SIXTEENTH ANNUAL REPORT

AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2018

Charles B. Johnson
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Julie P. Parrett
Pamela E. Seiser

Prepared for
CONOCOPHILLIPS ALASKA, INC.
Anchorage, Alaska

Prepared by
ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES
Fairbanks, Alaska

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Avian surveys in the ASDP study area were conducted by an experienced crew consisting of Tim Obritschkewitsch and co-authors John Shook and Julie Parrett. Chris Swingley programmed the tablet for aerial survey recording. Pam Odom provided travel and publication support. Will Lentz and Tony LaCortiglia supplied equipment and technical assistance. Bob Burgess reviewed the report. We thank the helicopter coordinators, Soloy Helicopters, North River Air, and the staff at Alpine for their assistance. This work was directed by Robyn McGhee, Environmental Studies Coordinator at ConocoPhillips; we appreciate Robyn's and ConocoPhillips' continued support.

INTRODUCTION

The Colville River delta and Northeast Planning Area of the National Petroleum Reserve in Alaska (NE NPR-A) have been focal points of exploration and development for oil and gas since the 1990s. During 2018, ABR, Inc., conducted wildlife surveys for selected birds and mammals in the Colville River delta and in the Willow area of the NE NPR-A in support of ConocoPhillips, Alaska, Inc. (CPAI). Previous studies in the area are described by Johnson et al. (2015, 2016, 2018). Surveys in the Willow project area in 2018 are reported separately (Johnson et al. 2019).

CPAI began producing oil on the Colville River delta in 2000 with the development of the CD-1 and CD-2 drill sites of the Alpine Satellite Development Project (ASDP). The CD-3 and CD-4 drill sites were constructed in 2005 and 2006, and CD-5 in NE NPR-A was constructed in 2014 and 2015. Readers are directed to prior reports for wildlife information from previous years for all these sites.

In this report, we present the results of avian surveys that were conducted on the Colville River delta (hereafter, Colville Delta) in 2018 along with tabular summaries of results from previous years. The surveys were designed initially to collect data on the distribution, abundance, and habitat use of 5 focal taxa (common names followed by Iñupiaq names; see Appendix A, Johnson et al. 2015, for scientific names) in support of permit applications: Spectacled Eider (Qavaasuk), King Eider (Qiŋalik), Tundra Swan (Qugruk), geese (Niġliq), and Yellow-billed Loon (Tuullik). 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. In 2018, surveys were conducted targeting Spectacled Eiders, a federally listed threatened species, and Yellow-billed Loons, a species listed as sensitive by BLM (BLM 2010) with a limited breeding range. Data were collected on other eider species concurrently during the Spectacled Eider survey. Systematic and incidental observations of Glaucous Gulls (Nauyavasrugruk) were recorded because of their importance as egg and chick predators, and incidental observations of Pacific Loons (Malġi) and Red-throated Loons (Qaqsrauq) were recorded during Yellow-billed Loon surveys, when they used the survey lakes.

Required state and federal permits were obtained for all survey activities, including a Scientific Permit (Permit No. 18-169 and amendment 18-169A1 issued 18 June 2018) from the State of Alaska and a Federal Fish and Wildlife Permit [Native Threatened Species Recovery–Threatened Wildlife; Migratory Birds, Permit No. TE012155-7 issued under Section 10(a)(1)(A) of the Endangered Species Act (58 FR 27474)] from the U.S. Fish and Wildlife Service Endangered Species Permit Office.

STUDY AREA

In 2018, the ASDP study area included the Colville Delta (Figure 1). Landforms, vegetation, and wildlife habitats in the Colville Delta study area were described in the Ecological Land Survey (Jorgenson et al. 1997; Appendix B), and the resulting habitat map has been updated several times to unify it with similar mapping of the surrounding Arctic Coastal Plain (ACP) (Wells et al. 2017).

The Colville Delta study area (552 km^2) comprises the CD North, CD South, and Northeast Delta subareas (Figure 1). These subareas are useful in describing the distribution of birds on the delta, and together they encompass the entire delta from the eastern bank of the East Channel of the Colville River to the west bank of the westernmost distributary of the Niġliq (Nechelik) Channel and inland to where the Colville River divides into these channels.

METHODS

Aerial surveys were used to collect data on eiders, loons, and gulls in the Colville Delta study area, because of the large size of the study area and the short periods of time that each species is at the optimal stage for data collection. In 2018, 1 aerial survey for eiders during pre-nesting was conducted using fixed-wing aircraft, and 2 aerial surveys (1 for nesting and 1 for brood-rearing) were conducted from a helicopter for Yellow-billed Loons. Incidental observations of nesting and brood-rearing gulls also were recorded during loon

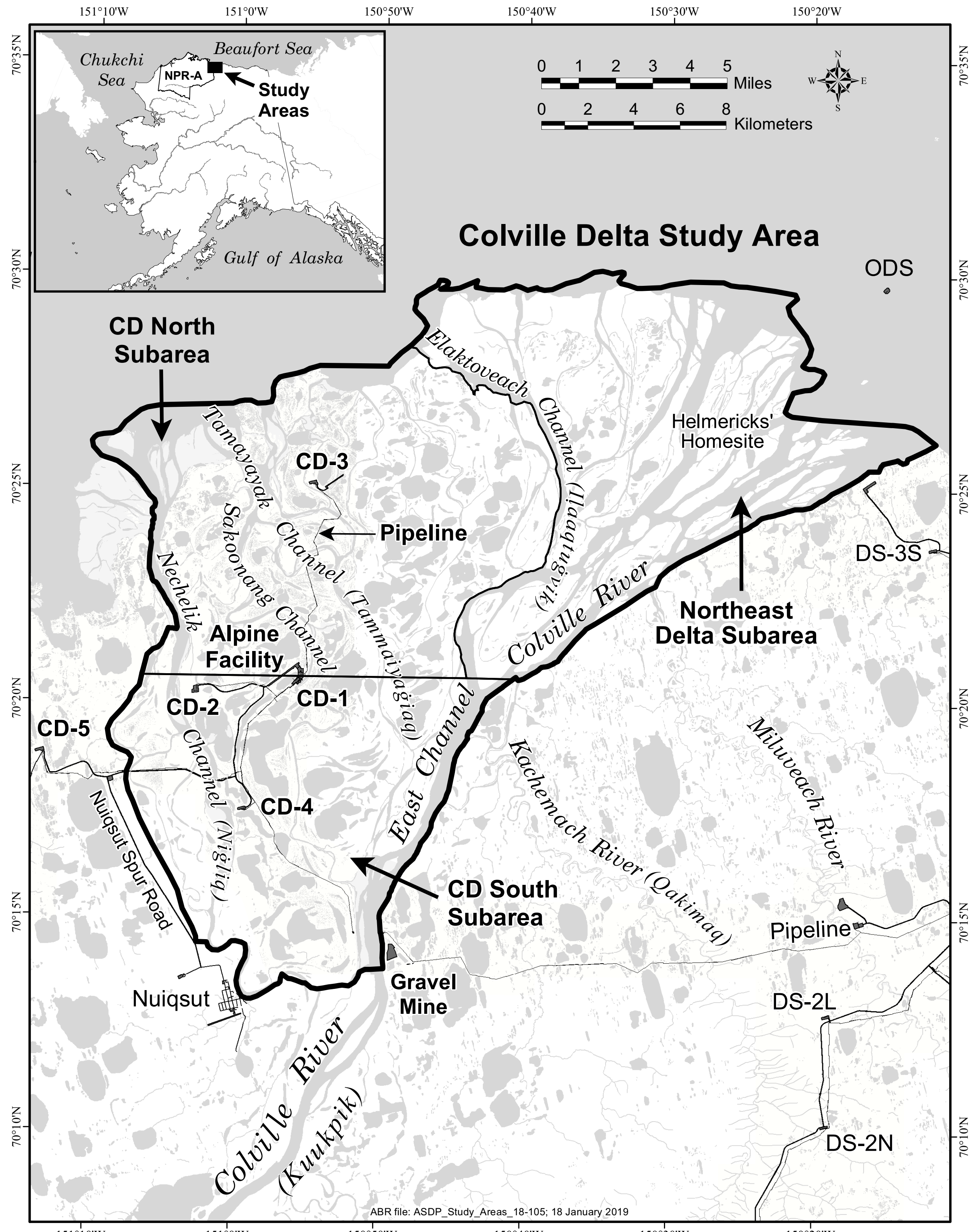

Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2018.

surveys. Each of these surveys was scheduled specifically (see Table 1 for survey details) for the period when the species was most easily detected or when the species was at an important stage of its breeding cycle (nesting or raising broods).

Concerns about disturbance to local residents and wildlife from survey flights have dictated that we conduct the fewest survey flights necessary and at the highest altitudes possible. Flight altitudes were set at the maximum level at which the target species could be adequately detected and counted (see survey protocols for each species group below). Survey flights specifically avoided the areas around the village of Nuiqsut, the Helmericks' homesite, and any active hunting parties. Daily phone calls, coordinated by the ConocoPhillips Village Outreach group and the Helicopter Coordinator based at Alpine, with Nuiqsut subsistence representatives were used to identify locations with active hunting parties. Additionally, aerial observers looked for people, boats, and off-road vehicles that might indicate presence of subsistence hunters. If hunting parties were present, we diverted the airplane or helicopter to reduce disturbance to hunters.

During the surveys, locations of eiders, loons, and gulls were recorded on digital orthophoto mosaics of 0.75–1 foot resolution natural color imagery acquired in 2004–2015 by Quantum Spatial (Anchorage, AK). Observations were collected on tablet computers with a customized application employing a moving map based on the orthophoto mosaic imagery. Bird locations plotted on tablets were reviewed before they were entered into a geographical information system (GIS) database.

In this report, we present data summaries with means plus or minus standard errors (mean ± SE), unless noted otherwise. Where appropriate, we report median values. Statistical significance is assigned at $P \leq 0.05$ unless otherwise stated. Analyses were conducted in Microsoft® Excel (Office 2010).

EIDER SURVEYS

We evaluated the regional abundance, distribution, and habitat selection of 2 species of eiders (Spectacled and King eiders) with data collected on 1 aerial survey flown annually during the pre-nesting period (Table 1), when male eiders were still present on the breeding grounds. Steller's and Common eiders were recorded if they were encountered. In 2018, we conducted the pre-nesting survey during 13–17 June using the same methods that were used on the Colville Delta study area since 1993 (for details, see Johnson et

Table 1. Avian surveys conducted in the Colville Delta study area, Alaska, 2018.

	Eider Survey	Yellow-billed Loon Surveys[a]	
Survey Description	Pre-nesting	Nesting	Brood-rearing
Number of Surveys	1	1	1
Survey Dates	13, 15, 17 June	21–25 June	15–21 Aug
Aircraft[b]	C185	A-Star	A-Star
Transect Width (km)	0.4	–	–
Transect Spacing (km)	0.4	–	–
Aircraft Altitude (m)	35–35	60–75	60–90
Notes	100% coverage	All lakes with adults, nests or broods in previous years	All lakes with adults, nests or broods in previous years

[a] Nests and broods of Pacific Loons, Red-throated Loons, Glaucous Gulls, and Sabine's Gulls were recorded incidentally.
[b] C185 = Cessna 185 fixed-wing airplane; A-Star = Airbus AS 350 B2 helicopter.

al. 2015). The survey was flown in a Cessna 185 airplane at 35–45 m above ground level and approximately 145 km/h. Two observers each counted eiders in a 200 m wide transect on each side of the airplane (400 m total transect width). A Global Positioning System (GPS) receiver was used to navigate east–west transect lines that were spaced 400 m apart achieving 100% coverage. Three areas were not surveyed in the Colville Delta study area: the extensive tidal flats and marine waters on the northernmost delta (Spectacled and King eiders rarely use those habitat types during the survey time period; Johnson et al. 1996), a ~1.6 km radius circle around the Helmericks' homesite, and the southernmost portion of the delta near Nuiqsut (see Figure 3 in Johnson et al. 2018). The latter 2 areas were avoided to reduce disturbance to residents.

We report numbers and densities for observed (total of flying and on the ground, male and female) eiders and indicated total eiders. Indicated total is a standardized method of counting ducks, which doubles the number of males in singles, pairs, and small groups and includes all birds in mixed flocks of 5 or more (no flying birds are included) to compensate for the lower detectability of females (USFWS 1987). We calculated population trend using indicated total in a linear regression with numbers transformed by natural logarithms. Because the same area was not surveyed in all years, we adjusted indicated totals to a standardized survey area by multiplying indicated density by the area surveyed in 21 of 25 years (501 km^2).

LOON SURVEYS

In 2018, we conducted 1 aerial survey on the Colville Delta study area for nesting Yellow-billed Loons on 21–25 June and 1 aerial survey for brood-rearing Yellow-billed Loons on 15–21 August (Table 1). We surveyed 115 lakes for nesting loons and 113 lakes for brood-rearing loons (Appendix A). Both nesting and brood-rearing surveys have been conducted annually in the Colville Delta study area during 24 years from 1993 to 2018, with the exception of 1994 and 1999, when no surveys were conducted. The CD North and CD South subareas were surveyed each year, and part of the Northeast Delta subarea was surveyed in all years except 2000 (Figure 1).

Methods for the nesting and brood-rearing survey were the same as in previous years (for details, see Johnson et al. 2015). Each year the nesting survey was conducted between 18 and 30 June and the brood-rearing survey between 15 and 27 August. Additional surveys were flown in 1996–1998, 2000–2002, and 2005–2014 (for details, see Johnson et al. 2015). All surveys were flown in a lake-to-lake pattern at 60–90 m above ground level. 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 2008–2015. We also surveyed small lakes (1–10 ha) and aquatic habitats adjacent to survey lakes because Yellow-billed Loons sometimes nest on small lakes next to larger lakes that are used for brood-rearing (North and Ryan 1989, Johnson et al. 2014a). During 2016–2018, however, we only surveyed lakes where Yellow-billed Loon adults, nests, or broods had been seen during the previous 23 years of surveys. 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. 2014a).

We recorded incidental observations of Pacific Loons and Red-throated Loons during nesting and brood-rearing surveys. All locations of loons and their nests were recorded on a tablet computer with a custom Android application. The application utilized a moving map with an adjustable scale that allowed the user to zoom in on map features. The scale at its finest level was approximately 1:15,000. Photos were taken of all Yellow-billed Loon nests to ensure maximum accuracy in mapping nest locations. Observation data were entered directly onto the tablet.

To make annual comparisons among years when different numbers of Yellow-billed Loon breeding territories were surveyed, we calculated territory occupancy by dividing the number of territories with nests or broods by the number of territories surveyed. We defined a territory as a single lake, several lakes, or portion of a lake occupied exclusively by a breeding pair with a nest or brood in at least 1 year. Territories were identified using data from all years; boundaries between territories were determined by nest and brood locations.

Population growth rates were calculated for Yellow-billed Loons with counts of adults and nests from the nesting survey and young seen on the brood-rearing survey. Counts were adjusted for survey effort by dividing counts by the number of territories surveyed and multiplying by the highest number of territories surveyed in all years (47). Population growth rates were estimated with log-linear regression on adjusted counts for years when helicopters were used for all surveys (2000–2018).

NEST FATE

Absence of broods is not a reliable indicator of nest failure because broods can disappear in the time between hatch and the brood survey. Therefore, we inspected the contents of nests at territories where a brood was not seen during the August survey to determine nest fate (for details, see Johnson et al. 2015). 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 (hatched at least 1 egg) if a brood was present, or if the nest contained ≥20 egg fragments. Apparent nesting success was calculated from the number of nests recorded on the nest survey divided by the number of nests that hatched at least 1 egg.

GULL SURVEYS

We recorded nests and broods of Glaucous Gulls incidentally and systematically during the nesting and brood surveys conducted for Yellow-billed Loons (see LOON SURVEYS, above). Glaucous Gulls nest singly and in loose aggregations or colonies. We considered a group of ≥3 nests occurring in proximity on the same lake or wetland complex in any 1 year to be a colony; if a colony had fewer nests in subsequent years it remained a colony. Traditional nest or colony locations within the study areas were checked systematically for activity, whereas nests and broods of gulls outside of traditional locations were recorded incidentally as they were encountered. Where a Glaucous Gull colony was identified, we displayed it on maps at 1 central location, even though some nests may be as far as 350 m apart. All nest and brood observations were recorded on a tablet computer with a custom Android application, and later downloaded into a GIS database.

We monitored trends in nest numbers systematically for Glaucous Gulls at 50 index lakes, which were a subset of lakes annually surveyed for Yellow-billed Loons in the Colville Delta study area since 2002. At that time, index lakes included 15 lakes with at least 1 year of gull nesting history, and 35 lakes with no history of nesting gulls. Of the 50 index lakes, 28 are in the CD North subarea, 20 are in the CD South subarea, and 2 are in the Northeast Delta subarea.

HABITAT MAPPING AND ANALYSIS

A wildlife habitat type was assigned to each observation of birds (on the ground, not flying), nests, or broods by plotting their coordinates on the wildlife habitat maps (Appendix B). For each bird species, habitat use (% of all observations in each identified habitat type) was determined separately for various seasons (e.g., pre-nesting, nesting, and brood-rearing), as appropriate. For each species and season, we calculated 1) the number of adults, flocks, nests, or broods in each habitat type, and 2) the percent of total observations in each habitat type (habitat use). Habitat use was calculated from group locations for groups (single birds, pairs, groups, flocks, adults with broods, and colonies) and nests. Habitat availability was calculated as the percent of each habitat type in the survey area. A statistical analysis of habitat selection was used for Spectacled Eiders, King Eiders, and Yellow-billed Loons, to evaluate whether habitat types were used in proportion to their availability. Methods are explained in more detail by Johnson et al. (2015).

DATA MANAGEMENT

All data collected during surveys for CPAI were compiled into a centralized database following CPAI's data management protocols (version 10.9, CPAI 2018). All nest, brood, bird, and bird group locations were recorded on Android tablets that could be downloaded into text and GIS files for data checking. Uniform attribute data were recorded for all observations and proofed after data collection. Survey data were submitted to CPAI in GIS-ready format with corresponding metadata.

RESULTS AND DISCUSSION

SEASONAL CONDITIONS IN THE STUDY AREA

In 2018, birds in the Colville Delta study area experienced the coldest spring in 22 years of record keeping. Persistent snow and lake ice probably delayed access to suitable nesting sites for many birds. However, the slow thaw had the positive effect of reduced flooding of nesting areas. We compiled data from 3 weather stations (Colville Village, Alpine, and Nuiqsut) that span the study area north to south, observing that the mean daily temperature during the breeding season increases ~2 °C southward between weather stations.

The cold spring followed a record warm winter. The cumulative freezing degree-days (FDD) over the winter of 2017/2018 (6,703 FDD) was the lowest in 20 years of records at Colville Village (Helmericks' homesite), and the fifth consecutive winter with a below average FDD (7,725 ± 153 FDD, [mean ± standard error; *n* = 20 years]; http://www.weather.gov/aprfc/FreezingDegreeDays).

Between 15 May and 15 June, when most birds arrive on local nesting grounds annually, only 4.4 cumulative thawing degree-days (TDD) were measured at Colville Village in 2018, well below the 22-year mean of 36.5 ± 5 cumulative TDD. Similar to 2017, early June was unusually cold (Figure 2). Mean temperatures in Colville Village in May 2018 (–6.1 °C) and June 2018 (0.8 °C) were colder than the long-term mean temperatures (–5.1 ± 0.5 °C and 3.6 ± 0.4 °C, respectively, *n* = 22 years). Not until 21 June did mean daily temperatures at Colville Village remain above freezing. Nuiqsut had reached the same status 9 days earlier.

Low temperatures during spring allowed snow to persist a record length of time in 2018. Snow depth on 15 May was moderate at Colville Village (23 cm) and equivalent to the long-term mean (23 ± 2 cm, *n* = 22 years). Measurable snow remained until 18 June at Colville Village, the latest date on record. Typically, sites south of Colville Village melt out a few days earlier. Alpine reported no snow cover on 7 June.

Spring floods on the Colville Delta were minor in 2018, as snow melt was gradual and ice jams caused limited backflow (Michael Baker International 2018). Water level at peak stage (15.9 ft British Petroleum Mean Sea Level) at the

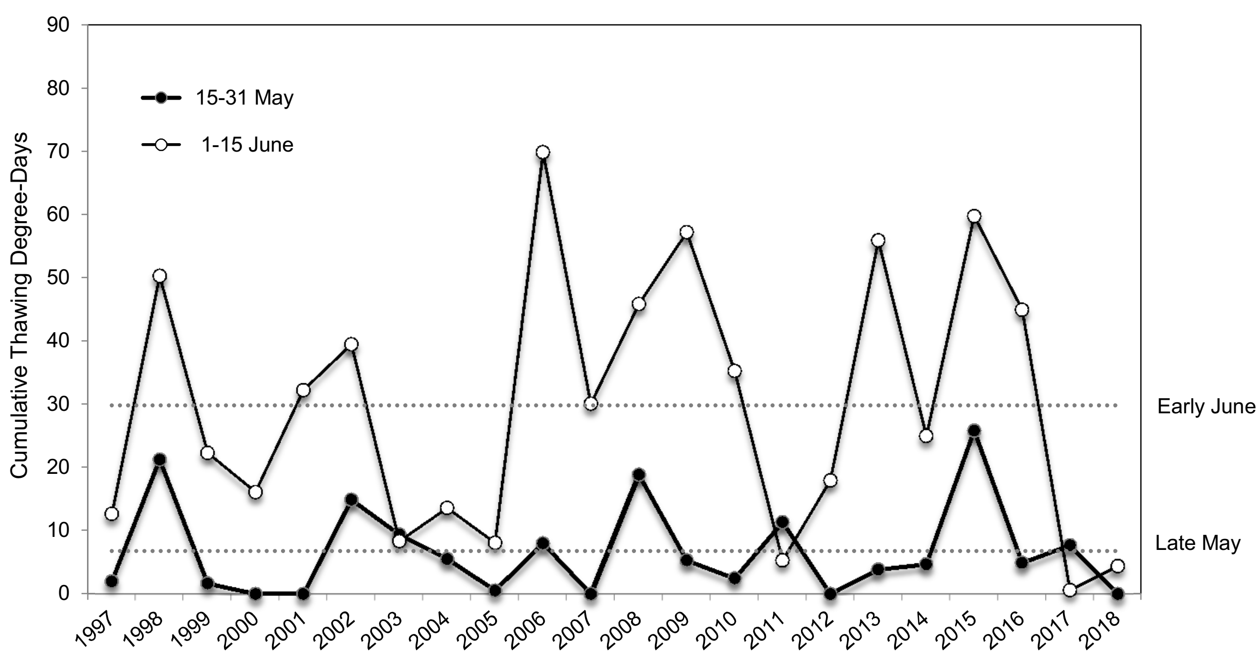

Figure 2. Cumulative number of thawing degree-days recorded 15 May–15 June at Colville Village, Colville River delta, Alaska, 1997–2018.

head of the Colville Delta (Monument 1 gauge) was below average height and occurred later than average (2 June). Peak discharge (331,000 cfs) in 2018 was near average (Michael Baker International 2018). During the loon nest survey, only a few loon lakes had visible evidence of receiving sediment-laden flood waters.

Timing of open water is important for aquatic feeding birds. Ice movement in the East Channel began 1 June, and by 5 June (1 day later than 2017) the channel was clear of ice (Michael Baker International 2017, 2018). Open water on Yellow-billed Loon breeding lakes became available later in 2018 than in the previous 4 years (Johnson et al. 2015, 2016, 2017, 2018). Ice coverage on 20 large lakes (>5 ha) on the Colville Delta study area (estimated visually during nesting surveys for loons on 21–25 June) was more extensive in 2018 (93%) than in the preceding 4 years (range 50–85%).

Timing of midge and mosquito emergence in 2018 also was delayed by cool temperatures. In most years, mosquitoes emerge in late June or early July. It was 3 July before warm weather (mean daily temperatures >7 °C) was favorable for mosquito emergence (Danks and Oliver 1972). In contrast to May and June, the mean temperature for July in 2018 (8.7 °C) was above average (7.7 ± 0.3 °C, n = 22 years), as it has been for the last 3 years. Rising temperatures increase insect activity and heat stress for nesting birds.

In summary, the timing of the 2018 nesting season was likely delayed for most species of ground-nesting birds on the Colville Delta study area. During other studies in the region, we observed no sign of hatch on the Colville Delta study area or at nearby CD-5 during 19–26 June. Male Spectacled Eiders were still present on the nesting grounds in the third week of June, indicating a late nesting season for that species. Late hatch extends brood rearing later into the year, when snow and ice can reduce fledging success (Cox et al. 2017). Despite the late spring, length of the snow-free period in 2018 (119 d) was near average for Colville Village (121 ± 3 d, n = 22 years). Average to below-average breeding conditions were reported for most waterfowl in northern Alaska in 2018 (USFWS 2018).

EIDERS

Four species of eiders may occur on the Colville Delta, but each varies in abundance and distribution. Of the 2 species of eiders that are most common in the Colville Delta study area, the Spectacled Eider has received the most attention because it was listed as "threatened" in 1993 (58 FR 27474–27480) under the Endangered Species Act of 1973, as amended. The outer Colville Delta is a concentration area for breeding Spectacled Eiders relative to surrounding areas; nonetheless, even there Spectacled Eiders nest at low densities and nest at even lower densities at inland portions of the Colville Delta study area (Burgess et al. 2002, 2003; Johnson et al. 2004, 2005). The King Eider, which is not protected under the Endangered Species Act, is more widespread and generally more numerous than the Spectacled Eider across the Arctic Coastal Plain, although their relative abundance varies geographically. The Steller's Eider was listed as a threatened species in 1997 (62 FR 31748–31757). Steller's Eiders are rare on the Colville Delta study area (2 observations by ABR and 1 by J. Bart, Boise State University, personal communication in 25 years of surveys; see summary in Johnson et al. 2014b) and immediate surroundings as these areas are east of their current Alaska breeding range centered around Utqiaġvik (Barrow). Although abundant in appropriate habitat, Common Eiders nest primarily on barrier islands and coastlines and are seen rarely (7 observations in 25 years) on surveys of the Colville Delta study area.

SPECTACLED EIDER

Distribution and Abundance

We recorded 43 Spectacled Eiders (on the ground and flying) and 44 indicated total Spectacled Eiders during the pre-nesting aerial survey in 2018 on the Colville Delta study area (Figure 3, Table 2). The number of pre-nesting Spectacled Eiders was below average on the Colville Delta study area in 2018 (Table 2). All observations of pre-nesting Spectacled Eiders in the Colville Delta study area in 2018 were of small groups of 1–4 birds. The CD North subarea contained 77% of the Spectacled Eiders observed, whereas the CD South subarea contained 17% (Appendix C). The density of pre-nesting

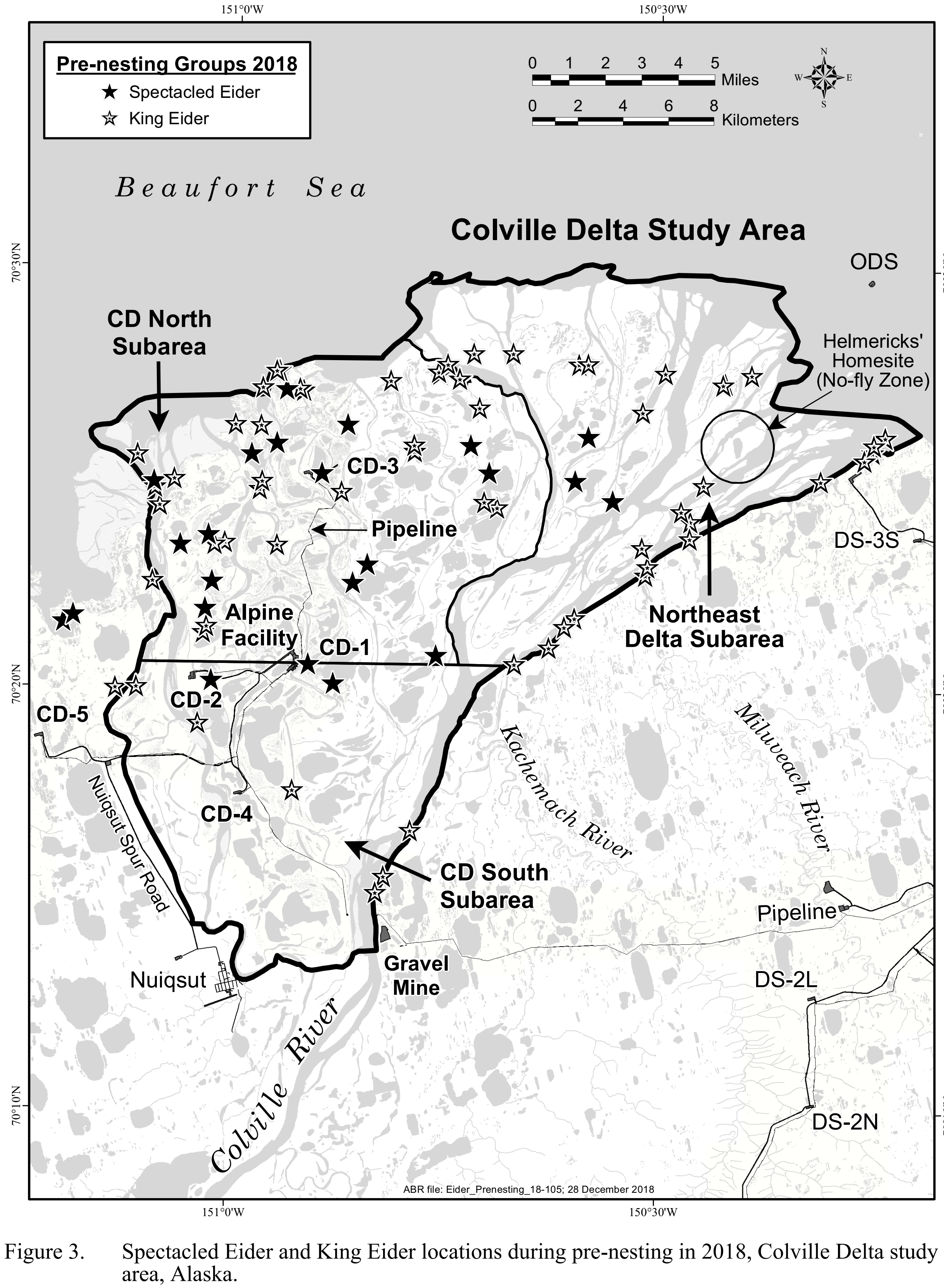

Figure 3. Spectacled Eider and King Eider locations during pre-nesting in 2018, Colville Delta study area, Alaska.

Table 2. Observed and indicated numbers and densities (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 1993–2018.

		Spectacled Eider				King Eider			
	Area Surveyed	Total[a]		Density[b]		Total[a]		Density[b]	
Year	(km²)	Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
1993	248.8	31	32	0.12	0.13	39	30	0.16	0.12
1994	455.7	79	57	0.17	0.13	58	35	0.13	0.08
1995	501.4	61	40	0.12	0.08	34	23	0.07	0.05
1996	501.4	41	40	0.08	0.08	59	43	0.12	0.09
1997	501.4	59	58	0.12	0.12	49	54	0.10	0.11
1998	501.4	71	70	0.14	0.14	57	18	0.11	0.04
2000	300.0	40	38	0.13	0.13	22	24	0.07	0.08
2001	501.4	38	36	0.08	0.07	35	22	0.07	0.04
2002	501.4	26	30	0.05	0.06	61	42	0.12	0.08
2003	501.4	24	20	0.05	0.04	50	38	0.10	0.08
2004	353.0	12	10	0.03	0.03	17	14	0.05	0.04
2005	501.4	16	14	0.03	0.03	46	22	0.09	0.04
2006	501.4	31	30	0.06	0.06	63	60	0.13	0.12
2007	501.4	52	48	0.10	0.10	30	28	0.06	0.06
2008	501.4	80	89	0.16	0.18	33	40	0.07	0.08
2009	501.4	41	42	0.08	0.08	33	30	0.07	0.06
2010	501.4	103	78	0.21	0.16	57	34	0.11	0.07
2011	501.4	99	95	0.20	0.19	133	129	0.27	0.26
2012	501.4	59	60	0.12	0.12	25	20	0.05	0.04
2013	501.4	63	66	0.13	0.13	38	24	0.08	0.05
2014	501.4	69	68	0.14	0.14	71	66	0.14	0.13
2015	501.4	59	54	0.12	0.11	57	42	0.11	0.08
2016	501.4	88	89	0.18	0.18	82	79	0.16	0.16
2017	501.4	56	66	0.11	0.13	99	91	0.20	0.18
2018	501.4	43	44	0.09	0.09	188	150	0.37	0.30
Mean		56.1	54.1	0.11	0.11	61.9	50.2	0.12	0.10
SE		5.2	5.0	0.01	0.01	8.4	7.8	0.01	0.01

[a] Observed total includes flying and non-flying eiders. Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987). Mean and standard error calculated for total observed or indicated when survey area = 501.4 km², *n* = 21 years.

[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of surveyed area. Means calculated for all years, *n* = 25 years.

Spectacled Eiders in the CD North subarea during 2018 (0.16 indicated birds/km²) was almost twice the density recorded on the much larger Colville Delta study area (0.09 indicated birds/km²). The distribution of pre-nesting Spectacled Eiders in 2018 was typical of previous years, when densities were highest north of Alpine and low south and northeast of Alpine (Figure 4). Over the 25 years that ABR and others have monitored Spectacled Eiders, their population trend has been relatively stable (Figure 5). In the CD North subarea, the growth rate is 2% (logarithmic growth rate of 1.02; ln(adults) = 0.019 (year) – 34.96, R^2 = 0.08, P = 0.17). The growth rate for the entire Colville Delta study area was slightly lower at 1.5% (ln(adults) = 0.015 (year) – 26.9, R^2 = 0.05, P = 0.27, n = 25 years). A recent analysis from pre-nesting surveys of Spectacled Eiders across the ACP in early–mid June estimated a slight decline (–1.2%) in Spectacled Eiders for the entire ACP (logarithmic growth rate = 0.988, n = 26 years; Wilson et al. 2018). However, none of the above growth rates differs significantly from equilibrium (a logarithmic growth rate of 1.0 equals 0% annual change, or equilibrium).

Habitat Use

Pre-nesting Spectacled Eiders used 19 of 24 available habitat types during 25 years of aerial surveys on the Colville Delta study area (Table 3). Seven habitat types were preferred (i.e., use significantly greater than availability, $P \leq 0.05$) including 3 primarily coastal, salt-affected habitat types (Brackish Water, Salt Marsh, and Salt-killed Tundra), 3 aquatic habitat types (Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, and Grass Marsh), and 1 terrestrial habitat type (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 of its disproportionate use. Deep Polygon Complex was used by 28% of the Spectacled Eider groups, yet occurred on only 2.7% of the study area. Deep Polygon Complex also is a preferred habitat type during the nesting season (Johnson et al. 2008). Patterned Wet Meadow was second highest in use (21% of Spectacled Eider groups) during pre-nesting but was not preferred because its use and availability were essentially equal. Six habitat types were avoided (use significantly less than availability), including Open Nearshore Water; Tidal Flat Barrens; River or Stream; Moist Sedge-Shrub Meadow; Tall, Low, or Dwarf Shrub; and Barrens. All other habitat types were used in proportion to their availability.

OTHER EIDERS

Distribution and Abundance

We recorded 188 observed (on the ground and flying) and 150 indicated total King Eiders on the 2018 pre-nesting aerial survey of the Colville Delta study area (Figure 3, Table 2). Both numbers were the highest counts of King Eiders recorded since surveys began in 1993 (Figure 6). King Eiders outnumbered Spectacled Eiders (44 indicated birds) in 2018, which has occurred in 11 of 25 years that ABR has conducted these surveys. King Eiders on the ACP have been increasing at a significant rate of 2.5% annually since 1986 (Wilson et al. 2018). King Eiders on the Colville Delta study area have had a similar annual growth rate (2.9%) since surveys began in 1993 (ln(adults) = 0.029 (year) – 55.2, R^2 = 0.15, P = 0.06, n = 25 years). King Eiders were observed in all 3 of the subareas, but they achieved their highest density (0.47 indicated birds/km²) in the Northeast Delta subarea in 2018 (Appendix C). The highest densities occur on the East Channel of the Colville River near the coast, where flocks of King Eiders collect in open water; lower densities are seen elsewhere on the delta (Figure 7). Relatively few King Eiders have nested on the Colville Delta study area in previous years (2007 was the last time a large area was searched for nests), suggesting that most of those observed during pre-nesting are in transit to other breeding areas (Johnson et al. 2008, 2017). Relatively high numbers of King Eiders on the Colville Delta study area in 2018 compared with previous years and relatively low numbers in NE NPR-A in 2018 compared with previous years (Figure 5) may indicate that delayed spring phenology in 2018 prevented King Eiders from dispersing to breeding sites by the time our pre-nesting surveys occurred.

No Steller's or Common eiders were seen in the Colville Delta study area in 2018. Steller's

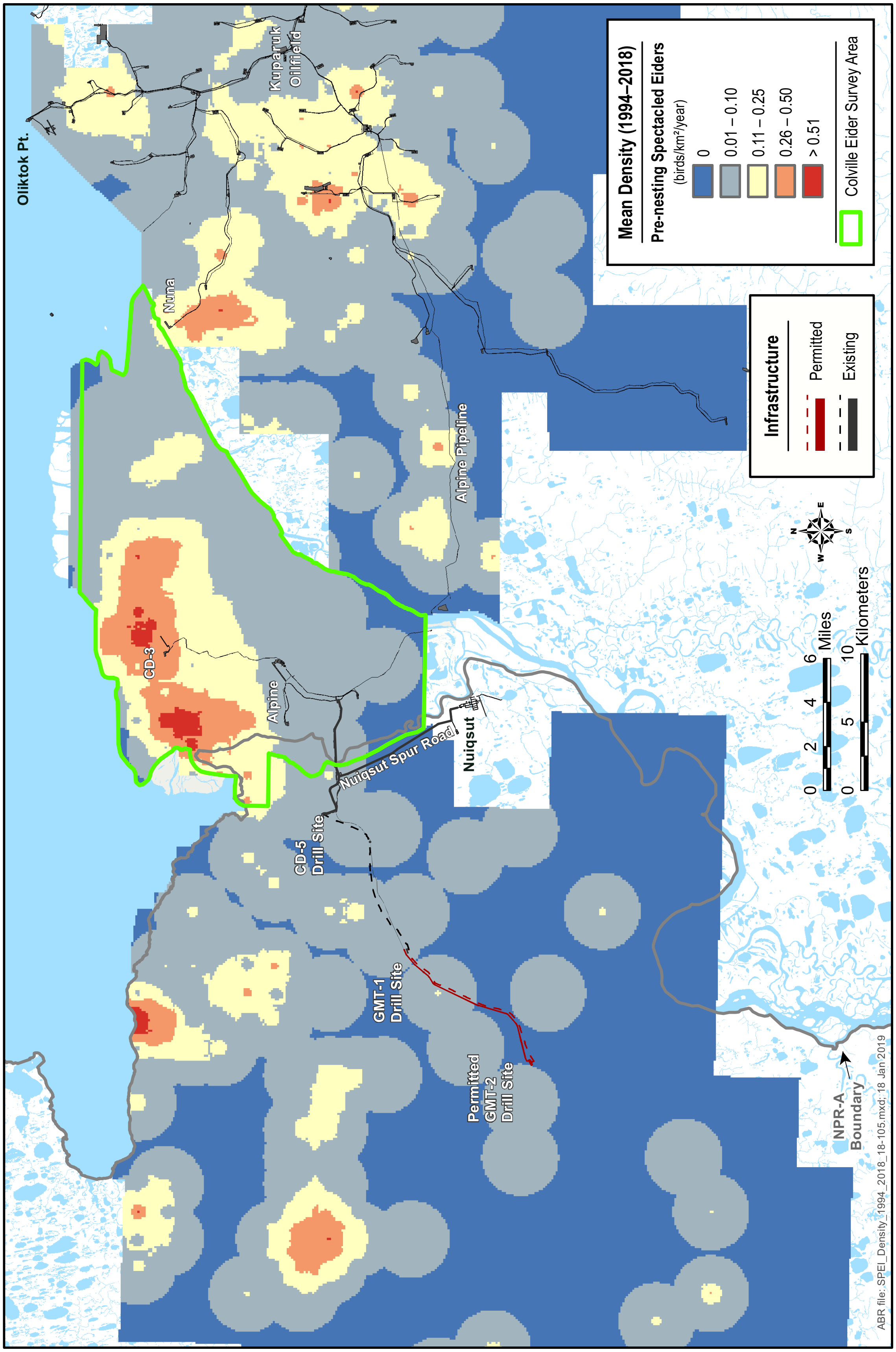

Figure 4. Pre-nesting Spectacled Eider density contours in the Colville Delta and NE NPR-A study areas, Alaska, 1994–2018.

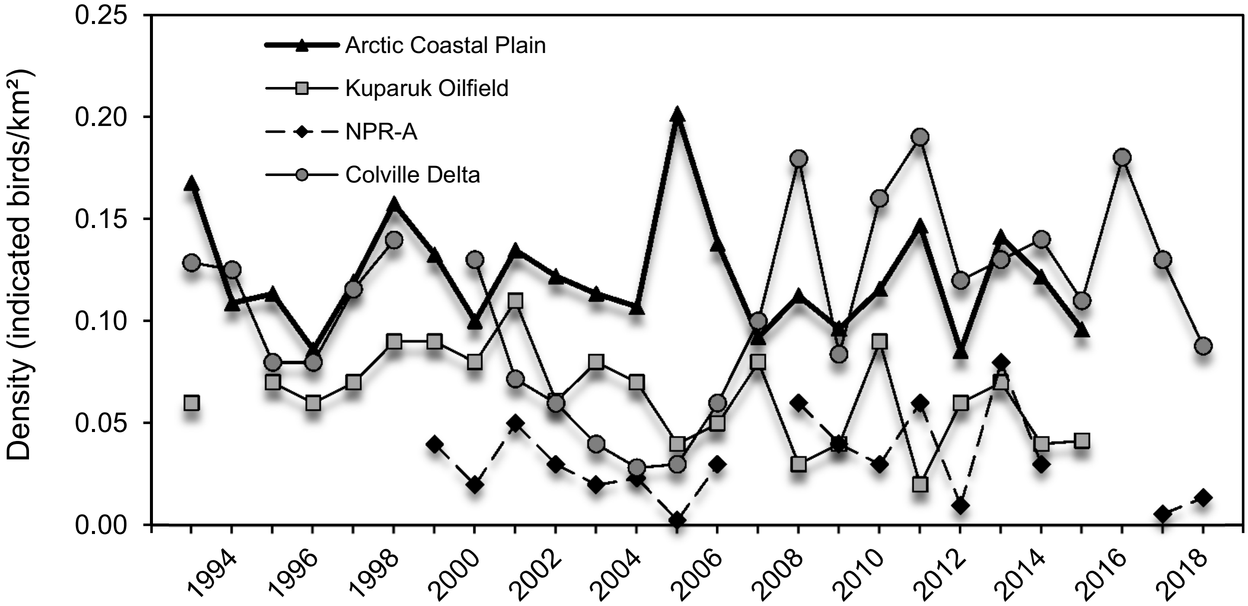

Figure 5. Annual densities of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2018.

Eiders rarely are seen in the vicinity of the Colville River delta and surrounding areas (Johnson et al. 2014b). Common Eiders are seen infrequently on the Colville River delta but are more abundant in the nearshore marine waters and barrier islands that are mostly outside the survey area.

Habitat Use

Unlike Spectacled and King eiders, Steller's and Common eiders have occurred too infrequently to support evaluations of pre-nesting habitat preferences in the Colville Delta study area. Pre-nesting King Eiders used 20 of 24 available habitat types in the Colville Delta study area over 25 years of aerial surveys (Table 3). Pre-nesting King Eiders preferred 5 of the same habitat types preferred by pre-nesting Spectacled Eiders in the Colville Delta study area: Brackish Water, Salt Marsh, Salt-killed Tundra, Shallow Open Water with Islands or Polygonized Margins, and Deep Polygon Complex. In addition to those 5 habitat types, pre-nesting King Eiders preferred River or Stream and Grass Marsh. River or Stream, which includes the river channels primarily in the Northeast Delta subarea, was used by 41% of the pre-nesting groups, (Figures 3 and 7). The high use of River or Stream suggests that many King Eiders were moving through to breeding areas farther east, because River or Stream is not potential breeding habitat. In contrast, Spectacled Eiders, which occur in high numbers during pre-nesting and nest in relatively high concentrations on the outer Colville River delta (0.8–1.0 nests/km²; ABR, unpublished data), avoid the River or Stream habitat type. Moreover, King Eiders nest at very low densities on the Colville River delta in the several locations where intensive nest searches have been conducted (Burgess et al. 2002, 2003; Johnson et al. 2003, 2008; Seiser and Johnson 2010, 2011a, 2011b, 2012, 2014a, 2014b), affirming that most of the pre-nesting King Eiders seen on the delta are stopping over during migration.

YELLOW-BILLED LOON

DISTRIBUTION AND ABUNDANCE

Twenty-three Yellow-billed Loon nests were found during the Yellow-billed Loon nest survey in 2018 (Figure 8, Table 4). One additional nest was inferred from the presence of a brood during August in a territory where a nest was not found during the nest survey. Of the 24 nests documented in 2018, 13 nests were located in the CD North

Table 3. Habitat selection by Spectacled Eider and King Eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998 and 2000–2018.

SPECIES Habitat type	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
SPECTACLED EIDER						
Open Nearshore Water	2	1	0.2	1.6	avoid	
Brackish Water	85	39	6.7	1.3	prefer	
Tapped Lake with Low-water Connection	42	17	2.9	4.5	ns	
Tapped Lake with High-water Connection	22	13	2.2	3.7	ns	
Salt Marsh	69	39	6.7	3.2	prefer	
Tidal Flat Barrens	2	1	0.2	7.0	avoid	
Salt-killed Tundra	97	54	9.3	5.1	prefer	
Deep Open Water without Islands	38	25	4.3	3.4	ns	
Deep Open Water with Islands or Polygonized Margins	42	22	3.8	2.2	prefer	
Shallow Open Water without Islands	6	4	0.7	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	11	8	1.4	0.1	prefer	low
River or Stream	39	18	3.1	14.4	avoid	
Sedge Marsh	1	1	0.2	<0.1	ns	low
Deep Polygon Complex	280	160	27.6	2.7	prefer	
Grass Marsh	10	6	1.0	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	94	48	8.3	8.2	ns	
Patterned Wet Meadow	216	120	20.7	19.2	ns	
Moist Sedge-Shrub Meadow	0	0	0	2.3	avoid	
Moist Tussock Tundra	1	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	0	0	0	5.0	avoid	
Barrens	6	2	0.3	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	1,063	579	100	100		
KING EIDER						
Open Nearshore Water	41	11	2.7	1.6	ns	
Brackish Water	69	35	8.5	1.3	prefer	
Tapped Lake with Low-water Connection	47	19	4.6	4.5	ns	
Tapped Lake with High-water Connection	16	7	1.7	3.7	avoid	
Salt Marsh	57	23	5.6	3.2	prefer	
Tidal Flat Barrens	4	2	0.5	7.0	avoid	
Salt-killed Tundra	60	32	7.7	5.1	prefer	
Deep Open Water without Islands	22	10	2.4	3.4	ns	
Deep Open Water with Islands or Polygonized Margins	19	9	2.2	2.2	ns	
Shallow Open Water without Islands	9	5	1.2	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	5	3	0.7	0.1	prefer	low
River or Stream	577	168	40.7	14.4	prefer	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	53	30	7.3	2.7	prefer	
Grass Marsh	9	4	1.0	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	19	12	2.9	8.2	avoid	
Patterned Wet Meadow	57	33	8.0	19.2	avoid	
Moist Sedge-Shrub Meadow	2	1	0.2	2.3	avoid	
Moist Tussock Tundra	1	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	3	2	0.5	5.0	avoid	
Barrens	15	6	1.5	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	1,085	413	100	100		

[a] Use = (groups/total groups) × 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] Low = expected number of groups < 5.

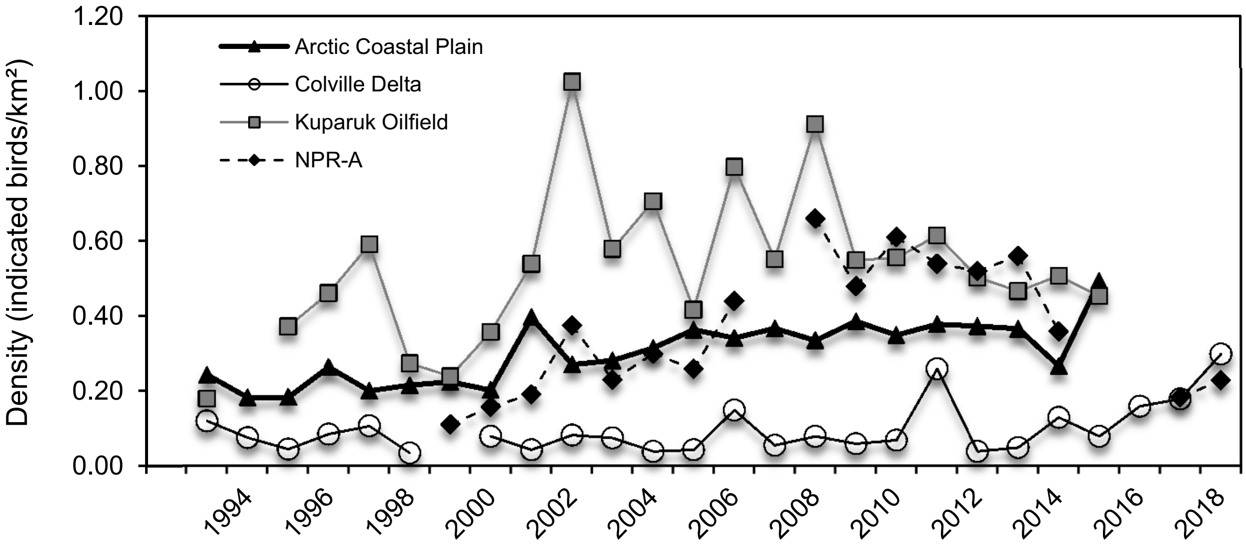

Figure 6. Annual densities of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2018.

subarea, 9 nests in the CD South subarea, and 2 nests in the Northeast Delta subarea (Appendix D). The total number of nests found on the nesting survey was above the long-term mean (20.8 ± 1.3 nests, *n* = 24 years; for densities see Appendix E). The count of 68 adults on the nesting survey also was higher than the long-term mean (57.7 ± 2.3 adults). The density of adults was lower in the CD North subarea (0.16 birds/km²) than the CD South subarea (0.19 birds/km²); however, the density of nests was equal between these areas (0.06 nests/km; Appendix D). Incidental records of Pacific Loon and Red-throated Loon nests and broods are presented in Appendices D and F.

Twenty-two of the 23 Yellow-billed Loon nests recorded in the Colville Delta study area in 2018 were on territories where Yellow-billed Loons have nested previously (ABR, unpublished data). Ten Yellow-billed Loon nests were located at the same nest sites (≤5 m away) used in previous years, 3 were very close (6–50 m) to nest sites used in previous years, 9 were at new nest sites (>50 m from previously recorded nests). A new territory was discovered on a lake where breeding had not previously been documented, although that lake had been surveyed during 2 previous years (2014 and 2015).

Since 1993, the number of nests recorded during the nesting survey in June ranged from 10 nests in 1997 to 33 nests in 2008 (Table 4). Additional surveys for nests occurred prior to 2016, resulting in 1–12 additional nests each year (Table 4). Therefore, the best metric for comparing nesting effort among years is the number of nests recorded on the standardized nest survey conducted in June. We used territory occupancy by nests to adjust for variable survey effort among years (36 to 47 territories were surveyed annually over 24 years). In 2018, 49% of the territories were occupied by nests during the nesting survey, which is near the long-term mean (50.1 ± 3.2%, *n* = 24 years; Table 4).

During the brood-rearing survey on 15–21 August, 58 adult Yellow-billed Loons, 6 broods, and 9 young were recorded in the Colville Delta study area (Figure 8, Table 5). We inferred 4 additional broods based on eggshell fragments at nests. Of the 10 broods, 6 were found in the CD North subarea, 2 were found in the CD South subarea, and 2 were found in the Northeast Delta subarea (Appendix D). The counts of 58 adults and 10 broods on the brood-rearing survey were above or near the long-term means (50.5 ± 2.4 adults; 12.4 ± 1.2 broods, *n* = 24 years; Table 5; for densities, see Appendix E). Adults and young were distributed fairly evenly during the brood-rearing survey between the CD North subarea (0.15 birds/km², 0.03 broods/km²) and CD South subarea (0.14 birds/km², 0.01 broods/km²; Appendix D).

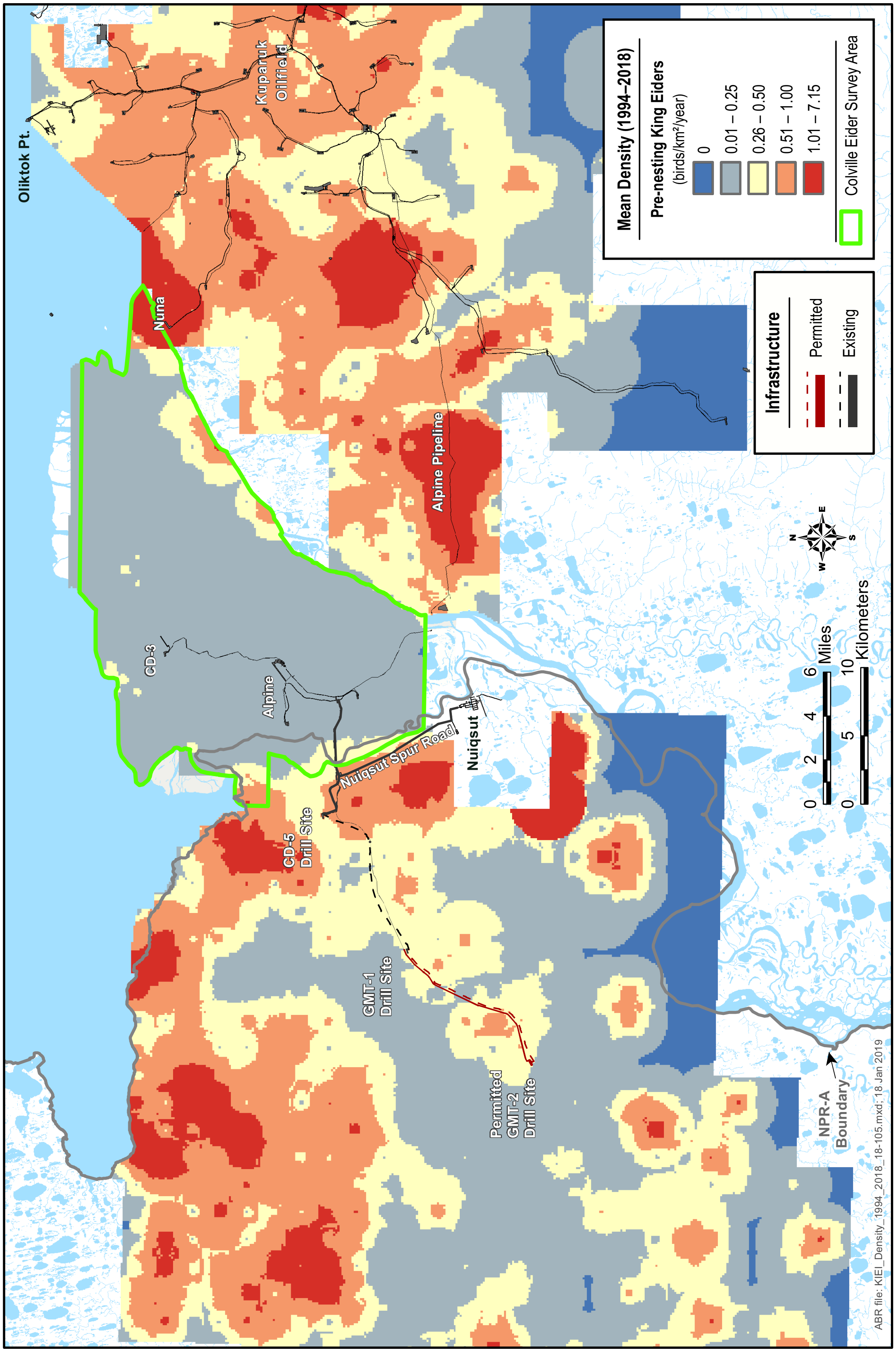

Figure 7. Pre-nesting King Eider density contours in the Colville Delta and NE NPR-A study areas, Alaska, 1994–2018.

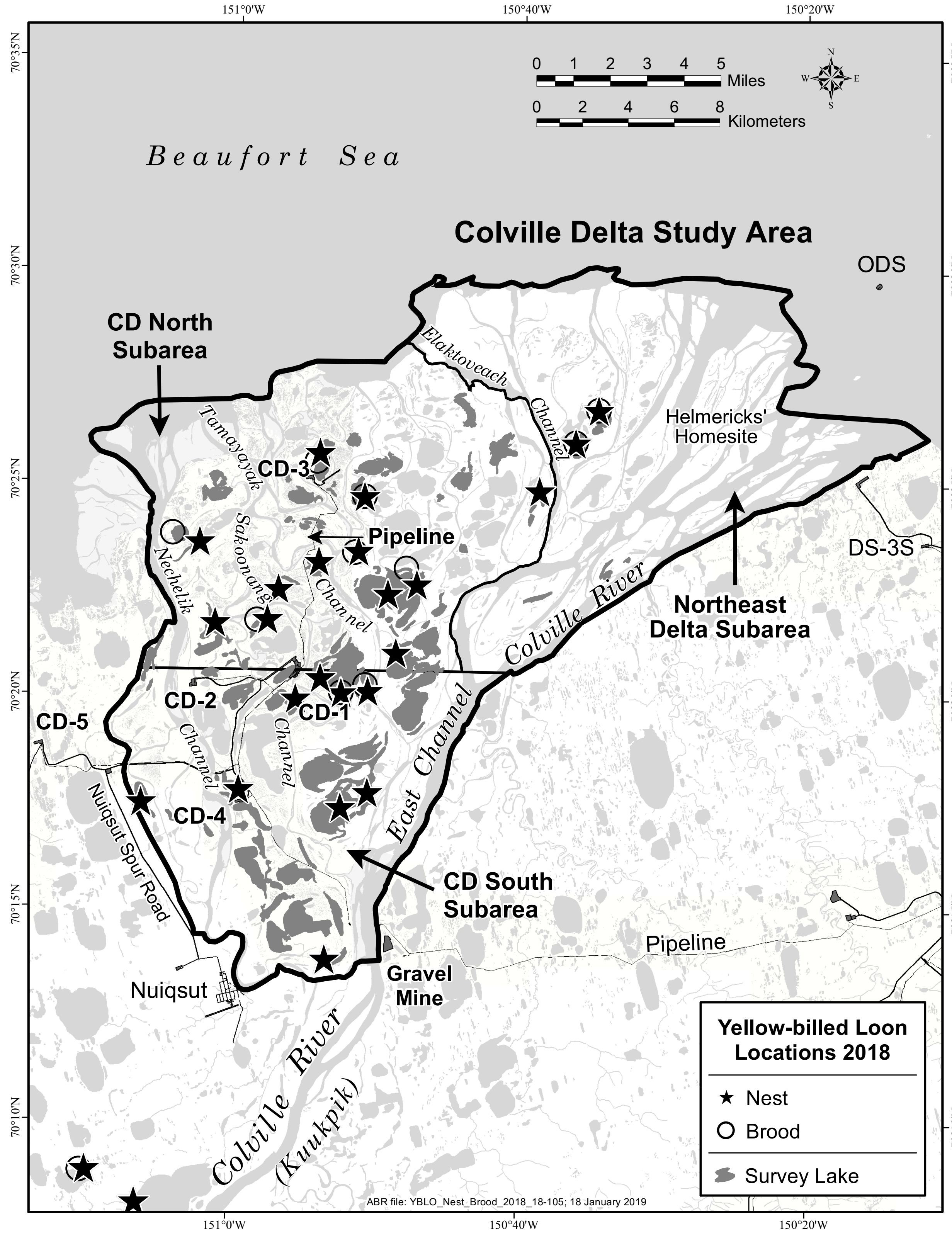

Figure 8. Yellow-billed Loon nest and brood locations, Colville Delta study area, Alaska, 2018.

Table 4. Number of Yellow-billed Loons and nests, and territory occupancy by nests, Colville Delta study area[a], Alaska, 1993, 1995–1998 and 2000–2018.

Year	Nesting Survey[b] No. Adults	Nesting Survey[b] No. Nests	All Surveys[c] No. Nests	No. Territories Surveyed	Nest Occupancy (%)[d]
1993	50	11	16[e,f]	43	26
1995	42	12	21[e,f]	40	30
1996	45	11	20[e,f,g]	36	30
1997	48	10	18[e,g]	39	26
1998	35	17	24[e,f,g]	42	40
2000	53	16	16	38	42
2001	54	19	20[e]	38	50
2002	46	17	22[e,f,g]	42	40
2003	53	25	27[f]	41	61
2004	41	24	26[f]	42	57
2005	56	30	31[f]	41	73
2006	63	24	28[g]	42	57
2007	66	27	31[g]	42	71
2008	69	33	38[g]	43	77
2009	67	27	30[g]	44	61
2010	69	23	35[g]	44	52
2011	70	23	29[g]	44	64
2012	57	25	32[g]	44	68
2013	67	12	17[f,g,h]	44	27
2014	78	26	32[g,h]	46	57
2015	63	19	25[f,h]	47	50
2016	68	18	18[i]	46	37
2017	56	26	28[f]	46	57
2018	68	23	24[f]	47	49
Mean	57.7	20.8	25.5	–	50.1
SE	2.3	1.3	1.3	–	3.2

[a] 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.
[b] Nesting survey is limited to surveys conducted between 18 and 30 June.
[c] Observation effort varied between years. Includes all nests found on loon aerial surveys, ground surveys, camera images or inferred by brood observations. Observation methods other than nesting survey are footnoted.
[d] Calculated as the number of nests found on the nesting survey divided by the number of territories surveyed. Excludes 1 renesting in 2007, 2011, and 2016, and 2 renestings in 2012 and 2015.
[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 (2006–2014), and early nesting (2011) surveys.
[h] Includes nest(s) documented on camera images only or nest(s) found after the nesting survey during camera setup.
[i] No surveys for nests were conducted in addition to the single June survey.

Table 5. Number of Yellow-billed Loons and broods, and territory occupancy by broods, Colville Delta study area, Alaska, 1993, 1995–1999, and 2000–2018.

	Brood-rearing Survey[a]			All Surveys[b]		
Year	No. Adults	No. Young	No. Broods	No. Broods	No. Territories Surveyed[c]	Brood Occupancy (%)[d]
1993	29	7	7	10[e]	34	29
1995	51	13	10	13[e]	43	30
1996	62	6	6	10[e]	37	27
1997	66	8	5	5	39	13
1998	55	15	12	12	42	29
2000	21	2	2	3[f]	36	8
2001	33	4	4	4	37	11
2002	66	9	8	9[e]	40	23
2003	47	16	14	14	40	35
2004	54	15	12	12	41	29
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]	43	63
2009	56	12	11	13[g]	44	30
2010	59	19	13	15[f,g,h]	42	36
2011	45	20	12	15[f,g,h]	42	36
2012	52	19	14	17[g,h]	44	39
2013	43	9	7	7	44	16
2014	48	4	4	8[f,g]	46	17
2015	58	10	9	10[h]	47	21
2016	43	6	6	11[g]	46	24
2017	52	10	8	12[g]	46	26
2018	58	9	6	10[g]	47	21
Mean	50.5	12.3	10.0	12.4	–	29.5
SE	2.4	1.3	1.0	1.2	–	2.8

[a] Brood-rearing surveys were conducted sometime between 15 and 27 August.
[b] Includes all broods found on brood-rearing survey and any additional broods found during other types of surveys as footnoted.
[c] 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.
[d] Calculated as the number of broods from all surveys divided by the number of territories surveyed.
[e] Includes brood(s) found during ground surveys.
[f] Includes brood(s) found during monitoring surveys.
[g] Includes broods from territories where no brood was seen but presence of a brood was determined from eggshell evidence.
[h] Includes broods from territories where broods were seen only on camera images.

During 24 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 5). In most years, an additional 1–6 broods were found during ground and/or monitoring surveys, or were determined by eggshell fragments at the nest indicating that hatching occurred (see *Nest Fate,* below). With the addition of these broods, the range of brood counts was 3–27. As was the case for nesting (above), we standardize for survey effort when estimating territory occupancy by broods. Brood occupancy has been below the long-term mean (29.5 ± 2.8%, n = 24 years) since 2013. Although brood occupancy has increased annually over the previous 4 years, it declined to 21% in 2018.

Since 1993, we have identified 48 Yellow-billed Loon territories composed of 63 lakes in the Colville Delta study area (Appendix G). One of the 48 territories, however, is no longer suitable for breeding Yellow-billed Loons. During fall 2009, the shoreline of that lake (L9210) eroded into the Colville River, changing it from Deep Open Water with Islands or Polygonized Margins to Tapped Lake with Low-water Connection; the latter is a habitat type not used by nesting loons. As a result, Yellow-billed Loons no longer nest in that lake, reducing the number of territories to 47. Twenty-four of the 47 territories were occupied by breeding Yellow-billed Loons in 2018.

Yellow-billed Loons in the Colville Delta study area have been characterized previously by stable or slightly increasing population growth, but annual growth appears be slowing. From 2000 to 2018, the growth rate of number of adults (adjusted by the number of territories surveyed; Figure 9) was slightly positive but not significantly different from equilibrium (ln(adults) = 0.007(year) – 10.5, R^2 = 0.09, P = 0.22, n = 19). Over the last 10 years, the number of adult Yellow-billed Loons has decreased slightly (ln(adults) = –0.014(year) + 33.4, R^2 = 0.18, P = 0.21). Similar but stronger trends were reported for the entire ACP. Adult numbers from 32 years of breeding pair waterfowl surveys were estimated to be increasing significantly at 1.3% (logarithmic growth rate = 1.013, 95% CI = 1.002–1.024, n = 32 years; Wilson et al. 2018). However, over the last 10 years, adult numbers on the ACP appear to be declining

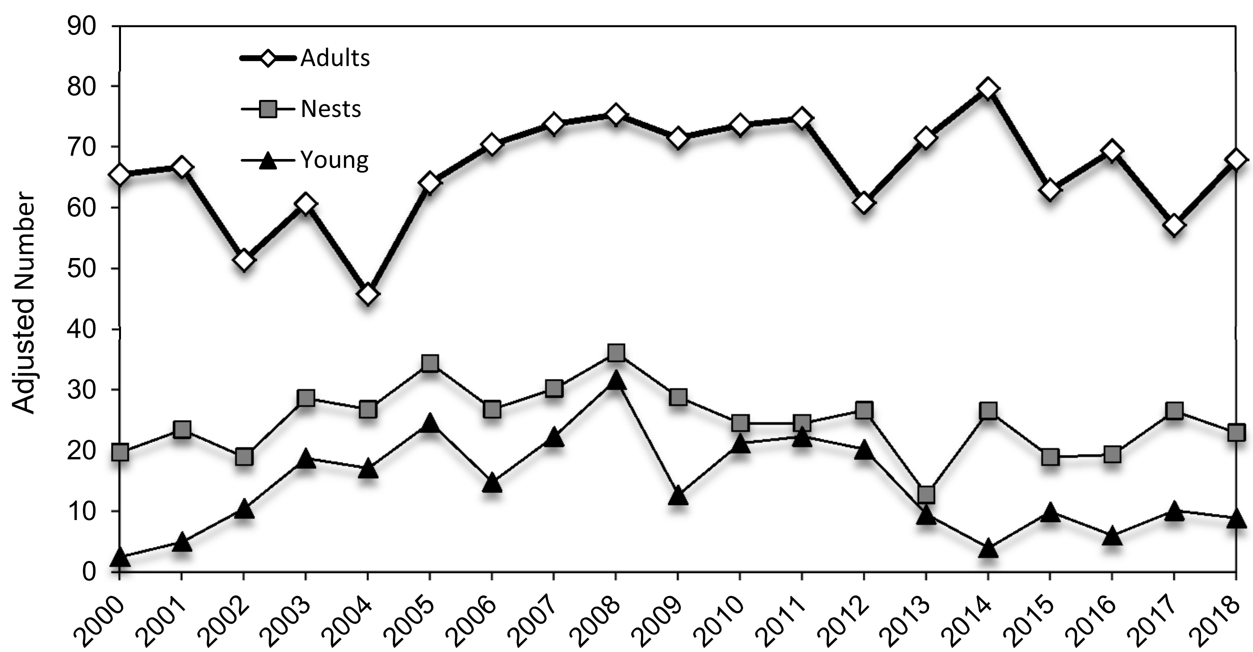

Figure 9. Annual numbers of Yellow-billed Loon adults and nests during the nesting survey and young during the brood-rearing survey, Colville Delta study area, Alaska, 2000–2018.

(logarithmic growth rate = 0.96, 95% CI = 0.907–1.025), as they have on the Colville Delta study area.

Numbers of nests and young on the Colville Delta have not displayed any long-term trend over the last 18 years, however both showed signs of decline over the last 10 years. Since 2009, the number of nests has declined 2% (ln(nests) = –0.020(year) + 42.5, $R^2 = 0.06$, $P = 0.50$), whereas the number of young declined 11% over that period (ln(young) = –0.11(year) + 219.2, $R^2 = 0.35$, $P = 0.07$).

Reduced nest and/or brood survival appear to be the primary causes of declines in production of young. Despite signs of recent declines in adult numbers, adult Yellow-billed Loons continue to reside on territories during the nesting survey. The number of breeding territories occupied by at least 1 loon during the nesting survey is consistently high (mean = 81.1 ± 1.7%, range = 69–98%, $n = 19$ years); however, not all adults that are present during June attempt to breed. Territory occupancy by nests is much lower and more variable (mean = 55.3 ± 2.9%, range = 27–77%, $n = 19$ years) than occupancy by adults, but occupancy by nests during the last 10 years has generally remained at or above the mean. The declining trend in the number of young appears to be a result of below average nest and/or brood survival particularly during the past 5 years (see Nest Fate, below).

HABITAT USE

Yellow-billed Loons nested in 12 of 24 available habitat types during nesting surveys conducted in the Colville Delta study area over 24 years (Table 6). Seven habitat types, supporting 505 of 540 total nests, were preferred for nesting (Tapped Lake with High-water Connection, Deep Open Water with Islands or Polygonized Margins, Deep Open Water without Islands, Sedge Marsh, Grass Marsh, Nonpatterned Wet Meadow, and Patterned Wet Meadow). Within these habitat types, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. Nests on shorelines of lakes or large islands (>0.5 ha) were assigned to the terrestrial habitat type on the lakeshore, whereas nests on small islands or in small patches of emergent vegetation ≤5 ha in size were assigned to the aquatic habitat type of the lake. Patterned Wet Meadow was the habitat type used most frequently for nesting (35% of all nests), and it also was the most abundant habitat type on the delta (24% of the loon survey area; Table 6). Deep Open Water with Islands or Polygonized Margins also was used frequently for nesting (26% of all nests), which reflects the high use of small islands by nesting Yellow-billed Loons (Table 6). Nesting Yellow-billed Loons avoided nesting in 11 habitat types, which together occupied 50% of the Colville Delta study area.

Yellow-billed Loons were highly selective in their use of brood-rearing habitat. All Yellow-billed Loon broods (238 broods over 23 years) were found in 5 lake habitat types, only 3 of which were preferred: Tapped Lake with High-water Connection, Deep Open Water without Islands, and Deep Open Water with Islands or Polygonized Margins (Table 6). The preferred habitat types occupied only 13% of the delta. A brood was observed in Brackish Water only during 1 survey; loons at that territory typically nest and rear broods on a lake classified as Deep Open Water with Islands or Polygonized Margins. The selection analyses for nesting and brood-rearing highlight the importance of large, deep waterbodies to breeding Yellow-billed Loons.

We have identified 47 territories (excluding 1 territory that is no longer suitable for breeding; see above) in the Colville Delta study area. Thirty-four territories are comprised of a single lake used for both nesting and brood-rearing, 10 territories are composed of 2 adjacent lakes, 2 are composed of 3 adjacent lakes, and 1 is composed of 4 lakes. Lakes used by breeding Yellow-billed Loons averaged 54.8 ± 12.7 ha in size (range 0.03–508.2 ha, $n = 54$ lakes). The smallest lake was used once and only for nesting. The largest lake supports 3 Yellow-billed Loon territories. The majority of lakes were used for both nesting and brood-rearing; the smallest of those lakes was 4.4 ha.

NEST FATE

During the brood-rearing survey in 2018, 6 of 24 Yellow-billed Loon nests had a brood. Because the absence of a brood does not always indicate nest failure, all 18 of the remaining nests without broods were visited on the ground to determine nest fate. Four of the 18 nests contained >20 egg fragments (range 35–75 fragments), indicating that at least 1 egg hatched. The remaining 14 nests

Table 6. Habitat selection by nesting (1993, 1995–1998, and 2000–2018) and brood-rearing (1995–1998 and 2000–2018) Yellow-billed Loons, Colville Delta study area[a], Alaska.

SEASON Habitat type	No. of Nests or Broods	Use (%)[b]	Availability (%)	Monte Carlo Results[c]	Sample Size[d]
NESTING					
Open Nearshore Water	0	0	2.0	avoid	
Brackish Water	0	0	1.1	avoid	
Tapped Lake with Low-water Connection	0	0	5.5	avoid	
Tapped Lake with High-water Connection	44	8.1	5.3	prefer	
Salt Marsh	2	0.4	2.6	avoid	
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	57	10.6	4.7	prefer	
Deep Open Water with Islands or Polygonized Margins	139	25.7	2.6	prefer	
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	0.4	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	5	0.9	0.0	prefer	low
Deep Polygon Complex	22	4.1	3.0	ns	
Grass Marsh	9	1.7	0.3	prefer	low
Young Basin Wetland Complex	0	0	<0.01	ns	low
Old Basin Wetland Complex	0	0	0.03	ns	low
Nonpatterned Wet Meadow	63	11.7	8.8	prefer	
Patterned Wet Meadow	188	34.8	24.2	prefer	
Moist Sedge-Shrub Meadow	6	1.1	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	avoid	low
Tall, Low, or Dwarf Shrub	3	0.6	6.6	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.1	ns	low
Total	540	100	100		
BROOD-REARING					
Open Nearshore Water	0	0.0	2.0	avoid	low
Brackish Water	1	0.4	1.1	ns	low
Tapped Lake with Low-water Connection	0	0.0	5.5	avoid	
Tapped Lake with High-water Connection	53	22.3	5.3	prefer	
Salt Marsh	0	0.0	2.6	avoid	
Tidal Flat Barrens	0	0.0	3.5	avoid	
Salt-killed Tundra	0	0.0	4.2	avoid	
Deep Open Water without Islands	107	45.0	4.7	prefer	
Deep Open Water with Islands or Polygonized Margins	76	31.9	2.6	prefer	
Shallow Open Water without Islands	0	0.0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	0	0.0	0.1	ns	low
River or Stream	0	0.0	8.8	avoid	
Sedge Marsh	0	0.0	0.0	ns	low

Table 6. Continued.

SEASON Habitat type	No. of Nests or Broods	Use (%)[b]	Availability (%)	Monte Carlo Results[c]	Sample Size[d]
Deep Polygon Complex	0	0.0	3.0	avoid	
Grass Marsh	1	0.4	0.3	ns	low
Young Basin Wetland Complex	0	0.0	<0.01	ns	low
Old Basin Wetland Complex	0	0.0	0.03	ns	low
Nonpatterned Wet Meadow	0	0.0	8.8	avoid	
Patterned Wet Meadow	0	0.0	24.2	avoid	
Moist Sedge-Shrub Meadow	0	0.0	3.2	avoid	
Moist Tussock Tundra	0	0.0	0.9	ns	low
Tall, Low, or Dwarf Shrub	0	0.0	6.6	avoid	
Barrens	0	0.0	12.1	avoid	
Human Modified	0	0.0	0.1	ns	low
Total	238	100	100		

[a] Excludes Northeast Delta subarea because only a portion of the subarea was surveyed each year.
[b] % use = (nests / total nests) × 100 or (broods / total broods) × 100.
[c] 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.
[d] Low = expected number <5.

lacked evidence of hatch; 3 contained 1 to 11 egg fragments, and 11 nests contained no egg remains. Overall, we determined that in addition to the 6 nests that had broods during the brood-rearing survey, 4 nests had broods that did not survive, resulting in 10 successful nests in 2018.

We began visiting inactive nests to verify nest fate in 2005. During 2005–2014, we also conducted weekly nest and brood monitoring surveys, which provide better estimates of the total number of nests and broods. Because of lower survey effort in 2015–2018, nesting success based on the total number of nests detected is not directly comparable to previous years. Restricting the annual data to nests found only on nesting surveys allows a standardized comparison of apparent nesting success among years when nest fate data were collected. Based on nest fate data and the presence of broods, 10 of 24 nests hatched in 2018 for an apparent nesting success of 42%. This estimate was well below the 14-year mean (51.3 ± 3.9%) and was among the 4 lowest estimates of nest success observed since 2005.

GLAUCOUS GULL

DISTRIBUTION AND ABUNDANCE

Including both systematic and incidental observations, we recorded 63 Glaucous Gull nests during the aerial survey for nesting loons; 34 of those nests were in the CD North subarea, 28 nests in the CD South subarea, and 1 nest in the Northeast Delta subarea (Figure 10). The number of Glaucous Gull nests on the Colville Delta study area has declined since 2016, when numbers peaked at 89 nests. Seven of the 8 Glaucous Gull colonies recorded in the Colville Delta study had fewer nests in 2018 than in 2017. Two colonies are located in CD South subarea, including the largest colony in 2018 comprising 17 nests, located ~6 km northeast of the CD-4 drill site. Nests were detected at 4 of the 5 colony sites in the CD North subarea, and the lone colony in the Northeast Delta Subarea was reduced to a single nest.

Over the last 17 years, the number of Glaucous Gull nests has increased based on numbers recorded systematically in the 50 index lakes in the Colville Delta study area that are monitored annually during the aerial survey for nesting loons (Figure 10, Table 7). The growth rate

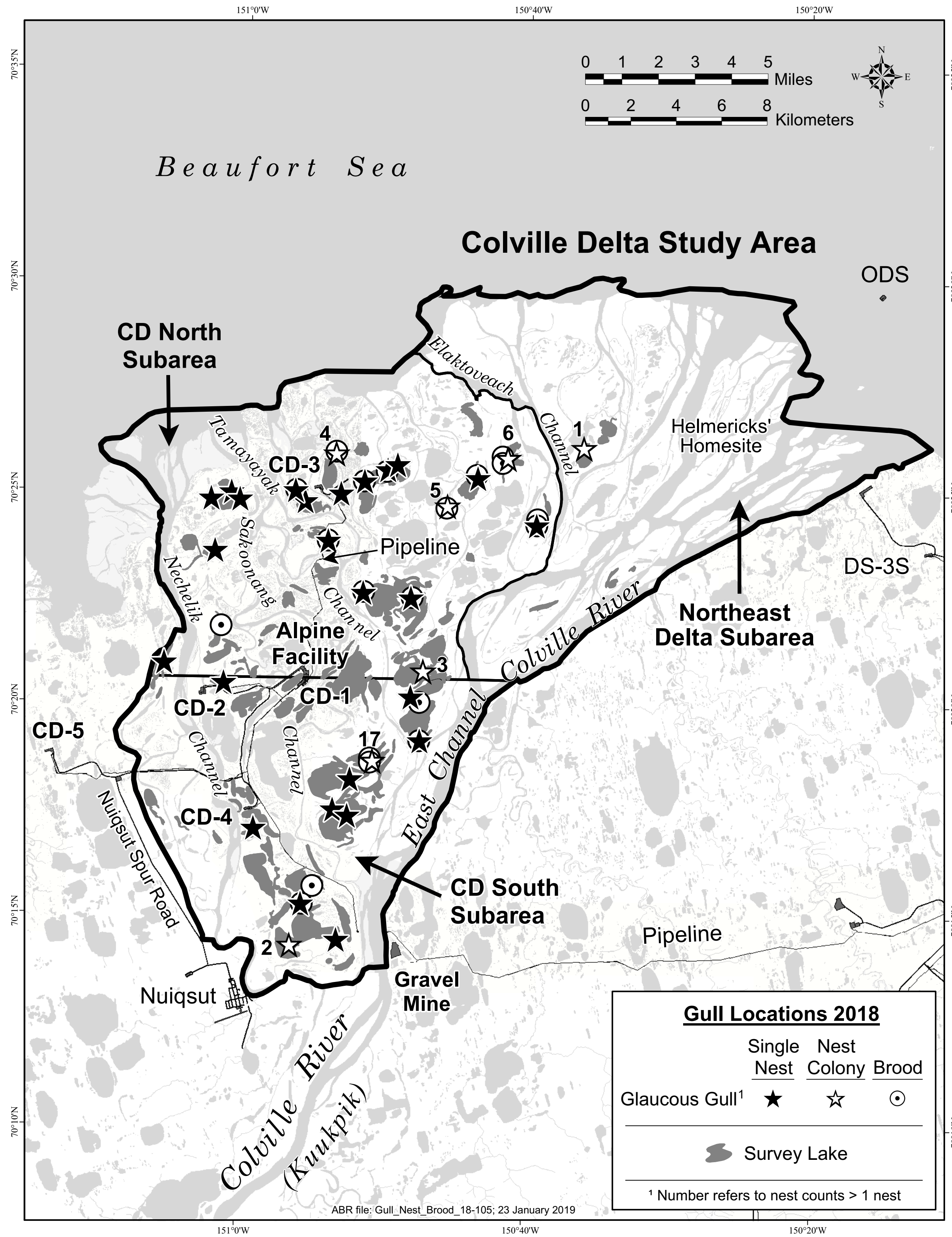

Figure 10. Glaucous Gull nest and brood locations, Colville Delta study area, Alaska, 2018.

Table 7. Number of Glaucous Gull nests recorded during aerial surveys for nesting loons on 50 index lakes, Colville Delta study area, Alaska, 2002–2018.

Year	Number of Nests				No. of Lakes with Nests[c]
	CD North Subarea[a]	CD South Subarea[b]	Northeast Delta Subarea	Total	
2002	11 (2, 1)	24 (18)	1	36	15
2003	11 (1, 1)	17 (14)	0	28	14
2004	19 (7, 1)	17 (13)	0	36	16
2005	18 (5, 1)	22 (15)	0	40	19
2006	15 (4, 1)	21 (16)	1	37	19
2007	16 (5, 1)	21 (13)	2	39	19
2008	19 (5, 1)	26 (18)	2	47	22
2009	17 (6, 1)	27 (19)	2	46	21
2010	17 (5, 2)	16 (6)	2	35	21
2011	17 (5, 2)	36 (17)	2	55	24
2012	26 (7, 5)	34 (17)	2	62	28
2013	19 (5, 4)	35 (23)	3	57	22
2014	27 (6, 5)	34 (18, 3)	2	63	27
2015	29 (6, 5)	29 (15, 4)	2	60	27
2016	29 (7, 5)	37 (20, 4)	4	70	26
2017	26 (7, 6)	35 (23, 6)	3	64	19
2018	22 (6,4)	27 (17,2)	0	49	17
Mean	19.9	26.9	1.6	48.5	20.9
SE	1.4	1.8	0.3	3.1	1.0

[a] First number in parentheses is the number of nests at the colony site in the northeastern part of the CD North subarea and second number is the number of nests at the site north of the CD-3 drill pad (see Figure 10).
[b] First number in parentheses is the number of nests at the colony site northeast of CD-4 drill pad and second number is the number of nests at site south of CD-4 drill pad (see Figure 10).
[c] Of 50 lakes monitored annually for Glaucous Gull nests, 2 occur in the Northeast Delta subarea, 20 in the CD South subarea, and 28 in the CD North subarea.

for nests on the index lakes was 5% (ln(nests) = 0.05 (year) – 96.67, R^2 = 0.82, P = <0.001). In 2018, 49 nests occupied 17 of the 50 index lakes (17-year range: 28 to 70 nests). The Glaucous Gull nest count in 2018 was the lowest since 2010 (Table 7).

A record number of Glaucous Gull young were counted in 2018. Twenty groups of Glaucous Gulls with young were recorded on 17 waterbodies in the Colville Delta study area during the 2018 survey for brood-rearing loons (Figure 10). We recorded 54 total adults, and 47 adults with 63 young in brood groups. Broods were present at 5 of the 7 colonies and the majority of the young were found in those colonies. Three broods were not associated with recorded nest sites. Typical timing of the loon brood survey occurs close to when young gulls fledge. In 2018, the plumage on young gulls indicated that fledging period was delayed compared with past years; thus, we may have recorded a larger number of young because they were not flight capable and remained in their nesting lakes.

HABITAT USE

Glaucous Gull nests and colonies were found in 10 different habitat types in the Colville Delta loon survey areas (Table 8). The 2 most commonly used habitat types were Deep Open Water with Islands or Polygonized Margins (57% of nests) and Tapped Lake with High-water Connection (19%) included colonies as well as single nesting gulls. The single nests were found on islands or complex shorelines in 7 other habitat types.

Table 8. Habitat use by nesting Glaucous Gulls, Colville Delta study area, Alaska, 2018.

Habitat type	Nests	Use (%)
Brackish Water	1	1.6
Tapped Lake with Low-water Connection	2	3.2
Tapped Lake with High-water Connection	12	19.0
Deep Open Water without Islands	2	3.2
Deep Open Water with Islands or Polygonized Margins	36	57.1
Shallow Open Water with Islands or Polygonized Margins	1	1.6
Deep Polygon Complex	3	4.8
Grass Marsh	4	6.3
Nonpatterned Wet Meadow	1	1.6
Patterned Wet Meadow	1	1.6
Total	63	100

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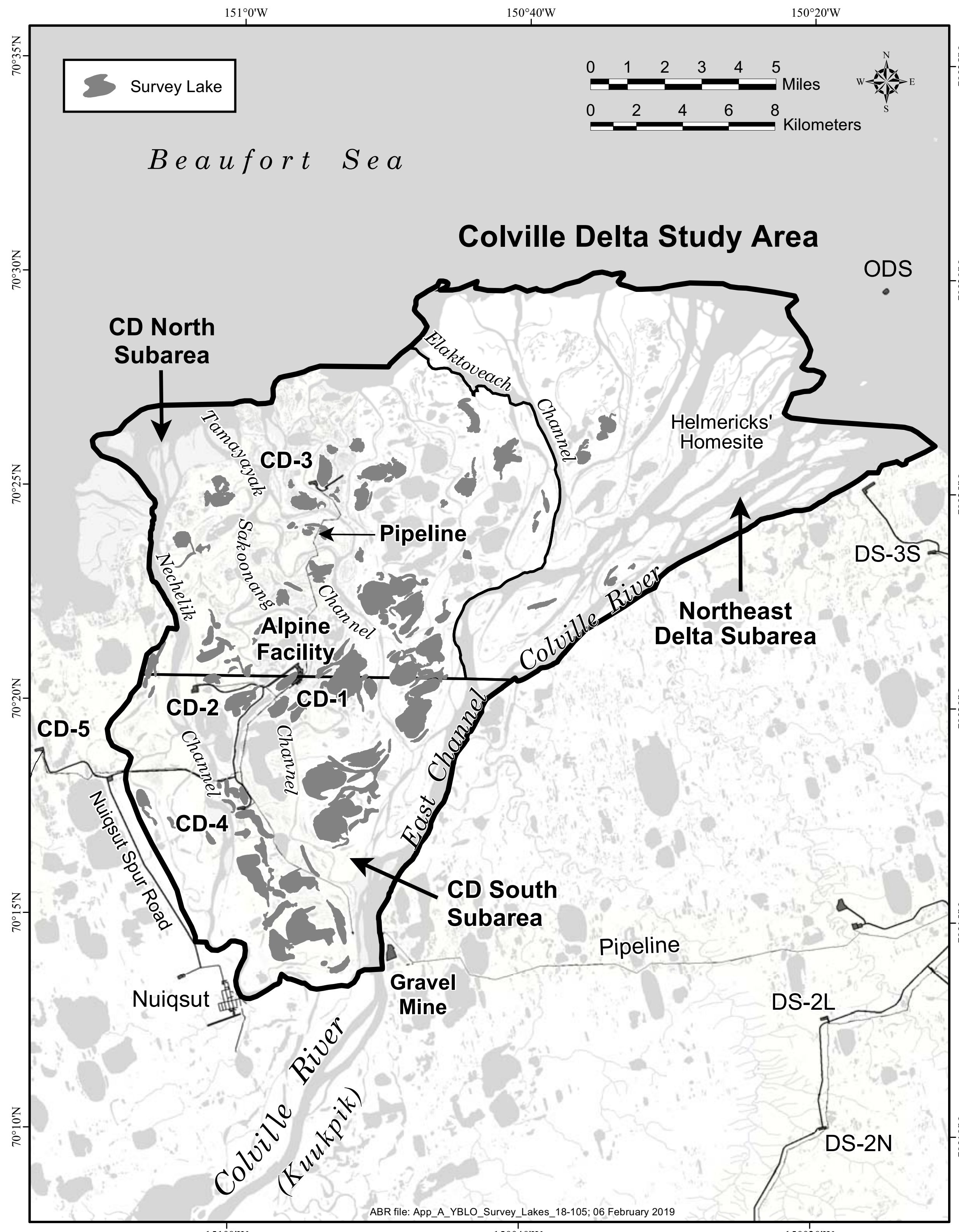
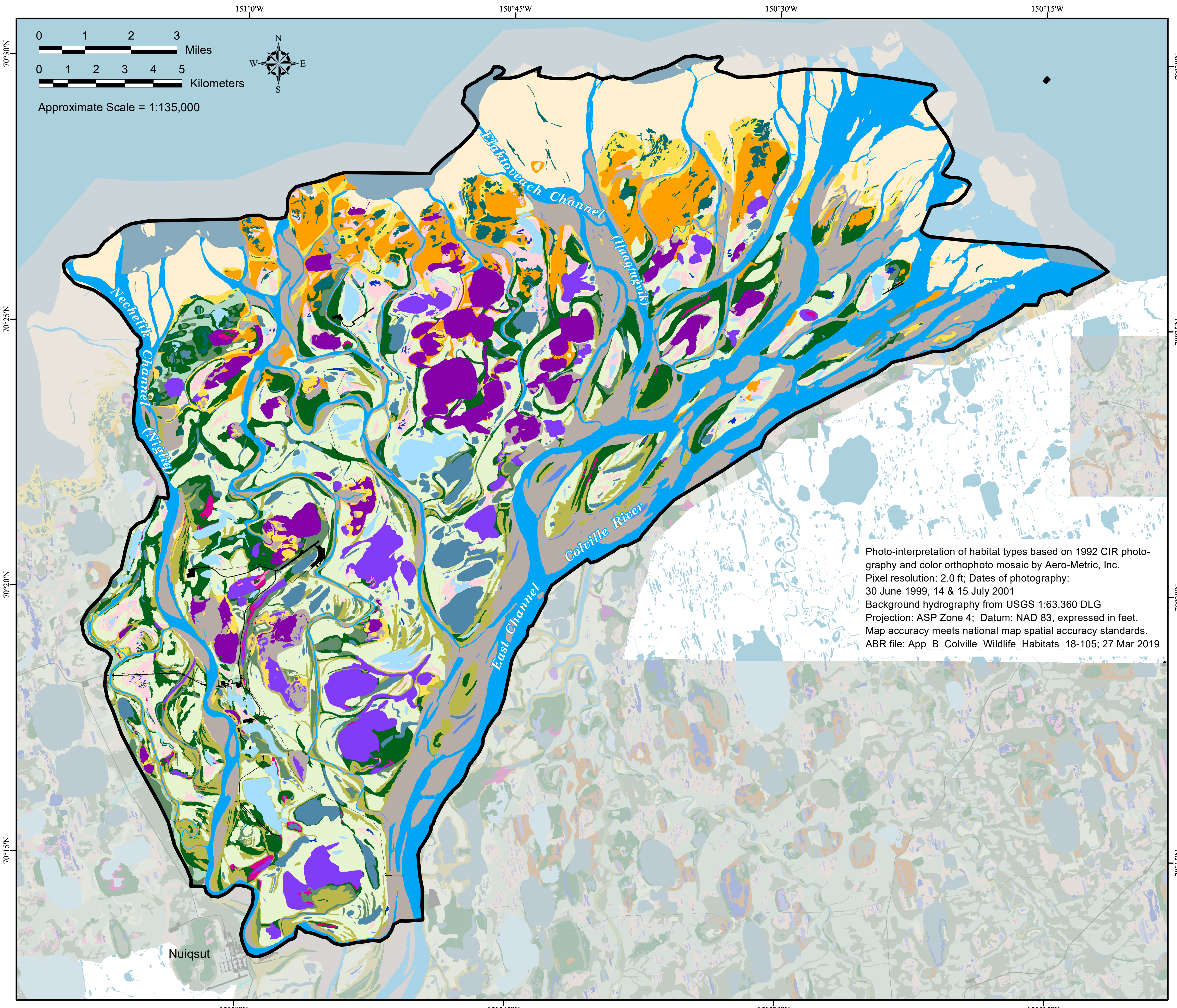


Appendix A. Lakes included in aerial surveys for Yellow-billed Loons, Colville Delta study area, Alaska, 2018.



Wildlife Habitat Type

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

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

**Appendix B.
Wildlife habitat types on the
Colville Delta study area, Alaska, 2018**

Appendix C. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2018.

SPECIES Subarea Location	Observed				Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
	Males	Females	Total	Pairs			
SPECTACLED EIDER							
CD North							
On ground	17	14	31	13	34	0.15	0.16
In flight	1	1	2	1	–	0.01	–
All birds	18	15	33	14	–	0.16	–
Northeast Delta							
On ground	2	2	4	2	4	0.03	0.03
In flight	1	1	2	1	–	0.01	–
All birds	3	3	6	3	–	0.04	–
CD South							
On ground	3	1	4	1	6	0.03	0.04
In flight	0	0	0	0	–	0.00	–
All birds	3	1	4	1	–	0.03	–
Total (subareas combined)							
On ground	22	17	39	16	44	0.08	0.09
In flight	2	2	4	2	–	0.01	–
All birds	24	19	43	18	–	0.09	–
KING EIDER							
CD North							
On ground	32	28	60	28	64	0.29	0.31
In flight	5	3	8	3	–	0.04	–
All birds	37	31	68	31	–	0.33	–
Northeast Delta							
On ground	37	36	73	36	74	0.46	0.47
In flight	18	19	37	18	–	0.23	–
All birds	55	55	110	54	–	0.70	–
CD South							
On ground	6	4	10	4	12	0.07	0.09
In flight	0	0	0	0	–	0.00	–
All birds	6	4	10	4	–	0.07	–
Total (subareas combined)							
On ground	75	68	143	68	150	0.29	0.30
In flight	23	22	45	21	–	0.09	–
All birds	98	90	188	89	–	0.37	–

[a] Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987).
[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 of loons and their nests, broods, and young during aerial surveys, Colville Delta study area, Alaska, 2018.

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	34	13[c]	–	0.16	0.06	76	1	–	6	1	–
Brood-rearing	31	6[d]	8	0.15	0.03	76	5	6	18	3	6
CD South											
Nesting	29	9	–	0.19	0.06	31	5	–	1	0	–
Brood-rearing	22	2[d]	3	0.14	0.01	24	3	3	0	0	0
Northeast Delta[e]											
Nesting	5	2	–	–	–	7	0	–	0	0	–
Brood-rearing	5	2[f]	2	–	–	9	0	0	2	1	1
Total (subareas combined)[g]											
Nesting	68	24	–	0.17	0.06	114	6	–	7	1	–
Brood-rearing	58	10	13	0.15	0.02	109	8	9	20	4	7

[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; see Figure 8.
[c] Number includes 1 nest indicated by the presence of brood on lake where no nest was found.
[d] Number includes 1 brood (assume 1 young) determined only by eggshell evidence.
[e] Densities were not calculated for the Northeast Delta subarea because only a portion of the subarea was surveyed.
[f] Number includes 2 broods (assume 1 young each), determined only by eggshell evidence.
[g] Total is the sum of all subareas but density calculations included only CD North and CD South for Colville Delta.

Appendix E. Annual density (number/km²) of Yellow-billed Loons, nests, and broods in the CD North and South subareas, Colville Delta study area, Alaska, 1993–2018.

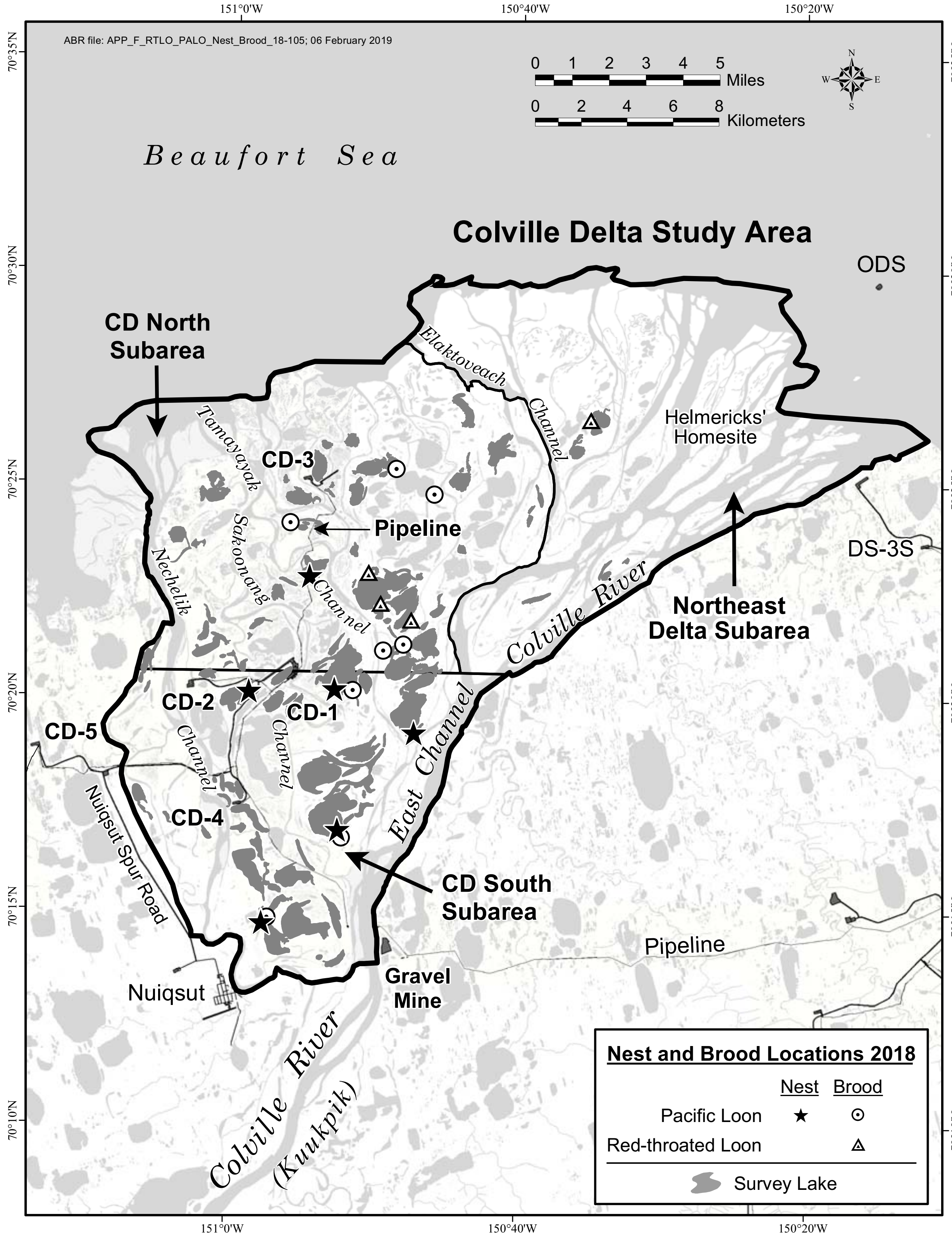
STUDY AREA Year	Nesting Survey Adults	Nests[a]	Brood-rearing Survey Adults	Broods[b]
COLVILLE DELTA[c]				
1993	0.14	0.02 (0.04)	0.08	0.02
1995	0.11	0.03 (0.05)	0.14	0.02
1996	0.12	0.03 (0.05)	0.17	0.02
1997	0.13	0.03 (0.04)	0.18	0.01
1998	0.09	0.04 (0.06)	0.14	0.03
2000	0.15	0.04 (0.04)	0.04	0.01
2001	0.15	0.05 (0.05)	0.07	0.01
2002	0.13	0.05 (0.06)	0.18	0.02
2003	0.14	0.07 (0.07)	0.13	0.04
2004	0.11	0.07 (0.07)	0.14	0.03
2005	0.15	0.08 (0.08)	0.10	0.04 (0.05)
2006	0.17	0.06 (0.07)	0.18	0.03 (0.04)
2007	0.17	0.07 (0.08)	0.14	0.05 (0.06)
2008	0.18	0.09 (0.10)	0.15	0.06 (0.07)
2009	0.17	0.07 (0.08)	0.15	0.02 (0.03)
2010	0.18	0.06 (0.09)	0.16	0.04 (0.04)
2011	0.19	0.06 (0.07)	0.12	0.03 (0.04)
2012	0.15	0.06 (0.08)	0.14	0.03 (0.04)
2013	0.18	0.03 (0.04)	0.11	0.02 (0.02)
2014	0.22	0.07 (0.09)	0.13	0.01 (0.02)
2015	0.16	0.05 (0.06)	0.15	0.02 (0.03)
2016	0.18	0.05 (0.05)[d]	0.11	0.02 (0.03)
2017	0.14	0.07 (0.08)[d]	0.14	0.02 (0.03)
2018	0.17	0.06 (0.06)[d]	0.15	0.02 (0.02)
Mean	0.15	0.05	0.13	0.03
SE	0.01	<0.01	0.01	<0.01

[a] Density of nests found on the nesting survey and, in parentheses, cumulative density including additional nests found during revisit (1996–2002), monitoring (2006–2014), and early nest surveys (2011, 2012, 2014), early camera monitoring (2013–2015), and nests inferred from the presence of broods where no nest was found during other surveys (1993–2017).

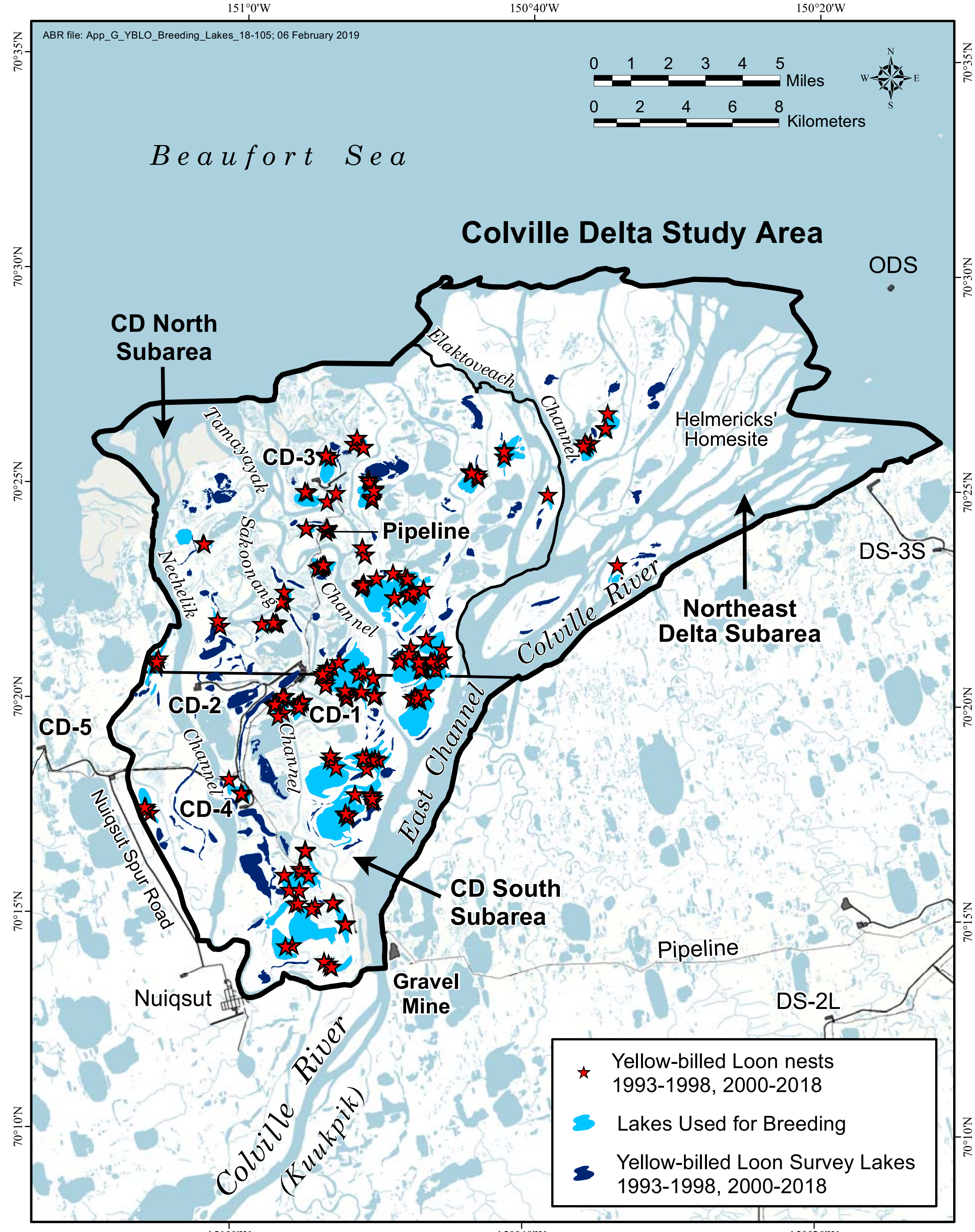
[b] Density of broods found on the brood-rearing survey and, in parentheses, cumulative density including additional broods found during monitoring surveys (2005–2014) or inferred from eggshell fragments at the nest (2008–2017).

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

[d] No additional surveys were conducted for nests but includes nests inferred from presence of broods.



Appendix F. Pacific Loon nests and broods and Red-throated Loon broods, Colville Delta study area, Alaska, 2018.



Appendix G. Lakes used by nesting and brood-rearing Yellow-billed Loons, Colville Delta study area, Alaska, 1993–1999 and 2000–2018.