SEVENTEENTH ANNUAL REPORT

AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2019

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Charles B. Johnson

Prepared for
CONOCOPHILLIPS ALASKA, INC.
Anchorage, Alaska

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

Cover: Yellow-billed Loon on a nest (red circle) seen during the June nest survey.

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Avian surveys in the ASDP study area were conducted by an experienced crew consisting of the authors and Adrian Gall. Chris Swingley programmed the tablet for aerial survey recording. Pam Odom provided travel and publication support, and Dorte Dissing provided GIS analysis and map creation. Joe Welch assisted with analysis and writing, and Kelly Lawhead reviewed goose photos. Will Lentz and Tony LaCortiglia supplied equipment and technical assistance. Adrian Gall reviewed the report. We thank the CPAI 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-Alaska (NE NPR-A) have been focal points of exploration and development for oil and gas since the 1990s. ConocoPhillips, Alaska, Inc. (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 was constructed in the NE NPR-A in 2014 and 2015. CPAI has supported surveys of avian wildlife in the ASDP area since 1993.

These surveys were originally designed 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), Greater White-fronted goose (Niġliq), Tundra Swan (Qugruk), 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. Readers are directed to prior reports for wildlife information from previous years for ASDP sites (Johnson et al. 2015, 2016, 2018, 2019) and for 2019 studies in the Willow project and Kuparuk areas (Shook et al. 2020, Attanas and Shook 2020).

In 2019, surveys focused on Spectacled Eiders, a federally listed threatened species, Yellow-billed Loons, a listed sensitive species by BLM (BLM 2010) with a limited breeding range, and brood-rearing geese, populations of which have been growing dramatically on the delta in recent years. Data were collected on other eider species concurrently during the Spectacled Eider survey. Systematic and incidental observations of Glaucous Gulls (Nauyavasrugruk) and incidental observations of Pacific Loons (Malġi) and Red-throated Loons (Qaqsrauq) were recorded during Yellow-billed Loon surveys. Surveys for brood-rearing geese were conducted on the Colville River delta in 2019, and a study of nesting Greater White-fronted Geese was conducted at CD-5 (Rozell and Johnson 2020, in prep.).

Other avian studies conducted for CPAI in 2019 included surveys for eiders and loons in the Willow project area and Kuparuk area (Shook et al. 2020, Attanas and Shook 2020), and nest searches for Spectacled Eiders at spill-response sites, water source lakes, and other tundra work sites on the Colville River delta, CD-5, and GMT-1 areas (Shook and Johnson 2019). Nesting Spectacled and King eiders also were monitored in the Kuparuk Oilfield on the eastern border of the Colville River delta in 2019 (Attanas and Shook 2020).

Required state and federal permits were obtained for all survey activities, including a Scientific Permit (No. 19-161) 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

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 2019, only the Colville Delta study area was surveyed (Figure 1).

Landforms, vegetation, and wildlife habitats in the Colville Delta study area were described in an 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, 2020).

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.

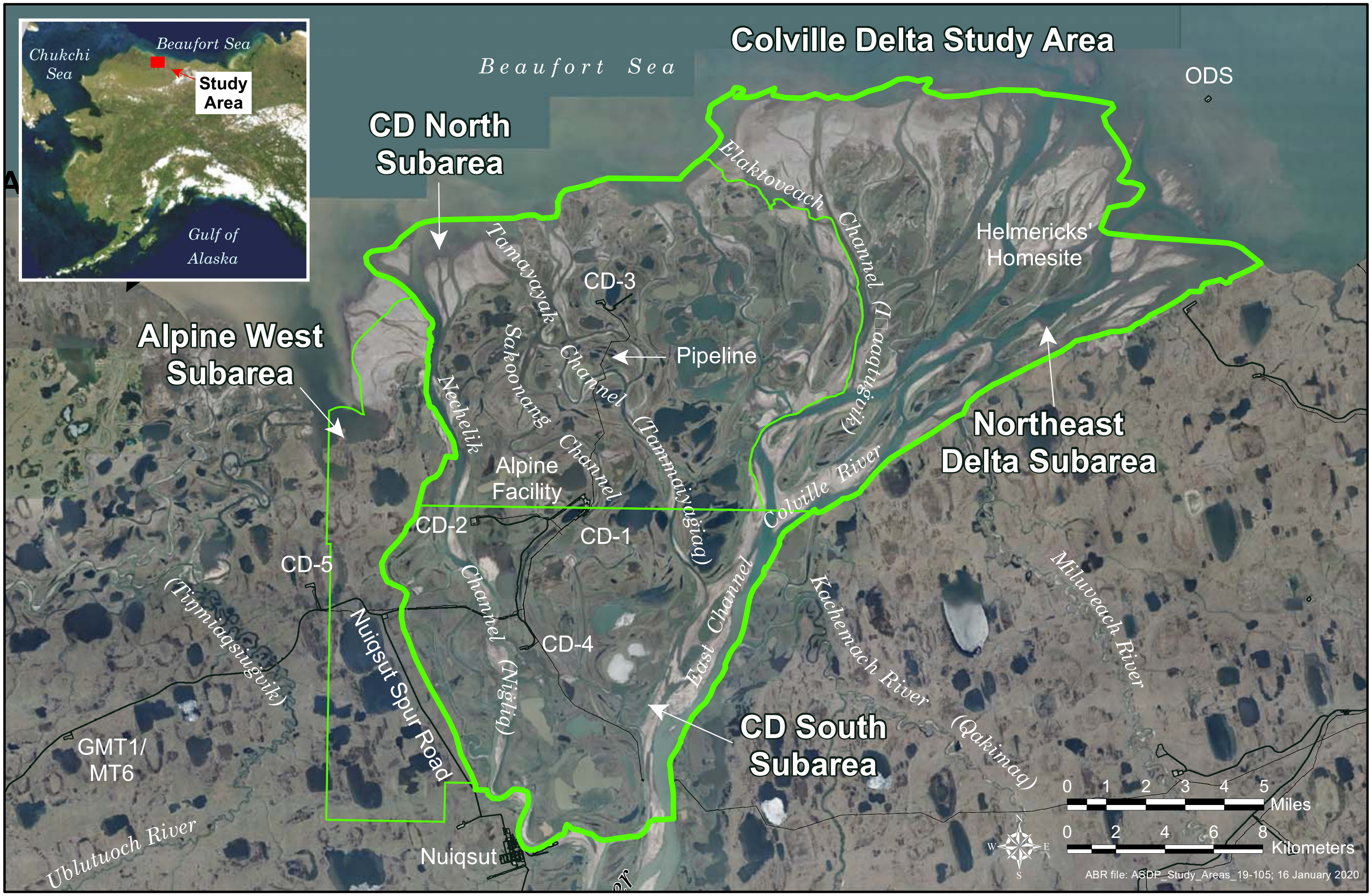

Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2019.

METHODS

Aerial surveys were used to collect data on eiders, loons, gulls, and geese 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 2019, we conducted 1 survey for eiders during pre-nesting and 1 survey for geese during brood-rearing using fixed-wing aircraft. We also conducted 2 surveys for Yellow-billed Loons (1 for nesting and 1 for brood-rearing) from a helicopter. Incidental observations of nesting and brood-rearing gulls also were recorded during loon surveys. Each of these surveys was scheduled specifically for the period when the species was most easily detected or when the species was at an important stage of its breeding cycle (i.e. nesting or raising broods) (Table 1).

Concerns about disturbance to local residents and wildlife from survey flights have dictated that we conduct the fewest survey flights necessary and at the highest altitudes possible. Flight altitudes were set at the maximum level at which the target species could be adequately detected and counted (see survey protocols for each species group below). Survey flights specifically avoided the areas around the village of Nuiqsut, the Helmericks' homesite, and any active hunting parties. Daily phone calls with Nuiqsut subsistence representatives, coordinated by the ConocoPhillips Village Outreach group and the Helicopter Coordinator based at Alpine, were used to identify locations of active hunting parties. Additionally, aerial observers looked for people, boats, and off-road vehicles that might indicate the 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 23–30 cm (8–12 in) 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.

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 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 2019, we conducted the pre-nesting survey on 16 and 18 June using the same methods that were used on the Colville Delta study area since 1993 (for details, see Johnson et al. 2015). The survey was flown in a Cessna 185 airplane at 35–45 m above ground level (agl) and at 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 Figure 3 in Johnson et al. 2018). The latter 2 areas were avoided to reduce disturbance to residents.

Results are presented as the total of eiders observed and the indicated total. Indicated total is a standardized calculation in which the observed number of males is doubled to compensate for the lower detectability of females (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987). Only males observed in singles, pairs, and small groups on the ground are included in the indicated total; flying birds are excluded. To calculate indicated total birds:

> Indicated Total Birds = (lone males × 2) + (flocked males × 2) + (pairs × 2) + (group total ×1).

Table 1. Avian surveys conducted in the Colville Delta study area, Alaska, 2019.

SURVEY TYPE Season	Number of Surveys	Survey Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
EIDER							
Pre-nesting	1	16, 18 Jun	C185	0.4	0.4	30–35	100% coverage
YELLOW-BILLED LOON[b]							
Nesting	1	19–25 Jun	A-Star	–	–	60–75	Lakes with adults, nests or broods in previous year
Brood-rearing	1	17–20 Aug	A-Star	–	–	60–90	Lakes with adults, nests or broods in previous year
GOOSE							
Brood-rearing	1	25–27 Jul	PA-18	–	–	75-150	Coastal and lake-to-lake pattern

[a] C185 = Cessna 185 fixed-wing airplane; A-Star = Airbus AS 350 B2 helicopter; PA-18 = Piper Super Cub fixed-wing airplane.

[b] Nests and broods of Pacific Loons, Red-throated Loons, Glaucous Gulls, and Sabine's Gulls were recorded incidentally.

Lone males are single, isolated males without a visible associated female; flocked males are 2–4 males in close association (no females in the flock); a pair is a male and female in close association; and a group is five or more of a mixed-sex grouping of the same species in close association, which cannot be separated into singles or pairs (e.g., one female with three males was considered to be four [a pair plus two males]).

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 22 of 26 years (501 km^2).

LOON SURVEYS

DISTRIBUTION AND ABUNDANCE

In 2019, we conducted 1 aerial survey on the Colville Delta study area for nesting Yellow-billed Loons on 19–25 June and 1 aerial survey for brood-rearing Yellow-billed Loons on 17–20 August (Table 1). We surveyed 112 lakes for nesting loons and 110 lakes for brood-rearing loons (Appendix A). Both nesting and brood-rearing surveys have been conducted annually in the Colville Delta study area for 24 years from 1993 to 2019, 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). Surveys were conducted by fixed-wing aircraft prior to 2000 and by helicopter thereafter. 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 during 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 agl. 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 2016–2019, however, we primarily surveyed lakes where Yellow-billed Loon adults, nests, or broods had been seen during the previous 24 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 those lakes for nesting (North 1986, Johnson et al. 2014a). Although the surveys were designed to maximize detection of Yellow-billed Loons, we recorded incidental observations of Pacific and Red-throated loons during all nesting and brood-rearing surveys.

All locations of loons and their nests were recorded on a tablet computer with a custom application. The application used 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.

We defined a territory as a single lake, several lakes, or portion of a lake occupied exclusively by 1 breeding pair with a nest or brood in 1 or more years. Territories were identified using data from all years; boundaries between territories were determined by locations where nests and broods were recorded and, additionally, by the locations of adults on multi-territory lakes. When we identified a new territory (i.e., when nests or broods are found in a lake not previously known to support breeding Yellow-billed Loons), we assumed that territory was available but unoccupied by breeding pairs in years before discovery. To make annual comparisons among years when different numbers of territories were surveyed, we first identified all territories within the surveyed lakes. Then, we calculated nest or brood occupancy by dividing the number of territories with nests or broods by the number of territories surveyed.

Productivity Relative to Infrastructure

We compared nest and brood occupancy of territories with nests <1 mile from the Alpine, CD-3, and CD-4 developments (referred to hereafter as territories near infrastructure) to overall productivity at territories across the entire Colville Delta study area. In order to provide a reference dataset, means for the Colville Delta study area were calculated only at territories with nests >1 mile from any of the 3 developments. Means for both territories near infrastructure and across the Colville Delta study area included only territories that had been surveyed during at least half of the pre- or post-development periods. Although we did not measure detectability, the detection of nests and broods is likely lower when surveying from fixed-wing aircraft than from helicopters. Therefore, during the years when surveys were conducted from fixed-wing aircraft (1993–1999), we supplemented the data with nests or broods found during other aerial surveys and ground-based nest searches. During years when the helicopter was used (2000–2019), we limited data to a single nest survey conducted during the third week in June and a brood survey conducted during the third week in August. Additional surveys were conducted in some years, but those additional data were excluded to standardize the search effort among years.

Nest and brood occupancy at territories near infrastructure and across the Colville Delta study area were calculated for the pre- and post-construction time periods for each development. We did not differentiate between years during which facilities were under construction verses operation; rather, we included all of the construction years in the post-construction period. The Alpine development includes a gravel airstrip and 2 gravel pads: CD-1, which includes a drill site, processing facility, and camp, and CD-2, which is a drill site. A ~3 km-long access road departs CD-1 via the airstrip and connects to the CD-2 drill site. Gravel infrastructure was first present during the 1998 breeding season and consisted only of the airstrip and CD-1 pad. Construction of the Alpine facilities spanned multiple years, with oil production first occurring in 2000. The pre-construction period at Alpine included surveys conducted in 1993, 1995–1997, whereas the post-construction period included surveys from 2000 to 2019.

CD-3 is a roadless development that is accessible by helicopter and fixed-wing aircraft during summer and by an ice road during winter. The gravel infrastructure at CD-3 includes an airstrip, drill site, and a 0.6-km road connecting the airstrip to the drill site. Gravel was first present at CD-3 during the 2005 breeding season and oil production began in August 2006. The pre-construction period at CD-3 included surveys conducted during 1993, 1995–1998, 2000–2004, whereas the post-construction period included data from 2005 to 2019.

The CD-4 development includes a drill site and an access road. The access road to the drill site is ~4.5 km long and departs from the CD-2 road. Similar to CD-3, gravel associated with the CD-4 development was first present during the 2005 breeding season with oil production beginning in August 2006. The pre-construction period at CD-4 included surveys conducted during 1993, 1995–1998, 2000–2004, whereas the post-construction period included surveys from 2005 to 2019.

POPULATION TRENDS

Population growth rates were calculated for Yellow-billed Loons using counts of adults and nests from the nesting survey and counts of young from 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 (50 prior to 2010 and 49 thereafter). Population growth rates were estimated with log-linear regression on adjusted counts for years when helicopters were used for all surveys (2000–2019).

NEST FATE

The 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 beginning in 2005 (see LOON SURVEYS, above). Glaucous Gulls nest singly and in loose aggregations or colonies. We considered a group of ≥3 nests in any 1 year occurring in proximity on the same lake or wetland complex to be a colony. Some wetlands or lakes contained <3 nest for years prior to attaining colony status; however, once an area supported a colony in any year, we include it in data analysis as a colony in previous years. Colony locations within the study area were checked systematically for activity, whereas nests and broods of gulls outside of traditional locations were recorded incidentally as they were encountered. When a Glaucous Gull colony was identified, we displayed it at 1 central location, even though some nests may be as far as 350 m apart. Glaucous Gulls fledge around 42 days of age after which they are not closely tended by adults (Weiser and Gilchrist 2012). Because the loon brood survey occurs close to the time when young gulls fledge, we focus on reporting the number of young seen during the loon brood survey as opposed to the number of adults. All locations of gull nests, broods, or colonies were recorded on a tablet computer with a custom-built data collection application.

We systematically 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 2005 (Appendix A). 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.

GOOSE BROOD SURVEY

We conducted 1 aerial survey for molting and brood-rearing Brant and Snow Geese on the outer Colville River delta during 25–27 July 2019 (Table 1). Brood surveys have been conducted annually on the Colville River delta using similar methods since 2005, and in some earlier years dating back to 1988. The survey was flown in a Piper PA-18 Super Cub aircraft at 75–150 m agl and approximately 100–120 km/h. A pilot and 1 observer flew in a lake-to-lake pattern and followed shorelines and river channels between the Nechelik and East channels of the Colville River (Appendix B). To account for geese that rear their broods immediately adjacent to the delta, we extended the survey into the Kuparuk study area on the east, and into the Alpine West subarea of the NE NPR-A study area to the west.

We used a digital tablet with a custom moving map application for navigation and recording goose locations. For each goose group observed, estimated numbers of adults and goslings were recorded, and locations were plotted on a digital orthophoto mosaic (23–30 cm resolution natural color imagery acquired in 2004–2015 by Quantum Spatial, Anchorage, AK). Most Brant and Snow Goose groups containing ≥50 birds, and many smaller groups, were photographed with a Nikon D810 image-stabilizing digital SLR camera (36.3 megapixel). Numbers of adults and goslings later were enumerated from the photographs to improve upon the visual estimates recorded during the flight. Multi-year analyses draw from historical studies using similar methods conducted by USFWS 1988–1991 (Bayha et al. 1992); and by ABR for CPAI 1992–2014 (Johnson et al. 2015) and for USGS 2015–2018 (Obritschkewitsch 2018).

To depict the density of Brant and Snow Geese, we used the inverse distance-weighted (IDW) interpolation technique of the Spatial Analyst extension of ArcMap software (Environmental Systems Research Institute, Inc. [ESRI], Redlands, CA) on a GIS platform. To calculate density, we divided the survey area into 1 km × 1 km grid cells and assigned the density of geese within each cell to the centroid of the cell. The IDW interpolation technique calculated a smoothed density surface for 152-m (500-ft) pixels based on the distance-weighted density of up to 8 centroids of the nearest grid cells within 1.4 km in the study area (power = 1). The analysis produced color maps exhibiting density distribution (or mean density for multi-year analyses) over the entire survey area.

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 (Appendix C). For each bird species, habitat use (% of all observations in each identified habitat type) was determined separately for various breeding stages (e.g., pre-nesting, nesting, and brood-rearing), as appropriate. For each species and breeding stage, 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 groups (single birds, pairs, groups, flocks, adults with broods, and colonies) and nests. 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 11.3, CPAI 2019). All nest, brood, bird, and bird group locations were recorded on tablet computers that were later 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

Weather stations near the Colville Delta study area include CD5, Nuiqsut, Alpine, and Colville Village (located at Helmericks' homestead). Snow depth data are not collected in Nuiqsut and the datasets for Alpine and CD5 only date back to 2011 and 2013, respectively. The dataset from Helmericks' dates back to 1997, and while there are differences in temperatures and snow depths among stations, trends are similar among stations. Therefore, we used the 22-year dataset of temperature and snow depth from Helmericks' to describe general weather patterns in the broader region, and supplemented records with snow depth data collected during spring breakup culvert surveys along the GMT1/MT6 and GMT2/MT7 roads (Michael Baker 2019a, 2019b) and in the Colville Delta (Michael Baker 2019c).

During the winter of 2018/2019, total freezing degree days (the sum of average daily temperatures <0 °C) measured at the NPR-A tundra monitoring station were the second lowest on record, indicating a very warm winter (Michael Baker 2019a). Daily average temperatures in May 2019 were at or above the long-term average, but still below freezing for most of the month (Figure 2). Total thawing degree-days (the sum of average daily temperatures >0 °C, TDD) for late May were also near average (Figure 3). Snow depth was above average in early May but started melting quickly in mid- and late-May as daily high temperatures were often above freezing. This resulted in near zero snow depths about a week earlier than the long-term mean date at Colville Village (1997–2019; Figure 2).

Spring floods on the Colville Delta were minimal and below bankfull levels but high enough to recharge lakes with typical hydraulic connections. Water level at peak stage (16.2 ft British Petroleum Mean Sea Level) at the head of the Colville Delta (Monument 1 gauge) was slightly below average height and occurred 6 days earlier (24 May) than average. Peak discharge (305,000 cfs) in 2019 was slightly below average (Michael Baker International 2019c). The ice in the East Channel began breaking up on 25 May and by 28 May, the majority of the East Channel was open. In early June during snow melt, average daily temperatures remained near the long-term average of 0 °C and the sum of TDD was well below average indicating 2019 had fewer fluctuations of average temperatures above zero in early June compared with the long-term average (Figures 2 and 3). Therefore, breakup was gradual and occurred between the dates of 15 May and 15 June, when most birds arrive on local nesting grounds. Warmer than average temperatures and earlier than average spring break-up conditions were reported during most waterfowl surveys in

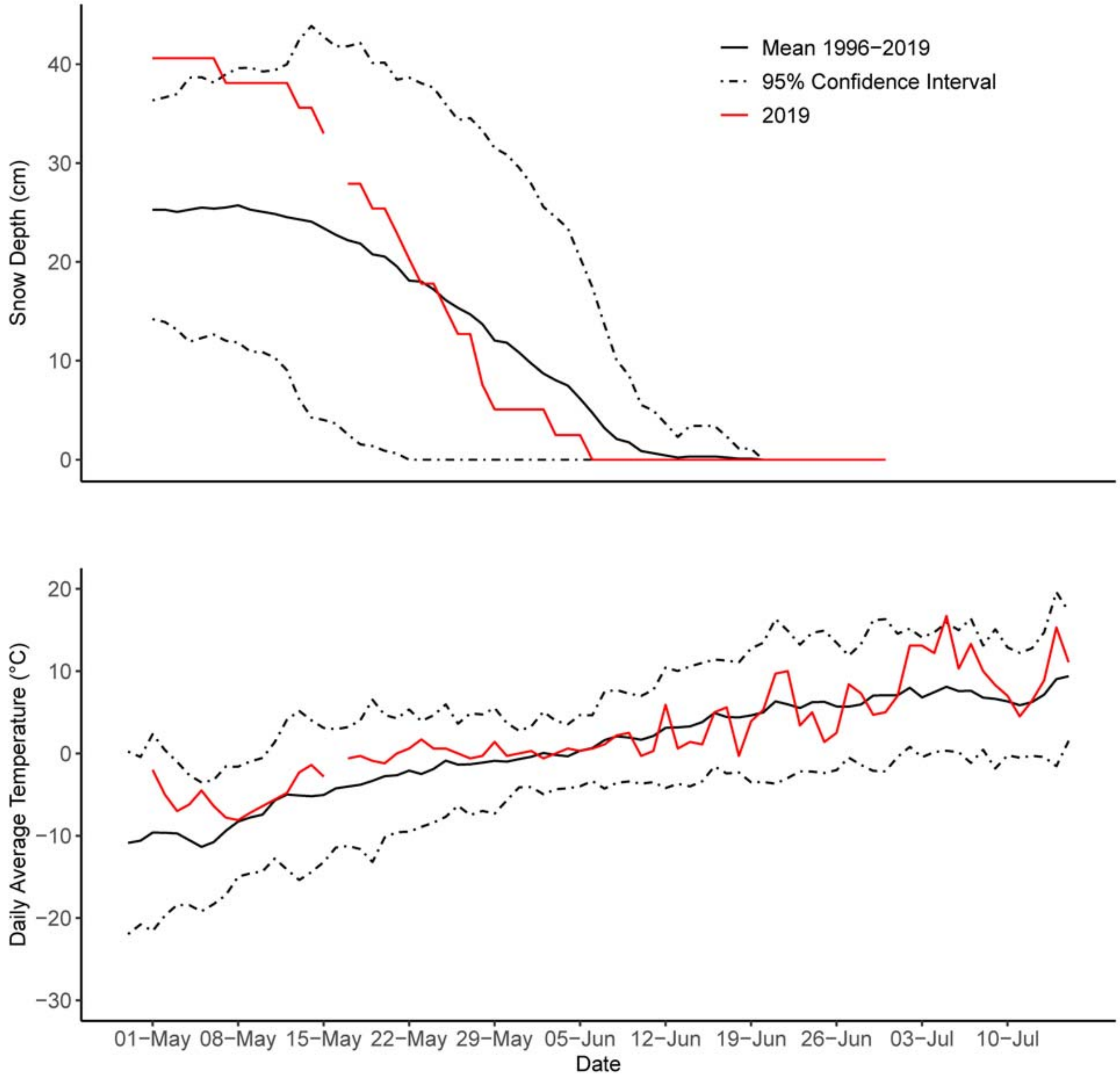

Figure 2. Snow depth and daily average temperature for spring and summer 2019 with mean for 1997–2019, Colville Village, Colville River delta, Alaska.

northern Alaska in 2019 (USFWS 2019). Ice coverage on 86 deep lakes (>5 ha) in the Colville Delta study area (estimated visually during nesting surveys for loons on 19–25 June) was less extensive in 2019 (mean = 35%) than previous years (mean = 67% ± 5.5%, *n* = 10 years).

The timing of eider surveys (16 June) was appropriate based on the condition of water bodies; shallow water bodies were thawed as were shallow margins of deep water bodies. The warm winter (indicated by total freezing degree days) may have contributed to thin ice on the deep lakes that Yellow-billed Loons use for breeding. A reduction in ice thickness likely accelerates moat formation during spring, making lakes available for breeding earlier than on average. Long-term lake ice thickness is not available, however, the ice thickness on the Colville River at Colville Village was 114 cm (45 in) in early May, well below the mean of 152 ± 6 cm (60 in ± 2 in; *n* = 22 years).

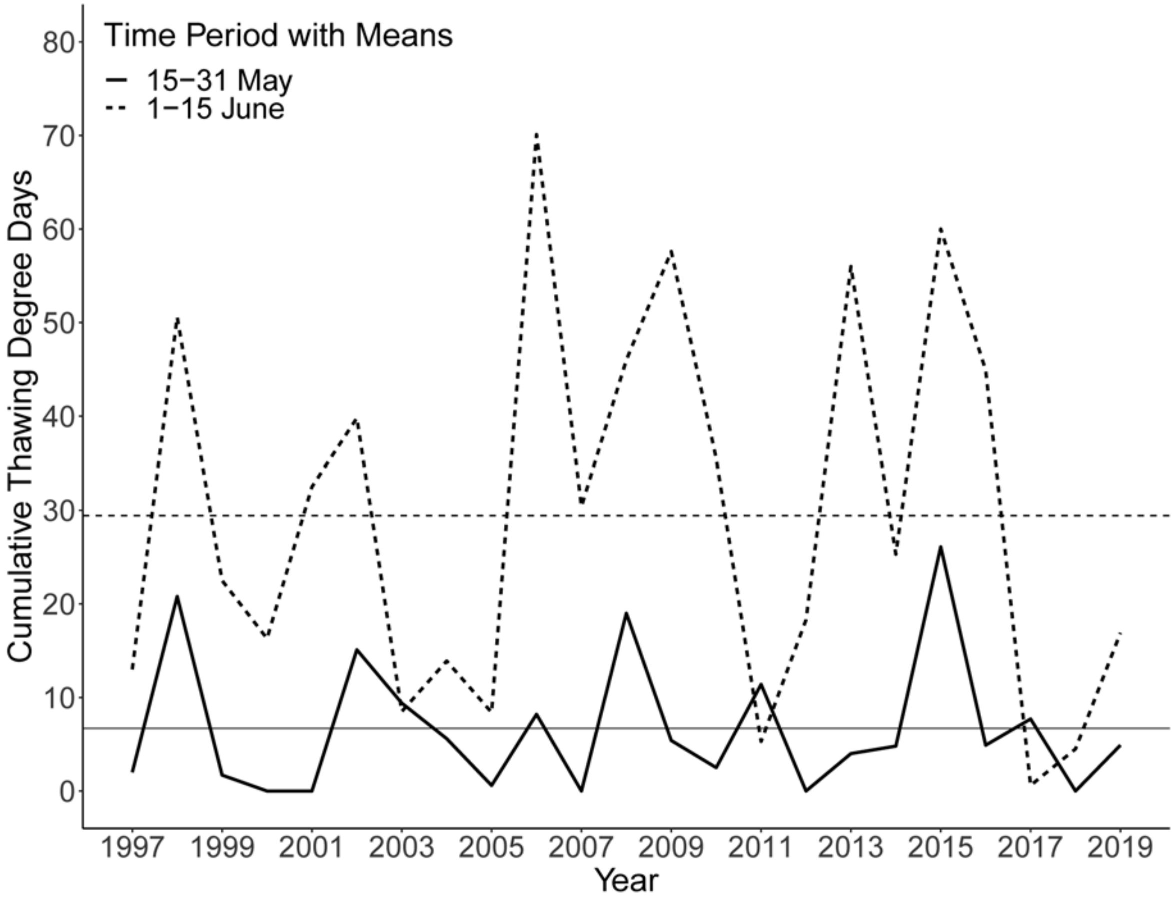

Figure 3. Cumulative number of thawing degree-days and means (horizontal lines) recorded for 15–31 May (6.7 ± 1.52) and 1–15 June (29.4 ± 4.25) recorded at Colville Village, Colville River delta, Alaska, 1997–2019.

EIDERS

Four species of eiders may occur in the Colville River delta, but each species 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 River delta is a concentration area for breeding Spectacled Eiders relative to surrounding areas; nonetheless, even there Spectacled Eiders nest at low densities (0.32 indicated birds/km² in CD North) and nest at even lower densities (0.01 indicated birds/km² in CD South) 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 communi- cation in 26 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 26 years) on surveys of the Colville Delta study area.

SPECTACLED EIDER

Distribution and Abundance

We recorded 56 Spectacled Eiders (on the ground and flying) and 74 indicated total Spectacled Eiders during the pre-nesting aerial survey in 2019 on the Colville Delta study area (Figure 4, Table 2). The number of indicated pre-nesting Spectacled Eiders was above average on the Colville Delta study area in 2019 (Table 2). All observations of pre-nesting Spectacled Eiders in the Colville Delta study area in 2019 were of small groups of 1–6 birds. The CD North subarea contained 89% of the Spectacled Eiders observed, whereas the CD South subarea contained only 3% (Appendix D). The density of pre-nesting Spectacled Eiders in the CD North subarea during 2019 (0.32 indicated birds/km^2) was more than twice the density recorded on the much larger Colville Delta study area (0.15 indicated birds/km^2). The distribution of pre-nesting Spectacled Eiders in 2019 was typical of previous years, when densities were highest north of Alpine and low south and northeast of Alpine (Figure 5). Over the 26 years that ABR and others have monitored Spectacled Eiders, their population trend has been relatively stable (Figure 6). In the CD North subarea, the growth rate is 2% (logarithmic growth rate of 1.02; ln(adults) = 0.021 (year) – 38.95, $R^2 = 0.10$, $P = 0.11$). The growth rate for the entire Colville Delta study area was slightly lower at 1.7% (ln(adults) = 0.017 (year) – 30.7, $R^2 = 0.07$, $P = 0.19$). 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.

Habitat Use

Pre-nesting Spectacled Eiders used 19 of 24 available habitats during 26 years of aerial surveys on the Colville Delta study area (Table 3). Seven

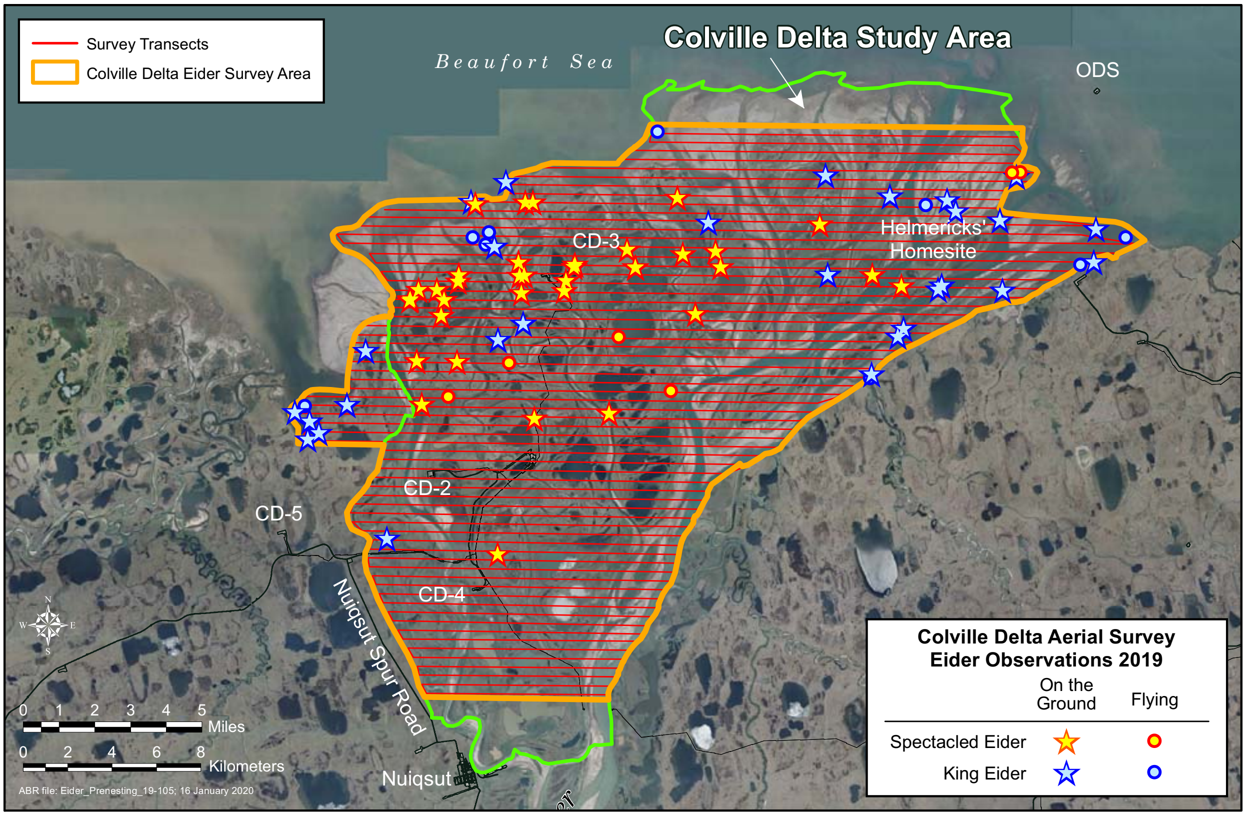

Figure 4. Spectacled Eider and King Eider locations during pre-nesting in 2019, Colville Delta study area, Alaska.

Table 2. Observed and indicated numbers and densities (birds/km^2) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 1993–2019.

		Spectacled Eider				King Eider			
	Area Surveyed	Total[a]		Density[b]		Total[a]		Density[b]	
Year	(km^2)	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
2019	501.4	56	74	0.11	0.15	112	99	0.22	0.20
Mean		56.1	55.0	0.11	0.11	64.2	52.5	0.12	0.10
SE		4.9	4.8	0.01	0.01	8.5	8.0	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 km^2, $n = 22$ years.

[b] Numbers not corrected for sightability. Density (birds/km^2) based on 100% coverage of surveyed area. Means calculated for all years, $n = 26$ years.

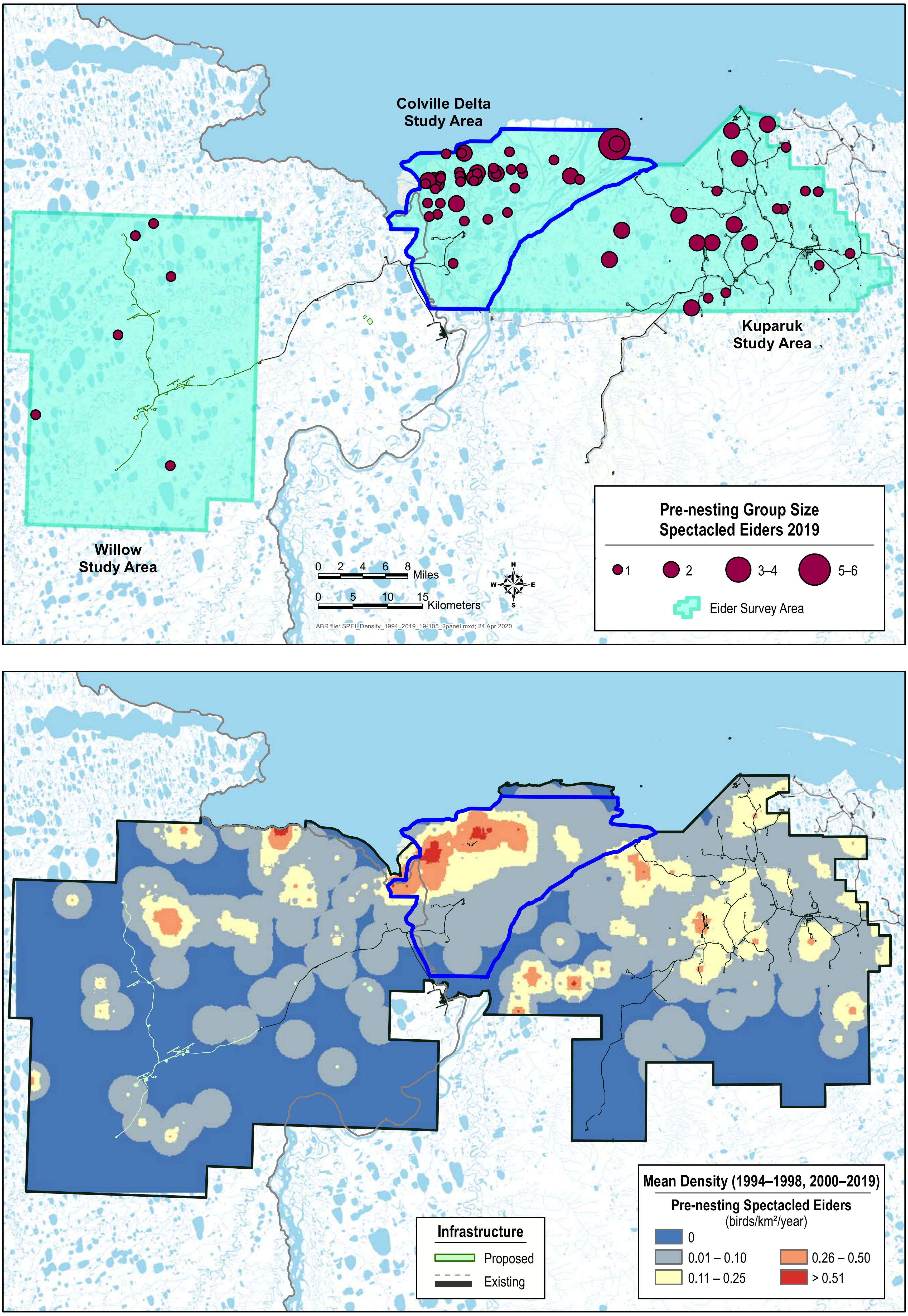

Figure 5. Group size (2019) and mean densities (mean of areas surveyed 1–26 years) of Spectacled Eiders observed during pre-nesting aerial surveys in the Colville Delta (blue outline), NPR-A, and Kuparuk study areas, Alaska, 1994–1998 and 2000–2019..

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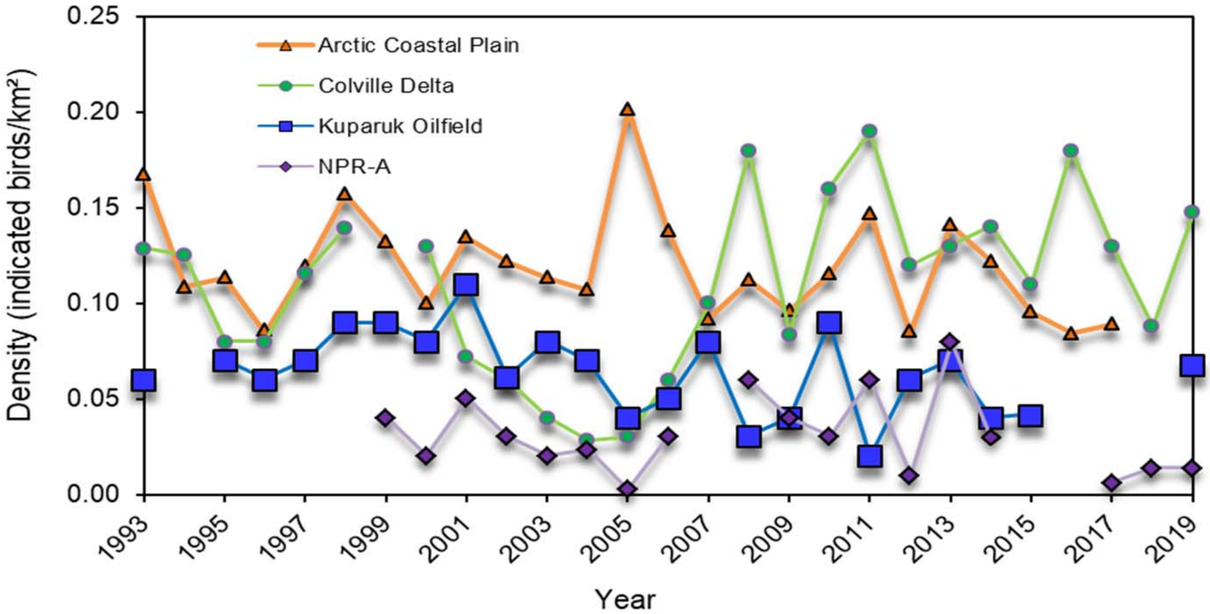

Figure 6. Annual densities of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2019.

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 disproportionate use; Deep Polygon Complex was used by 28% of the Spectacled Eider groups, yet occurred on only 2.8% 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 (21% 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 Connection; 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 112 observed (on the ground and flying) and 99 indicated total King Eiders on the 2019 pre-nesting aerial survey of the Colville Delta study area (Figure 4, Table 2). Both numbers were the third highest counts of King Eiders recorded since surveys began in 1993. King Eiders outnumbered Spectacled Eiders (74 indicated birds) in 2019, which has occurred in 12 of 26 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 (3.3%) since surveys began in 1993 (ln(adults) = 0.033 (year) – 63.1, $R^2 = 0.20$, $P = 0.02$; Figure 7). King Eiders were observed in all 3 of the subareas, but they achieved their highest density (0.55 indicated birds/km²) in the Northeast Delta subarea in 2019 (Appendix D). The highest densities occur on the East Channel of the Colville River near the coast, where flocks of King Eiders

Table 3. Habitat selection by Spectacled Eider and King Eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998, and 2000–2019.

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	93	44	7.2	1.3	prefer	
Tapped Lake with Low-water Connection	42	17	2.8	4.5	avoid	
Tapped Lake with High-water Connection	23	14	2.3	3.6	ns	
Salt Marsh	69	39	6.3	3.2	prefer	
Tidal Flat Barrens	2	1	0.2	7.1	avoid	
Salt-killed Tundra	102	58	9.4	5.1	prefer	
Deep Open Water without Islands	40	27	4.4	3.4	ns	
Deep Open Water with Islands or Polygonized Margins	43	23	3.7	2.2	prefer	
Shallow Open Water without Islands	7	5	0.8	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	12	9	1.5	0.1	prefer	low
River or Stream	39	18	2.9	14.4	avoid	
Sedge Marsh	1	1	0.2	0.0	ns	low
Deep Polygon Complex	292	169	27.5	2.8	prefer	
Grass Marsh	10	6	1.0	0.2	prefer	low
Young Basin Wetland Complex	0	0	0.0	0.0	ns	low
Old Basin Wetland Complex	0	0	0.0	0.0	ns	low
Nonpatterned Wet Meadow	98	51	8.3	8.3	ns	
Patterned Wet Meadow	224	128	20.8	19.1	ns	
Moist Sedge-Shrub Meadow	0	0	0.0	2.3	avoid	
Moist Tussock Tundra	1	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	0	0	0.0	5.0	avoid	
Barrens	7	3	0.5	14.8	avoid	
Human Modified	0	0	0.0	0.1	ns	low
Total	1107	615	100	100		
KING EIDER						
Open Nearshore Water	41	11	2.5	1.6	ns	
Brackish Water	71	36	8.3	1.3	prefer	
Tapped Lake with Low-water Connection	51	21	4.8	4.5	ns	
Tapped Lake with High-water Connection	16	7	1.6	3.6	avoid	
Salt Marsh	57	23	5.3	3.2	prefer	
Tidal Flat Barrens	4	2	0.5	7.1	avoid	
Salt-killed Tundra	65	35	8.1	5.1	prefer	
Deep Open Water without Islands	22	10	2.3	3.4	ns	
Deep Open Water with Islands or Polygonized Margins	19	9	2.1	2.2	ns	
Shallow Open Water without Islands	11	6	1.4	0.4	prefer	low
Shallow Open Water with Islands or Polygonized Margins	5	3	0.7	0.1	prefer	low
River or Stream	665	181	41.7	14.4	prefer	
Sedge Marsh	0	0	0.0	0.0	ns	low
Deep Polygon Complex	54	31	7.1	2.8	prefer	
Grass Marsh	9	4	0.9	0.2	prefer	low
Young Basin Wetland Complex	0	0	0.0	0.0	ns	low
Old Basin Wetland Complex	0	0	0.0	0.0	ns	low
Nonpatterned Wet Meadow	19	12	2.8	8.3	avoid	
Patterned Wet Meadow	57	33	7.6	19.1	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	1.4	14.8	avoid	
Human Modified	0	0	0.0	0.1	ns	low
Total	1,187	434	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.

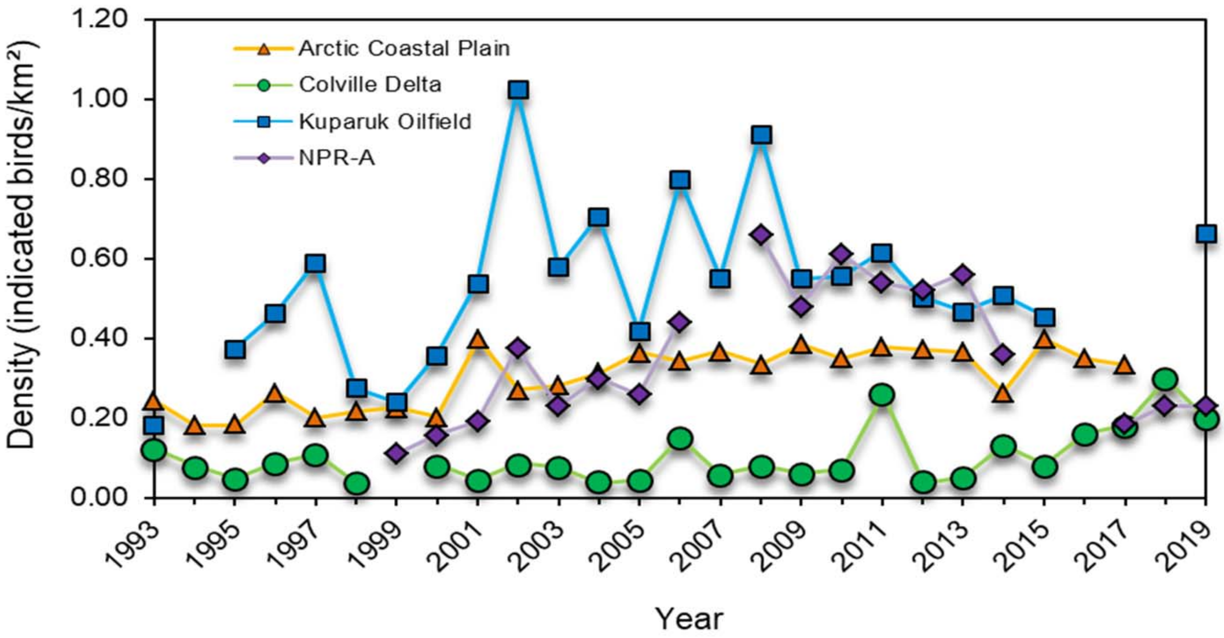

Figure 7. Annual densities of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2019.

collect in open water; lower densities are seen elsewhere on the delta (Figure 8). 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).

No Steller's or Common eiders were seen in the Colville Delta study area in 2019. Steller's 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 habitats in the Colville Delta study area over 25 years of aerial surveys (Table 3). Pre-nesting King Eiders preferred 6 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, Deep Polygon Complex, and Grass Marsh. In addition to those 6 habitats, pre-nesting King Eiders preferred Shallow Open Water without Islands and River or Stream. River or Stream, which includes the river channels primarily in the Northeast Delta subarea, was used by 42% of the pre-nesting groups, (Figure 8). 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.

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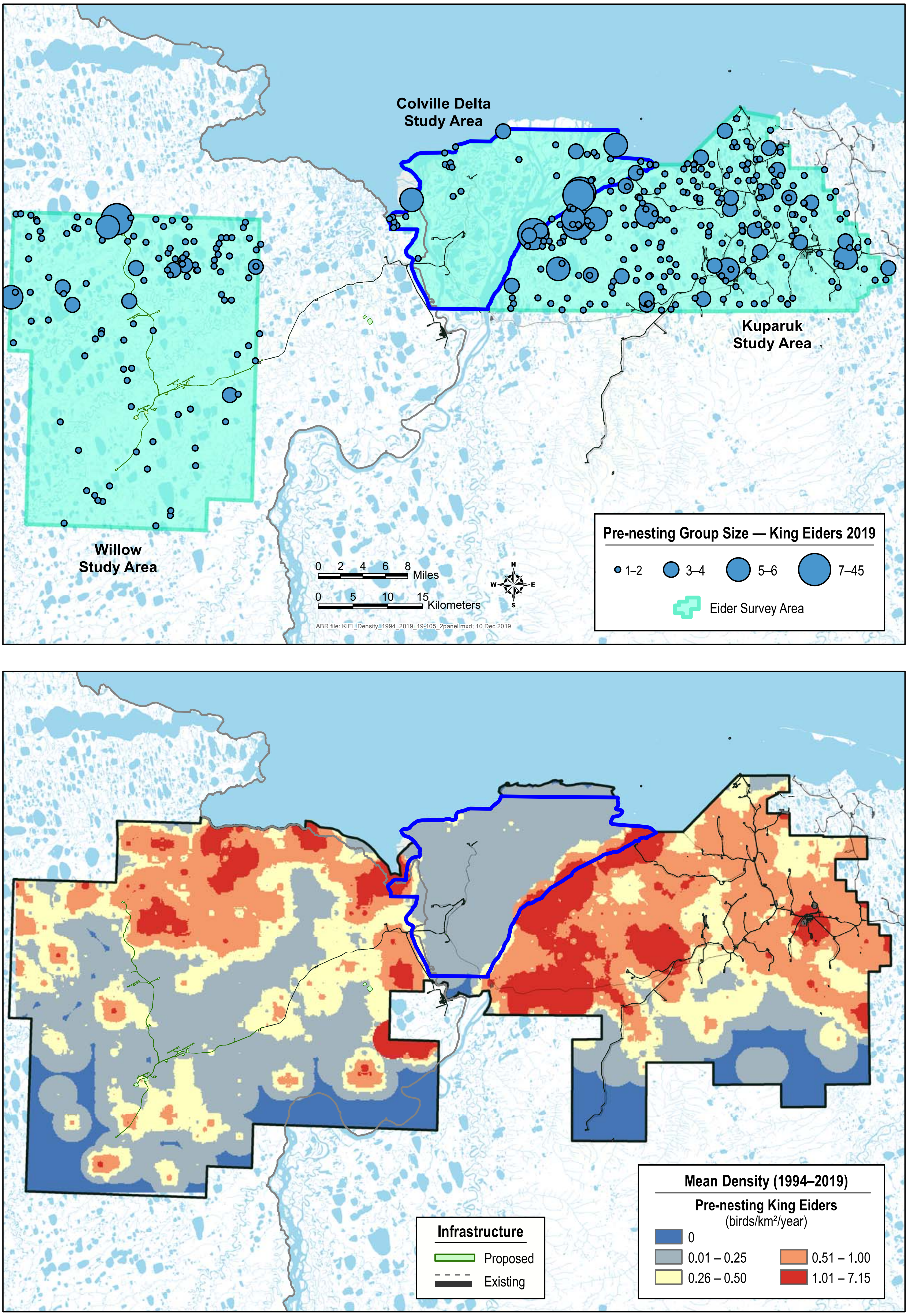

Figure 8. Group size (2019) and mean densities (mean of areas surveyed 1–26 years) of King Eiders observed during pre-nesting aerial surveys in the Colville Delta (blue outline), NPR-A, and Kuparuk study areas, Alaska, 2019.

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YELLOW-BILLED LOON

DISTRIBUTION AND ABUNDANCE

Thirty Yellow-billed Loon nests were found during the Yellow-billed Loon nest survey in 2019 (Figure 9, Table 4). Two additional nests were inferred from the presence of broods during August in territories where nests were not found during the nest survey. Of the 32 nests documented in 2019, 15 nests were located in the CD North subarea, 14 nests in the CD South subarea, and 3 nests in the Northeast Delta subarea (Appendix E). The total number of nests found on the nesting survey was above the long-term mean (21.1 ± 1.3 nests, *n* = 25 years; for densities see Appendix F). The count of 64 adults on the nesting survey also was higher than the long-term mean (58.3 ± 2.2 adults). The density of adults and nests was lower in the CD North subarea (0.13 birds/km², 0.07 nests/km²) than the CD South subarea (0.22 birds/km², 0.09 nests/birds/km²; Appendix E). Incidental records of Pacific and Red-throated loon nests and broods are presented in Appendices E and G.

Thirty of the 32 Yellow-billed Loon nests recorded in the Colville Delta study area in 2019 were on territories where Yellow-billed Loons have nested previously (ABR, unpublished data). A new territory was discovered in 2019 on a lake where breeding had not previously been documented. That lake had been surveyed since surveys began in the Colville Delta study area in 1993. An additional territory was identified on a lake that we previously considered to host only 1 breeding pair of loons; however, in 2019, we found 2 nests on that lake. Both nests were in areas that had been used previously for nesting but not during the same year.

Not only did Yellow-billed Loons occur on territories used in previous years, breeding loons reused previous nest sites. Twenty-one of 32 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, and 8 were at new nest sites (>50 m from previously recorded nests). Locations of the 2 nests inferred from the presence of a brood were unknown.

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. 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 nest occupancy, or the proportion of territories with a nest, to adjust for variable survey effort among years (38 to 49 territories were surveyed annually over 25 years). In 2019, 61% of the territories were occupied by nests during the nesting survey, which is well above the long-term mean (47.1 ± 2.8%, *n* = 25 years; Table 4).

During the brood-rearing survey, 83 adult Yellow-billed Loons, 21 broods, and 25 young were recorded in the Colville Delta study area (Figure 9, Table 5). We inferred 3 additional broods based on eggshell fragments at nests. Of the 24 broods, 13 were found in the CD North subarea, 9 were found in the CD South subarea, and 2 were found in the Northeast Delta subarea (Appendix E). The counts of 83 adults and 24 broods on the brood-rearing survey were well above long-term means (51.8 ± 2.6 adults; 12.8 ± 1.2 broods, *n* = 25 years; Table 5; for densities, see Appendix F). Although the density of adults during the brood-rearing survey was lower in the CD North subarea (0.19 birds/km²) than the CD South subarea (0.24 birds/km²), the density of broods was identical (0.06 broods/km²; Appendix E).

During 25 years of brood-rearing surveys in the Colville Delta study area, the lowest number 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 brood occupancy, or the proportion of territories with a brood. In 2019, 49% of the territories were occupied by broods. Similar to nest occupancy, brood occupancy also was well above the long-term mean (29.1 ± 2.7%) and was the fourth highest estimate since surveys began in 1993.

Since 1993, we have identified 50 Yellow-billed Loon territories composed of 63 lakes in the Colville Delta study area (Appendix H). One of the 50 territories, however, is no longer

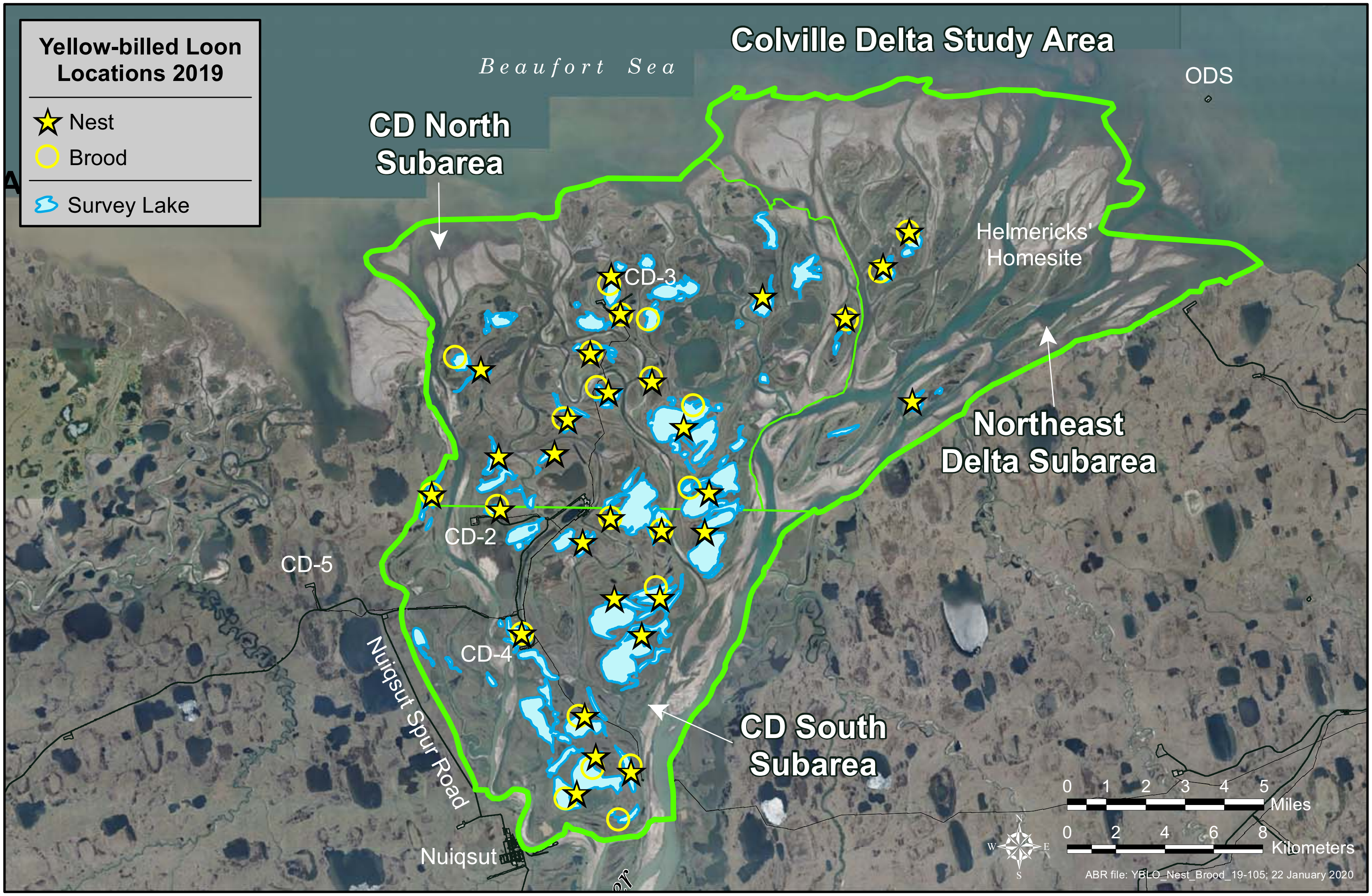

Figure 9. Yellow-billed Loon nest and brood locations, Colville Delta study area, Alaska, 2019.

Table 4. Number of Yellow-billed Loons and nests, and nest occupancy, Colville Delta study area, Alaska, 1993, 1995–1998 and 2000–2019.

	Nesting Survey[b]		All Surveys[c]		
Year	No. Adults	No. Nests	No. Nests	No. Territories Surveyed	Nest Occupancy (%)[d]
1993	50	11	16[e,f]	45	24
1995	42	12	21[e,f]	41	29
1996	45	11	20[e,f,g]	38	29
1997	48	10	18[e,g]	41	24
1998	36	17	24[e,f,g]	44	39
2000	53	16	16	40	40
2001	54	19	20[e]	39	49
2002	46	17	22[e,f,g]	44	39
2003	53	25	27[f]	43	58
2004	41	24	26[f]	44	55
2005	57	30	31[f]	43	70
2006	65	24	28[g]	44	55
2007	66	27	31[g]	44	61
2008	69	33	38[g]	45	73
2009	68	27	30[g]	46	59
2010	69	23	35[g]	46	50
2011	72	23	29[g]	46	50
2012	59	25	32[g]	46	54
2013	67	12	17[f,g,h]	46	26
2014	78	26	32[g,h]	48	54
2015	63	19	25[f,h]	49	39
2016	68	18	18	48	38
2017	56	26	28[f]	48	54
2018	68	23	24[f]	49	47
2019	64	30	32[f]	49	61
Mean	58.3	21.1	25.6	–	47.1
SE	2.2	1.3	1.3	–	2.8

[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 a single 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.

Table 5. Number of Yellow-billed Loons, broods, and brood occupancy, Colville Delta study area, Alaska, 1993, 1995–1998 and 2000–2019.

Year	Brood-rearing Survey[a] No. Adults	Brood-rearing Survey[a] No. Young	Brood-rearing Survey[a] No. Broods	All Surveys[b] No. Broods	No. Territories Surveyed[c]	Brood Occupancy (%)[d]
1993	29	7	7	10[e]	35	29
1995	51	13	10	12[e]	45	27
1996	62	6	6	10[e]	39	26
1997	66	8	5	5	41	12
1998	55	15	12	12	44	27
2000	21	2	2	3[f]	37	8
2001	33	4	4	4	38	11
2002	66	9	8	9[e]	41	22
2003	47	16	14	14	41	34
2004	54	15	12	12	43	28
2005	39	21	17	21[f,g]	41	51
2006	66	13	13	16[f]	42	38
2007	53	20	17	23[f,g]	43	53
2008	57	29	22	27[f,g]	45	60
2009	56	12	11	13[g]	46	28
2010	59	20	14	15[f,g,h]	44	34
2011	45	20	12	15[f,g,h]	44	34
2012	52	19	14	17[g,h]	46	37
2013	43	9	7	7	46	15
2014	48	4	4	8[f,g]	48	17
2015	58	10	9	10[h]	49	20
2016	43	6	6	11[g]	48	23
2017	52	10	8	12[g]	48	25
2018	58	9	6	10[g]	49	20
2019	83	25	21	24[g]	49	49
Mean	51.8	12.9	10.4	12.8	–	29.1
SE	2.6	1.4	1.1	1.2	–	2.7

[a] Brood-rearing surveys were conducted sometime between 15 and 27 August.
[b] Includes all broods found on brood-rearing surveys 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.

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 and Polygonized Margins to Tapped Lake with Low-water Connection; the latter is a habitat not used by nesting loons, because water has drained from the lake and now fluctuates with the river levels. As a result, Yellow-billed Loons no longer nest in that lake, reducing the number of territories to 49. Thirty-two of the 49 territories were occupied by breeding Yellow-billed Loons in 2019.

Productivity Relative to Infrastructure

Of the 50 territories identified over 25 years of surveys in the Colville Delta study area, 11 territories have had nests within 1 mile of gravel infrastructure (hereafter, referred to as territories near infrastructure). Four territories are near the Alpine development, 6 are near the CD-3 development, and 3 (including 2 that are also near Alpine) are near the CD-4 development (Figure 10).

Mean nest and brood occupancy at territories near infrastructure did not appear to differ from means observed at territories across the Colville Delta study area during either the pre- or post-construction time periods (Figure 11). Further, nest and brood occupancy at territories near infrastructure during the pre-construction time period did not appear different from that observed during the post-construction time period, suggesting that proximity to infrastructure did not have a large effect on productivity. The 95% confidence intervals of the means overlap extensively between both groups of territories and both time periods, allowing us to infer that statistically significant differences do not exist. These results support Johnson et al. (2019b), which found no evidence that nests and broods were being displaced from long-standing territories near oil infrastructure in the Colville Delta study area. They found that lake characteristics, such as lake type and size, were the most predictive variables of nest and brood occupancy.

Sample sizes, however, were constrained by the few territories that occur near infrastructure. This constraint resulted in large confidence intervals around nest and brood occupancy means, indicating that precision around those estimates is low. Large confidence intervals also reflect the high annual variation in productivity at individual territories (Appendices I, J, K). Nesting pairs are subject to a variety of stochastic events independent of proximity to infrastructure. These events include flooding, which can delay or prevent nesting in some years (e.g. 2000, 2001, 2015 [Johnson et al. 2015. 2016]), wind events that cause lake ice to shift and crush eggs, and competition for territories with other Yellow-billed Loons. All of these events have been documented at territories monitored by time-lapse cameras. For example, the nest at Territory 8 was covered by shifting ice during 2 consecutive years of the post-construction period at CD-3. Additionally, a pair at that same territory lost its brood after the adult left its nest to engage in a territorial fight with an intruding Yellow-billed Loon. The occurrence of such events, especially in a small dataset, lowers the power to detect differences in productivity related to proximity of infrastructure. As a result, conclusions regarding differences in nest and brood occupancy among these groups of territories are less certain than they would be with a larger sample of territories near infrastructure and with lower annual variation in nest occupancy and nesting success.

The limited pedestrian traffic associated with the developments in the Colville River delta study area may be one reason why we did not detect obvious reductions in nest and brood occupancy at territories near infrastructure. The types of human activities associated with infrastructure are important when considering potential responses from birds. In general, pedestrians elicit stronger reactions from birds than vehicles traveling at constant speeds. People on foot are more likely to elicit flight responses and at farther distances than vehicles (Klein 1993, Rodgers and Smith 1995, McLeod et al 2013). Human activity associated with the Alpine, CD-3 and CD-4 infrastructure is generally limited to vehicle traffic on roads and pads and aircraft traffic on airstrips. Pedestrian traffic is generally confined to the airstrips and pads and occurs less often along roads and bridges. Perhaps most importantly, pedestrian traffic is strictly controlled on the tundra during the period when most birds are nesting. Results from this study may not be directly applicable to other areas if human activity is associated with more foot traffic (i.e. people walking on roads or traveling on the tundra).

All but 2 of the 11 territories near infrastructure continue to be occupied by Yellow-billed nests and broods despite their proximity to infrastructure. Territory 9, the territory in the lake that drained, no longer contains suitable breeding habitat and Territory 7 near CD-3 has not contained breeding Yellow-billed Loons for the last 9 years (Figure 10). Large-scale habitat changes prevent Yellow-billed Loons from breeding in Territory 9 but reasons for the lapse in use at Territory 7 are not well understood. The earliest published records of Yellow-billed Loons nesting in that territory occurred during the mid-1980s (North 1986). ABR began conducting surveys on the Colville delta in 1993 and consistently recorded breeding Yellow-billed Loons in Territory 7 through 2010, 6 years after gravel was laid at CD-3. The territory was occupied by nests during all 6 of those years and by broods during 4 of the years. However, since then, Yellow-billed Loon adults have rarely been seen there and nests and broods have not been found. Competitive exclusion with Pacific Loons could be preventing occupancy by Yellow-billed Loons. Since 2011, 1 or 2 Pacific Loon nests have been found annually on that lake and at nest sites previously occupied by Yellow-billed Loons. The presence of breeding Pacific Loons, especially multiple pairs, may preclude nesting by Yellow-billed Loons except on large lakes with convoluted shorelines (North 1994, Earnst 2006, Haynes 2014). This turnover in territory ownership between loon species has been observed in at least 3 other territories in the Colville Delta study area (ABR, unpublished data). In those cases, Yellow-billed Loons regained territory ownership within 2 to 5 years and continued to breed on those territories. These observations suggest that competition and ownership of some territories can be dynamic between species and may negatively affect Yellow-billed Loon nest and brood occupancy during some years.

Some territories near infrastructure were unoccupied during the pre-construction periods and only occupied during the post-construction periods. Yellow-billed Loon nests and broods were recorded on territories only during the post-construction periods at 4 of the 11 territories (territories 15, 212, 47, and 49; Appendices J and K). Two of the territories, territories 212 and 15 near Alpine, have been surveyed annually since 1993 (Figure 10). Although adult loons were observed yearly in Territory 15 during the pre-construction period, breeding was first recorded there in 2000 while Alpine was under construction. Despite the long survey history at Territory 212, only 1 Yellow-billed Loon adult had been seen there prior to finding a nest in 2019. Territories 47 and 49, both near CD-3, were not included regularly in aerial loon surveys until 2010 and 2015, respectively; however those lakes were surveyed on foot in 2000–2007 during avian studies associated with CD-3. Both territories are on small lakes (< 5 ha) and were occupied by breeding Pacific Loons during many of those years, which likely precluded nesting by Yellow-billed loons.

POPULATION TRENDS

Yellow-billed Loons in the Colville Delta study area have been characterized previously by stable or slightly increasing population growth, but annual growth appears to be stabilizing. From 2000 to 2019, the growth rate of the number of adults (adjusted by the number of territories surveyed; Figure 12) was slightly positive but not significantly different from equilibrium ($\ln(\text{adults}) = 0.004(\text{year}) - 4.5$, $R^2 = 0.04$, $P = 0.42$, $n = 20$). Over the last 10 years, the growth rate of the number of adults was slightly negative but also not significantly different from equilibrium ($\ln(\text{adults}) = -0.017(\text{year}) + 39.8$, $R^2 = 0.27$, $P = 0.13$). 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 indicated a non-significant decline (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 study area have not displayed any long-term trends over the last 20 years. Although both showed significant declines during the decade preceding 2016 and 2017 (Johnson et al. 2017, Johnson et al. 2018), those declines have slowed in

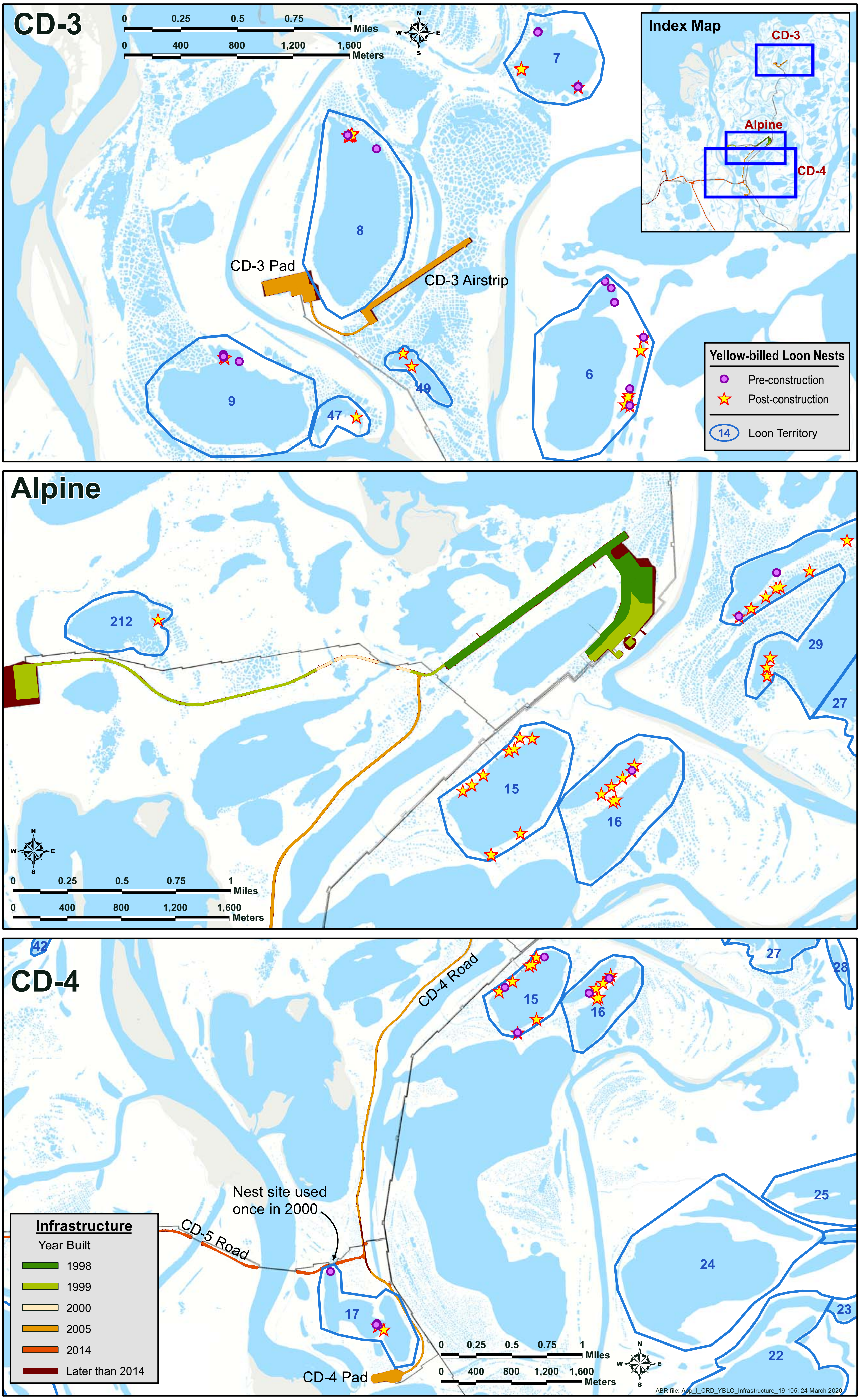

Figure 10. Yellow-billed Loon territories with nests within 1 mile of the Alpine, CD-3 and CD-4 developments during the pre- and post-construction periods at each development, Colville Delta study area, Alaska..

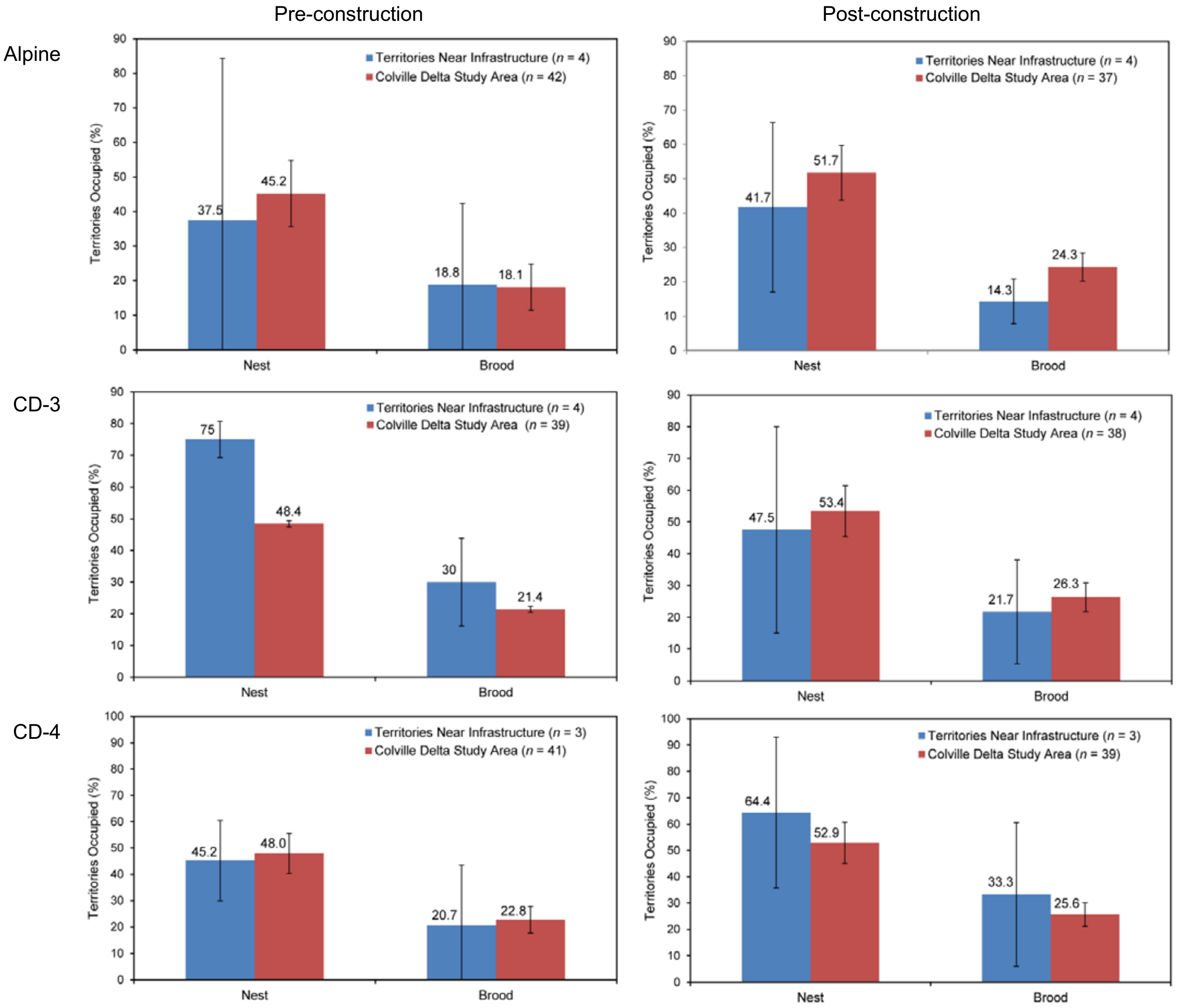

Figure 11. Mean nest and brood occupancy (with 95% confidence intervals) at Yellow-billed Loon territories containing nests within 1,600 m (1 mile) of gravel infrastructure compared to means at territories across the Colville Delta study area during the pre- and post-construction periods at the Alpine, CD-3, CD-4 developments, Alaska.

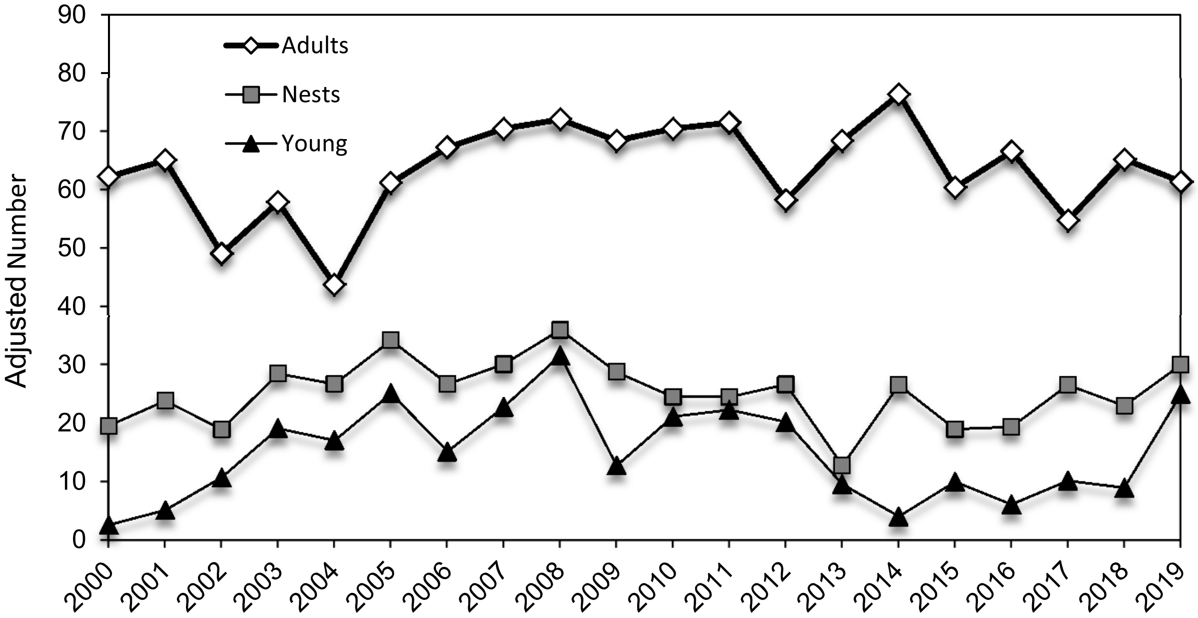

Figure 12. Annual numbers of Yellow-billed Loon adults and nests during the nesting survey and young during the brood-rearing survey, Colville Delta study area, Alaska, 2000–2019.

recent years (Johnson et al. 2019a). In the most recent decade (2010–2019), the growth rate in the number of nests was positive (ln(nests) = 0.013(year) – 22.7, $R^2 = 0.02$, $P = 0.67$), whereas the number of young declined 5% over that period (ln(young) = –0.05(year) + 114,5, $R^2 = 0.08$, $P = 0.44$). Neither trend, however, was significantly different from equilibrium.

Nest occupancy, brood occupancy, and chick production were all well above average during 2019, which contrasts with the previous 6 years of below average brood occupancy and chick production. Reduced nest and/or brood survival appeared to be the primary causes of declines in production of young during those years. Despite signs of possible 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 = 78.5 ± 1.7%, range = 66–96%, *n* = 20 years); however, not all adults that are present during June attempt to breed. Although nest occupancy is much lower and more variable (mean = 51.6 ± 2.5%, range = 26–73%, *n* = 20 years) than adult occupancy, nest occupancy during the last 10 years has generally remained near or above the mean. The declining trend in the number of young appears to be slowing and increasing somewhat from the low numbers observed between 2014 and 2018 (Figure 12).

HABITAT USE

Yellow-billed Loons nested in 12 of 24 available habitats during nesting surveys conducted in the Colville Delta study area over 25 years (Table 6). Six habitats, supporting 464 of 567 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, and Patterned Wet Meadow). Within these habitats, nearly half (48%, *n* = 553 nests) of the nests were built on islands but loons also built nests on peninsulas (24%), shorelines (25%), and in emergent vegetation (3%). Nests on shorelines of lakes or large islands (>0.5 ha) were assigned to the terrestrial habitat on the lakeshore, whereas nests on small islands or in small patches of emergent vegetation ≤5 ha in size were assigned to the habitat of the lake. Patterned Wet Meadow was the habitat used most frequently for nesting (34% of all nests), and it also was the most abundant habitat on the delta (24% of the loon survey area;

Table 6. Habitat selection by nesting (1993, 1995–1998, and 2000–2019) and brood-rearing (1995–1998 and 2000–2019) 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	47	8.3	5.3	prefer	
Salt Marsh	3	0.5	2.6	avoid	
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	63	11.1	4.7	prefer	
Deep Open Water with Islands or Polygonized Margins	146	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	8.7	avoid	
Sedge Marsh	5	0.9	0.0	prefer	low
Deep Polygon Complex	25	4.4	3.0	ns	
Grass Marsh	10	1.8	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	64	11.3	8.8	ns	
Patterned Wet Meadow	193	34.0	24.2	prefer	
Moist Sedge-Shrub Meadow	6	1.1	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	avoid	
Tall, Low, or Dwarf Shrub	3	0.5	6.6	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.1	ns	low
Total	567	100	100		
BROOD-REARING					
Open Nearshore Water	0	0.0	2.0	avoid	
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	56	21.8	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	116	45.1	4.7	prefer	
Deep Open Water with Islands or Polygonized Margins	83	32.3	2.7	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

Table 6. Continued.

SEASON Habitat type	No. of Nests or Broods	Use (%)[b]	Availability (%)	Monte Carlo Results[c]	Sample Size[d]
River or Stream	0	0.0	8.7	avoid	
Sedge Marsh	0	0.0	0.0	ns	low
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	<0.1	ns	low
Old Basin Wetland Complex	0	0.0	<0.1	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	257	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.

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 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 (257 broods over 24 years) were found in 5 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. 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 49 territories (excluding 1 territory that is no longer suitable for breeding; see above) in the Colville Delta study area. Thirty-five territories are comprised of a single lake used for both nesting and brood-rearing, 11 territories are composed of 2 adjacent lakes, 2 are composed of 3 adjacent lakes, and 1 is composed of 4 lakes. Lakes used by nesting and brood-rearing Yellow-billed Loons averaged 53.2 ± 12.3 ha in size (range 0.03–508.2 ha, $n = 56$ lakes). The smallest lake was used once and only for nesting. Its shoreline was ~10 m from the lake used for brood-rearing. The largest lake supports 4 Yellow-billed Loon territories. The majority of lakes were used for both nesting and brood-rearing; the smallest of those lakes was 4.8 ha.

NEST FATE

During the brood-rearing survey in 2019, 21 of 32 Yellow-billed Loon nests (including 2 nests that were inferred from the presence of broods) found during the nest survey had a brood. Because the absence of a brood does not always indicate nest failure, 10 of the remaining 11 nests without broods were visited on the ground to determine nest fate; 1 nest was on an island in water that was too deep for wading and too small to access by helicopter. Three of the 10 nests contained >20 egg fragments (range 35–75 fragments), indicating that at least 1 egg hatched. Nine nests lacked evidence of hatch and contained no egg remains. We were unable to determine nest fate at the remaining nest because the nest has been destroyed by wave action. Overall, we determined that in addition to the 21 nests that had broods during the brood-rearing survey, 3 nests had broods that did not survive, resulting in 24 successful nests in 2019.

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 2015–2019, 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 nests determined from single nest surveys and hatching determined from nest fate data and the presence of broods, 22 of 30 nests hatched in 2019 for an apparent nesting success of 73%. This estimate was well above the 15-year mean (52.7 ± 3.9%) and was the second-highest estimate of nest success observed since 2005.

GLAUCOUS GULL

DISTRIBUTION AND ABUNDANCE

Including both systematic and incidental observations, we recorded 74 Glaucous Gull nests during the aerial survey for nesting loons during 2019; 39 of those nests were in the CD North subarea, 31 nests in the CD South subarea, and 4 nest in the Northeast Delta subarea (Figure 13). Forty-seven (64%) nests were found at colonies. We have identified 8 Glaucous Gull colonies in the Colville Delta study area since 2005, the first year gulls were systematically incorporated into surveys. Five colonies are located in the CD North subarea, 2 are in the CD South subarea, and 1 is in the Northeast Delta subarea. All 8 colonies were active in 2019. The CD-4 Northeast Colony is the largest Glaucous Gull colony in the Colville Delta study area and is located ~6 km northeast of the CD-4 drill site. This colony contained 20 nests in 2019, which was above the 18-year mean (16.8 ± 0.9 nests/year, range 6–23 nests).

Glaucous Gull nests have been recorded systematically during Yellow-billed Loon surveys in 50 index lakes in the Colville Delta study area since 2005 (Appendix A). Five of the 8 colonies are located in an index lake. Over the last 15 years, the number of Glaucous Gull nests has increased at these index lakes (Figure 14, Table 7). The annual growth rate for nest numbers on the index lakes was ~4% (ln(nests) = 0.035 (year) – 66.96, R^2 = 0.51, P = <0.01). In 2019, 54 nests occupied 18 of the 50 index lakes (range 35–70 nests, n = 15 years). The Glaucous Gull nest count in 2019 was near the 15-year average of 51.9 ± 2.8 nests (Table 7).

Including both systematic and incidental observations, 46 Glaucous Gull chicks were recorded in the Colville Delta study area during the 2019 survey for brood-rearing loons (Figure 13). Broods were present at 5 of the 8 colonies and accounted for the majority (72%) of the chicks (33) seen during 2019. Most young gulls seen during the survey appeared to be flight capable or had already attained juvenal plumage.

HABITAT USE

Glaucous Gull nests and colonies were found in 10 different habitats in the Colville Delta loon survey areas (Table 8). The 2 most commonly used habitats were Deep Open Water with Islands or Polygonized Margins (42% of nests) and Patterned Wet Meadow (28%) included colonies as well as single nesting gulls. The single nests were found on islands or complex shorelines in 6 other habitats.

BROOD-REARING GEESE

BRANT

Distribution and Abundance

Brant production in the Colville Delta study area, as measured by numbers of adults and young on brood surveys, was high in 2019. During the aerial survey for brood-rearing geese, we counted 5,210 Brant (2,880 adults and 2,330 young) in 44

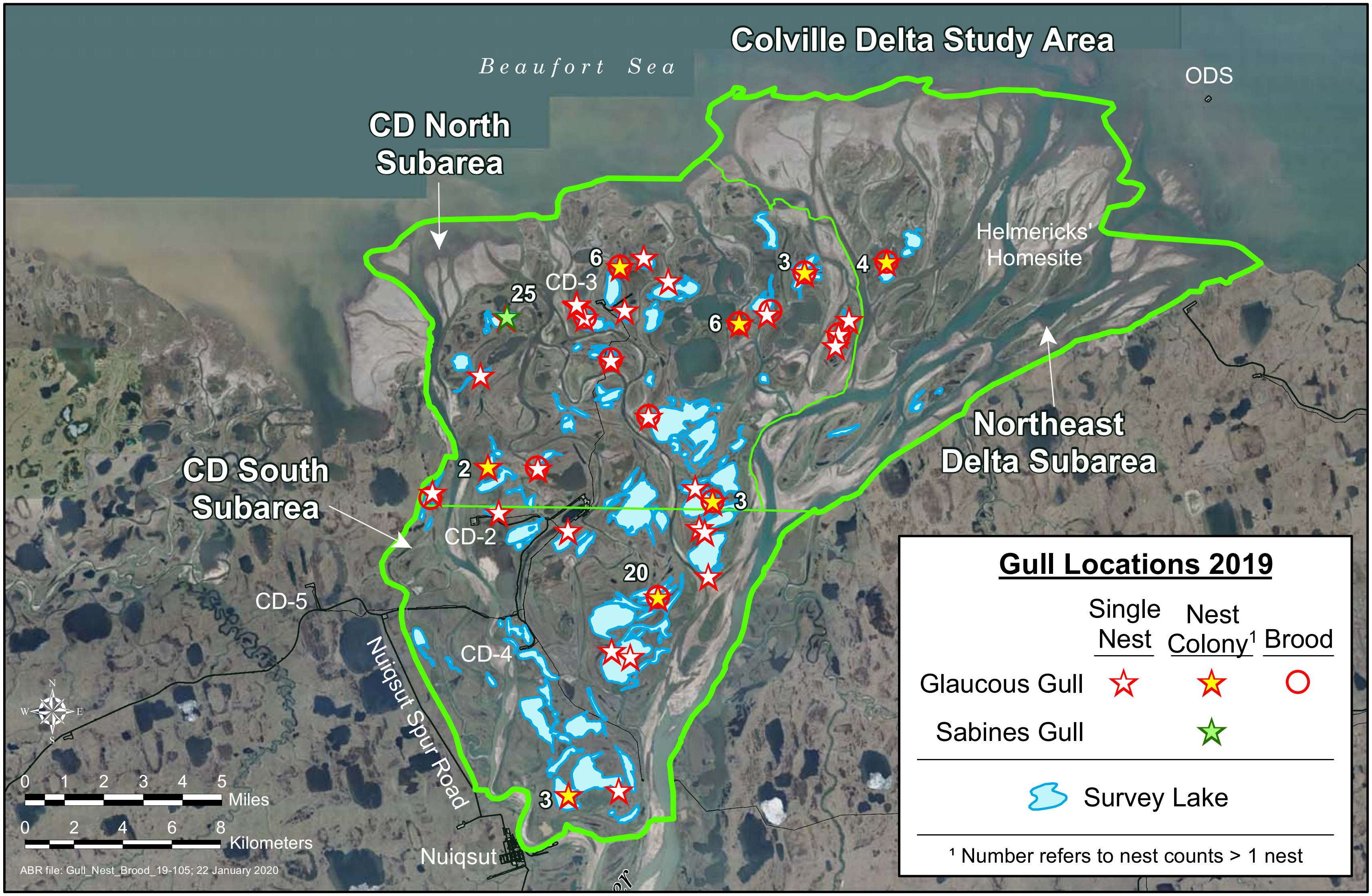

Figure 13. Glaucous Gull nest and brood locations, Colville Delta study area, Alaska, 2019.

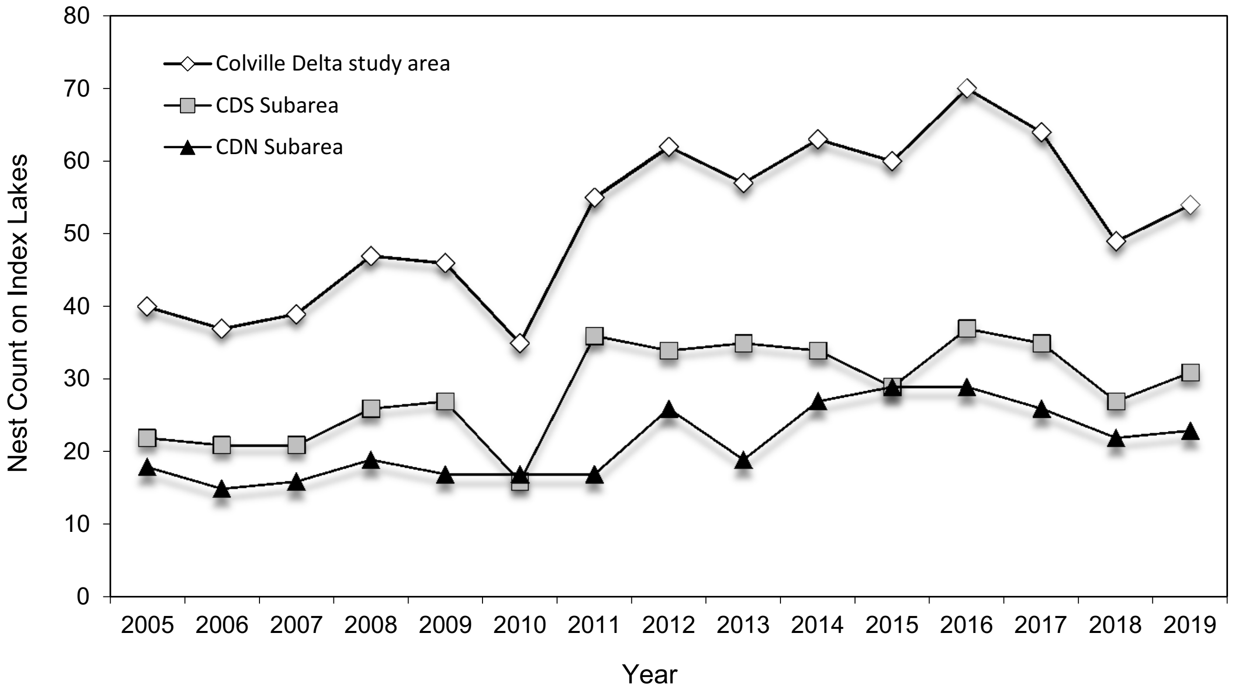

Figure 14. Annual number of Glaucous Gull nests recorded during aerial loon surveys on 50 index lakes, Colville Delta study area, Alaska, 2005–2019.

locations in the Colville Delta study area (Figure 15, Table 9). All Brant groups included broods (except for a single adult Brant in a Snow Goose brood group), and goslings comprised 45% of the total number of birds. Surveys producing comparable data on the total number of Brant (adults + goslings) have been conducted in the area as far back as 1989 (Bayha et al. 1992, Johnson et al. 2015, Obritschkewitsch 2018) and the total count in 2019 was well above the 23-year mean of combined adults and goslings (1,888 ± 339 [mean ± SE]) (Table 9). Adults were enumerated separately from goslings in 21 years, and the total count of adult Brant in 2019 was the second-highest on record. The percentage of goslings in 2019 was near average, but the total count of goslings was the second-highest in the 20 years that goslings were recorded (Table 9). Seven groups containing 1,340 Brant (739 adults and 601 goslings) were located in the Northeast Delta subarea, and 37 groups totaling 3,870 Brant (2,141 adults and 1,729 goslings) were located in the CD North subarea. An additional 16 groups (628 adults and 583 young) were found in the Kuparuk study area immediately east of the delta; and 4 groups (64 adults and 63 young) were found in the Alpine West subarea of the NE NPR-A study area, just west of the Colville River delta (Figure 15).

Brant distribution during the brood-rearing period in 2019 resembled the cumulative distribution since 2005 (Figure 15). The largest concentrations of brood-rearing birds were found on the outer delta across much of the CD North subarea, on the west side of the Northeast Delta subarea, and to a lesser extent along the Kuparuk coastline just east of the Colville River delta. Consistent with results since 2005, very few molting adults without goslings were found in the Colville Delta study area in 2019.

The number of adult Brant present in the Colville Delta study area during the brood-rearing period is not a reliable measure of the size of the local breeding population. Failed breeders typically depart the Colville River delta prior to the brood-rearing period and molt in other areas on the ACP, including the large molting area northeast of Teshekpuk Lake (Lewis et al. 2009). Additionally, some successful breeders from the Colville River delta rear their broods on coastal salt marshes outside the delta, at least as far east as Kavearak

Table 7. Number of Glaucous Gull nests recorded on 50 index lakes and associated nesting colonies, Colville Delta study area, Alaska, 2002–2019.

	CD North Subarea				CD South Subarea			Northeast Delta Subarea		
Year	Butterfly Lake Colony	CD3 North Colony	Alpine East Colony	All Nests[a]	Alpine South Colony	CD South Colony	All Nests[a]	All Nests[a]	Study Area Total	No. of Lakes with Nests[b]
2002[c]	2	1	1	11	18	1	24	1	36	15
2003[c]	1	1	2	11	14	0	17	0	28	14
2004[c]	7	1	2	19	13	0	17	0	36	16
2005	5	1	2	18	15	1	22	0	40	19
2006	4	1	1	15	16	0	21	1	37	19
2007	5	1	1	16	13	2	21	2	39	19
2008	5	1	2	19	18	2	26	2	47	22
2009	6	1	1	17	19	1	27	2	46	21
2010	5	2	1	17	6	2	16	2	35	21
2011	5	2	0	17	17	4	36	2	55	24
2012	7	5	1	26	17	1	34	2	62	28
2013	5	4	1	19	23	0	35	3	57	22
2014	6	5	1	27	18	3	34	2	63	27
2015	6	5	1	29	15	4	29	2	60	27
2016	7	5	2	29	20	4	37	4	70	26
2017	7	6	2	26	23	4	35	3	64	19
2018	6	4	3	22	17	2	27	0	49	17
2019	3	6	3	23	20	3	31	0	54	18
Mean	5.5	3.3	1.5	21.3	17.1	2.2	28.7	1.8	51.9	21.9
SE	0.3	0.5	0.2	1.3	1.1	0.4	1.7	0.3	2.8	0.9

[a] Nest count at colonies plus counts of gulls nesting individually or in groups of < 3 gulls.

[b] 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.

[c] Includes nests from avian ground nest searches and other aerial surveys because data were collected prior to standardizing data collection during loon surveys; excluded from calculation of overall mean.

Table 8. Habitat use by nesting Glaucous Gulls, Colville Delta study area, Alaska, 2019.

Habitat type	Nests	Use (%)
Tapped Lake with High-water Connection	5	6.8
Salt Marsh	1	1.4
Deep Open Water without Islands	1	1.4
Deep Open Water with Islands or Polygonized Margins	31	41.9
Deep Polygon Complex	4	5.4
Grass Marsh	7	9.5
Nonpatterned Wet Meadow	2	2.7
Patterned Wet Meadow	21	28.4
Moist Sedge-Shrub Meadow	1	1.4
Barrens	1	1.4
Total	74	100

Point in the Kuparuk Oilfield (Sedinger and Stickney 2000) and likely to the west in the adjacent Fish Creek delta. Although small Brant colonies are found in the Kuparuk Oilfield (Stickney and Ritchie 1996), it is likely that many Brant broods present on the mainland east of the Colville River during our survey originated on islands in the eastern Colville River delta. Since 1998, the number of adults on the delta during the brood-rearing period has increased at a rate of 10.7% annually (ln(adults) = 0.107 (year) – 208.2, $R^2 = 0.37$, $P = 0.004$). Numbers vary widely from year to year, probably due to variation in nesting effort, departure of failed breeders from the Colville River delta, and variable movements of broods out of the Colville Delta study area prior to our survey.

Habitat Use

Brant broods primarily occupied coastal salt-affected habitats in the Colville Delta study area in 2019 (Table 10). Most groups (40 of 44) were distributed among 6 salt-affected habitats: Brackish Water (16 groups), Salt Marsh (11 groups), Salt-killed Tundra (6 groups), Tapped Lake with Low-water Connection (3 groups), Tidal Flat Barrens (3 groups), and Open Nearshore Water (1 group). In general, Brant in low Arctic colonies typically rear their broods in salt marsh habitats within about 1 km of tidal areas (Sedinger and Flint 1991, Stickney and Ritchie 1996).

SNOW GOOSE

Distribution and Abundance

Snow Goose adults and goslings were found in record numbers in the Colville River delta in 2019. A total of 45,209 Snow Geese (21,556 adults and 23,653 goslings) were counted in 474 groups in the Colville Delta study area (Figure 16, Table 11). The number of adult birds was 64% higher than the next-highest year (13,135 in 2018), and the number of goslings was 121% higher (10,679 in 2018). All but 6 groups contained broods, and goslings comprised 52% of the total number of birds counted. A total of 151 groups containing 21,144 Snow Geese (9,871 adults and 11,273 goslings) were found in the Northeast Delta subarea, and 323 groups totaling 24,065 Snow Geese (11,685 adults and 12,380 goslings) were found in the CD North subarea. An additional 51 groups (1,853 adults and 1,552 young) were found in the Kuparuk study area immediately east of the delta; and 15 groups (211 adults and 272 young) were found in the Alpine West subarea of the NPR-A study area, just west of the Colville River delta (Figure 16).

Snow Goose numbers in the Colville Delta study area have increased dramatically over the past 15 years, from fewer than 1,000 geese (adults + goslings) in 2005 to over 45,000 geese in 2019 (Table 11). The number of adult Snow Geese on the delta during the brood-rearing period has increased at a rate of 27.5% annually since 2005

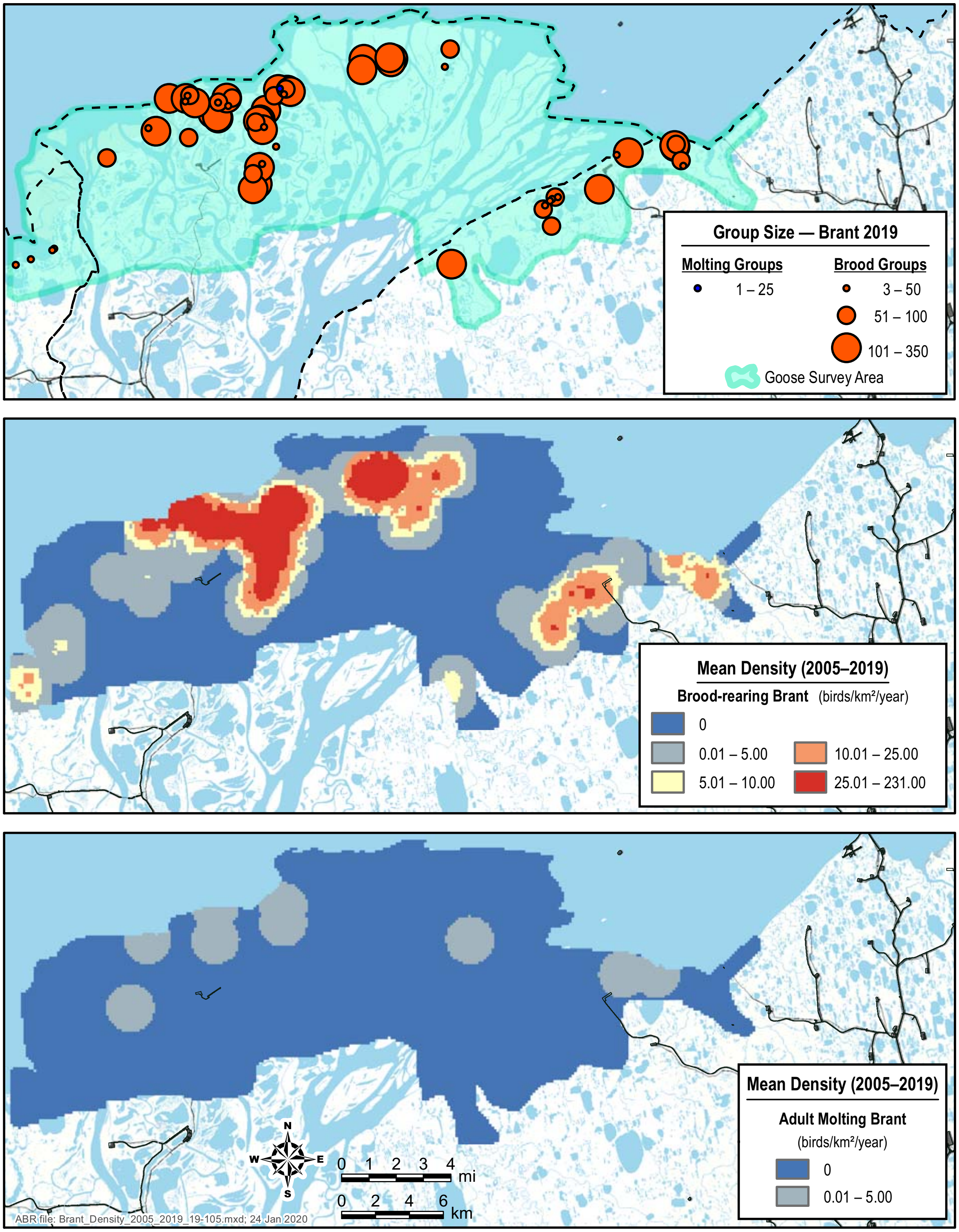

Figure 15. Brant brood-rearing and molting locations in 2019 (top) and mean density distribution in the Colville Delta, western Kuparuk, and eastern NE NPR-A study areas, Alaska, 2005–2019 (middle and bottom).

Table 9. Number of Brant adults and goslings during aerial surveys, Colville Delta study area, Alaska, 1988–2019.

Year	Total Birds	Adults	Goslings	% Goslings	No. Groups	Survey Date(s)
1988[a]	no data[b]	173[b]	no data[b]	no data[b]	no data	25, 26 July
1989[a]	197[c,d]	no data[c,d]	no data[c,d]	no data[c,d]	no data	12, 13 August
1990[a]	628[c]	no data[c]	no data[c]	no data[c]	no data	2, 9 August
1991[a]	460[c,d]	no data[c,d]	no data[c,d]	no data[c,d]	no data	1, 7 August
1992	0	0	0	-	0	27 July
1993	720	347	373	51	5	27 July
1995	1,480	768	712	48	6	4 August
1996	993	478	515	52	7	25 July
1998	1,974	836	1,138	58	13	27 July
2005	3,847	2,360	1,487	39	16	30 July
2006	438	296	142	32	4	29 July
2007	980	446	534	54	6	30 July
2008	3,637	1,839	1,798	49	22	29 July
2009	679	501	178	26	6	29 July
2010	1,474	746	728	49	11	28 July
2011	1,986	1,221	765	39	10	28 July
2012	1,145	776	369	32	7	26 July
2013	795	439	356	45	9	26 July
2014	2,067	1,049	1,018	49	13	31 July
2015	2,614	1,215	1,399	54	17	30 July
2016	1,992	1,007	985	49	17	25 July
2017	5,775	2,950	2,825	49	41	22–23 July
2018	4,332	2,606	1,726	40	35	30–31 July
2019	5,210	2,880	2,330	45	44	25–27 July
Mean	1,888	1,092	969	45.3	14.5	
SE	339	197	170	1.9	2.7	

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

Table 10. Habitat use by brood-rearing/molting Brant and Snow Geese, Colville Delta study area, Alaska, 2019.

Habitat	Brant		Snow Geese	
	No. of Groups	Use (%)	No. of Groups	Use (%)
Open Nearshore Water	1	2.3	2	0.4
Brackish Water	16	36.4	48	10.1
Tapped Lake with Low-water Connection	3	6.8	26	5.5
Tapped Lake with High-water Connection	0	0	13	2.7
Salt Marsh	11	25.0	34	7.2
Tidal Flat Barrens	3	6.8	19	4.0
Salt-killed Tundra	6	13.6	63	13.3
Deep Open Water without Islands	0	0	27	5.7
Deep Open Water with Islands or Polygonized Margins	0	0	31	6.5
Shallow Open Water without Islands	0	0	2	0.4
Shallow Open Water with Islands or Polygonized Margins	0	0	4	0.8
River or Stream	2	4.5	34	7.2
Deep Polygon Complex	2	4.5	21	4.4
Nonpatterned Wet Meadow	0	0	35	7.4
Patterned Wet Meadow	0	0	74	15.6
Moist Sedge-Shrub Meadow	0	0	12	2.5
Moist Tussock Tundra	0	0	5	1.1
Tall, Low, or Dwarf Shrub	0	0	2	0.4
Barrens	0	0	22	4.6
Total	44	100	474	100

(ln(adults) = 0.275 (year) – 544.8, $R^2 = 0.92$, $P < 0.001$). Maximal 5-year mean densities have increased from 150 birds/km² during 2005–2009 to 465 birds/km² during 2015–2019 (Appendix L), reaching a single-year maximum of over 900 birds/km² in 2019 (Figure 13). Brood-rearing geese have expanded their range inland in the Kuparuk study area, west into the NPR-A study area, and several kilometers south in the Colville Delta study area during this period (Appendix L).

Snow Goose breeding populations have been expanding in North America since at least the 1960s (Kerbes 1983, Kerbes et al. 1983, McCormick and Poston 1988, Alisauskas and Boyd 1994) perhaps due to increased availability of agricultural resources in wintering areas (Davis et al. 1989). Snow Geese forage by grubbing for roots and rhizomes during spring prior to emergence of above-ground vegetation (Kerbes et al. 1990). This behavior, coupled with high fidelity to breeding areas (Ganter and Cooke 1998) has resulted in long-term degradation of some nesting areas and arctic coastal salt marshes used for brood-rearing (Kerbes et al. 1990, Ganter et al. 1995, Srivastava and Jefferies 1996). Over-population of breeding colonies has led to decreased growth and survival of goslings (Cooch et al. 1991, Gadallah and Jefferies 1995), and eventual dispersal of young breeders to higher quality breeding areas (Ganter and Cooke 1998).

Rapid growth of the Snow Goose colony on the Colville River delta has likely resulted from dispersal of breeding birds from heavily grazed colonies elsewhere in the Arctic. If numbers continue to grow on the Colville River delta, one might predict an eventual impact on local Brant populations due to degradation of salt marsh habitats used by both species during brood rearing. A 2012–2014 study found no differences in Brant gosling growth rates or forage biomass in the Colville River delta compared to measurements in the 1990s (Hupp et al. 2017); however, the Snow Goose population has grown substantially over the past 5 years.

Habitat Use

Snow Geese occupied both saline and freshwater habitats in the Colville Delta study area during the brood-rearing period in 2019 (Table 10). Fifty-nine percent of groups (282 of 474) were found in non-saline habitats: primarily wet meadows (109 groups, patterned and non-patterned meadows combined), deep-open water habitats (58 groups combined), and rivers or streams (34 groups). In salt-affected areas, Snow Geese were distributed among 6 different habitats, including Salt-killed Tundra (63 groups), Brackish Water (48 groups), Salt Marsh (34 groups), Tapped Lake with Low-water Connection (26 groups), Tidal Flat Barrens (19 groups), and Open Nearshore Water (2 groups).

When the Colville River delta colony was newly established and relatively small, most Snow Geese occupied saline habitats near the coast during the brood-rearing period. As densities increased in the late 2000s, broods and molting adults dispersed inland and into freshwater habitats. In 2014, 77% of Snow Goose groups were found in salt-affected habitats (Johnson et al. 2015), compared to only 41% in 2019. A similar expansion of Snow Geese from coastal to inland areas was documented on the Ikpikpuk River delta in Alaska over the past 2 decades (Burgess et al. 2019).

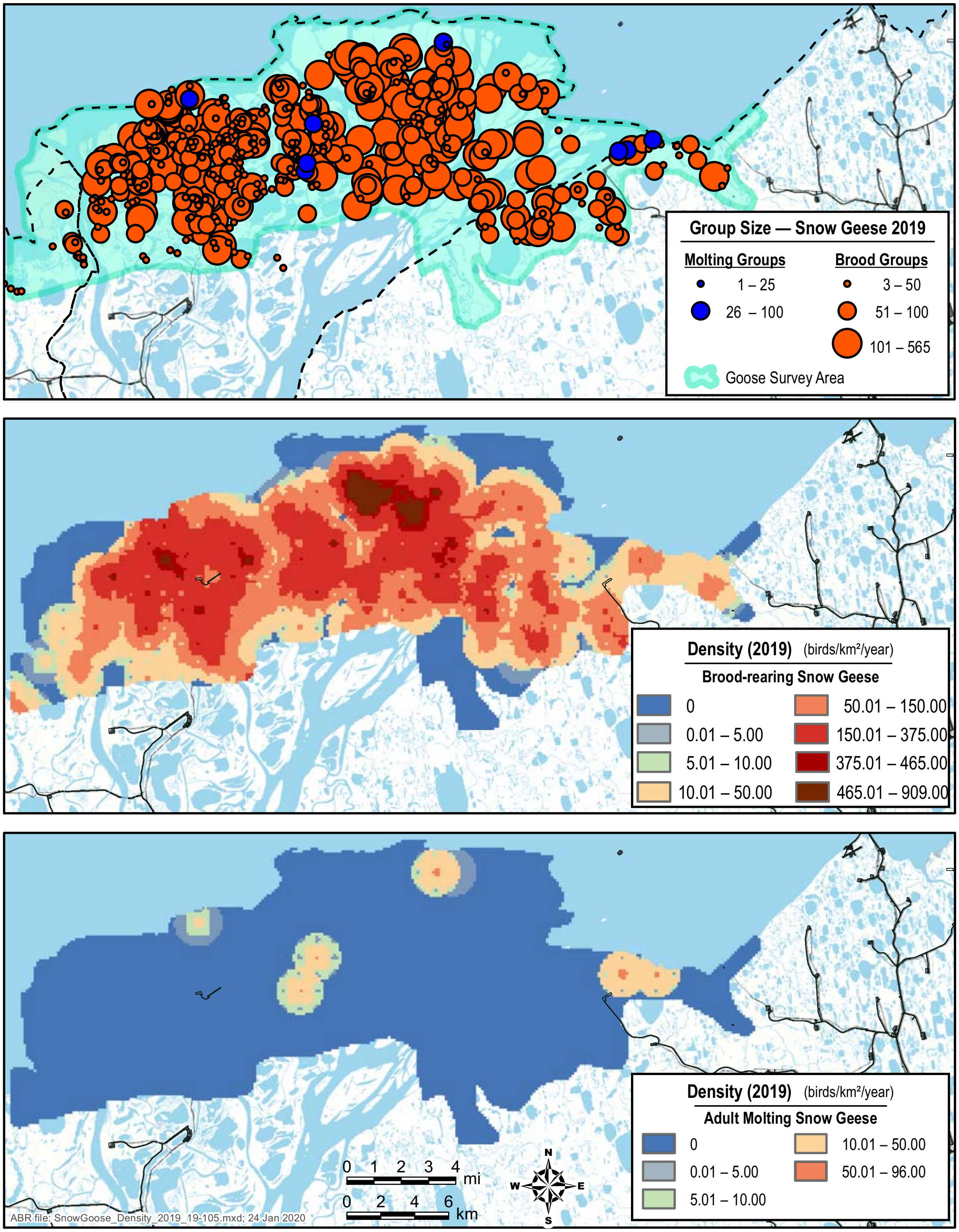

Figure 16. Snow Goose brood-rearing and molting locations (top) and density distribution (middle and bottom) in the Colville Delta, western Kuparuk, and eastern NE NPR-A study areas, Alaska, 2019.

Table 11. Number of Snow Goose adults and goslings during aerial surveys, Colville Delta study area, Alaska, 2005–2019.

Year	Total Birds	Adults	Goslings	% Goslings	No. Groups	Survey Date(s)
2005	972	412	560	58	11	30 July
2006	997	421	576	58	9	29 July
2007	1,154	596	558	48	13	30 July
2008	1,967	834	1,133	58	22	29 July
2009	678	463	215	32	15	29 July
2010	1,873	883	990	53	19	28 July
2011	4,023	1,745	2,278	57	36	28 July
2012	4,035	2,009	2,026	50	57	26 July
2013	2,454	1,568	886	36	31	26 July
2014	2,545	1,524	1,021	40	26	31 July
2015	11,557	4,593	6,964	60	101	30 July
2016	9,754	4,990	4,764	49	106	25 July
2017	19,624	8,951	10,673	54	169	22–23 July
2018	23,814	13,135	10,679	45	233	30–31 July
2019	45,209	21,556	23,653	52	474	25–27 July
Mean	8,710	4,245	4,465	50	88	
SE	3,194	1,554	1,653	2.2	32.4	

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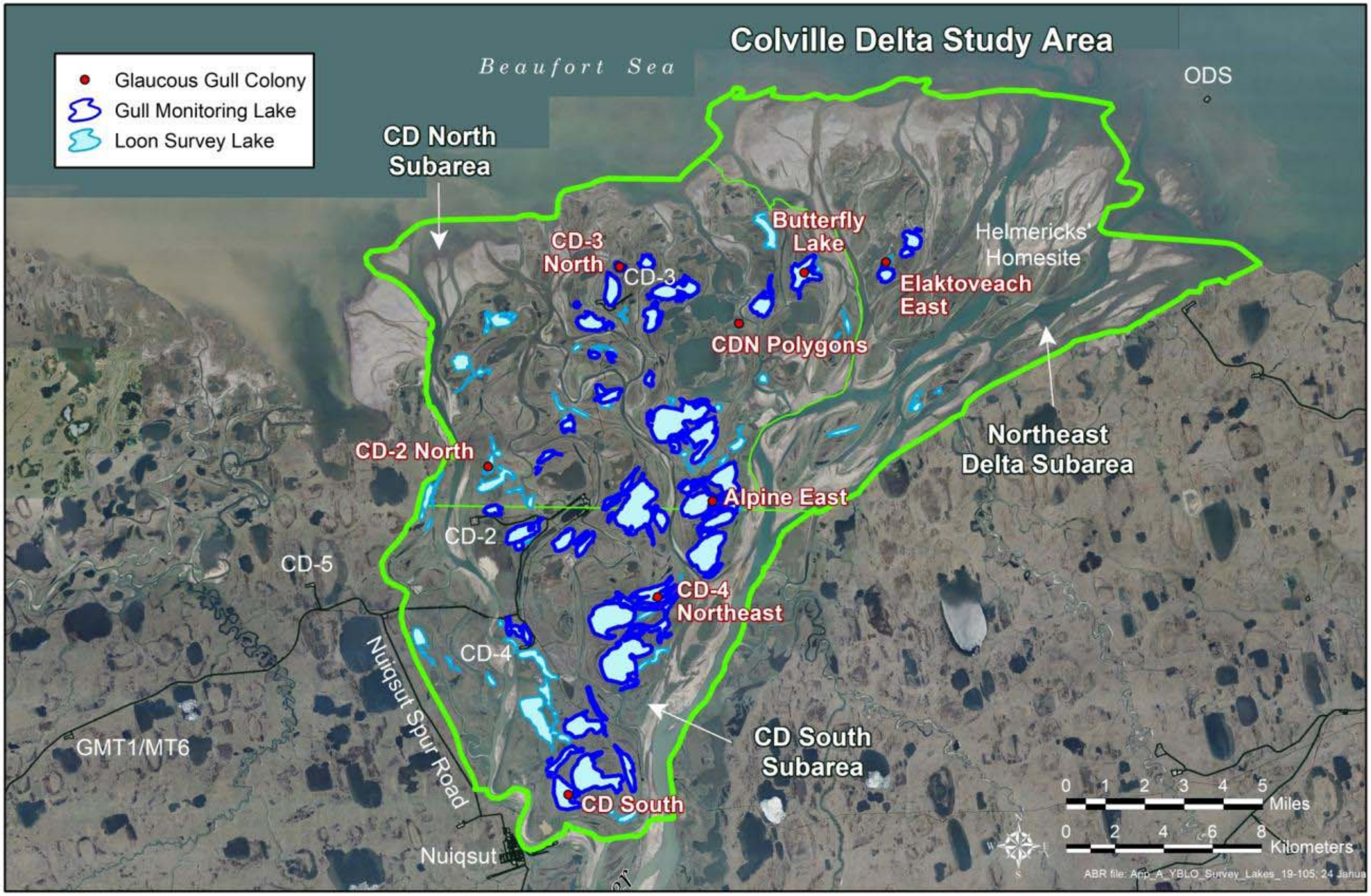
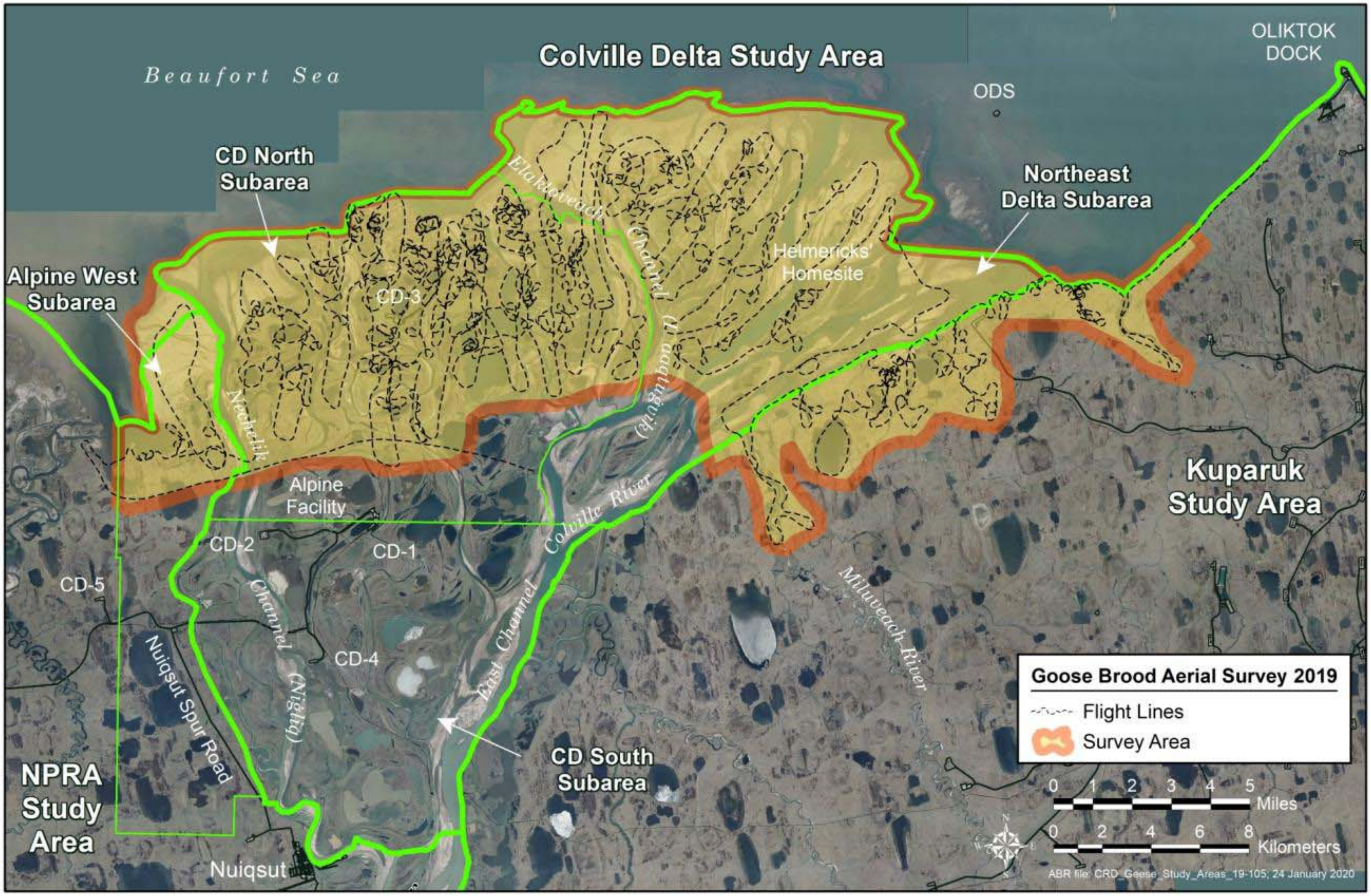


Appendix A. Lakes included in aerial surveys for Yellow-billed Loons, the 50 monitoring lakes systematically surveyed for Glaucous Gulls and gull colony locations, Colville Delta study area, Alaska, 2019.



Appendix B. Flight lines of aerial surveys for brood-rearing and molting Brant and Snow Geese in the Colville Delta, western Kuparuk, and eastern NE NPR-A study areas, Alaska, 2019.

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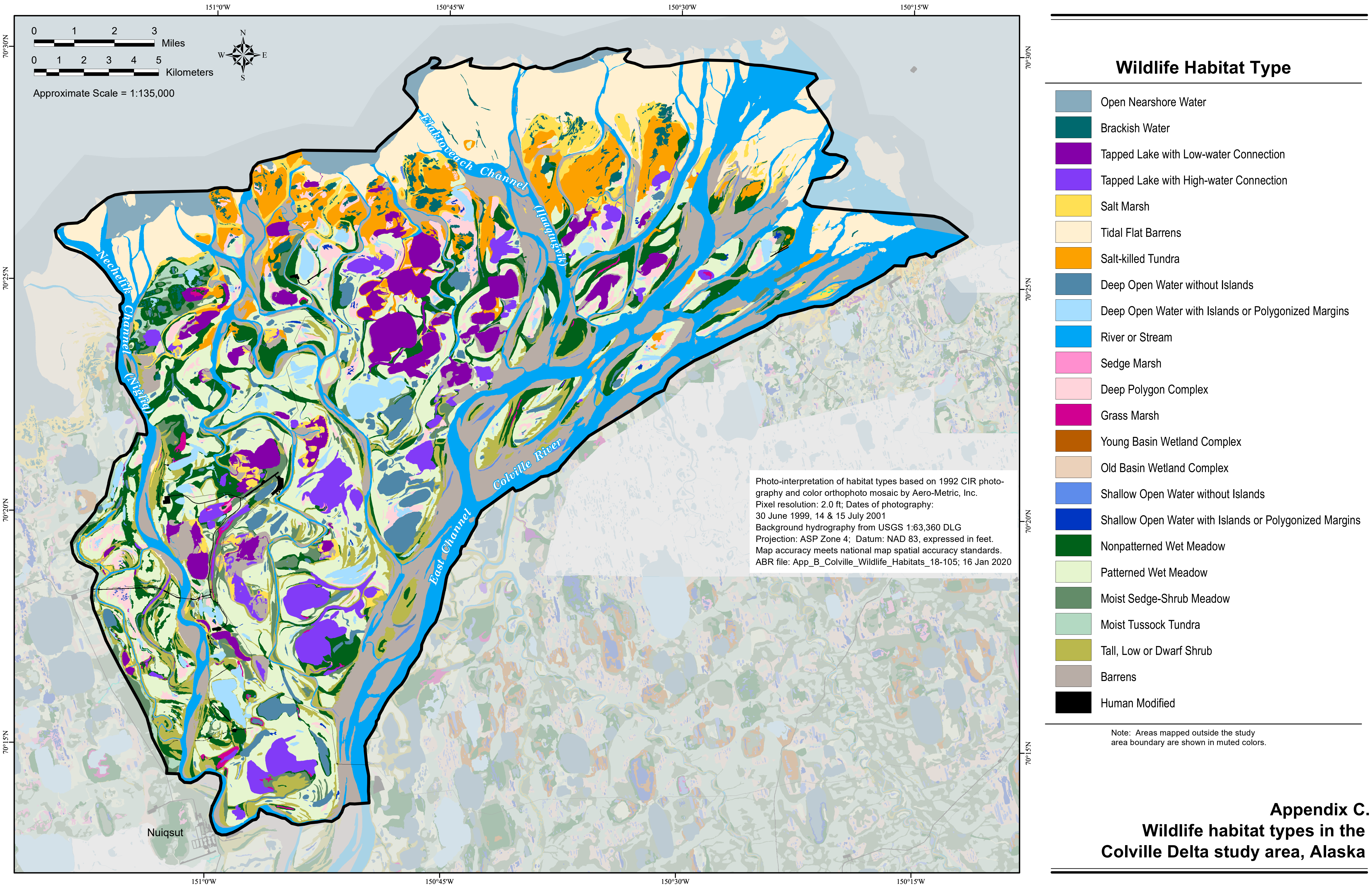

Photo-interpretation of habitat types based on 1992 CIR photography and color orthophoto mosaic by Aero-Metric, Inc.
Pixel resolution: 2.0 ft; Dates of photography:
30 June 1999, 14 & 15 July 2001
Background hydrography from USGS 1:63,360 DLG
Projection: ASP Zone 4; Datum: NAD 83, expressed in feet.
Map accuracy meets national map spatial accuracy standards.
ABR file: App_B_Colville_Wildlife_Habitats_18-105; 16 Jan 2020

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

Appendix C.
Wildlife habitat types in the Colville Delta study area, Alaska

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Appendix D. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2019.

SPECIES Subarea Location	Observed				Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
	Males	Females	Total	Pairs			
SPECTACLED EIDER							
CD North							
On ground	3	1	4	1	6	0.03	0.04
In flight	4	4	8	4	–	0.05	–
All birds	7	5	12	5	–	0.08	–
Northeast Delta							
On ground	3	1	4	1	6	0.03	0.04
In flight	4	4	8	4	–	0.05	–
All birds	7	5	12	5	–	0.08	–
CD South							
On ground	1	0	1	0	2	0.01	0.01
In flight	0	0	0	0	–	0.00	–
All birds	1	0	1	0	–	0.01	–
Total (subareas combined)							
On ground	37	7	44	7	74	0.09	0.15
In flight	8	4	12	4	–	0.02	–
All birds	45	11	56	11	–	0.11	–
KING EIDER							
CD North							
On ground	5	4	9	4	10	0.04	0.05
In flight	3	2	5	2	–	0.02	–
All birds	8	6	14	6	–	0.07	–
Northeast Delta							
On ground	51	32	83	17	87	0.53	0.55
In flight	9	4	13	4	–	0.08	–
All birds	60	36	96	21	–	0.61	–
CD South							
On ground	1	1	2	1	2	0.01	0.01
In flight	0	0	0	0	–	0.00	–
All birds	1	1	2	1	–	0.01	–
Total (subareas combined)							
On ground	57	37	94	22	99	0.19	0.20
In flight	12	6	18	6	–	0.04	–
All birds	69	43	112	28	–	0.22	–

[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 E. Number and density of loons and their nests, broods, and young during aerial surveys in the CD North, CD South, and Northeast Delta subareas, Colville Delta study area, Alaska, 2019.

STUDY AREA Subarea[b] Survey Type	Yellow-billed Loon					Pacific Loon[a]			Red-throated Loon[a]		
	Number			Density (number/km²)		Number			Number		
	Adults	Nests/ Brood	Young	Adults	Nests/ Broods	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
COLVILLE DELTA											
CD North											
Nesting	27	15[c]	–	0.13	0.07	75	30	–	3	0	–
Brood-rearing	40	13[d]	13	0.19	0.06	47	23	25	4	1	2
CD South											
Nesting	34	14[c]	–	0.22	0.09	39	10	–	3	0	–
Brood-rearing	37	9[e]	10	0.24	0.06	22	6	7	7	0	0
Northeast Delta[f]											
Nesting	3	3	–	–	–	7	3	–	0	0	–
Brood-rearing	6	2	2	–	–	1	1	1	0	0	0
Total (subareas combined)[g]											
Nesting	61	29	–	0.17	0.08	114	40	–	6	0	–
Brood-rearing	77	21	23	0.21	0.06	69	29	32	11	1	2

[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 9.

[c] Number includes 1 nest indicated by the presence of brood on lake where no nest was found.

[d] Number includes 1 brood determined only by eggshell evidence.

[e] Number includes 2 broods 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.

Appendix F. Annual density (number/km²) of Yellow-billed Loons, nests, and broods, Colville Delta study area, Alaska, 1993, 1995–1998, and 2000–2019.

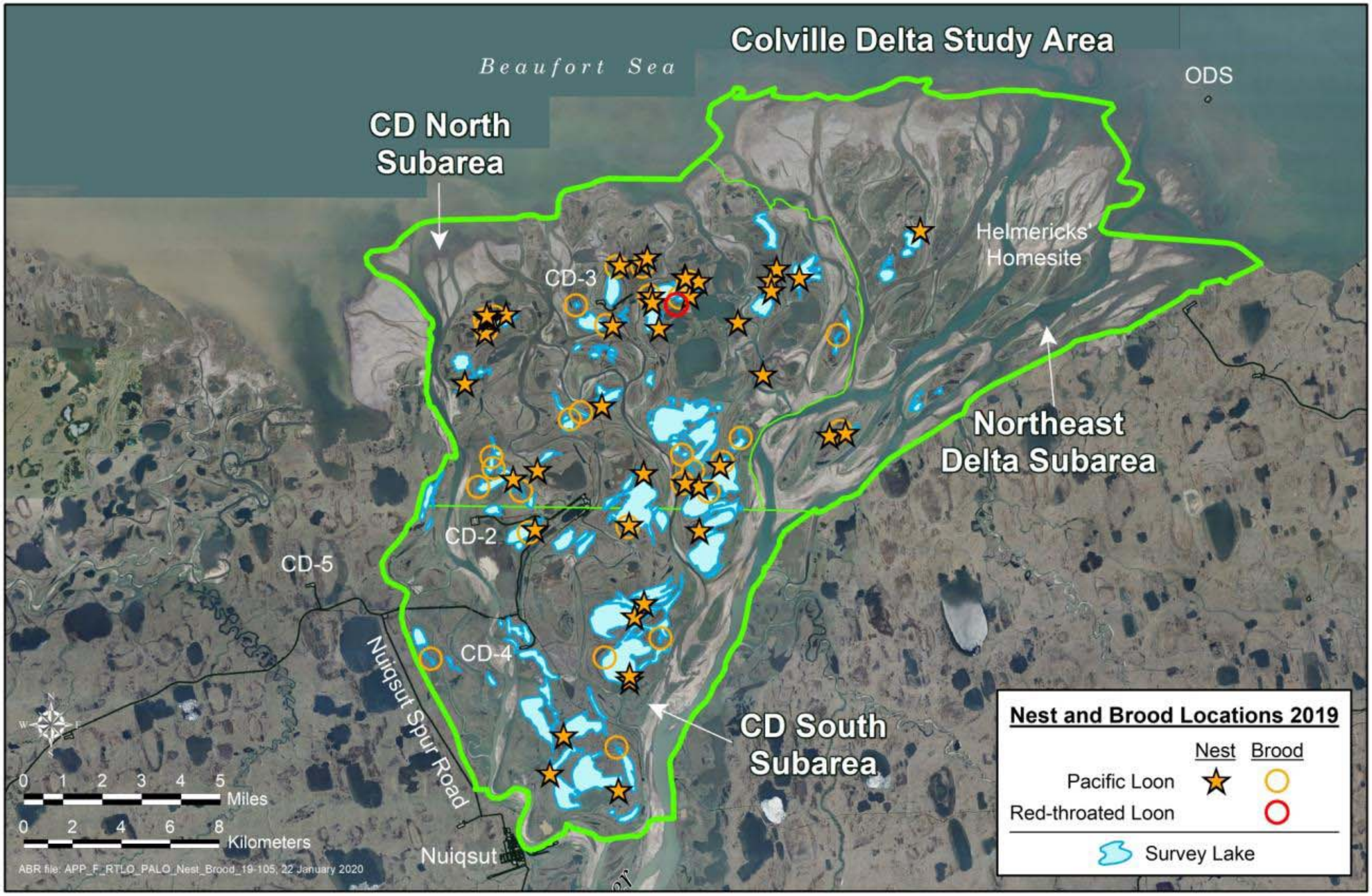
STUDY AREA Year	Nesting Survey Adults	Nests[a]	Brood-rearing Survey Adults	Broods[b]
COLVILLE DELTA[c]				
1993	0.14	0.02 (0.04)	0.08	0.02
1995	0.11	0.03 (0.05)	0.14	0.02
1996	0.12	0.03 (0.05)	0.17	0.02
1997	0.13	0.03 (0.04)	0.18	0.01
1998	0.09	0.04 (0.06)	0.14	0.03
2000	0.15	0.04 (0.04)	0.04	0.01
2001	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)
2019	0.17	0.07 (0.08)[d]	0.21	0.05 (0.06)
Mean	0.15	0.06	0.14	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 (1993–2019).

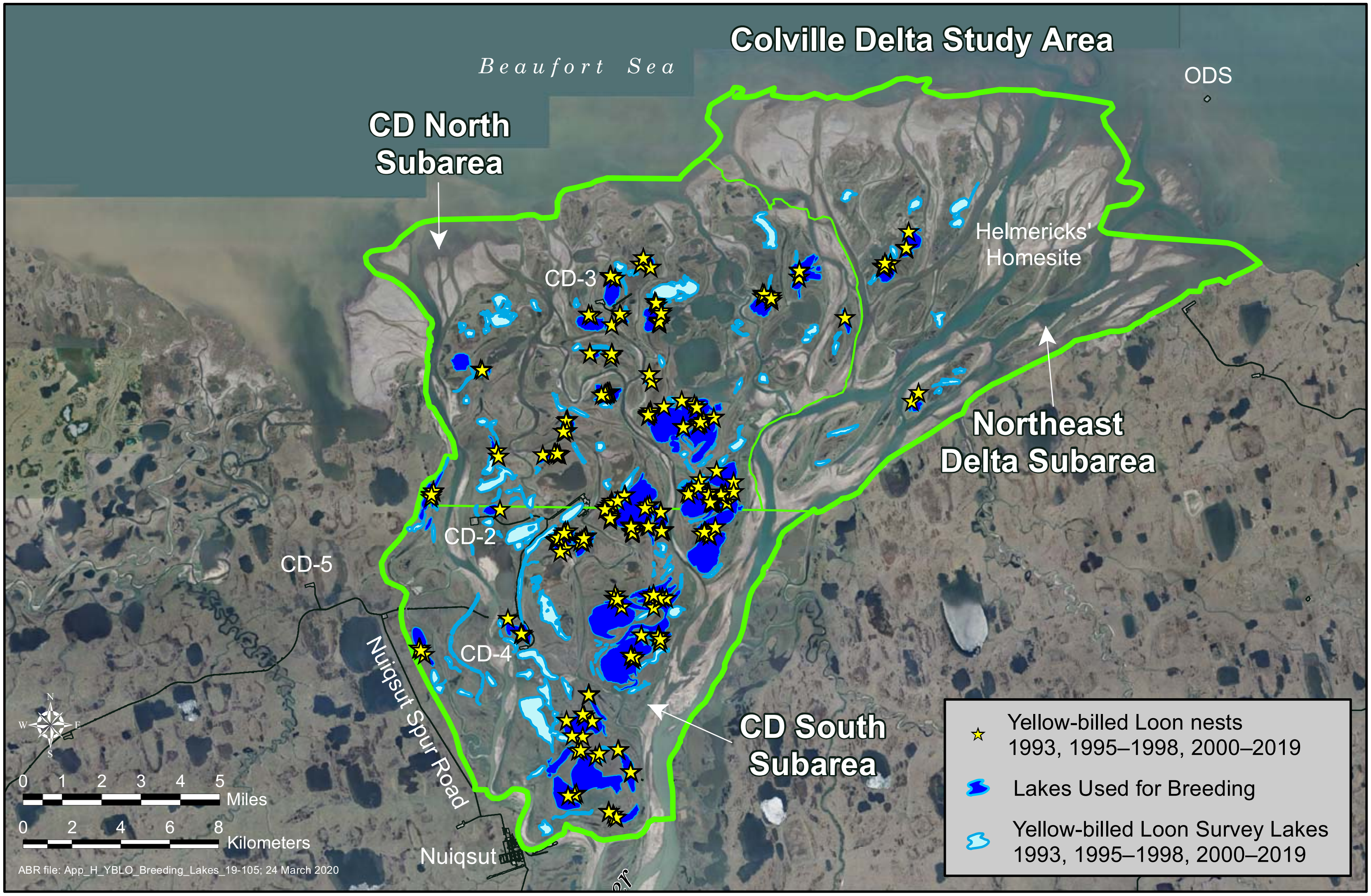
[b] Density of broods found on the brood-rearing survey and, in parentheses, cumulative density including additional broods foun during monitoring surveys (2005–2014) or inferred from eggshell fragments at the nest (2005–2019).

[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 G. Pacific Loon nests and broods and Red-throated Loon broods, Colville Delta study area, Alaska, 2019.



Appendix H. Lakes used by nesting and brood-rearing Yellow-billed Loons, Colville Delta study area, Alaska, 1993, 1995–1998, and 2000–2019.

Appendix I. Nest occupancy, brood occupancy, and distance from infrastructure at Yellow-billed Loon territories containing nests within 1,600 m (1 mile) of Alpine gravel infrastructure during the pre- and post-construction periods compared to occupancy across the Colville Delta study area, Alaska.

	Pre-Construction (1993, 1995–1997)				Post-Construction (1998, 2000–2019)				
Territory	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) to Infrastructure (m)[a]	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) Infrastructure (m)[a]	Infrastructure within 1,600 m[b]
15[c]	4	0	0	–	21	52.4	19.0	828 ± 71.0[c,d]	Airstrip, access road, CD-1 pad[c]
16[c]	4	50.0	50.0	834[c,e]	21	47.6	19.0	924 ± 29.6[c,e]	Airstrip, access road, CD-1 pad[c]
29	4	100	25.0	782 ± 80.6	21	61.9	14.3	916 ± 58.6	Airstrip, CD-1 pad
212	4	0	0	–	21[f]	4.8	4.8	419	CD-2 drill site, access road
Mean[g]	–	37.5	18.8	–	–	41.7	14.3	–	
SE[g]	–	23.9	12.0	–	–	12.6	3.3	–	
95% CI		46.8	23.5			24.7	6.5		
Territories Surveyed[g]		4	4	–		4	4	–	

Appendix I. Continued.

	Pre-Construction (1993, 1995–1997)				Post-Construction (1998, 2000–2019)				
Territory	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) to Infrastructure (m)[a]	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) Infrastructure (m)[a]	Infrastructure within 1,600 m[b]
Colville Delta Study Area[h]									
Mean[g]	–	45.2	18.1	–	–	51.7	24.3	–	
SE[g]	–	4.9	3.4	–	–	4.1	2.1	–	
95% CI	–	9.6	6.7			8.0	4.1		
Territories Surveyed[g]		42	41	–		37	37	–	

[a] Mean distance of nests to the closest gravel infrastructure associated with Alpine or the CD-4 development; nest distances during the pre-construction period were calculated from the post-construction infrastructure layer.

[b] Gravel infrastructure within 1,600 m of all nest sites at each territory; infrastructure included an airstrip, CD-1 pad (including a camp, drill site, and processing facility), CD-2 drill site, and access road.

[c] Territory also contained nest sites within 1,600 m of the CD-4 access road, which was constructed in 2005.

[d] All but 2 nests were closest to the CD-4 access road despite the proximity of Alpine.

[e] All nests were closest to the CD-1 pad despite the proximity of the CD-4 access road.

[f] Territory only surveyed for nests during 21 years but only surveyed for broods during 14 years; however, the territory was consistently occupied by nesting Pacific Loons so we assumed the territory was not occupied by a Yellow-billed Loon brood during those years.

[g] Overall mean and SE for pre-construction included territories that were surveyed during > 50% of the pre- construction years (4 years); post construction mean and SE calculated similarly for territories surveyed during 50% of post-construction years (21 years).

[h] Includes only territories with nests > 1,600 m from all gravel infrastructure in the Colville Delta study area.

Appendix J. Nest occupancy, brood occupancy, and distance from infrastructure at Yellow-billed Loon territories containing nests within 1,600 m (1 mile) of the CD-3 gravel infrastructure during the pre- and post-construction periods compared to occupancy across the Colville Delta study area, Alaska.

	Pre-Construction (1993, 1995–1998, 2000–2004)				Post-Construction (2005–2019)				
Territory	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) to Infrastructure (m)[a]	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) Infrastructure (m)[a]	Infrastructure within 1,600 m[b]
6	10	80.0	40.0	1,299 ± 89.8	15	86.7	26.7	1,482 ± 22.6	Airstrip
7	10	70.0	30.0	1,393 ± 40.2	15	33.3	20.0	1,290 ± 16.4	Airstrip
8	10	80.0	10.0	1,001 ± 16.1	15	60	40.0	1,025 ± 2.5	Airstrip, access road, drill site
9[c]	10	70.0	40.0	522 ± 4.2	5	80	80.0	530 ± 0	Airstrip, access road, drill site
47[d,e]	3	0	0	–	10	10	0	581	Airstrip, access road, drill site
49[d,f]	0	–	–	–	5	40	40.0	350 ± 54.6	Airstrip, access road, drill site
Mean[g]	–	75.0	30.0	–	–	47.5	21.7	–	
SE[g]	–	2.9	7.1	–	–	16.6	8.3	–	
95% CI		5.7	13.9			32.5	16.3		
Territories Surveyed[g]	–	4	4	–	–	4	4	–	

Appendix J. Continued.

	Pre-Construction (1993, 1995–1998, 2000–2004)				Post-Construction (2005–2019)				
Territory	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) to Infrastructure (m)[a]	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) Infrastructure (m)[a]	Infrastructure within 1,600 m[b]
Colville Delta Study Area[h]									
Mean[g]	–	48.4	21.4	–	–	53.4	26.3	–	
SE[g]	–	4.1	2.5	–	–	4.1	2.3	–	
95% CI		8.0	4.9			8.0	4.5		
Territories Surveyed[g]	–	39	39	–	–	38	38	–	

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[a] Mean distance of nests to the gravel infrastructure associated with CD-3 development; nest distances during the pre-construction period were calculated from the post-construction infrastructure layer.

[b] Gravel infrastructure within 1,600 m of all nest sites at each territory; infrastructure included an airstrip, drill site, and access road.

[c] Lake became unsuitable for breeding during fall 2009 when the lake drained into the Colville River.

[d] Territory not included consistently in surveys because lake size was <5 ha, the minimum lake size included in Yellow-billed Loon surveys;

[e] Territory was systematically surveyed beginning in 2010 because of its proximity to Territory 9, which drained the previous year.

[f] Territory was systematically surveyed from 2015 on after an incidental observation of an adult Yellow-billed Loon in the lake.

[g] Overall mean and SE for pre-construction included territories that were surveyed during > 50% of the pre- construction years (10 years); post construction mean and SE calculated similarly for territories surveyed during 50% of post-construction years (15 years).

[h] Includes only territories with nests > 1,600 m from all gravel infrastructure in the Colville Delta study area.

Appendix K. Nest occupancy, brood occupancy, and distance from infrastructure at Yellow-billed Loon territories containing nests within 1,600 m (1 mile) of the CD-4 gravel infrastructure during the pre- and post-construction periods compared to occupancy across the Colville Delta study area, Alaska.

	Pre-Construction (1993, 1995–1998, 2000–2004)				Post-Construction (2005–2019)				
Territory	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) to Infrastructure (m)[a]	Years Surveyed	Nest Occupancy (%)	Brood Occupancy (%)	Mean Nest Distance (± SE) Infrastructure (m)[a]	Infrastructure within 1,600 m[b]
15[c]	10	30.0	0	794 ± 142.4[c,d]	15	53.3	26.7	871 ± 81.5[c,e]	Access road[c]
16[c]	10	50.0	40.0	942 ± 36.3[c,f]	15	47.6	13.3	901 ± 39.6[c,f]	Access road[c]
17	9	55.6	22.2	283 ± 55.3	15	93.3	60.0	333 ± 2.4	Drill site, access road
Mean[g]	–	45.2	20.7	–	–	64.4	33.3	–	
SE[g]	–	7.8	11.6	–	–	14.6	13.9	–	
95% CI		15.3	22.7			28.6	27.2		
Territories Surveyed[g]		3	3	–		3	3	–	
Colville Delta Study Area[h]									
Mean[g]	–	48.0	22.8	–	–	52.9	25.6	–	
SE[g]	–	3.9	2.6	–	–	4.0	2.3	–	
95% CI		7.6	5.1			7.8	4.5		
Territories Surveyed[g]		41	41	–		39	39	–	

[a] Mean distance of nests to the closest gravel infrastructure associated with Alpine or the CD-4 development; nest distances during the pre-construction period were calculated from the post-construction infrastructure.

[b] Gravel infrastructure within 1,600 m of all nest sites at each territory; CD-4 infrastructure included a drill site and access road that departs from the Alpine airstrip.

[c] Territory also contained nests within 1,600 m of Alpine, which began construction in 1998;

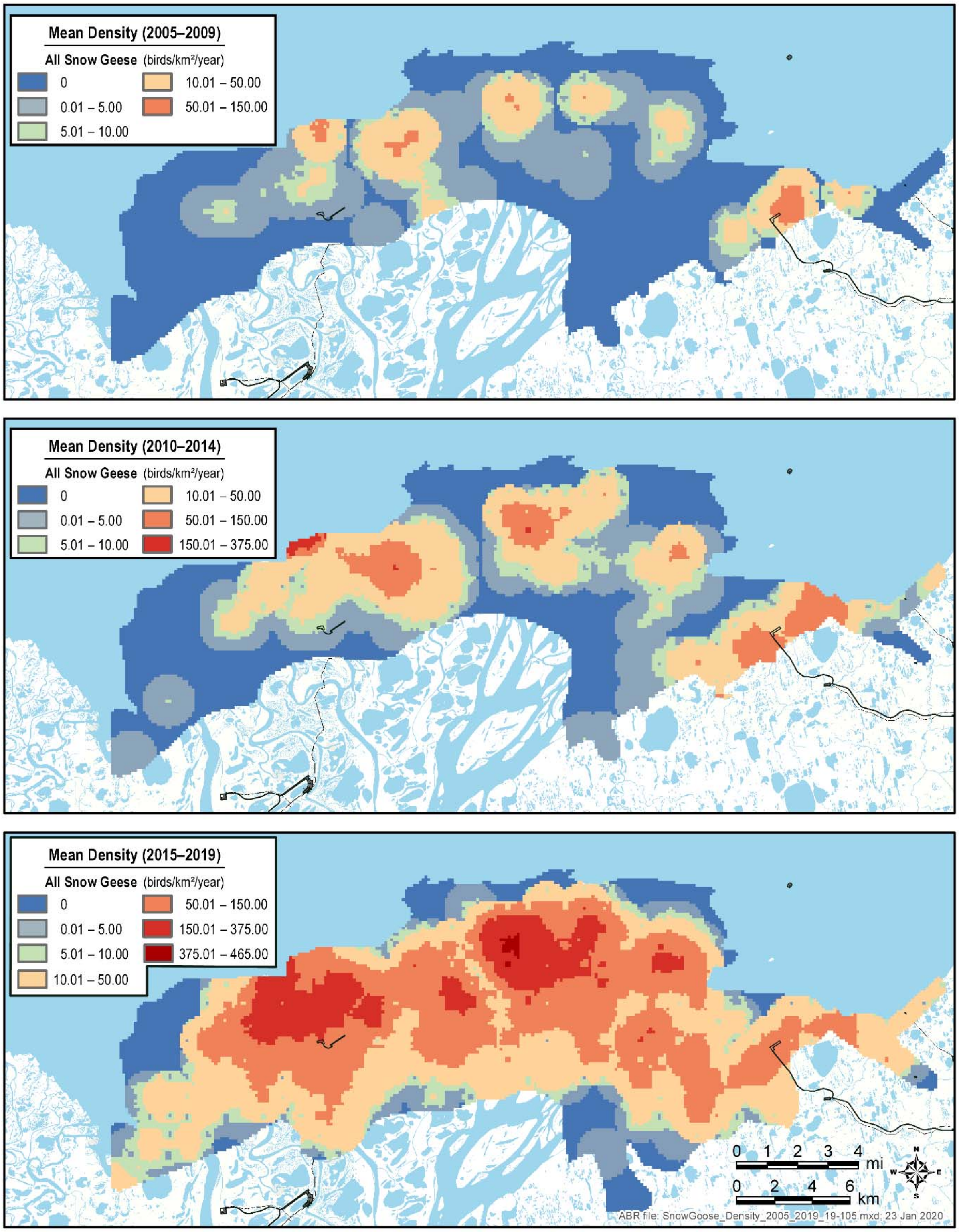
[d] All but 2 nests were closest to where the CD-4 road would eventually be placed despite the proximity of Alpine.

[e] All nests were closest to the CD-4 road despite the proximity of Alpine.

[f] All nests were closest to the CD-1 pad at Alpine despite the proximity of the CD-4 road.

[g] Overall mean and SE for pre-construction included territories that were surveyed during > 50% of the pre- construction years (10 years); post construction mean and SE calculated similarly for territories surveyed during 50% of post-construction years (15 years).

[h] Includes only territories with nests > 1,600 m from all gravel infrastructure in the Colville Delta study area.



Appendix L. Mean density of Snow Geese (brood-rearing and molting combined) in the Colville Delta, western Kuparuk, and eastern NE NPR-A study areas, Alaska, 2005–2009, 2010–2014, and 2015–2019.