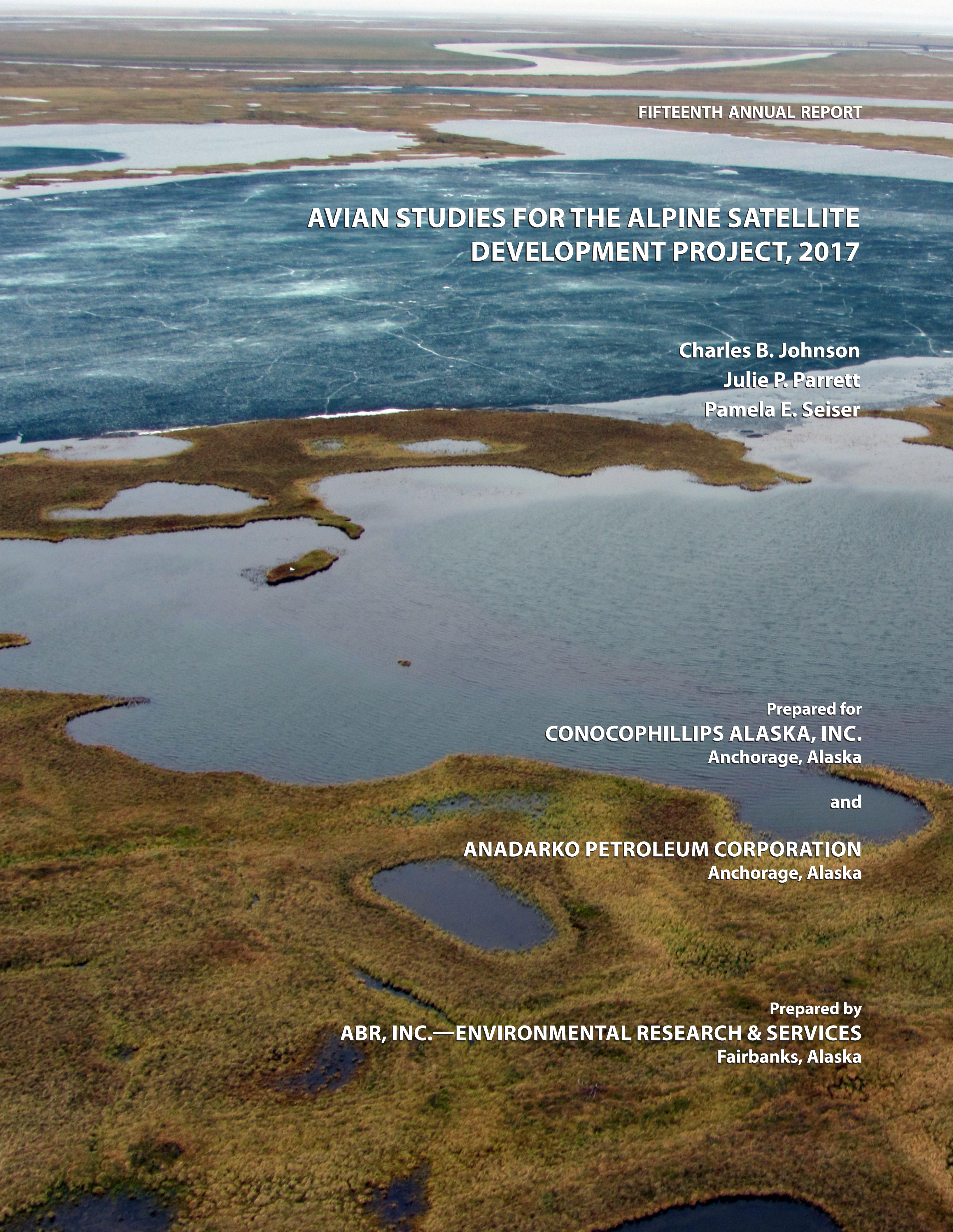

FIFTEENTH ANNUAL REPORT

AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2017

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Prepared for
CONOCOPHILLIPS ALASKA, INC.
Anchorage, Alaska

and

ANADARKO PETROLEUM CORPORATION
Anchorage, Alaska

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

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ACKNOWLEDGMENTS

Avian surveys in the Alpine Satellite Development Plan area were conducted by an experienced crew consisting of Tim Obritschkewitsch, John Shook, and the co-author Julie Parrett. Tawna Morgan 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. 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 2017, 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, 2017). Surveys in the Willow area are reported separately (Johnson et al. 2018).

CPAI began producing oil on the Colville River delta in 2000 with the development of the CD-1 and CD-2 drill sites in 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 in 2017 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 2017, surveys were conducted targeting Spectacled Eiders, a federally listed threatened species, and Yellow-billed Loons, a species with a limited breeding range. Data were collected on other eider species concurrently during the Spectacled Eider survey and on other loon species and gulls during Yellow-billed Loon surveys. Other avian studies conducted for CPAI in 2017 included research on factors affecting nesting behavior of Greater White-fronted Geese (Niġlivik) at CD-5 (Rozell and Johnson 2018) and nest searches for Spectacled Eider along ice roads and spill-response sites on the Colville River delta, CD-5, and GMT-1 areas (Seiser and Johnson, 2018). Nesting Spectacled and King eiders also were monitored in the Kuparuk Oilfield on the eastern border of the Colville River delta in 2017 (Morgan and Attanas, 2018).

Required state and federal permits were obtained for all survey activities, including a Scientific Permit (Permit No. 17-132) from the State of Alaska and a Federal Fish and Wildlife Permit [Native Threatened Species Recovery–Threatened Wildlife; Migratory Birds, Permit No. TE012155-6 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

The ASDP study area comprised separate study areas on the Colville River delta and the easternmost portion of the NE NPR-A (Johnson et al. 2015). In 2017, only the Colville Delta study area was included in surveys (Figure 1).

Landforms, vegetation, and wildlife habitats in the Colville River delta were described in the Ecological Land Survey (Jorgenson et al. 1997; see Johnson et al. [2015] for the most recently updated habitat map and descriptions), and the resulting habitat map has been updated several times to unify it with similar mapping of the surrounding Coastal Plain (Wells et al. 2017).

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

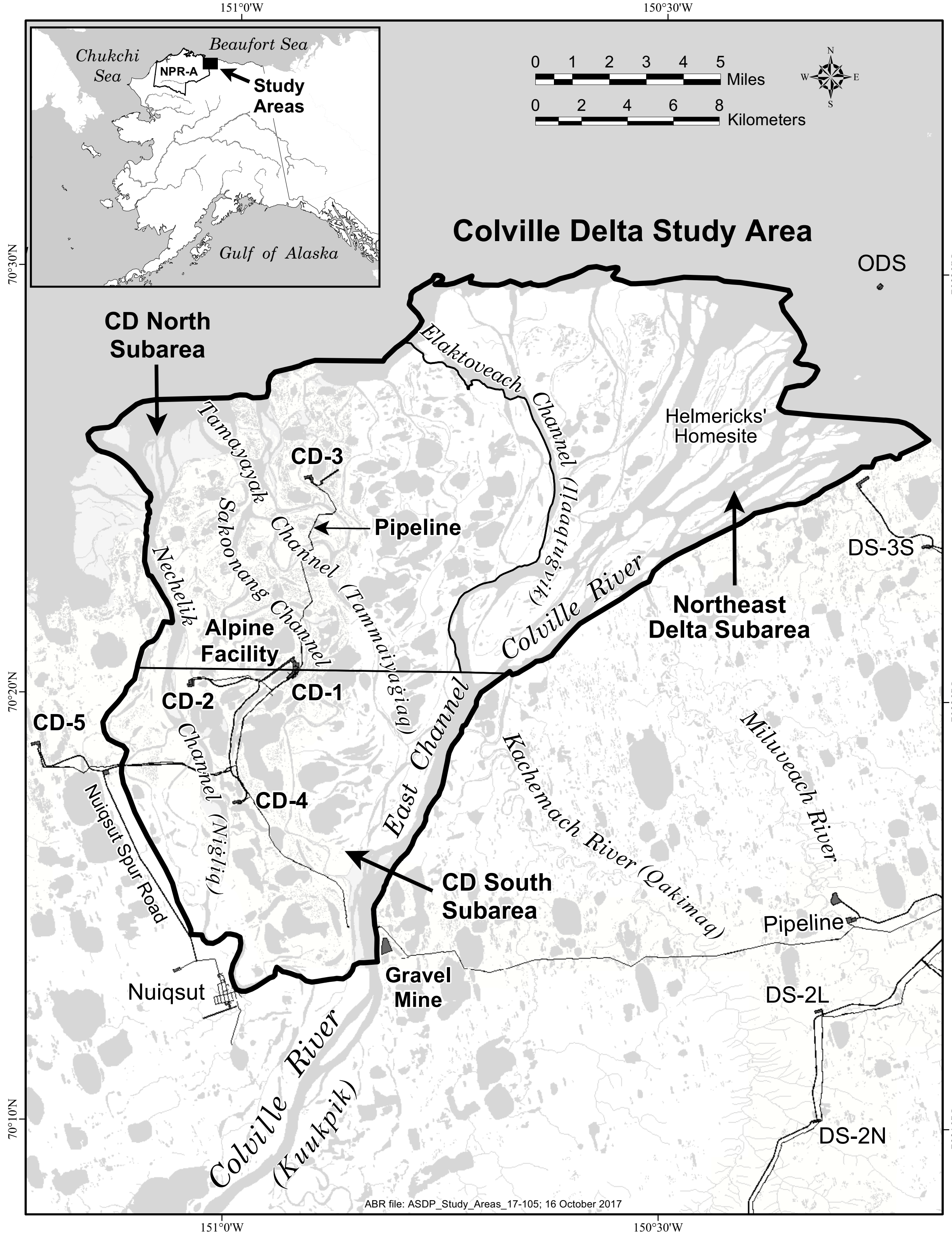

Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2017.

the short periods of time that each species is at the optimal stage for data collection. In 2017, 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. Nesting and brood-rearing gulls also were recorded during loon 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.

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). In a trial of a new data collection system during the loon brood survey, observations were collected on a tablet computer with a customized application employing a moving map based on the orthophoto mosaic imagery. Bird locations plotted on maps 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 2017, we conducted the pre-nesting survey during 16–17 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, 2017.

	Eider Survey	Yellow-billed Loon Surveys[a]	
Description	Pre-nesting	Nesting	Brood-rearing
Number of Surveys	1	1	1
Survey Dates	16–17 June	21–24 June	21–24 Aug
Aircraft[b]	C185	A-Star	A-Star
Transect Width (km)	0.4	–	–
Transect Spacing (km)	0.4	–	–
Aircraft Altitude (m)	30–35	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 30–35 m above ground level (agl) and approximately 145 km/h. Two observers each counted eiders in a 200 m wide transect on each side of the airplane (400 m total transect width). 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 habitats during the survey time period; Johnson et al. 1996), a ~1.6 km radius circle around the Helmericks' homesite, and the southernmost portion of the delta near Nuiqsut (see Appendix B in Johnson et al. [2017]). The latter 2 areas were avoided to reduce disturbance to residents.

LOON SURVEYS

In 2017, we conducted 1 aerial survey for nesting Yellow-billed Loons on 21–24 June and 1 aerial survey for brood-rearing Yellow-billed Loons on 21–24 August (Table 1). We surveyed 129 lakes for both nesting loons and brood-rearing loons (Appendix A). Both nesting and brood-rearing surveys have been conducted annually in the Colville Delta study area during 23 years from 1993 to 2017, 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 and 2017, however, we only surveyed lakes where Yellow-billed Loon adults, nests, or broods had been seen during the previous 22 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 (Malġi) and Red-throated Loons (Qaqsrauq) during all nesting and brood-rearing surveys. All locations of loons and their nests and broods were recorded on color photomosaics (1:30,000 scale). In 2005–2017, Yellow-billed Loon nest locations also were marked on high resolution color images of nest site areas (~1:1,500 scale). During the brood survey, in a trial of a new data collection technique, observations were collected on a tablet computer with a customized Android application that utilized a moving map with a minimum scale of 1:30,000.

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 (46). Population growth rates were estimated with log-linear regression on adjusted counts for years when helicopters were used for all surveys (2000–2017).

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 if a brood was present, or if the nest contained ≥20 egg fragments.

GULL SURVEYS

We recorded nests and broods of Glaucous Gulls 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 or more nests occurring in proximity on the same lake or wetland complex to be a colony. Nests and broods of gulls were recorded incidentally as they were encountered, whereas traditional nest or colony locations within the study areas were checked systematically for activity. Once a Glaucous Gull colony was identified, we used 1 central location to map all nests, even though some nests may be as far as 350 m apart. All nest and brood observations were recorded on color photomosaic field maps (1:30,000 scale) and later entered into a GIS database.

We monitored trends in nest numbers 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 was assigned to each observation of birds (on the ground, not flying), nests, or broods by plotting their coordinates on the wildlife habitat maps (see Figure 2 in Johnson et al. [2015]). 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, and 2) the percent of total observations in each habitat (habitat use). Habitat use was calculated from group locations for species when birds were in pairs, flocks, or broods. Habitat availability was calculated as the percent of each habitat in the survey area. A statistical analysis of habitat selection was used for Spectacled Eiders, King Eiders, and Yellow-billed Loons, to evaluate whether habitats 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 10.3, CPAI 2017). All 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 to CPAI in GIS-ready format with corresponding metadata.

RESULTS AND DISCUSSION

SEASONAL CONDITIONS IN THE STUDY AREA

Spring snow cover and timing of break-up in 2017 were typical despite a record warm winter for the Arctic Coastal Plain. The accumulated freezing degree-days (FDD) over the winter of 2016/2017 (6,703 FDD) was the lowest in 19 years of records at Colville Village (Helmericks' homesite), and the fourth consecutive winter that had an FDD below the long-term average (7,725 ± 153 FDD, [mean ± standard error; n = 19 years]; http://www.weather.gov/aprfc/FreezingDegree Days).

The snow depth was near normal levels in mid-May on the Colville River delta, and the arctic snow pack was near the long-term median (Natural Resource Conservation Service 2017). Snow depth on 15 May at Colville Village was equal to the 21-year mean (23 ± 2 cm) as was the first snow-free date (3 June ± 1 d). Sites south of Colville Village melted out a few days earlier. Alpine reported no snow cover on 26 May. The snow-free period at Colville Village was shorter in 2017 (136 day) than in 2016 (172 days). A shorter snow-free duration in the Arctic leaves a shorter period for birds to raise their young (Cox et al. 2017).

Melt water first reached the head of the Colville River delta (Monument 1) on 22 May in 2017. Peak water stage in 2017 occurred at Colville Village (Monument 35) on 1 June at 1.3 m above mean sea level (Michael Baker International 2017). Timing of peak discharge and peak water levels matched the date of the 21-year mean (30 May; Michael Baker International 2017). Both peak discharge in 2017 (8,155 cubic meters per second) and peak water stage (4.5 m above mean sea level) were below the long-term average.

Despite a warm winter, the period when birds arrive was colder than normal. Only 8.3 cumulative thawing degree-days (TDD) were measured at Colville Village, during period of waterfowl arrival and peak initiation of nests (15 May–15 June), well below the 21-year mean of 31 ± 4 cumulative TDD (Figure 2). Typically, during this period, the first 2 weeks in June contribute the majority of the thawing degree-days. Only 0.2 TDD were recorded in early June, a record low of for Colville Village. The mean temperature in May (–3.7 °C) was warmer than the 21-year mean (–5.1 ± 0.5 °C), yet mean temperature in June (2.4 °C) was cooler than the 21-year mean (3.7 ± 0.4 °C). Spring thaw on Colville River delta was interrupted in early June when temperatures dropped back to freezing levels.

Water on Yellow-billed Loon breeding lakes became available later in 2017 than in the previous 3 years. Ice coverage on 22 large lakes (>5 ha) was estimated visually during aerial surveys for loons on 21–24 June. Ice cover on breeding lakes was more extensive in 2017 (82%) than in the preceding 3-year period (65 ± 8%).

Water clarity in Yellow-billed Loon breeding lakes remained high in June because there was minimal flooding in 2017. Only 13% of 53 lakes surveyed during loon nest surveys on 21–23 June were obviously murky from flooding in 2017. In contrast, during the high-water year of 2015, 80% of the lakes were murky in June.

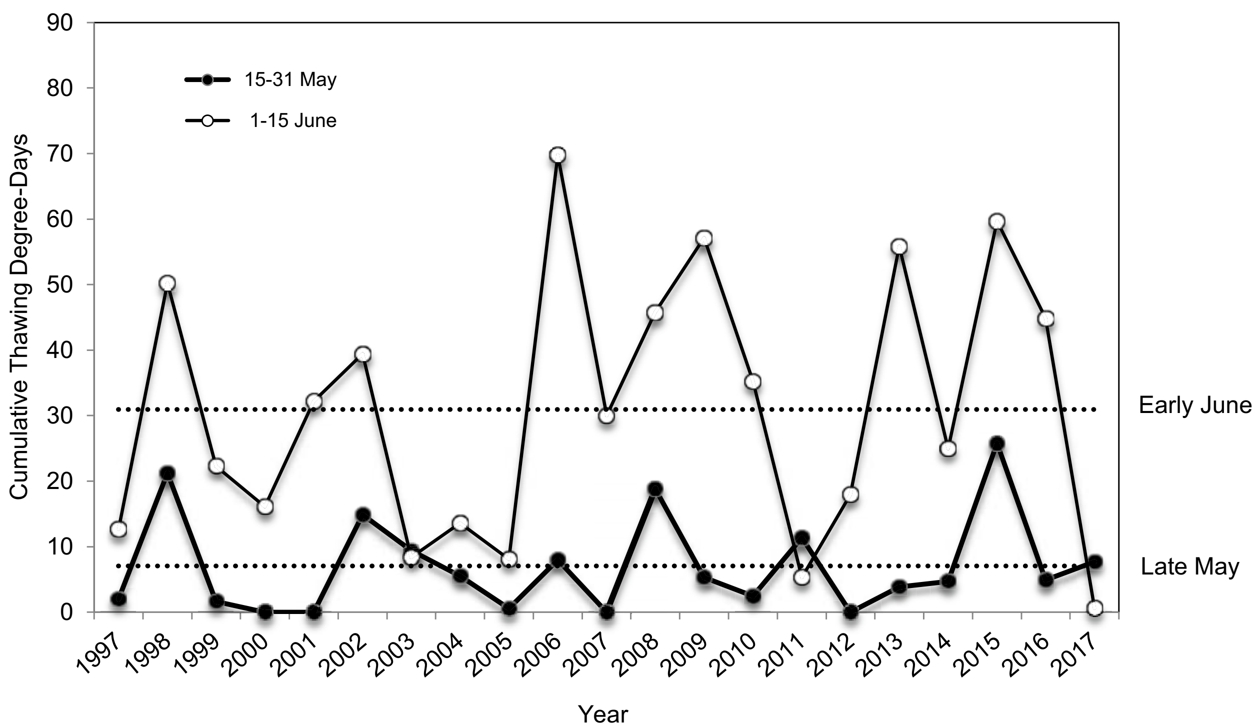

Figure 2. Cumulative number of thawing degree-days recorded 15 May–15 June at Colville Village, Colville River delta, Alaska, 1997–2017.

Timing of midge and mosquito emergence was about average. Nest-search crews who began work in the CD-5 areas on 8 June reported midge activity on 20 June. A 5-day period warm of weather (mean daily temperatures >10 °C) during 22–27 June brought on the emergence of mosquitoes. Early emergence of mosquitos is an irritant to incubating birds. In most years mosquitos emerge in late June or early July.

Generally birds did not nest as early in 2017 as they did in 2016. Goose broods typically are not observed until the end of June or early July. In 2016, broods of geese were observed commonly by nest searchers during 20–25 June. In 2017, no broods of geese were observed by nest searchers until after 25 June in the Colville, CD-5, and GMT-1 areas. The median hatch date for Greater White-fronted Geese in the CD-5 area in 2017 was 30 June (Rozell and Johnson 2018). Hatch dates at CD-5 have ranged between 24 June and 3 July (n = 4 years; Johnson et al. 2014b, 2015; Rozell and Johnson 2016, 2018).

EIDERS

Four species of eiders may occur in the ASDP area, but each varies in frequency of occurrence 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 River delta is a concentration area for breeding Spectacled Eiders relative to surrounding areas; nonetheless, Spectacled Eiders nest there annually at low densities and nest at even lower densities at inland portions of the Colville River delta (Burgess et al. 2002, 2003; Johnson et al. 2004, 2005). The King Eider, which is not protected under the Endangered Species Act, is an annual breeder that 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 River delta and immediate surroundings as these areas are east of their current Alaska breeding range centered around Utqiaġvik (Barrow). The Colville Delta study area is within the range of Common Eiders, which nest primarily on barrier islands and coastlines but are seen rarely on surveys of the Colville Delta study area.

SPECTACLED EIDER

Distribution and Abundance

We recorded 56 Spectacled Eiders (on the ground and flying) and 66 indicated total Spectacled Eiders during the pre-nesting aerial survey in 2017 on the Colville Delta study area (Figure 3, Table 2). Indicated total is a standardized method of counting ducks, which doubles the number of males in singles, pairs, and small groups (no flying birds are included) to compensate for the lower detectability of females (USFWS 1987). The number of pre-nesting Spectacled Eiders was about average on the Colville Delta study area in 2017 (Table 2). All observations of pre-nesting Spectacled Eiders in the Colville Delta study area in 2017 were of small groups of 1–3 birds. The CD North subarea contained 85% of the Spectacled Eiders observed, whereas the CD South subarea contained 9% (Appendix B). The density of pre-nesting Spectacled Eiders in the CD North subarea during 2017 (0.27 indicated birds/km²) was twice the density recorded on the much larger Colville Delta study area (0.13 indicated birds/km²). The distribution of pre-nesting Spectacled Eiders in 2017 was typical of previous years, when densities were highest north of Alpine and low south and northeast of Alpine (Figure 4). Over the 24 years that ABR and others have monitored Spectacled Eiders, their population trend has been relatively stable (Figure 5). In the CD North subarea, the annual growth rate is 2% (logarithmic growth rate of 1.02; ln(adults) = 0.023 (year) – 43.6, R^2 = 0.11, P = 0.12). The growth rate for the entire Colville Delta study area is similar at 2% (ln(adults) = 0.018 (year) – 32.27, R^2 = 0.06, P = 0.24, n = 24 years). A recent reanalysis combining 2 separate datasets from pre-nesting surveys of Spectacled Eiders, the ACP breeding pair waterfowl survey conducted in late June with North Slope eider surveys conducted in early–mid June, estimated a slight annual decline (–1%) in Spectacled Eiders for the entire ACP (logarithmic growth rate = 0.99, n = 25 years; Wilson et al., *in prep.*). However, none of the above growth rates

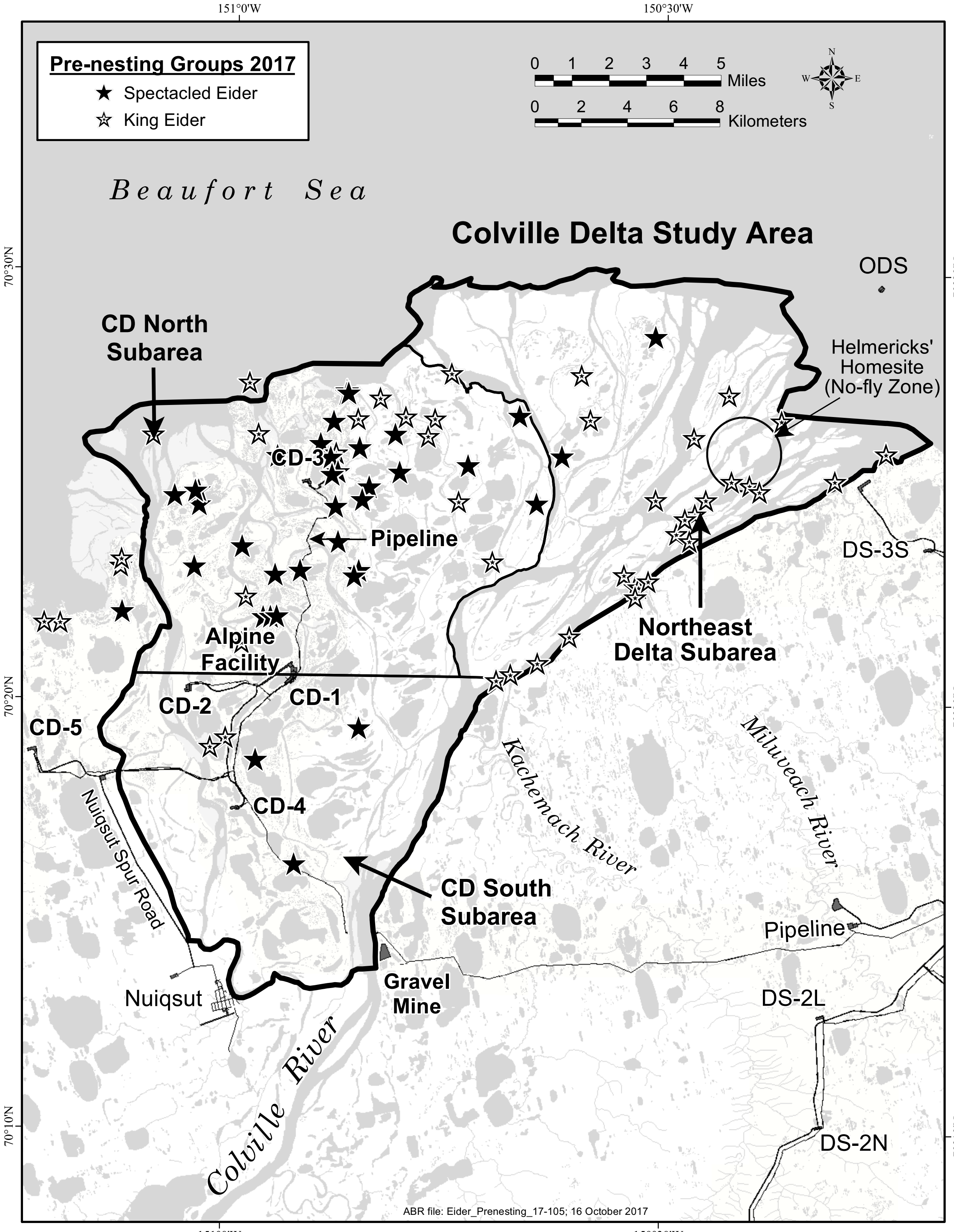

Figure 3. Spectacled Eider and King Eider locations during pre-nesting in 2017, Colville Delta study area, Alaska.

Table 2. Observed and indicated numbers and densities (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 1993–2017.

		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
Mean		56.6	53.7	0.11	0.11	55.6	45.3	0.11	0.09
SE		5.4	5.2	0.01	0.01	5.8	6.3	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). Mean and standard error calculated for total observed or indicated when survey area = 501.4 km², n = 20 years.

[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of surveyed area. Means calculated for all years, n = 24 years.

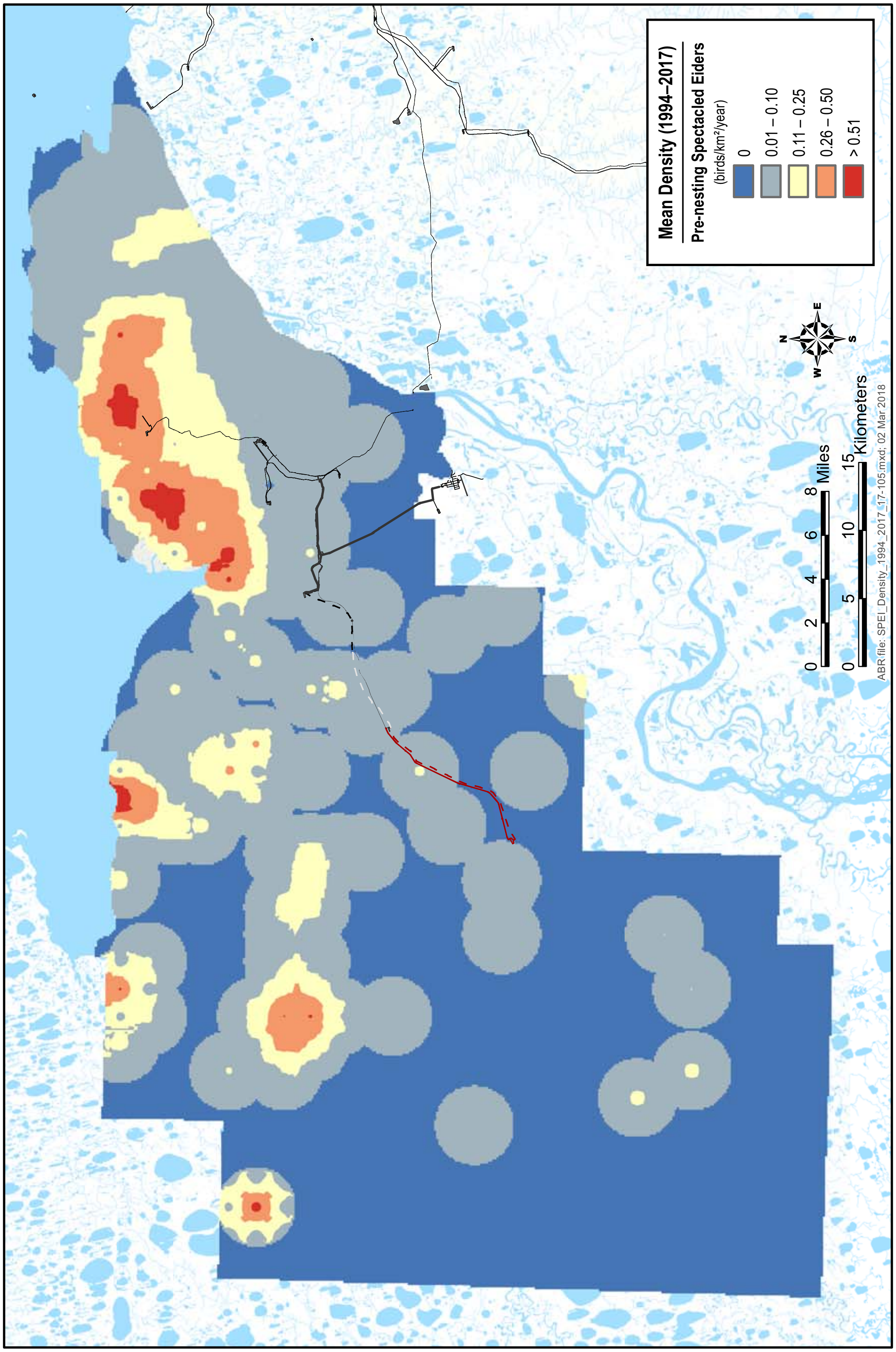

Figure 4. Spectacled Eider density contours in the Colville Delta and NE NPR–A study areas, Alaska, 1994–2017.

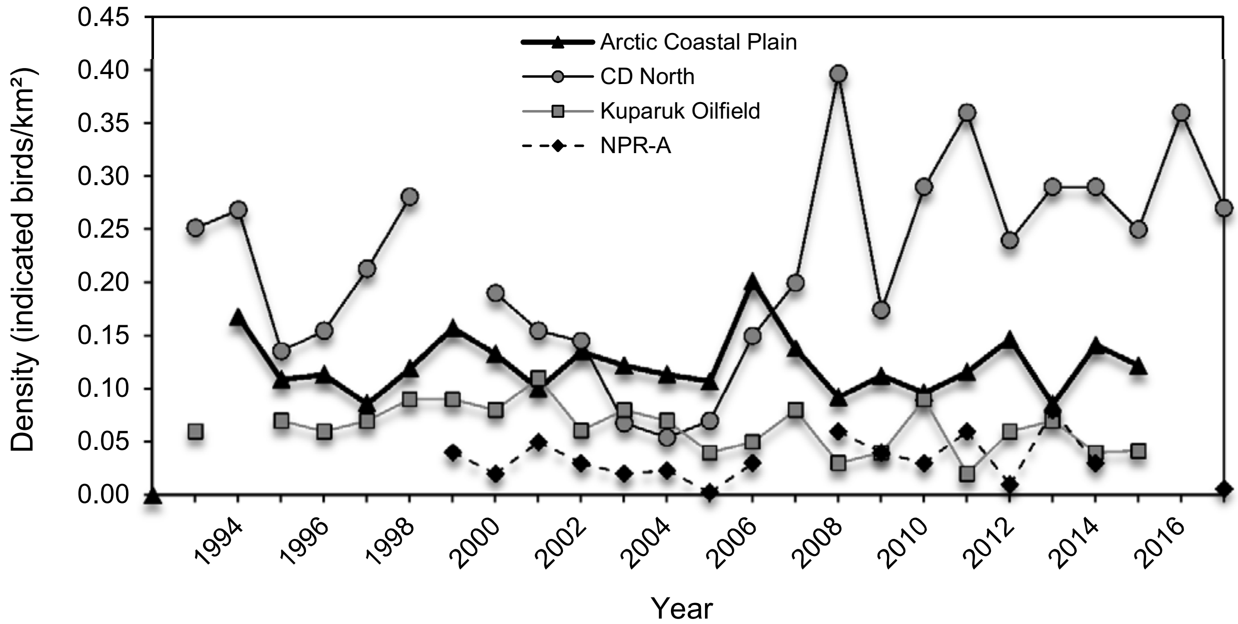

Figure 5. Annual densities of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2017.

differs significantly from 0% (a logarithmic growth rate of 1.0 equals 0% annual change, or equilibrium).

Habitat Use

Pre-nesting Spectacled Eiders used 18 of 24 available habitats during 24 years of aerial surveys on the Colville Delta study area (Table 3). Seven habitats were preferred (i.e., use significantly greater than availability, $P \leq 0.05$) including 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 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 of its dispro-portionate 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 during the nesting season (Johnson et al. 2008). Patterned Wet Meadow was second highest in use (20% of Spectacled Eider groups) during pre-nesting but was not preferred because its use and availability were essentially equal. Seven habitats were avoided (use significantly less than availability), including Open Nearshore Water; Tapped Lake with Low-water Connections; Tidal Flat Barrens; River or Stream; Moist Sedge-Shrub Meadow; Tall, Low, or Dwarf Shrub; and Barrens. All other habitats were used in proportion to their availability.

OTHER EIDERS

Distribution and Abundance

We recorded 99 observed (on the ground and flying) and 91 indicated total King Eiders on the 2017 pre-nesting aerial survey of the Colville Delta study area (Figure 3, Table 2). The number of King Eiders recorded in 2017 was the second highest recorded in 24 years (Figure 6). King Eiders out-numbered Spectacled Eiders (66 indicated birds) in 2017, which has occurred in 10 of 24 years that ABR has conducted this survey. King Eiders on the ACP have been increasing at a significant rate of 2% annually since 1986 (Wilson et al., *in prep.*). Although King Eiders on the Colville Delta study area have had an equivalent

Table 3. Habitat selection by Spectacled Eider and King Eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998 and 2000–2017.

SPECIES Habitat	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	89	41	7.3	1.3	prefer	
Tapped Lake with Low-water Connection	38	16	2.9	4.5	avoid	
Tapped Lake with High-water Connection	22	13	2.3	3.7	ns	
Salt Marsh	67	38	6.8	3.2	prefer	
Tidal Flat Barrens	2	1	0.2	7.0	avoid	
Salt-killed Tundra	93	52	9.3	5.1	prefer	
Deep Open Water without Islands	37	23	4.1	3.4	ns	
Deep Open Water with Islands or Polygonized	43	24	4.3	2.1	prefer	
Shallow Open Water without Islands	6	4	0.7	0.4	ns	low
Shallow Open Water with Islands or Polygonized	9	7	1.2	0.1	prefer	low
River or Stream	34	16	2.9	14.4	avoid	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	279	159	28.3	2.7	prefer	
Grass Marsh	10	6	1.1	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	90	46	8.2	8.2	ns	
Patterned Wet Meadow	200	111	19.8	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	4.9	avoid	
Barrens	6	2	0.4	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	1,028	561	100	100		
KING EIDER						
Open Nearshore Water	29	9	2.4	1.6	ns	
Brackish Water	63	32	8.6	1.3	prefer	low
Tapped Lake with Low-water Connection	35	16	4.3	4.5	ns	
Tapped Lake with High-water Connection	14	6	1.6	3.7	avoid	
Salt Marsh	53	21	5.7	3.2	prefer	
Tidal Flat Barrens	4	2	0.5	7.0	avoid	
Salt-killed Tundra	58	31	8.4	5.1	prefer	
Deep Open Water without Islands	22	10	2.7	3.4	ns	
Deep Open Water with Islands or Polygonized	19	9	2.4	2.1	ns	
Shallow Open Water without Islands	7	4	1.1	0.4	ns	low
Shallow Open Water with Islands or Polygonized	5	3	0.8	0.1	prefer	low
River or Stream	480	143	38.5	14.4	prefer	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	53	30	8.1	2.7	prefer	
Grass Marsh	8	3	0.8	0.2	ns	low

Table 3. Continued.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
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	17	11	3.0	8.2	avoid	
Patterned Wet Meadow	55	32	8.6	19.2	avoid	
Moist Sedge-Shrub Meadow	2	1	0.3	2.3	avoid	
Moist Tussock Tundra	1	1	0.3	0.6	ns	low
Tall, Low, or Dwarf Shrub	2	1	0.3	4.9	avoid	
Barrens	15	6	1.6	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	942	371	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 < 5.

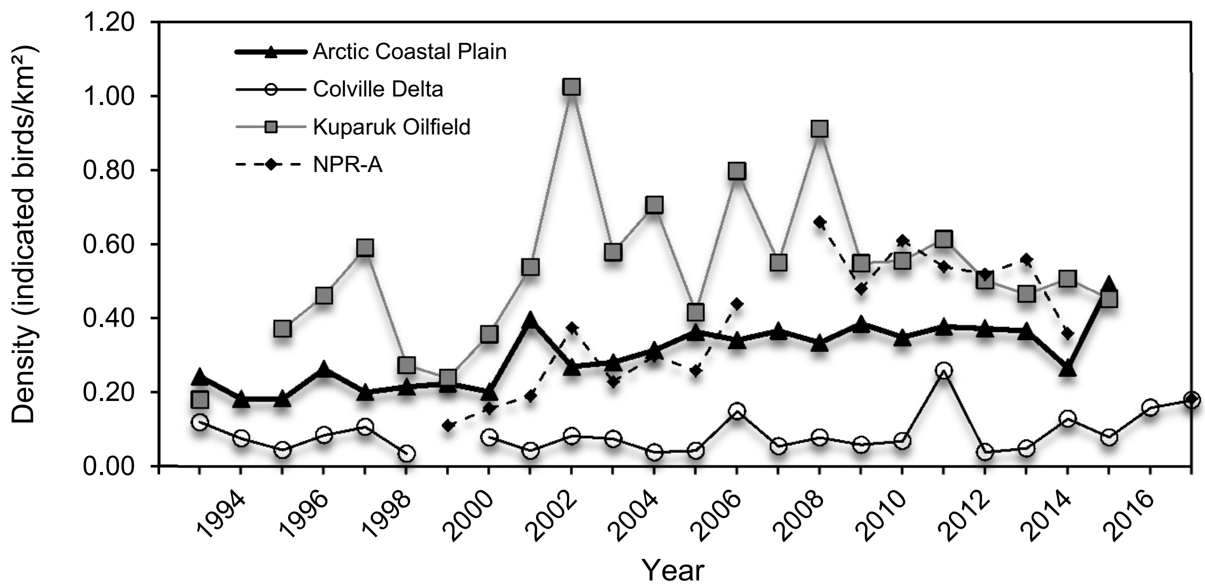

Figure 6. Annual densities of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2017.

annual growth rate since surveys began in 1993, it does not differ significantly from equilibrium (ln(adults) = 0.02 (year) – 36.36, R^2 = 0.08, P = 0.19, n = 24 years). King Eiders were observed in all 3 of the subareas, but they achieved their highest density (0.41 indicated birds/km²) in the Northeast Delta subarea in 2017 (Figure 7, Appendix B). 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. Relatively few King Eiders nest on the Colville River delta, suggesting that most of those observed during pre-nesting are in transit to other breeding areas (Johnson et al. 2017).

No Steller's or Common eiders were seen in the Colville Delta study area in 2017. Steller's Eiders rarely are seen in the vicinity of the Colville River delta (Johnson et al. 2014c). 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 on the Colville River delta. Pre-nesting King Eiders used 20 of 24 available habitats in the Colville Delta study area over 24 years of aerial surveys (Table 3). Pre-nesting King Eiders preferred 5 of the same habitats 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 4 habitats, pre-nesting King Eiders preferred River or Stream. The high use of River or Stream, which includes the river channels primarily in the Northeast Delta subarea (Figures 3 and 7), 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. 2003; Johnson et al. 2003, 2008; Seiser and Johnson 2010, 2011a, 2011b, 2012, 2014 a, 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-six Yellow-billed Loon nests were found during the Yellow-billed Loon nest survey in 2017 (Figure 8, Table 4). Two additional nests were inferred from the presence of broods during August on lakes where nests were not found during the nest survey. Of the 28 nests documented in 2017, 12 nests were located in the CD North subarea, 14 nests in the CD South subarea, and 2 nests in the Northeast Delta subarea (Appendix C). The total number of nests found on the nesting survey was above the long-term mean (20.7 ± 1.4 nests, n = 23 years; for densities see Appendix D) and among the highest counts since 1993. The count of 56 adults on the nesting survey, however, was nearly identical to the long-term mean (57.2 ± 2.3 adults). The density of adults and nests was lower in the CD North subarea (0.12 birds/km², 0.06 nests/km²) than in the CD South subarea (0.17 birds/km², and 0.09 nests/km; Appendix C). Incidental records of Pacific and Red-throated Loon nests and broods are presented in Appendices C and E.

All but 1 of the 26 Yellow-billed Loon nests recorded in the Colville Delta study area in 2017 were on territories where Yellow-billed Loons have nested previously (Johnson et al. 2009, 2010, 2011, 2012, 2013, 2014b, 2015, 2016). Fourteen of the 26 Yellow-billed Loon nests were located at the same nest sites used in previous years, 9 were very close (≤50 m) to nest sites used in previous years, and 2 were at new nest sites. Of the nests at new sites, 1 was on lake previously used for nesting, whereas the other was on a new lake adjacent to a lake previously used for nesting. The addition of the lake where we had not documented breeding in previous years increases the number of known breeding territories from 45 to 46. The nest was on an 8-ha lake classified as Deep Open Water

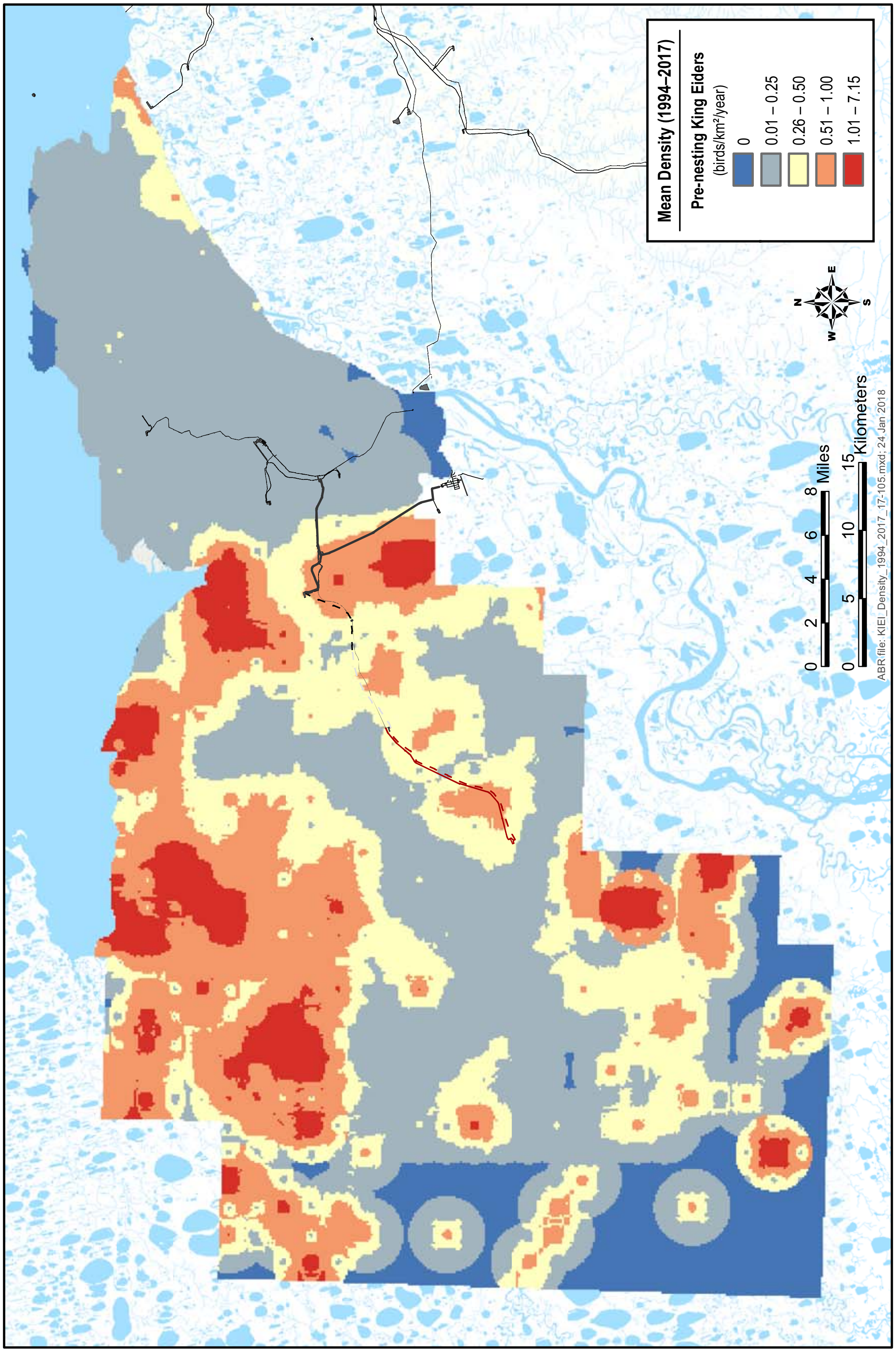

Figure 7. King Eider density contours in the Colville Delta and NE NPR–A study areas, Alaska, 1994–2017.

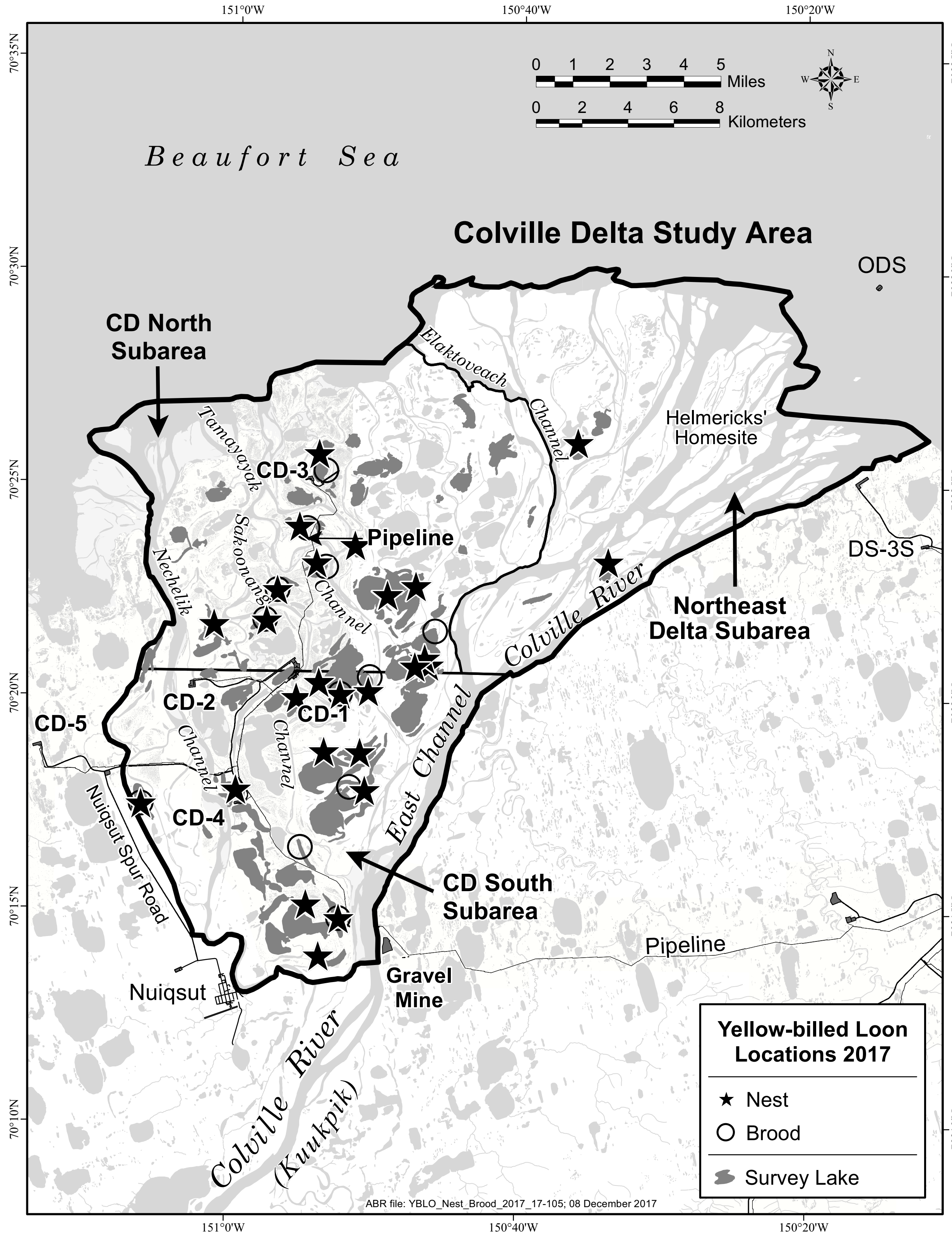

Figure 8. Yellow-billed Loon nest and brood locations, Colville Delta study area, Alaska, 2017.

Table 4. Number of Yellow-billed Loons and nests, and territory occupancy by nests, Colville Delta study area[a], Alaska, 1993–2017.

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]	41	26.8
1995	42	12	21[e,f]	39	30.8
1996	45	11	20[e,f,g]	35	31.4
1997	48	10	18[e,g]	38	26.3
1998	35	17	24[e,f,g]	40	42.5
2000	53	16	16	37	43.2
2001	54	19	20[e]	37	51.4
2002	46	17	22[e,f,g]	41	41.5
2003	53	25	27[f]	41	61.0
2004	41	24	26[f]	41	58.5
2005	56	30	31[f]	40	75.0
2006	63	24	28[g]	41	58.5
2007	66	27	31[g]	41	65.9
2008	69	33	38[g]	42	78.6
2009	67	27	30[g]	43	62.8
2010	69	23	35[g]	42	54.8
2011	70	23	29[g]	42	54.8
2012	57	25	32[g]	43	58.1
2013	67	12	17[f,g,h]	43	27.9
2014	78	26	32[g,h]	44	59.1
2015	63	19	25[f,h]	45	42.2
2016	68	18	18[i]	46	39.1
2017	56	26	28[f]	46	56.5
Mean	57.2	20.7	25.4		49.9
SE	2.3	1.4	1.3		3.1

[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 survey 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.

without Islands. One or 2 loons have been seen in this lake since 2014, which was the first year we included this lake in aerial loon surveys.

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). In years prior to 2016, additional surveys for nests occurred during ground, revisit, and/or monitoring surveys, resulting in 1–12 additional nests each year. Because we only conducted single nest surveys during 2015–2017, nest counts from the nest survey, as opposed to all surveys, provide the best metric for comparing nesting effort in 2017 with previous years. These nest counts, however, are not directly comparable among years because survey coverage varied annually from 35 to 46 identified territories. To adjust for variable coverage, we used territory occupancy by nests, calculated as the number of nests found on the nesting survey divided by the number of territories surveyed. Of the territories surveyed in 2017, 56% were occupied by nests during the nesting survey, which is well above the long-term mean (49.9 ± 3.1%, n = 23 years; Table 4).

During the brood-rearing survey on 21–24 August, 52 Yellow-billed Loons, 8 broods, and 10 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 12 broods, 6 were found in the CD North subarea, and 6 were found in the CD South subarea (Appendix C). No broods were seen in the Northeast Delta subarea. The counts of 52 adults and 12 broods on the brood-rearing survey were both near the long-term means (50.2 ± 2.4 adults; 12.5 ± 1.2 broods, n = 23 years; Table 5; for densities, see Appendix D). Similar to the distribution of adults during the nest survey, the density of adults during the brood-rearing survey was lower in the CD North subarea (0.11 birds/km²) than in the CD South subarea (0.19 birds/km²). The density of broods was similar in both these areas, however (0.03 broods/km² and 0.04 broods/km², respectively; Appendix C).

During the 23 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. Like nest counts, these raw counts of broods are not directly comparable because survey coverage varied annually from 34 to 46 territories (Table 5). We calculated territory occupancy by broods (the number of broods seen on all surveys divided by the number of territories surveyed) to standardize for survey effort. Brood occupancy has been well below the long-term mean (30.4 ± 2.9%, n = 23 years) since 2013. Although brood occupancy has increased annually over the last 5 years, in 2017 (26%) it remained below the long-term mean. The low productivity observed in 2015–2017 does not appear to be related to the reduction in nest survey effort during those years. Restricting brood occupancy estimates to the subset of broods seen at nests found during the single nesting survey standardizes survey effort among years. After standardizing for survey effort, brood occupancy in 2017 (13%) was still well below average (20.3 ± 2.3%, n = 23 years).

Yellow-billed Loons on the Colville Delta study area have been characterized previously by stable or slightly increasing population growth, but annual growth appears be slowing. From 2000–2017, the growth rate of adults (adjusted by the number of territories surveyed; Figure 9) was slightly positive but not significantly different from equilibrium (ln(adults) = 0.0081(year) – 11.981, R^2 = 0.084, P = 0.240, n = 18). This trend contrasts with several consecutive years of significantly positive growth rates on the Colville Delta. The population trend estimated from the ACP breeding pair waterfowl survey, however, still indicates population growth (logarithmic growth rate = 1.02, 90% CI = 1.007–1.026, n = 31 years; Wilson et al., *in prep.*). Measures of long-term productivity have been more variable on the Colville Delta study area; in line with the relative stability of the adult population, neither nests nor young (adjusted for the number of territories surveyed) have shown significant change over 18 years.

Although trends are not detectable in long-term data, growth indices over the last 10 years show declines in numbers of adults, nests, and young. Since 2008, the growth rate of adults

Table 5. Number of Yellow-billed Loons and broods, and territory occupancy by broods, Colville Delta study area, Alaska, 1993–2017.

	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]	42	32
1996	62	6	6	10[e]	36	28
1997	66	8	5	5	38	13
1998	55	15	12	12	41	30
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	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]	41	56
2008	57	29	22	27[f,g]	42	64
2009	56	12	11	13[g]	43	30
2010	59	19	13	15[f,g,h]	42	36
2011	45	20	12	15[f,g,h]	42	36
2012	52	19	14	17[g,h]	43	40
2013	43	9	7	7	43	16
2014	48	4	4	8[f,g]	44	18
2015	58	10	9	10[h]	45	22
2016	43	6	6	11[g]	46	24
2017	52	10	8	12[g]	46	26
Mean	50.2	12.5	10.1	12.5		30.4
SE	2.4	1.4	1.0	1.2		2.9

[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.

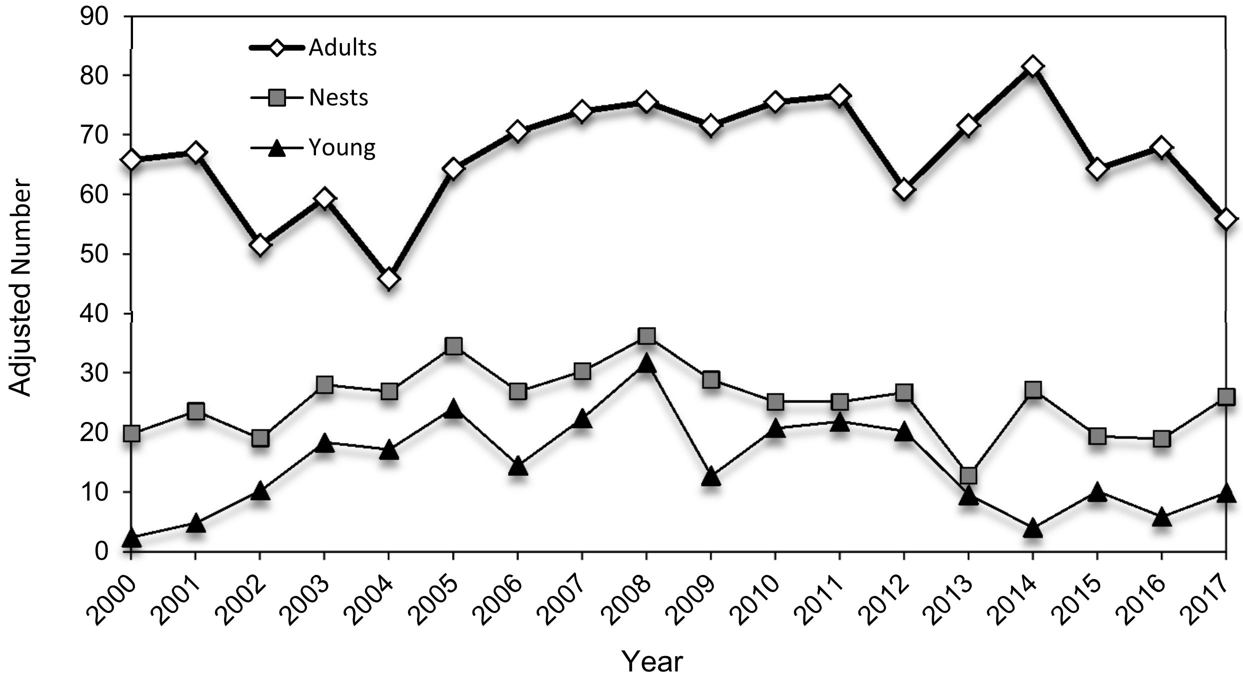

Figure 9. Annual numbers of Yellow-billed Loon adults and nests during the nesting survey and young during the brood-rearing survey, Colville Delta study area, Alaska, 2000–2017.

was negative but not significantly different from 0% (ln(adults) = –0.021(year) + 47.17, R^2 = 0.310, P = 0.094). Productivity, particularly in the number of young, also shows signs of decline. The number of nests has declined by 4.9% annually (ln(nests) = –0.049(year) +101.73, R^2 = 0.261, P = 0.13). The number of young detected over the last 10 years continues to show a negative trend, decreasing by 15.2% annually (ln(young) = –0.152(year) + 307.38, R^2 = 0.529, P = 0.017). Reduced nest and/or brood survival appear to be the primary causes of declines in production of young. Despite signs that population growth is slowing, 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 = 82.6 ± 1.9%, range = 71–100%, n = 18 years); however, not all adults that are present during June attempt to breed. Territory occupancy by nests is much lower and more variable (mean = 54.9 ± 3.1%, range = 28–79%, n = 18 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 during the past 5 years (see Nest Fate, below).

HABITAT USE

Yellow-billed Loons nested in 12 of 24 available habitats during nesting surveys conducted in the Colville Delta study area over 23 years (Table 6). Seven habitats, supporting 466 of 519 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 habitats, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. Nests on shorelines of lakes were assigned to the terrestrial habitat on the lakeshore, whereas nests on islands or in patches of emergent vegetation <5 ha in size were assigned to the aquatic habitat of the lake. Patterned Wet Meadow was the habitat used most frequently for nesting (35% of all nests), and it also was the most abundant habitat on the delta (24% of the loon survey area; Table 6). Nesting Yellow-billed Loons

Table 6. Habitat selection by nesting (1993–1998 and 2000–2017) and brood-rearing (1995–1998 and 2000–2017) Yellow-billed Loons, Colville Delta study area[a], Alaska.

SEASON Habitat	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	5.4	avoid	
Tapped Lake with High-water Connection	41	7.9	5.3	prefer	
Salt Marsh	1	0.2	2.6	avoid	
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	53	10.2	4.8	prefer	
Deep Open Water with Islands or Polygonized Margins	135	26.0	2.5	prefer	
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized	2	0.4	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	5	1.0	<0.1	prefer	low
Deep Polygon Complex	22	4.2	2.9	ns	
Grass Marsh	9	1.7	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	60	11.6	8.8	prefer	
Patterned Wet Meadow	182	35.1	24.4	prefer	
Moist Sedge-Shrub Meadow	6	1.2	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	avoid	low
Tall, Low, or Dwarf Shrub	3	0.6	6.5	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.1	ns	low
Total	519	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	2.0	avoid	low
Brackish Water	1	0.4	1.1	ns	low
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	51	22.0	5.3	prefer	
Salt Marsh	0	0	2.6	avoid	
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	105	45.3	4.8	prefer	
Deep Open Water with Islands or Polygonized Margins	74	31.9	2.5	prefer	
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized	0	0	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	0	0	<0.1	ns	low

Table 6. Continued.

SEASON Habitat	No. of Nests or Broods	Use (%)[b]	Availability (%)	Monte Carlo Results[c]	Sample Size[d]
BROOD-REARING (continued)					
Deep Polygon Complex	0	0	2.9	avoid	
Grass Marsh	1	0.4	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	8.8	avoid	
Patterned Wet Meadow	0	0	24.4	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	232	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.

avoided nesting in 11 habitats, which together occupied 50% of the Colville Delta study area.

Yellow-billed Loons were highly selective in their use of brood-rearing habitat. All Yellow-billed Loon broods (232 broods over 23 years) were found in 4 lake habitats, 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 habitats occupied only 13% of the delta. Brackish Water was the only shallow-water habitat used during brood-rearing and was used by 1 brood. The selection analyses for nesting and brood-rearing highlight the importance of large, deep waterbodies to breeding Yellow-billed Loons.

NEST FATE

During the brood-rearing survey, 8 of 28 Yellow-billed Loon nests had a brood. Because the absence of a brood does not always indicate nest failure, 18 of the remaining 20 nests without broods were visited on the ground to determine nest fate. Four of the 18 nests contained >20 egg fragments (range 22–75 fragments), indicating that at least 1 egg hatched. The remaining 14 nests lacked evidence of hatch; 1 contained a single egg fragment, and 13 nests contained no egg remains. Overall, we determined that in addition to the 8 nests that had broods during the brood-rearing survey, 4 nests had broods that did not survive, resulting in a total of 12 successful nests.

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 2015–2017, 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 2017 for an apparent nesting success of 41%. This estimate was well below the 13-year mean (52.5 ± 4.0%) and was among the 3 lowest estimates of nest success observed since 2005.

GULLS

DISTRIBUTION AND ABUNDANCE

We recorded 78 Glaucous Gull nests during the aerial survey for nesting loons; 40 of those nests were in the CD North subarea, 35 nests in the CD South subarea, and 3 nests in the Northeast Delta subarea (Figure 10). The number of Glaucous Gull nests on the Colville Delta study area during 2017 was 12% lower than the record high count of 89 nests in 2016. There are 7 known Glaucous Gull colonies in the Colville Delta study area. The largest colony in 2017 comprised 23 nests and was located ~6 km northeast of the CD-4 drill site. Other colonies in the Colville Delta study area include 2 with 7 nests each in the northeastern part of the CD North subarea, 1 with 6 nests north of the CD-3 drill site, 1 with 3 nests north of the CD-2 drill site, and 1 with 4 nests south of the CD-4 drill site (Figure 10).

Over the last 16 years, the number of Glaucous Gull nests has increased based on numbers 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 annual growth rate for nests on the index lakes was 5% (ln(nests) = 0.053 (year) – 101.92, R^2 = 0.82, P = <0.001). In 2017, 64 nests occupied 19 of the 50 index lakes (16-year range: 28 to 70 nests). Fewer index lakes were occupied with active Glaucous Gull nests in 2017 compared to last 9 years (Table 7).

In 2017, 18 groups of Glaucous Gulls with young were recorded on 14 waterbodies in the Colville Delta study area during the survey for brood-rearing loons (Figure 10). Broods totaled 27 adults and 28 young. Counts of young Glaucous Gulls were low compared with other years (2005 to 2017, range: 26 to 56 young). The majority of the young were found outside of colonies. Six broods were present at 5 of the 7 colonies. Young gulls had varying degrees of flight capability at the time of the loon survey, and some may have moved in or out of the loon survey area before the brood survey was conducted.

HABITAT USE

Glaucous Gull nests and colonies were found in 9 different habitats in the Colville Delta study area (Table 8). The 4 most commonly used habitats also contained colonies: Deep Open Water with Islands or Polygonized Margins (33% of nests), Patterned Wet Meadow (29%), Tapped Lake with High-water Connection (18%), and Grass Marsh (5%). The largest Glaucous Gull colony (23 nests) was located primarily on a large island classified as Patterned Wet Meadow. The remaining nests were found on islands or complex shorelines in 5 other habitats.

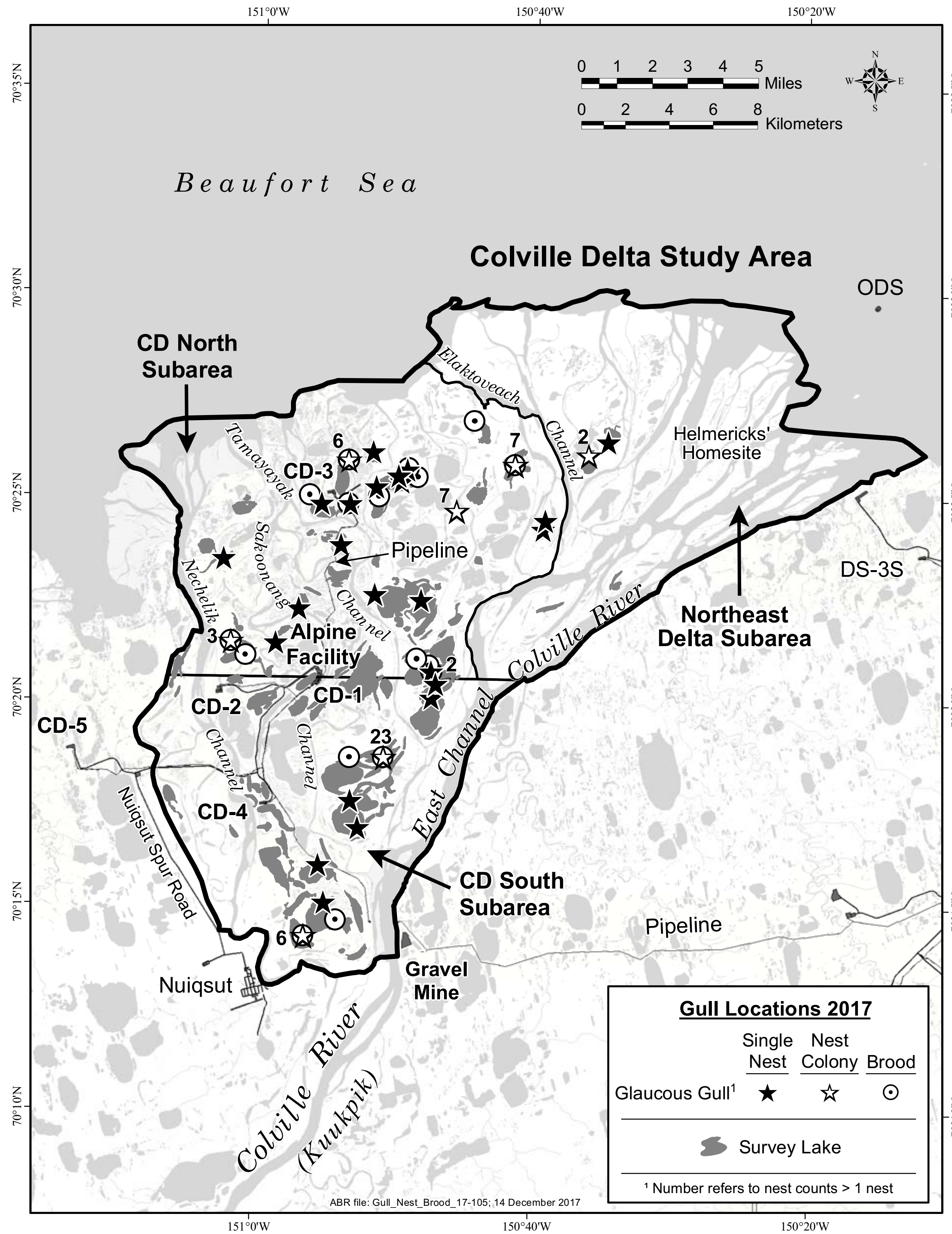

Figure 10. Glaucous Gull and Sabine's Gull nest and brood locations, Colville Delta study area, Alaska, 2017.

Table 7. Number of Glaucous Gull nests recorded during aerial surveys for nesting loons on 50 index lakes, Colville Delta study area, Alaska, 2002–2017.

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
Mean	19.8	26.9	1.8	48.4	21.2
SE	1.5	1.9	0.3	3.3	1.1

[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 the presence of Glaucous Gull nests, 2 occur in the Northeast Delta subarea, 20 in the CD South subarea, and 28 in the CD North subarea.

Table 8. Habitat use by nesting Glaucous Gulls, Colville Delta study area, Alaska, 2017.

Habitat	Nests	Use (%)
Tapped Lake with High-water Connection	14	17.9
Deep Open Water without Islands	1	1.3
Deep Open Water with Islands or Polygonized Margins	26	33.3
Deep Polygon Complex	3	3.9
Grass Marsh	4	5.1
Nonpatterned Wet Meadow	3	3.8
Patterned Wet Meadow	23	29.5
Moist Sedge-Shrub Meadow	3	3.9
Barrens	1	1.3
Total	78	100

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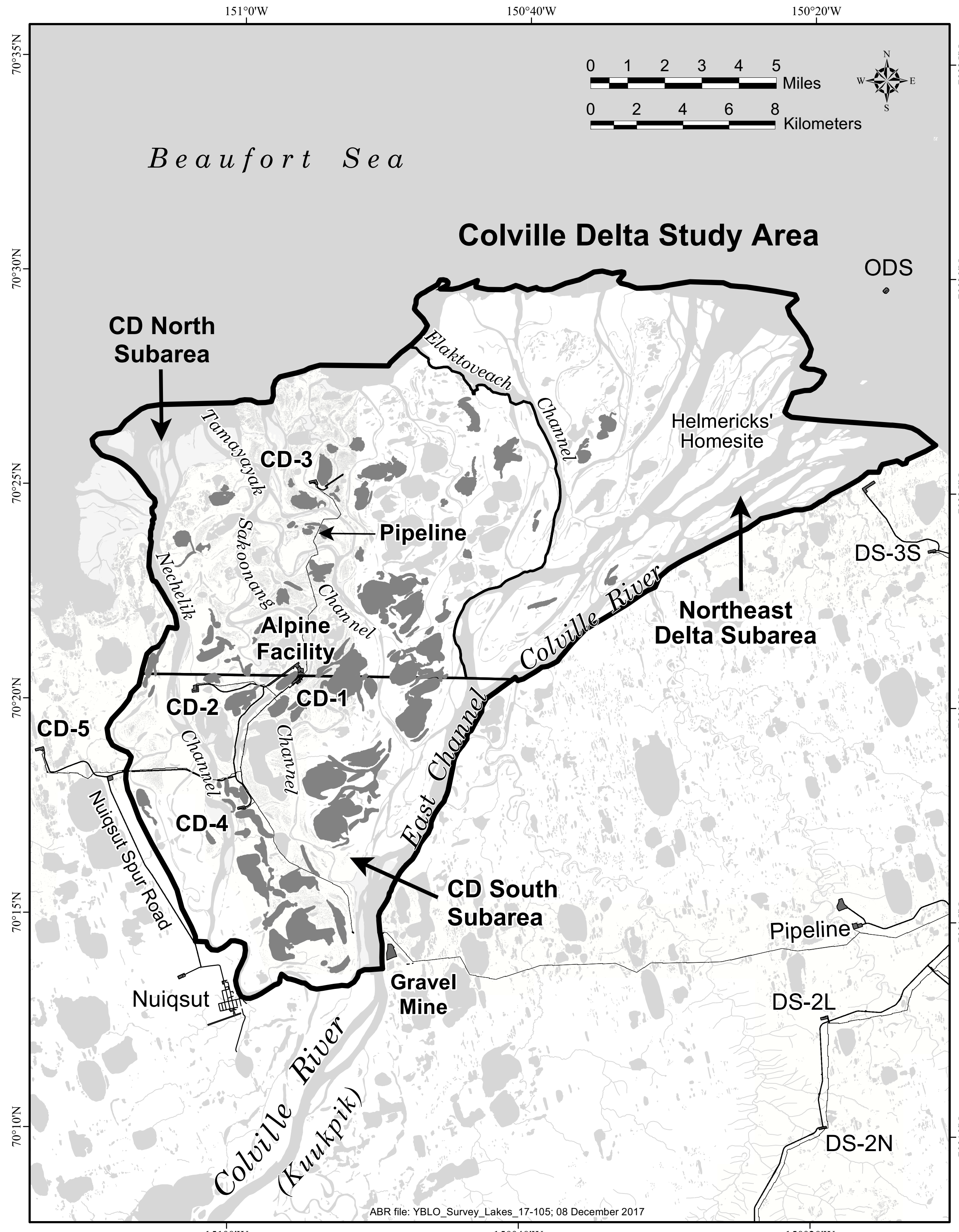


Appendix A. Lakes included in aerial surveys for Yellow-billed Loons, Colville Delta study area, Alaska, 2017.

Appendix B. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2017.

SPECIES Subarea Location	Observed Males	 Females	 Total	 Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
SPECTACLED EIDER							
CD North							
On ground	28	14	42	13	56	0.20	0.27
In flight	5	3	8	3	–	0.04	–
All birds	33	17	50	16	–	0.24	–
Northeast Delta							
On ground	2	1	3	1	4	0.02	0.03
In flight	0	0	0	0	–	0.00	–
All birds	2	1	3	1	–	0.02	–
CD South							
On ground	3	0	3	0	6	0.02	0.04
In flight	0	0	0	0	–	0.00	–
All birds	3	0	3	0	–	0.02	–
Total (subareas combined)							
On ground	33	15	48	14	66	0.10	0.13
In flight	5	3	8	3	–	0.02	–
All birds	38	18	56	17	–	0.11	–
KING EIDER							
CD North							
On ground	11	9	20	9	22	0.10	0.11
In flight	4	4	8	4	–	0.04	–
All birds	15	13	28	13	–	0.14	–
Northeast Delta							
On ground	35	23	58	21	65	0.37	0.41
In flight	5	2	7	1		0.04	–
All birds	40	25	65	22	–	0.41	–
CD South							
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	–
Total (subareas combined)							
On ground	48	34	82	32	91	0.16	0.18
In flight	10	7	17	6	–	0.03	–
All birds	58	41	99	38	–	0.20	–

[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 C. Number and density of loons and their nests, broods, and young during aerial surveys in the CD North and CD South subareas, Colville Delta study area, Alaska, 2017.

	Yellow-billed Loon					Pacific Loon[a]			Red-throated Loon[a]		
STUDY AREA	Number			Density (number/km²)		Number			Number		
Subarea[b] / Survey Type	Adults	Nests/ Brood	Young	Adults	Nests/ Broods	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
COLVILLE DELTA											
CD North											
Nesting	25	12	–	0.12	0.06	63	21	–	7	0	–
Brood-rearing	23	6[c]	7	0.11	0.03	37	9	10	4	2	2
CD South											
Nesting	27	14[d]	–	0.17	0.09	39	8	–	5	0	–
Brood-rearing	29	6[e]	7	0.19	0.04	27	6	7	5	2	3
Northeast Delta[f]											
Nesting	4	2	–	–	–	8	1	–	2	0	–
Brood-rearing	0	0	0	–	–	2	0	0	0	0	0
Total (subareas combined)[g]											
Nesting	56	28	–	0.15	0.08	110	30	–	14	0	–
Brood-rearing	52	12	14	0.14	0.03	66	15	17	9	4	5

[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 brood (assume 1 young) determined only by eggshell evidence.
[d] Number includes 2 nests indicated by the presence of brood on lake where no nest was found.
[e] Number includes 3 broods (assume 1 young each) determined only by eggshell evidence.
[f] Densities were not calculated for the Northeast Delta subarea because only a portion of the subarea was surveyed.
[g] Total is the sum of all subareas but density calculations included only CD North and CD South for Colville Delta.

Appendix D. Annual density (number/km²) of Yellow-billed Loons, nests, and broods, Colville Delta study area, Alaska, 1993–2017.

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)
Mean	0.15	0.05 (0.08)[e]	0.13	0.03 (0.04)
SE	<0.01	<0.01 (<0.01)[e]	<0.01	<0.01 (<0.01)

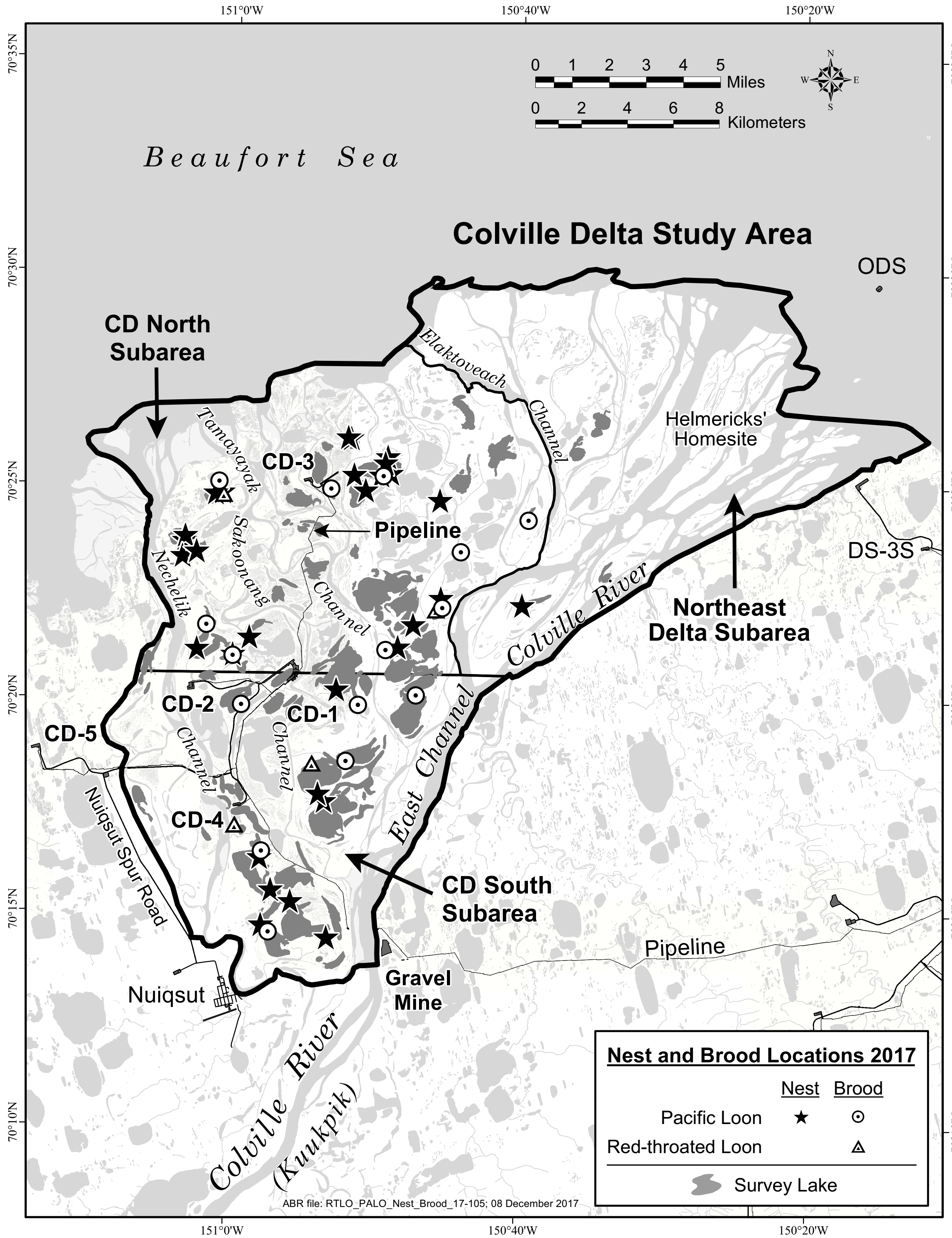
[a] Density of nests found on the nesting survey and, in parentheses, cumulative density including additional nests found during revisit (1996–2002), monitoring (2006–2014), and early nest surveys (2011, 2012, 2014), early camera monitoring (2013–2015), and nests inferred from the presence of broods 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.

[e] Mean density and SE with additional nests and broods includes only years when monitoring surveys were conducted: 2006–2014 for nests, 2005–2014 for broods.



Appendix E. Pacific Loon nests and broods, Colville Delta study area, Alaska, 2017.