aerial photographic surveys of Brant colonies on the Yukon-Kuskokwim Delta, Alaska, 2011. Unpubl. report, U.S. Fish and Wildlife Service, Migratory Bird management, Anchorage, AK. 10 pp. <http://alaska.fws.gov/mbsp/mbm/waterfowl/surveys/ pdf/brant_ykd.pdf>

PERSONAL COMMUNICATIONS

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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	Niġliŋġaq	*Branta bernicla*
Tundra Swan	Qugruk	*Cygnus columbianus*
Steller's Eider	Igniqauqtuq	*Polysticta stelleri*
Spectacled Eider	Qavaasuk	*Somateria fischeri*
King Eider	Qiŋalik	*Somateria spectabilis*
Common Eider	Amauligruaq	*Somateria mollissima*
Red-throated Loon	Qaqsrauq	*Gavia stellata*
Pacific Loon	Malġi	*Gavia pacifica*
Yellow-billed Loon	Tuullik	*Gavia adamsii*
Glaucous Gull	Nauyavasrugruk	*Larus hyperboreus*
Sabine's Gull	Iqirgagiak	*Xema sabini*
Parasitic Jaeger	Migiaqsaayuk	*Stercorarius parasiticus*
Golden Eagle	Tiŋmiaqpak	*Aquila chrysaetos*
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 NPRA study areas, Alaska, 2011. Species associations of some habitats vary between the Colville Delta and the NE NPRA 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).

Appendix B. Continued.

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

Appendix B. Continued.

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

Appendix C. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2011.

SPECIES Subarea Location	Observed				Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
	Males	Females	Total	Pairs			
SPECTACLED EIDER							
CD North							
On ground	37	20	57	19	74	0.28	0.36
In flight	9	6	15	4	–	0.07	–
All birds	46	26	72	23	–	0.35	–
Northeast Delta							
On ground	6	4	10	4	12	0.06	0.08
In flight	5	3	8	3	–	0.05	–
All birds	11	7	18	7	–	0.11	–
CD South							
On ground	6	3	9	2	9	0.07	0.07
In flight	0	0	0	0	–	0	–
All birds	6	3	9	2	–	0.07	–
Total (subareas combined)							
On ground	49	27	76	25	95	0.15	0.19
In flight	14	9	23	7	–	0.05	–
All birds	63	36	99	32	–	0.20	–
KING EIDER							
CD North							
On ground	15	8	23	8	30	0.11	0.15
In flight	5	4	9	4	–	0.04	–
All birds	20	12	32	12	–	0.15	–
Northeast Delta							
On ground	44	46	90	4	93	0.57	0.59
In flight	6	1	7	1	–	0.04	–
All birds	50	47	97	5	–	0.62	–
CD South							
On ground	3	1	4	1	6	0.03	0.04
In flight	0	0	0	0	–	0	–
All birds	3	1	4	1	–	0.03	–
Total (subareas combined)							
On ground	62	55	117	13	129	0.23	0.26
In flight	11	5	16	5	–	0.03	–
All birds	73	60	133	18	–	0.27	–

[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 NPRA study area, Alaska, 2011.

SPECIES Subarea Location	Observed				Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
	Males	Females	Total	Pairs			
SPECTACLED EIDER							
Development							
On ground	0	0	0	0	0	0	0
In flight	0	0	0	0	–	0	–
All birds	0	0	0	0	–	0	–
Alpine West							
On ground	3	3	6	3	6	0.14	0.14
In flight	0	0	0	0	–	0	–
All birds	3	3	6	3	–	0.14	–
Fish Creek Delta							
On ground	2	1	3	1	4	0.05	0.07
In flight	0	0	0	0	–	0	–
All birds	2	1	3	1	–	0.05	–
Total (subareas combined)							
On ground	5	4	9	4	10	0.05	0.06
In flight	0	0	0	0	–	0	–
All birds	5	4	9	4	–	0.05	–
KING EIDER							
Development							
On ground	22	17	39	16	44	0.53	0.60
In flight	2	1	3	1	–	0.04	–
All birds	24	18	42	17	–	0.58	–
Alpine West							
On ground	12	9	21	9	24	0.50	0.57
In flight	3	2	5	1	–	0.12	–
All birds	15	11	26	10	–	0.62	–
Fish Creek Delta							
On ground	13	9	22	8	26	0.38	0.45
In flight	16	13	29	12	–	0.51	–
All birds	29	22	51	20	–	0.89	–
Total (subareas combined)							
On ground	47	35	82	33	94	0.48	0.55
In flight	21	16	37	14	–	0.22	–
All birds	68	51	119	47	–	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 t western portion of the Development subareas were not surveyed in 2011 (see Figure 1)

Appendix E. Number and density of loons and their nests, broods, and young during aerial surveys, Colville Delta and NE NPRA study areas, Alaska, 2011.

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	43	14[c]	–	0.21	0.07	85	8	–	4	0	–
Brood-rearing	20	4[d]	3	0.10	0.02	31	3	3	2	0	0
CD South											
Nesting	26	13[c]	–	0.17	0.08	50	8	–	7	1	–
Brood-rearing	24	9	14	0.15	0.06	17	3	4	1	1	1
Northeast Delta[e]											
Nesting	3	2	–	–	–	15	0	–	0	0	–
Brood-rearing	1	2	3	–	–	6	4	4	0	0	0
Total (subareas combined)[f]											
Nesting	72	29[c]	–	0.19	0.07	150	15	–	11	1	–
Brood-rearing	45	15[d]	20	0.12	0.04	54	10	11	3	1	1
NE NPRA											
Alpine West											
Nesting	2	1[c]	–	0.03	0.01	45	6	–	0	0	–
Brood-rearing	1	0	0	0.01	0	59	11	16	1	0	0
Fish Creek Delta											
Nesting	16	7[c]	–	0.12	0.05	78	6	–	0	0	–
Brood-rearing	13	3	4	0.10	0.02	13	0	0	0	0	0
Fish and Judy Creek Corridor[e]											
Nesting	12	5[c]	–	0.29	0.12	14	1	–	2	0	–
Brood-rearing	17	1	1	0.41	0.02	0	0	0	0	0	0
Total (subareas combined)[f]											
Nesting	30	13[c]	–	0.12	0.05	137	13	–	2	0	–
Brood-rearing	31	4	5	0.12	0.02	72	11	16	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 nests found during 13 June survey and weekly monitoring surveys: 3 nests in the CD North subarea and 3 nests in the CD South subarea of the Colville Delta study area, and 1 nest in the Alpine West subarea, 3 nests in the Fish Creek Delta subarea, and 1 nest in the Fish and Judy Creek Corridor subarea of the NE NPRA study area

[d] Number includes 1 brood in the CD North subarea of the Colville Delta study area determined by eggshell evidence

[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 NPRA (251.2 km² total)

Appendix F. Annual density (number/km²) of Yellow-billed Loons, nests, and broods, Colville Delta (1993–2011) and NE NPRA (2001–2011) study areas, Alaska.

STUDYAREA Year	Nesting Survey Adults	Nests[a]	Brood-rearing Survey Adults	Broods[b]
COLVILLE DELTA[c]				
1993	0.14	0.03	0.08	0.02
1995	0.10	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 (0.03)
Mean	0.15	0.05 (0.08)[d]	0.13	0.03 (0.05)
SE	<0.01	<0.01 (<0.01)[d]	0.01	<0.01 (<0.01)
NE NPRA[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)

[a] Density of nests found on the nesting survey and, in parentheses, cumulative density including additional nests found during revisit (1996–2002) and monitoring (2006–2011) surveys

[b] Density of broods found on the brood-rearing survey and, in parentheses, cumulative density including additional broods found during monitoring surveys 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: 2006–2011

[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 2008–2011, Fish Creek Delta (130.5 km²) in 2005–2006 and 2008–2011, and the Fish and Judy Creek Corridor (255.9 km²) in 2008–2010. In 2011, the eastern one-quarter of the Fish and Judy Creek Corridor subarea (41.0 km²) was surveyed.

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

Appendix G. Annual number of Tundra Swan nests and broods during aerial surveys, NE NPRA study area, Alaska, 2001–2011.

SEASON Year	Alpine West	Development	Exploration	Fish Creek Delta	Fish Creek West
NESTING					
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	–
BROOD-REARING					
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	–

[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, only a small portion (130.9 km²) of the Development Subarea was surveyed

Appendix H. Annual number of Glaucous Gull nests[a] in the Alpine West and Fish Creek Delta subareas, NE NPRA study area, Alaska, 2005–2011.

Year	Alpine West Subarea[b]	Fish Creek Delta Subarea	Total
2005	13 (11)	4	17
2006	17 (13)	11	28
2008	19 (13)	7	26
2009	9 (5)	3	12
2010	12 (9)	2	14
2011	19 (16)	4	23

[a] Data was collected during aerial surveys for nesting Yellow-billed Loons

[b] Number in parenthesis is number of nests included in total that were found in 2 nesting colonies