# AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2020

## EIGHTEENTH ANNUAL REPORT

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Prepared for

**CONOCOPHILLIPS ALASKA, INC.**
Anchorage, Alaska

Prepared by

**ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES**
Fairbanks , Alaska

COVER
Aerial view of tundra during eider prenesting surveys in early June, 2020.
Photograph by ABR.

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## EXECUTIVE SUMMARY

- In 2020, ABR conducted aerial surveys for Spectacled Eiders (*Somateria fischeri*) and Yellow-billed Loons (*Gavia* adamsii) in the Colville Delta study area in support of the Alpine Satellite Development Project (ASDP). Glaucous Gull (*Larus hyperboreus*) nests and broods were recorded during loon surveys as an index of nest predators.

- Pre-nesting eider surveys were flown in June along pre-determined transect lines with a small, fixed-wing aircraft. Surveys for nesting loons conducted in June and for brood-rearing loons conducted in July were flown in a lake-to-lake pattern with a helicopter.

- Spring conditions in 2020 had above average snow depth through most of May, with rapid melt in late May that occurred almost a week earlier than the long-term mean recorded at Alpine. The Colville River experienced a short duration, high magnitude flood event due to ice jams in the Niġliq and East channels.

- We recorded 45 Spectacled Eiders and 36 indicated total Spectacled Eiders during the pre-nesting aerial survey, which was below the long-term average for the Colville Delta study area. Over the 27 years that ABR and others have monitored Spectacled Eiders on the Arctic Coastal Plain (ACP), their population trend has been stable.

- Pre-nesting Spectacled Eiders used 19 of 24 available habitats during 27 years of aerial surveys on the Colville Delta study area. There were 7 preferred habitats, 8 avoided habitats and 6 that were used in proportion to their availability.

- We recorded 129 observed and 108 indicated total King Eiders; these were the third highest counts of King Eiders recorded since surveys began in 1993. King Eiders on the Colville Delta study area have had an annual growth rate of 3.8% over the past 28 years.

- We found 31 Yellow-billed Loon nests and 51 adults during the Yellow-billed Loon nest survey in 2020. The total number of nests found on the nesting survey was well above the long-term mean whereas the count of adults was lower than the long-term mean. The proportion of territories occupied by nests (63%) during the nesting survey was well above the long-term mean, indicating that nesting effort was high in 2020.

- During the brood-rearing survey, 64 adult Yellow-billed Loons, 11 broods, and 14 young were seen in the Colville Delta study area. Eggshell evidence collected at inactive nests indicated that an additional 4 nests hatched, resulting in a total of 15 broods. Despite the high nesting effort, the proportion of territories occupied by a brood (31%) was slightly below the long-term mean, as was the fledging rate of 0.45 chicks/nest. Poor hatching success, as opposed to low nesting effort or low chick survival, appeared to be the primary cause of the low fledging rate in 2020.

- Over the past 12 years, the adult population of nesting Yellow-billed Loons has decreased 2.5% annually. The numbers of nests and young underwent significant annual declines between 2010 and 2017, but those trends appear to be slowing and reversing. The population growth of adults and young in the Colville Delta study area show opposing trends. This pattern suggests that annual production of young eventually declines when adult density is high whereas the opposite is true when adult density is not high.

- Yellow-billed Loons preferred 7 of 24 habitats for nesting and only 3 habitats for brood-rearing. The habitats preferred during the brood-rearing season occupied only 12% of the delta. The habitat selection analyses highlight the importance of large, deep waterbodies to nesting and brood-rearing Yellow-billed Loons.

- All 8 Glaucous Gull colonies in the Colville Delta study area contained nests in 2020; the largest colony located 6 km northeast of the CD-4 drill site contained 20 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. We recorded 61 nests on

23 index lakes in 2020, which was above the long-term mean. The annual growth rate for nest numbers on the index lakes was nearly 4% from 2005–2020. The increase in nest numbers is occurring both among colony-nesting gulls (3.5% annual growth) and those outside of colonies (3.6% annual growth).

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## ACKNOWLEDGMENTS

Avian surveys were conducted by an experienced crew consisting of Julie Parrett, Tim Obritschkewitsch, and Robert McNown. Chris Swingley programmed the tablets for data recording. Will Lentz and Tony LaCortiglia supplied equipment and technical assistance. Pam Odom provided travel and publication support, and Dorte Dissing provided GIS analysis and created report maps. Joe Welch assisted with analysis and writing. Adrian Gall reviewed the report. We thank the Alpine helicopter coordinators, Soloy Helicopters, North River Air, and the staff at Alpine for their friendly assistance. This work was directed by Jasmine Woodland at Weston Solutions and Christina Pohl and Robyn McGhee, Environmental Studies Coordinators at ConocoPhillips. We also thank Jasmine, Christina, and Lynn DeGeorge, Alpine Field Environmental Coordinator, for their reviews of the report. We appreciate 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 aerial and ground surveys of avian wildlife in the ASDP area since 1993.

Aerial surveys were used to collect data on eiders, loons, and gulls in the Colville Delta study area because of the large size of the study area and the short periods of time that each species is at the optimal stage for data collection. 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; Appendix A) 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 (e.g. Johnson et al. 2015, 2016, 2018, 2019, Shook et al. 2020a).

In 2020, surveys focused on 2 species and 1 species group: 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 (mainly King Eider) 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 planned for the Colville River delta in 2020, however they were cancelled to avoid potential disturbance to caribou hunters.

Other avian studies conducted for CPAI in 2020 included aerial surveys for eiders and loons in the Willow and GMT project areas (Parrett and Shook 2021, Rozell et al. 2021) and a ground-based study of nesting King Eiders in the GMT and Willow study areas (Rozell et al. 2021). Nest searches for Spectacled Eiders were conducted at Alaska Clean Seas (ASC) spill-response sites and other ACS, pipeline, and ice road tundra work sites on the Colville River delta and GMT areas (Shook and Attanas 2020b). ABR obtained the required state and federal permits for all survey activities, including a Scientific Permit (Permit No. 20-130) 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 during 2001–2006 and 2008–2014 (e.g., see Johnson et al. 2015) but have focused only the Colville River delta thereafter. From 2015 to 2020 only the Colville Delta study area was surveyed (Figure 1). The Colville Delta study area is located within the larger Arctic Coastal Plain (ACP), which has been the focus of breeding waterbird surveys conducted by the U.S. Fish and Wildlife Service for over 30 years (Wilson et al. 2018).

The Colville Delta study area (552 km²) 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

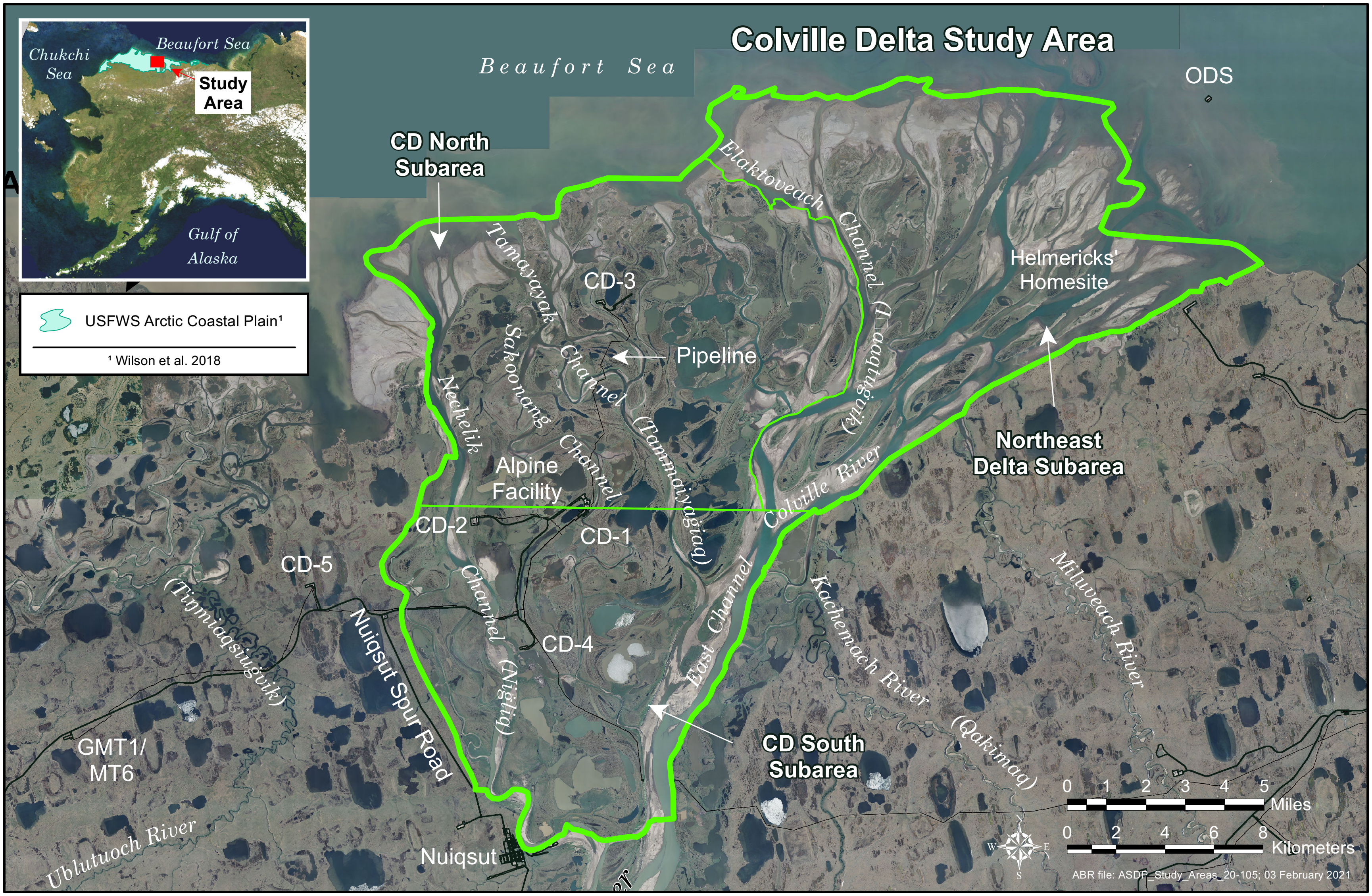



Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2020.

inland to where the Colville River divides into these channels.

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 ACP (Wells et al. 2017, 2020).

## METHODS

In 2020, we conducted 1 aerial survey for eiders from a fixed-wing aircraft during pre-nesting and 2 aerial surveys for Yellow-billed Loons (1 for nesting and 1 for brood-rearing) from a helicopter. During the Yellow-billed Loon brood-rearing survey, nests also were inspected for signs of hatch. Incidental observations of nesting and brood-rearing gulls 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, subsistence users, 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. The ConocoPhillips Village Outreach group and the Helicopter Coordinator based at Alpine coordinated daily phone calls with Nuiqsut subsistence representatives 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, the airplane or helicopter was diverted to reduce disturbance to hunters.

During the surveys, we recorded locations of eiders, loons, and gulls on tablet computers with a customized application. The app employed a moving map based 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 tablets and reviewed before they were exported into a geographical information system (GIS) database.

Table 1. Avian surveys conducted in the Colville Delta study area, Alaska, 2020.

| SURVEY TYPE Season | Survey Dates | Aircraft[a] | Transect Width (km) | Transect Spacing (km) | Aircraft Altitude (m) | Notes |
|---|---|---|---|---|---|---|
| EIDER | | | | | | |
| Pre-nesting | 13–15 Jun | C185 | 0.4 | 0.4 | 30–35 | 100% coverage |
| YELLOW-BILLED LOON[b] | | | | | | |
| Nesting | 18, 20–21 Jun | A-Star | – | – | 60–75 | Lakes with adults, nests or broods in previous years |
| Brood-rearing | 17–19 Aug | A-Star | – | – | 60–90 | Lakes with adults, nests or broods in previous years |

[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, and Glaucous Gulls were recorded incidentally.

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 2020, we conducted the pre-nesting survey on 13–15 June using the same methods that have been 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 counted eiders in a 200-m wide transect on opposite sides 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 to achieve 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. The latter 2 areas were avoided to reduce disturbance to residents.

Results are presented as total 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 (USFWS 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:

$$\text{Indicated Total Birds} = (\text{lone males} \times 2) + (\text{flocked males} \times 2) + (\text{pairs} \times 2) + (\text{group total} \times 1).$$

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 5 or more of a mixed-sex grouping of the same species in close association, which cannot be separated into singles or pairs (e.g., 1 female with 3 males was considered to be 4 [a pair plus 2 males]).

### POPULATION TRENDS

We calculated population trends of indicated total by year using a simple linear regression. The indicated total was log-transformed to meet assumptions of normality. 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 23 of 27 years (501 km²).

## LOON SURVEYS

### DISTRIBUTION AND ABUNDANCE

In 2020, we conducted an aerial survey on the Colville Delta study area for nesting Yellow-billed Loons on 18, 20–21 June and an aerial survey for brood-rearing Yellow-billed Loons, including visits to nests to verify nest fate, on 17–19 August (Table 1). We surveyed 119 lakes for nesting loons and 112 lakes for brood-rearing loons (Appendix C). Both nesting and brood-rearing surveys have been conducted annually in the Colville Delta study area for 26 years from 1993 to 2020, except for 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 comparable to surveys conducted in previous years. 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 based on lake size (1993–2016) or based on prior adult occupancy (2016–2020). The surveys 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 2016–2020, we primarily surveyed lakes where Yellow-billed Loon adults, nests, or broods had been seen during the previous 25 years of surveys. Tapped Lakes with Low-water Connections (lakes with water levels that 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 the detection of Yellow-billed Loons, we also recorded incidental observations of Pacific and Red-throated loons during the 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.

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 (Johnson et al. 2019). 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 were 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 comparisons among years when different numbers of territories were surveyed, we first identified all territories within the survey area. Then, we calculated nest or brood occupancy by dividing the number of territories with nests or broods by the number of territories surveyed.

Fledging rate was defined as the number of chicks seen on the brood survey divided by the number of nests. Because the denominator is the number of nests, survey effort must be standardized among years. In order to facilitate long-term comparisons, we limited these data to only those young counted during the brood-rearing survey at nests detected on the nesting survey.

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. 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.

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 (2000–2020).

## GLAUCOUS 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. Glaucous Gulls nest singly and in loose aggregations or colonies. We considered a group of ≥3 nests in any 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 consider it a colony in all 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 occurred close to the time when young gulls fledge, we focused 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 C). At that time, index lakes included 19 lakes with at least 1 year of gull nesting history, and 31 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

An aerial survey for molting and brood-rearing Brant and Snow geese was planned for late July in the outer Colville River delta. Brood surveys have been conducted annually on the delta since 2005, and in some earlier years dating back to 1988 (Shook et al. 2020b). During 2020, large numbers of caribou moved into the area during the third and fourth weeks of July. The survey was postponed and ultimately canceled to avoid disturbing caribou and subsistence hunters. CPAI helicopter flights were also restricted during this time in the outer Colville River and Fish Creek deltas to limit disturbance to wildlife and subsistence hunting activities.

## 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 location on the wildlife habitat map (Appendix B). 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). 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 eiders (single birds, pairs, groups, or flocks) and individual locations of Yellow-billed Loon nests and young. Habitat availability was calculated as the percent of each wildlife habitat in the survey area.

For Spectacled and King eiders and Yellow-billed Loons, we evaluated whether or not habitats were used in proportion to their availability. We excluded the Northeast Delta subarea from habitat selection analyses for Yellow-billed Loons because we only surveyed a portion of that subarea. Multiple years of comparable survey data were used in the analysis of habitat selection. We calculated the number of observations and the area (sq km$^2$) for each wildlife habitat in all survey years (1993–1998 and 2000–2020) to represent the total habitat use and availability, respectively.

We inferred habitat selection by comparing observed habitat use to random habitat use. Monte Carlo simulations (10,000 iterations) were used to calculate a frequency distribution of random habitat use, with the sample sizes in each simulation equaling the number of observed nests or groups of birds in that season. The resulting distribution was used to compute 95% confidence intervals around the expected value of habitat use (Haefner 1996, Manly 1997). We defined habitat preference (i.e., use > availability) as observed habitat use greater than the 95% confidence interval of simulated random use, which represents an alpha level of 0.05 (2-tailed test). Conversely, we defined habitat avoidance (i.e., use < availability) as observed habitat use below the 95% confidence interval of simulated random use. The simulations and calculations of confidence intervals were conducted in the statistical program R (version 4.0.3; R Core Team 2020).

## DENSITY MAPS

To summarize mean annual distribution and abundance of eiders and Yellow-billed Loons, 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. We mapped pre-nesting Spectacled and King eiders (1994–2010) and Yellow-billed Loon adults, nests, and young (1993, 1995–1998 and 2000–2020). For eiders, we calculated mean density from the indicated total numbers of pre-nesting eiders within 2 km × 2 km grid cells. For loons, we calculated annual mean density from the total number of adults and nests seen on the nest survey and the number of young seen on the brood survey within 1 km × 1 km grid cells.

Annual mean density values for grid cells were calculated by dividing the cumulative number of birds or nests observed in each cell (total across all surveys) by the area surveyed in each cell and the number of times (years) the cell was surveyed. We assigned the calculated densities to the centroid of the cells. The IDW interpolation technique calculated a smoothed density surface for 152 m based on the distance-weighted density of up to 8 centroids of the nearest grid cells within 2.8 km (eiders) and 1.4 km (loons) in the study area (power = 1). The analysis produced color maps exhibiting density distribution averaged among all survey years of comparable survey data over the entire survey area.

## DATA MANAGEMENT

All data collected during surveys for CPAI were compiled into centralized PostgreSQL databases. All nest, brood, bird, and bird group locations were recorded on tablet computers that were exported into the PostgreSQL database for data checking. We recorded uniform attribute data for all observations and conducted a series of data checks after collection. Survey data were submitted to CPAI in GIS-ready format with corresponding metadata following CPAI's data management protocols (version 11.3, CPAI 2019).

# 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 measurements have not been collected historically in Nuiqsut, and they were not collected in 2020 at the Helmericks site (the station with the longest data record). Weather data for Alpine and CD5 date back to 2011 and 2013, respectively, and we used the 10-year dataset of temperatures and snow depths from Alpine to describe general weather patterns in the broader region. Station data were supplemented with water surface elevation data collected at gage stations on the Colville River delta during spring breakup (Michael Baker 2020).

Daily average temperatures were somewhat below normal during the first 3 weeks of May 2020, and then near normal through 10 June (Figure 2). Total thawing degree-days (the sum of average daily temperatures >0 °C, TDD) for late May were below average (Figure 3), and snow depth was above average throughout all of May. Snow melted rapidly during the last week of May, and snow depths fell to near zero about a week earlier than the long-term mean date at Alpine (2011–2020; Figure 2).

Spring breakup in 2020 was characterized as "a dynamic, short duration, historically high magnitude event" (Michael Baker 2020). Floodwater was recorded on the delta on 18 May, and at the head of the Colville River delta (Monument 1 monitoring station, about 5.5 km south of Nuiqsut) on 22 May. Water levels rose gradually on the East and Niġliq channels until 27 May, when an ice jam upstream of Monument 1 released and flushed the channel ice from the head of the delta. Ice jams reformed downstream at bifurcations in the Niġliq and East channels, and backwater from these jams extended upstream to the head of the delta, where water levels reached peak stage on 28 May, about 2 days ahead of the historical average. Water surface elevations reached peak levels throughout the delta on 29 May and was accompanied by overbank flooding and floodplain inundation. Ice jams in both channels released on 29 May, and water levels

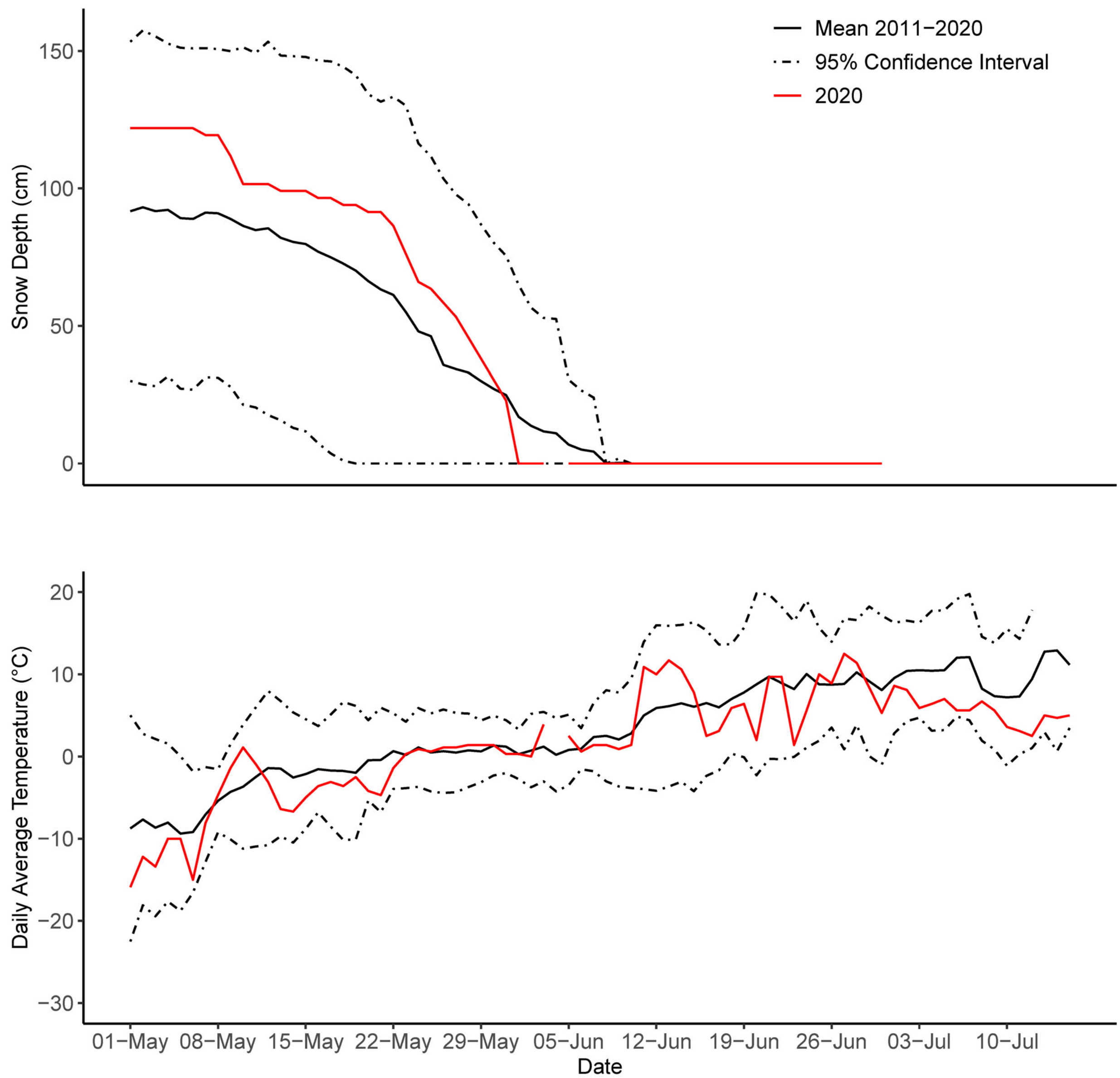



Figure 2. Snow depth and daily average temperature for spring and summer 2020 with mean for 2011–2020, Alpine, Colville River delta, Alaska.

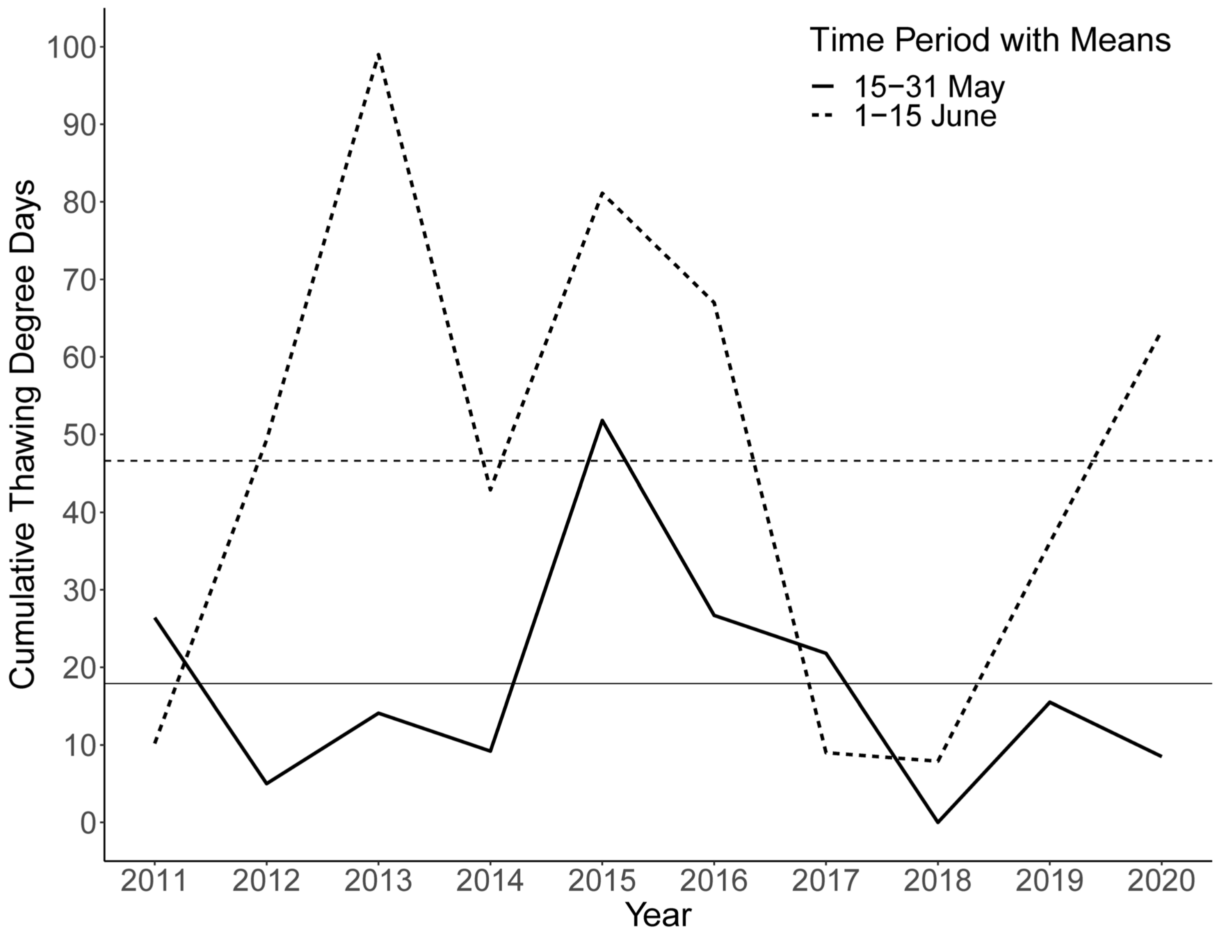



Figure 3. Cumulative number of thawing degree-days and means (horizontal lines) recorded for 15–31 May and 1–15 June recorded at Alpine, Colville River delta, Alaska, 2011–2020.

steadily receded thereafter. Peak stage at Monument 1 was the second highest on record and corresponded to an estimated recurrence interval of 25.5 years (Michael Baker 2020).

Nearly 50% of survey lakes ($n$ = 85 lakes) were visibly murky during loon surveys on 18 June, indicating that those lakes had received flood water from the Colville River. Yellow-billed Loons typically begin arriving on nesting lakes during the first week of June (Johnson et al. 2014c, 2015) and likely arrived as floodwaters receded starting on 29 May. Based on visual estimates during the nesting survey, water levels appeared to be typical for mid- to late June. This observation suggests that water levels in lakes were reduced to normal levels quickly and did not persist long enough to preclude nesting by loons (see Yellow-billed Loon, Distribution and Abundance, below). The timing of eider surveys (13–15 June) was appropriate based on the condition of waterbodies; shallow waterbodies were thawed as were shallow margins of deep waterbodies.

## 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). King Eiders, which are not protected under the Endangered Species Act, are more widespread and generally more numerous than Spectacled Eiders across the Arctic Coastal Plain, although their relative abundance varies geographically.

The 2 other species of eiders are uncommon to rare in the Colville River delta. Steller's Eiders were listed as a threatened species in 1997 (62 FR 31748–31757). Steller's Eiders are rare on the Colville Delta study area (2 observations by ABR and 1 by J. Bart, Boise State University, personal communication in 27 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. Although abundant in appropriate habitat, Common Eiders nest primarily on barrier islands and coastlines and are seen rarely (7 observations in 27 years) on surveys of the Colville Delta study area.

## SPECTACLED EIDER

### Distribution and Abundance

We recorded 45 Spectacled Eiders (on the ground and flying) and 36 indicated total Spectacled Eiders during the pre-nesting aerial survey in 2020 on the Colville Delta study area (Figure 4, Table 2). The number of indicated pre-nesting Spectacled Eiders in 2020 was below the long-term average for the Colville Delta study area (Table 2). All observations of pre-nesting Spectacled Eiders in the Colville Delta study area in 2020 were of small groups of 1–3 birds. The CD North subarea contained 80% of the Spectacled Eiders observed, whereas the CD South subarea contained only 4% of the Spectacled Eiders observed (Appendix D). The density of pre-nesting Spectacled Eiders in the CD North subarea during 2020 (0.14 indicated birds/km²) was more than twice the density recorded on the much larger Colville Delta study area (0.07 indicated birds/km²). The distribution of pre-nesting Spectacled Eiders in 2020 was typical of previous years, when densities were highest north of Alpine and low south and northeast of Alpine (Figure 5). On the Arctic Coastal Plain, Spectacled Eider densities are generally highest near Utqiaġvik and the Colville River delta and lower at inland sites.

Over the 27 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 1.7%; ln(adults) = 0.017 (year) – 29.45, $R^2 = 0.07$, $p = 0.19$). The growth rate for the entire Colville Delta study area was slightly lower at 1.3% (ln(adults) = 0.013 (year) – 22.0, $R^2 = 0.04$, $p = 0.30$). 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

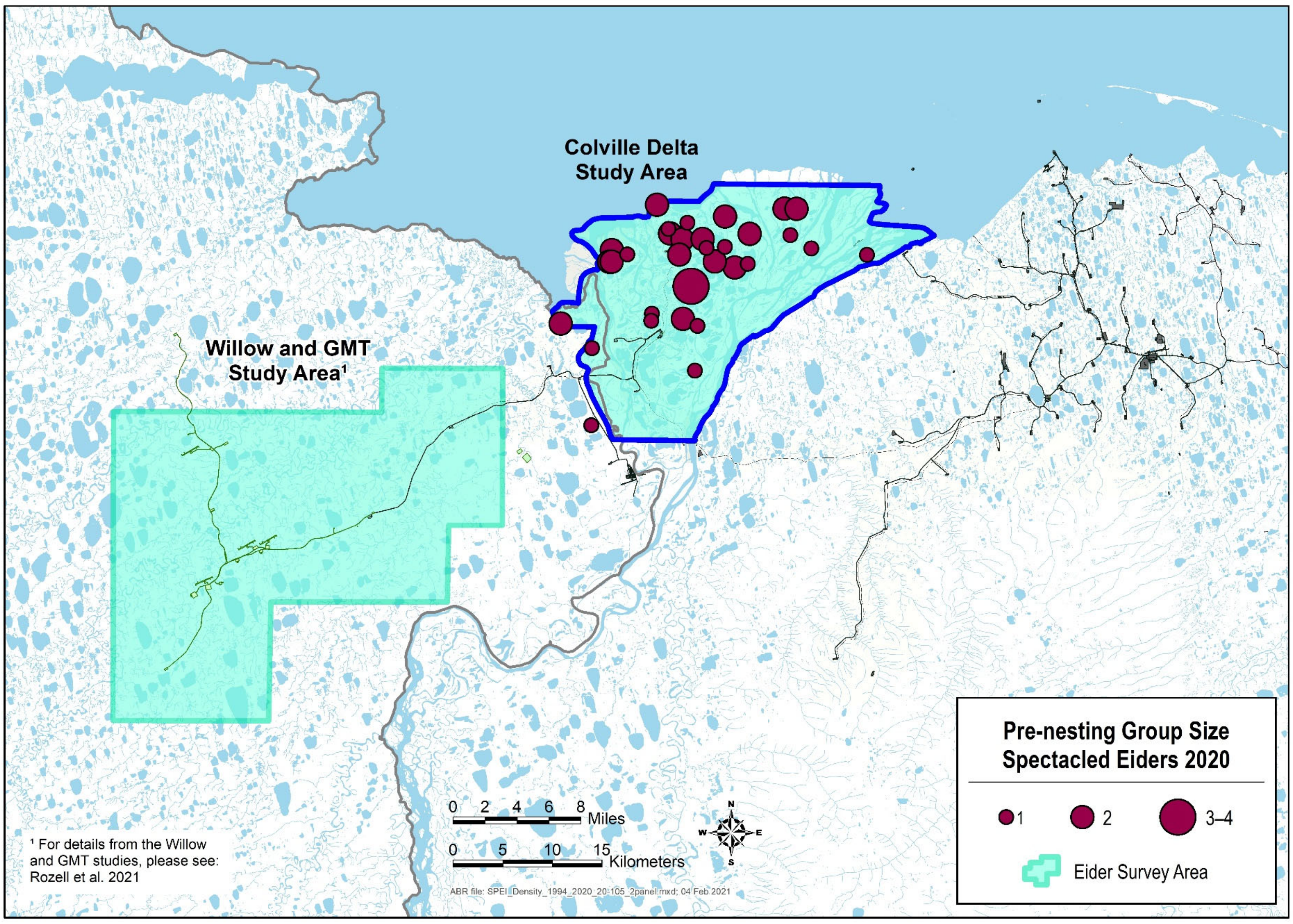
Pre-nesting Spectacled Eiders used 19 of 24 available habitats during 27 years of aerial surveys on the Colville Delta study area (Table 3). Seven habitats were preferred (i.e., use significantly greater than availability, $p \leq 0.05$) including 3 primarily coastal, salt-affected habitats (Brackish Water, Salt Marsh, and Salt-killed Tundra), 3 aquatic habitats (Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, and Grass Marsh), and 1 terrestrial habitat (Deep Polygon Complex). Deep Polygon Complex, which consists of a mosaic of small, deep, polygon ponds with relatively narrow vegetated rims and sometimes with islets, is notable because of its 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. Eight habitats were avoided (use significantly less than availability), including Open Nearshore Water; Tapped Lake with Low-water Connection; Tapped Lake with

Table 2. Observed and indicated numbers and densities (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 1993–1998 and 2000–2020.

| Year | Area Surveyed (km²) | Spectacled Eider | | | | King Eider | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Total[a] | | Density[b] | | Total[a] | | Density[b] | |
| | | 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 |
| 2020 | 501.4 | 45 | 36 | 0.09 | 0.07 | 129 | 108 | 0.26 | 0.22 |
| Mean | | 55.7 | 54.2 | 0.11 | 0.11 | 67.0 | 52.5 | 0.13 | 0.10 |
| SE | | 4.9 | 4.8 | 0.01 | 0.01 | 8.4 | 7.8 | 0.01 | 0.01 |

[a] Observed total includes flying and non-flying eiders. Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987). Mean and standard error calculated for total observed or indicated when survey area = 501.4 km², *n* = 23 years.

[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of surveyed area. Means calculated for all years, *n* = 27 years.



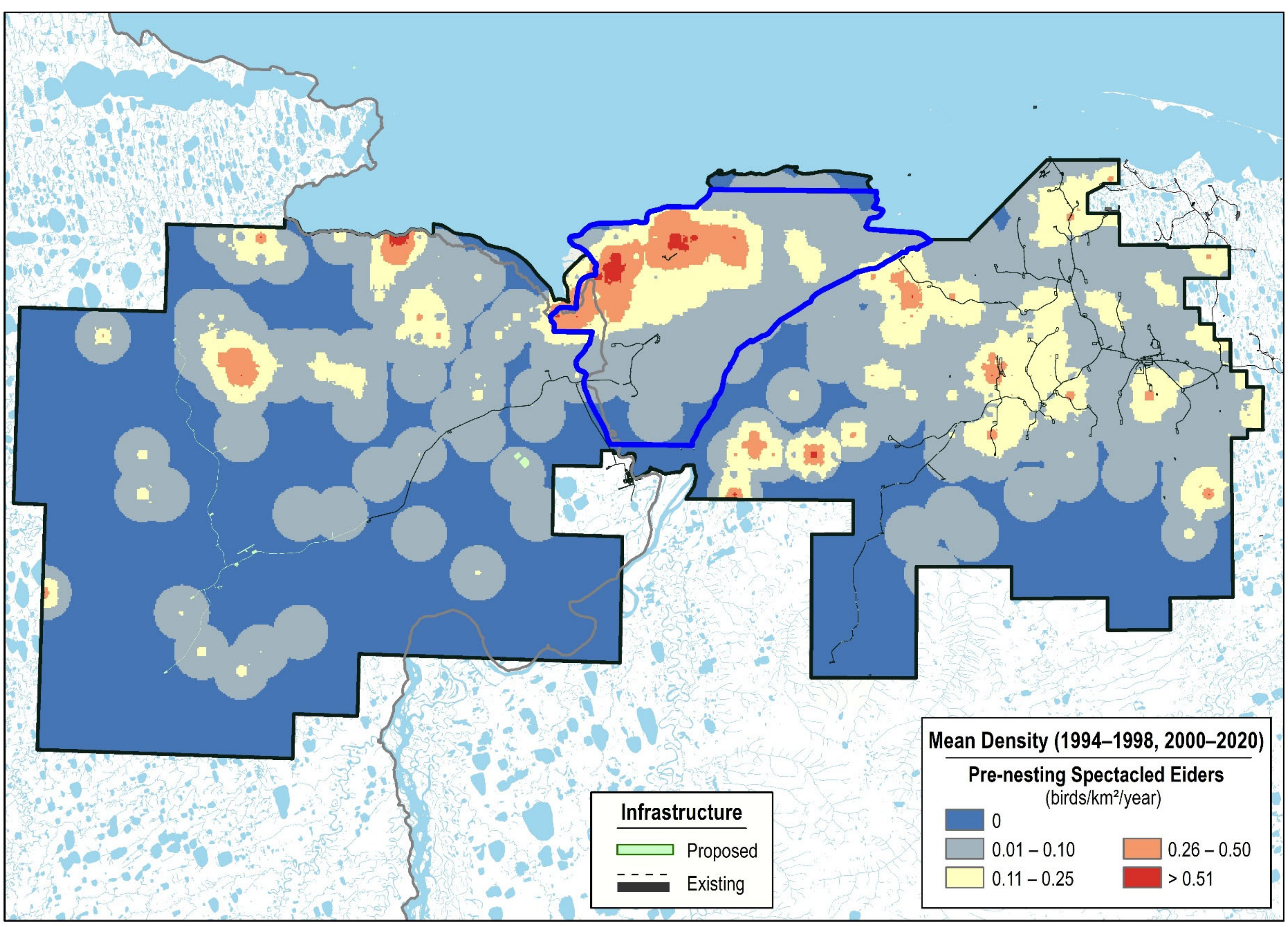




Figure 5. Group size (2020) and mean densities (mean of areas surveyed 1–27 years) of Spectacled Eiders observed during pre-nesting aerial surveys in the Colville Delta (blue outline), NPR-A, and Kuparuk study areas, Alaska, 1994–2020. No Spectacled Eiders were observed in the Willow and GMT study area in 2020.

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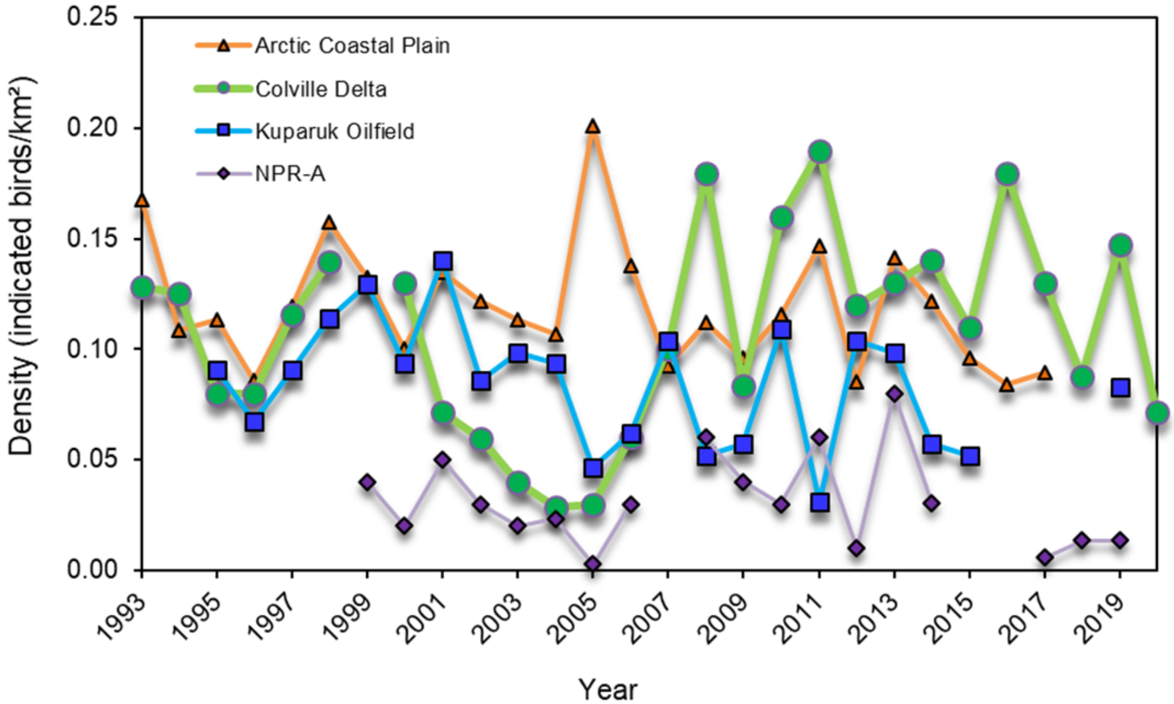


Figure 6. Annual densities of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the North Slope, Alaska, 1993–2020. The Arctic Coastal Plain surveys were performed by the U.S. Fish and Wildlife Service.

High-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 129 observed (on the ground and flying) and 108 indicated total King Eiders on the 2020 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 (36 indicated birds) in 2020, which has occurred in 11 of 27 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 (3.8%) since surveys began in 1993 (ln(adults) = 0.038 (year) – 73.6, $R^2 = 0.26$, $p = 0.01$; Figure 7). The reasons for the increased growth are difficult to determine but are possibly related to increased survival in the non-breeding season, perhaps related to declining sea-ice and increasing food availability in wintering and migration areas (Powel et al. 2018). King Eiders were observed in all 3 of the subareas, but density was highest (0.27 indicated birds/km²) in the CD North subarea in 2020 (Appendix D). Typically, the highest densities occur on the East Channel of the Colville River near the coast, and to a lesser extent in coastal areas of the outer delta, where flocks of King Eiders collect in open water (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 King Eiders observed during pre-nesting aerial surveys 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 2020. 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.

Table 3. Habitat selection by Spectacled Eider and King Eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998, and 2000–2020.

| SPECIES<br>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 | 95 | 45 | 7.1 | 1.3 | prefer | |
| Tapped Lake with Low-water Connection | 39 | 17 | 2.7 | 4.5 | avoid | |
| Tapped Lake with High-water Connection | 21 | 13 | 2.1 | 3.6 | avoid | |
| Salt Marsh | 65 | 37 | 5.8 | 3.2 | prefer | |
| Tidal Flat Barrens | 2 | 1 | 0.2 | 7.1 | avoid | |
| Salt-killed Tundra | 105 | 60 | 9.5 | 5.1 | prefer | |
| Deep Open Water without Islands | 42 | 28 | 4.4 | 3.3 | ns | |
| Deep Open Water with Islands or Polygonized | 54 | 28 | 4.4 | 2.2 | prefer | |
| Shallow Open Water without Islands | 7 | 5 | 0.8 | 0.4 | ns | low |
| Shallow Open Water with Islands or Polygonized | 12 | 9 | 1.4 | 0.1 | prefer | low |
| River or Stream | 39 | 18 | 2.8 | 14.4 | avoid | |
| Sedge Marsh | 1 | 1 | 0.2 | <0.1 | ns | low |
| Deep Polygon Complex | 312 | 180 | 28.4 | 2.8 | prefer | |
| Grass Marsh | 11 | 7 | 1.1 | 0.2 | prefer | low |
| Young Basin Wetland Complex | 0 | 0 | 0 | <0.1 | ns | low |
| Old Basin Wetland Complex | 0 | 0 | 0 | <0.1 | ns | low |
| Nonpatterned Wet Meadow | 95 | 49 | 7.7 | 8.3 | ns | |
| Patterned Wet Meadow | 227 | 130 | 20.5 | 19.1 | ns | |
| Moist Sedge-Shrub Meadow | 0 | 0 | 0 | 2.3 | avoid | |
| Moist Tussock Tundra | 1 | 1 | 0.2 | 0.6 | ns | low |
| Tall, Low, or Dwarf Shrub | 0 | 0 | 0 | 5.0 | avoid | |
| Barrens | 7 | 3 | 0.5 | 14.8 | avoid | |
| Human Modified | 0 | 0 | 0 | 0.1 | ns | low |
| Total | 1,137 | 633 | 100 | 100 | | |
| KING EIDER | | | | | | |
| Open Nearshore Water | 43 | 8 | 1.8 | 1.6 | ns | |
| Brackish Water | 78 | 37 | 8.1 | 1.3 | prefer | |
| Tapped Lake with Low-water Connection | 57 | 22 | 4.8 | 4.5 | ns | |
| Tapped Lake with High-water Connection | 18 | 8 | 1.8 | 3.6 | avoid | |
| Salt Marsh | 49 | 19 | 4.2 | 3.2 | ns | |
| Tidal Flat Barrens | 4 | 2 | 0.4 | 7.1 | avoid | |
| Salt-killed Tundra | 73 | 40 | 8.8 | 5.1 | prefer | |
| Deep Open Water without Islands | 14 | 6 | 1.3 | 3.3 | avoid | |
| Deep Open Water with Islands or Polygonized | 25 | 12 | 2.6 | 2.2 | ns | |
| Shallow Open Water without Islands | 9 | 5 | 1.1 | 0.4 | ns | low |
| Shallow Open Water with Islands or Polygonized | 8 | 5 | 1.1 | 0.1 | prefer | low |
| River or Stream | 741 | 199 | 43.5 | 14.4 | prefer | |
| Sedge Marsh | 0 | 0 | 0 | <0.1 | ns | low |
| Deep Polygon Complex | 68 | 39 | 8.5 | 2.8 | prefer | |
| Grass Marsh | 11 | 5 | 1.1 | 0.2 | prefer | low |
| Young Basin Wetland Complex | 0 | 0 | 0 | <0.1 | ns | low |

Table 3. Continued.

| SPECIES<br>Habitat type | No. of Adults | No. of Groups | Use (%)[a] | Availability (%) | Monte Carlo Results[b] | Sample Size[c] |
|---|---|---|---|---|---|---|
| KING EIDER (continued) | | | | | | |
| Old Basin Wetland Complex | 0 | 0 | 0 | <0.1 | ns | low |
| Nonpatterned Wet Meadow | 18 | 11 | 2.4 | 8.3 | avoid | |
| Patterned Wet Meadow | 51 | 31 | 6.8 | 19.1 | avoid | |
| Moist Sedge-Shrub Meadow | 2 | 1 | 0.2 | 2.3 | avoid | |
| Moist Tussock Tundra | 0 | 0 | 0 | 0.6 | ns | low |
| Tall, Low, or Dwarf Shrub | 7 | 4 | 0.9 | 5.0 | avoid | |
| Barrens | 5 | 3 | 0.7 | 14.8 | avoid | |
| Human Modified | 0 | 0 | 0 | 0.1 | ns | low |
| Total | 1,281 | 457 | 100 | 100 | | |

[a] Use = (groups/total groups) × 100.
[b] Significance calculated from 10,000 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.

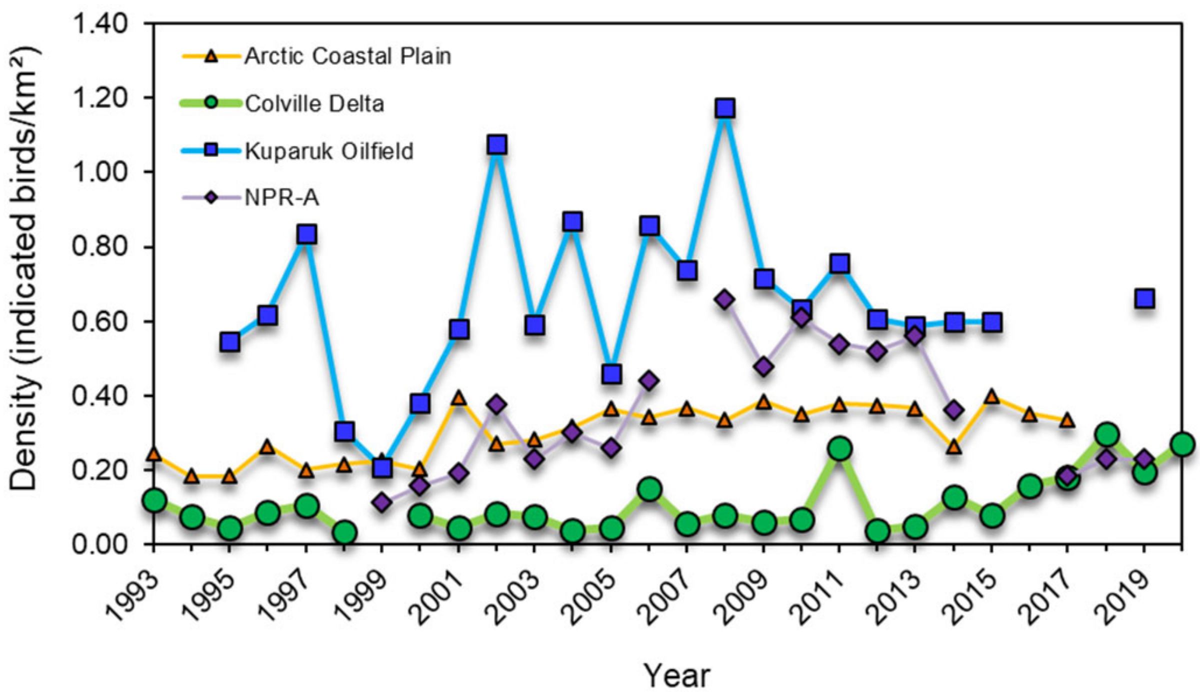


Figure 7. Annual densities of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the North Slope, Alaska, 1993–2020. The Arctic Coastal Plain surveys were performed by the U.S. Fish and Wildlife Service

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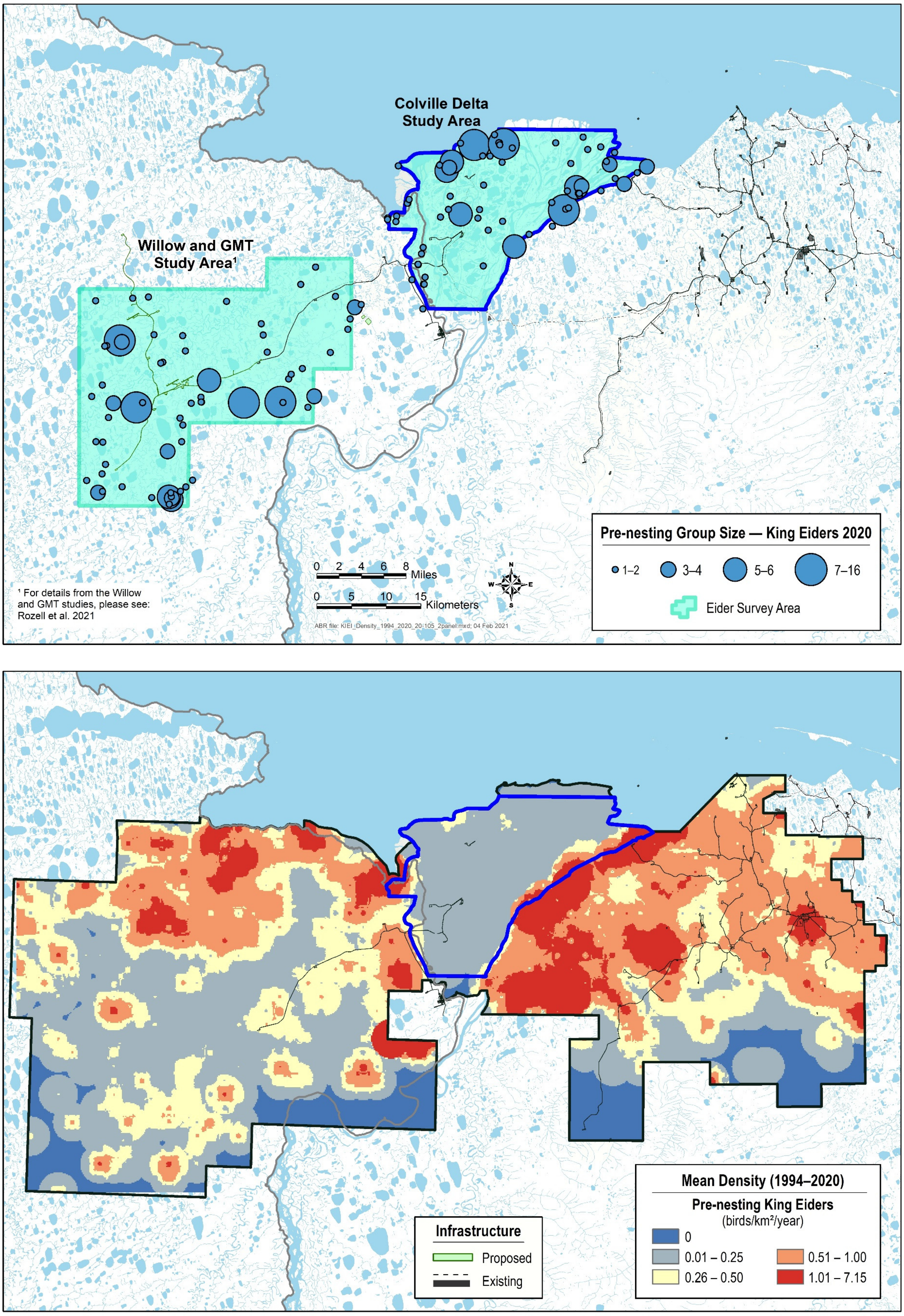


Figure 8. Group size (2020) and mean densities (mean of areas surveyed 1–27 years) of King Eiders observed during pre-nesting aerial surveys in the Colville Delta (blue outline), NPR-A, and Kuparuk study areas, Alaska, 1994–2020.

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Habitat Use

Pre-nesting King Eiders used 19 of 24 available habitats in the Colville Delta study area over 27 years of aerial surveys (Table 3). Pre-nesting King Eiders preferred 5 of the same habitats preferred by pre-nesting Spectacled Eiders in the Colville Delta study area: Brackish Water, Salt-killed Tundra, Shallow Open Water with Islands or Polygonized Margins, Deep Polygon Complex, and Grass Marsh. Additionally, they preferred River or Stream habitat, including the river channels primarily in the Northeast Delta subarea, which was used by 44% of the pre-nesting groups (Figure 8). 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.

The high use of River or Stream habitat suggests that many King Eiders were moving through to breeding areas farther east, because River or Stream habitat is not potential breeding habitat. In contrast, Spectacled Eiders, which occur in high numbers during pre-nesting and nest in relatively high concentrations on the outer Colville River delta (0.8–1.0 nests/km²; ABR, unpublished data), avoid the River or Stream habitat type. Moreover, King Eiders nest at very low densities on the Colville River delta in the several locations where intensive nest searches have been conducted (Burgess et al. 2002, 2003; Johnson et al. 2003, 2008; Seiser and Johnson 2010, 2011a, 2011b, 2012, 2014a, 2014b), affirming that most of the pre-nesting King Eiders seen on the delta are stopping over during migration.

## YELLOW-BILLED LOON

Distribution and Abundance

We found 31 Yellow-billed Loon nests and 51 adults during the Yellow-billed Loon nest survey in 2020 (Figure 9, Table 4). Of the 31 nests, 16 nests were located in the CD North subarea and 15 nests in the CD South subarea. No nests were found in the Northeast Delta subarea (Appendix E). The total number of nests found on the nesting survey was well above the long-term mean (21.5 ± 1.3 nests, $n$ = 26 years; for densities see Appendix F). The count of 51 adults on the nesting survey, however, was lower than the long-term mean (57.5 ± 2.1 adults). The density of adults and nests was lower in the CD North subarea (0.12 birds/km², 0.08 nests/km²) than the CD South subarea (0.16 birds/km², 0.10 nests/birds/km²; Appendix E). Incidental records of Pacific and Red-throated loon nests and broods are presented in Appendices E and G.

The distribution of Yellow-billed Loon adults and nests in the Colville Delta study area in 2020 was typical of previous years, with the highest densities occurring throughout the central portion of the study area (Figures 10, 11). The density distribution is influenced by the availability of large, deep lakes that are concentrated in the central portion of the study area. In contrast, Tapped Lakes with Low-water Connections are widespread in areas along the Niġliq, Main, and Elaktoveach channels and this lake type is not used by breeding Yellow-billed Loons. Similarly high nest densities occur in the adjacent NE NPR-A on lakes along the confluence of Fish and Judy creeks.

All 31 Yellow-billed Loon nests in the Colville Delta study area in 2020 were on lakes where Yellow-billed Loons have nested previously (ABR, unpublished data). Not only did Yellow-billed Loons breed on lakes used in previous years, loons reused nest sites from previous years. Eighteen of 31 Yellow-billed Loon nests were located at the same nest sites (≤5 m away) used during the previous 26 years, 4 were very close (6–50 m) to nest sites used in previous years, and 9 were at new nest sites (>50 m from previously recorded nests but still in the same territory).

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 single, annual standardized nesting survey conducted in June. We used nest occupancy, or the proportion of territories with a nest, because it is a metric that is not sensitive to survey effort (38 to 49 territories were surveyed annually over 26 years). In 2020, 63% of the territories were occupied by nests during the nesting survey, which is well above the long-term mean (47.7 ± 2.7%, $n$ = 26 years; Table 4).

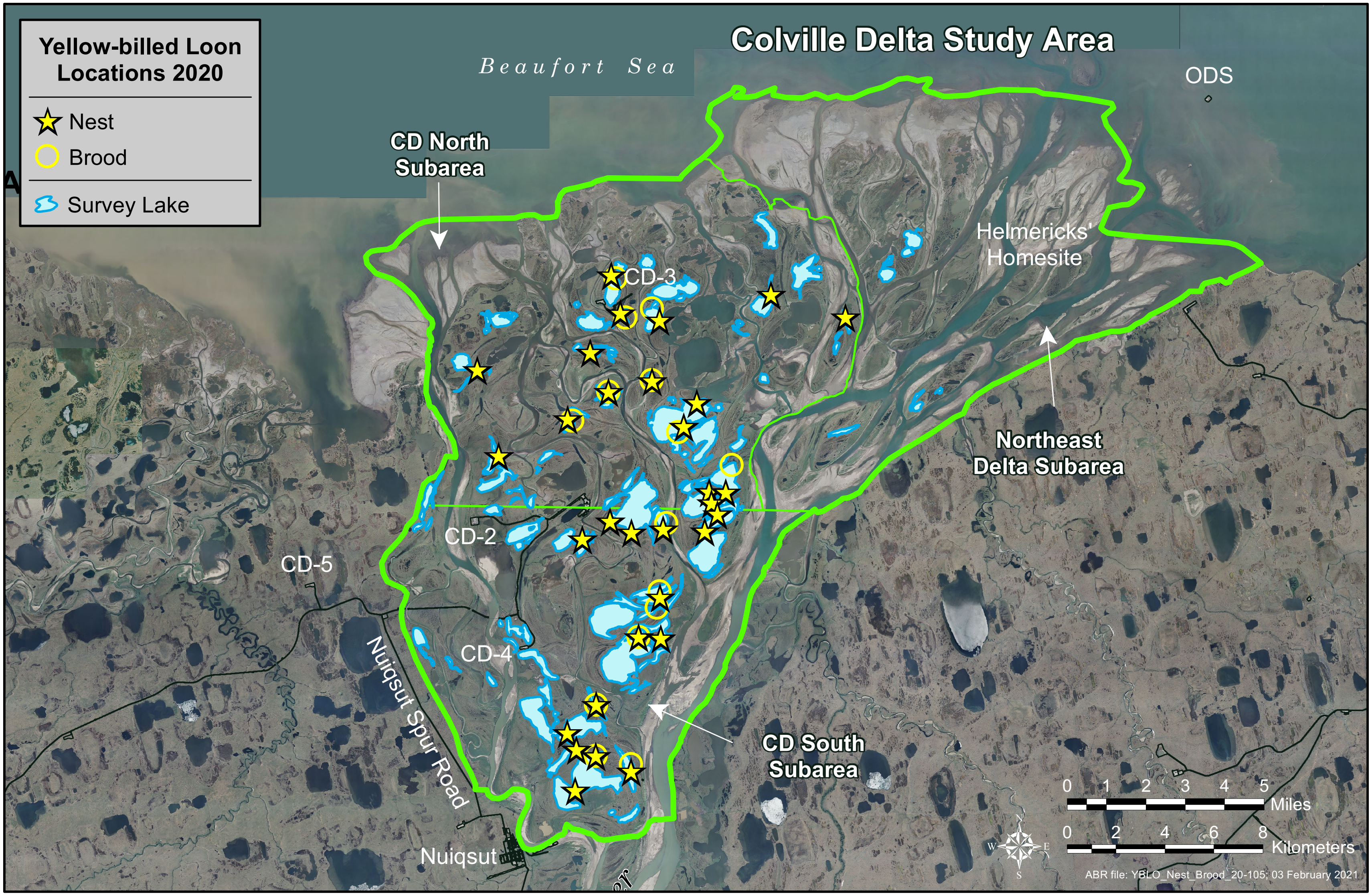


Figure 9. Yellow-billed Loon nest and brood locations, Colville Delta study area, Alaska, 2020.

Table 4. Number of Yellow-billed Loons and nests, and nest occupancy, Colville Delta study area, Alaska, 1993, 1995–1998 and 2000–2020.

| | 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] | 43 | 28 |
| 1996 | 45 | 11 | 20[e,f,g] | 38 | 29 |
| 1997 | 48 | 10 | 18[e,g] | 41 | 24 |
| 1998 | 35 | 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 | 56 | 30 | 31[f] | 43 | 70 |
| 2006 | 63 | 24 | 28[g] | 44 | 55 |
| 2007 | 66 | 27 | 31[g] | 44 | 61 |
| 2008 | 69 | 33 | 38[g] | 45 | 73 |
| 2009 | 67 | 27 | 30[g] | 46 | 59 |
| 2010 | 69 | 23 | 35[g] | 46 | 50 |
| 2011 | 70 | 23 | 29[g] | 46 | 50 |
| 2012 | 57 | 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 | 54 | 26 | 28[f] | 48 | 54 |
| 2018 | 67 | 23 | 24[f] | 49 | 47 |
| 2019 | 63 | 30 | 32[f] | 49 | 61 |
| 2020 | 51 | 31 | 31 | 49 | 63 |
| Mean | 57.5 | 21.5 | 25.8 | – | 47.7 |
| SE | 2.1 | 1.3 | 1.3 | – | 2.7 |

[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.

During the brood-rearing survey, 64 adult Yellow-billed Loons, 11 broods, and 14 young were seen in the Colville Delta study area (Figure 9, Table 5). One brood contained 3 young, which is atypical for loons. All 3 chicks were similarly sized and likely of similar age. Common Loon pairs have been documented raising >2 chicks but it was unknown whether these broods were a result of >2 eggs laid by the same female, nest parasitism, or chick adoption (Evers et al. 2020). In addition to the 11 broods that were seen during the aerial survey, we inferred 4 broods based on eggshell fragments at nests (see Nest Fate, below). Including these broods that did not survey until the brood-rearing survey, a total of 15 broods were produced by pairs nesting in the Colville Delta study area (Table 5). Of the 15 broods, 8 were found in the CD North subarea and 7 were found in the CD South subarea. No broods were found in the Northeast Delta subarea (Appendix E).

The count of 64 adults was well above the long-term mean (52.3 ± 2.6 adults) whereas the count of 15 broods was only slightly above the long-term mean (12.9 ± 1.2 broods, $n$ = 26 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 (0.15 birds/km²) than the CD South subarea (0.21 birds/km²), the density of broods was the same (0.04 broods/km²; Appendix E).

Similar to nests, the distribution of young in the Colville Delta study area during 2020 was typical of previous years (Figure 12). Mean annual density distribution maps of nests and young are useful for detecting broad landscape level patterns in distribution and understanding which areas are most productive in terms of consistently producing young. The density distribution of young highlights the importance of the central portion of the Colville Delta study area.

During 26 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 2020, 31% of the territories were occupied by broods. Unlike nest occupancy, which was well above the long-term mean, brood occupancy was closer to the long-term mean (29.2 ± 2.6%, $n$ = 26 years).

One goal of brood-rearing surveys is to estimate how many chicks survive to fledging. The number of chicks surviving to at least 6 weeks of age has been used as an estimator of fledging in Common Loons because chick mortality is minimal after 6 weeks of age (Evers et al. 2020). Yellow-billed Loons appear to be similar. Most Yellow-billed Loon chick mortality occurs during the first 2 weeks following hatch and is less common thereafter (Uher-Koch et al. 2020, ABR unpublished data). Most Yellow-billed Loon chicks in the Colville Delta study area are ~6 to 8 weeks old during the brood-rearing survey (based on hatch dates observed during camera monitoring in previous years; see Johnson et al. 2015), so chicks/nest serves as an approximation of the fledging rate. The fledging rate differs from measures of brood occupancy and apparent nest success in that the fledging rate incorporates nesting effort, nest and brood survival, and brood size into one metric. Although the number of nests recorded in 2020 was well above the long-term mean, the fledging rate of 0.45 chicks/nest was slightly below the long-term mean (mean = 0.48 ± 0.04 chicks/nest, $n$ = 26 years). Nest fate data indicate that poor hatching success, as opposed to low nesting effort or low chick survival, was the primary cause of the low fledging rate observed during 2020 (see Nest Fate, below). Nests were not monitored with time-lapse cameras in 2020 so the causes of the poor hatching success are unknown; however, previous camera studies have shown that predation by Glaucous Gulls, Parasitic Jaegers (Migiaqsaayuk, *Stercorarius parasiticus*), brown bear (Akłaq, *Ursus arctos*), and red fox (Kayuqtuq, *Vulpes vulpes*) have been the primary cause of poor hatching success in the Colville Delta study area (Johnson et al. 2016).

Table 5. Number of Yellow-billed Loons, broods, and brood occupancy, Colville Delta study area, Alaska, 1993, 1995–1998 and 2000–2020.

| Year | Brood-rearing Survey[a] | | | All Surveys[b] | No. Territories Surveyed[c] | Brood Occupancy (%)[d] |
|---|---|---|---|---|---|---|
| | No. Adults | No. Young | No. Broods | No. Broods | | |
| 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 |
| 2020 | 64 | 14 | 11 | 15[g] | 49 | 31 |
| Mean | 52.3 | 12.9 | 10.5 | 12.9 | – | 29.2 |
| SE | 2.6 | 1.3 | 1.0 | 1.2 | – | 2.6 |

[a] Brood-rearing surveys were conducted 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.

Nest Fate

During the brood-rearing survey in 2020, 11 Yellow-billed Loon pairs with a nest during June were seen with a brood and 20 pairs lacked a brood. Because the absence of a brood does not always indicate nest failure, 19 of the 20 nests without broods were visited on the ground to determine nest fate by inspecting eggshell fragments; 1 nest was on an island in water that was too deep for wading and too small to access by helicopter. Of the 19 nests inspected, 15 failed to hatch young; 3 contained 4–11 egg fragments and 12 contained no egg remains. The remaining 4 nests contained >20 egg fragments (range 30–95 fragments), indicating that at least 1 egg hatched. By analyzing eggshell fragments, we determined that in addition to the 11 loon pairs that were seen with broods during the brood-rearing survey, 4 additional pairs had broods that did not survive, resulting in 15 successful nests in 2020.

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 2015–2020, 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, 15 of 31 nests hatched in 2020 for an apparent nesting success of 48%. This estimate was below the 16-year mean (52.4 ± 3.7%).

Population Trends

Yellow-billed Loons nesting in the Colville Delta study area have been characterized by an adult population that, over the long-term, has fluctuated around an equilibrium state (Figure 13; ln(adults) = 0.000(year) + 4.7, $R^2$ = -0.05, $p$ = 0.96, $n$ = 21 years). This dynamic appears similar to Common Loons and is reflective of a long-lived species with a low lifetime reproductive performance (Evers et al. 2020). Despite the long-term population stability, short-term trends have been detected in the Colville Delta study area. Yellow-billed Loons displayed annual population growth (at 1.4–1.6% annually; Johnson et al. 2016, 2017) from 2005 until around 2014 when growth began to slow and eventually decline. From 2008 to 2020, adult numbers have declined significantly at almost 2.5% annually (ln(adults) = –0.024(year) + 51.8, $R^2$ = 0.44, $p$ < 0.01). Opposite long-term but similar short-term 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, from 2008 to 2017 (the last year data were available), adult numbers on the ACP indicated a non-significant decline (logarithmic growth rate = 0.96, 95% CI = 0.907–1.025), as they have in the Colville Delta study area.

As with adults, numbers of nests and young in the Colville Delta study area over the last 21 years do not show long-term trends but shorter periods of growth and decline have been detected. Although productivity initially increased as the adult population grew, numbers of nests and young eventually underwent significant declines between 2010 and 2017 (Johnson et al. 2017, 2018). Those declines have slowed and have begun to reverse. Despite the negative trend in the adult population, the growth rate in the number of nests over the most recent decade (2011–2020) was positive, although not significantly different from equilibrium (ln(nests) = 0.035(year) – 68.4, $R^2$ = 0.05, $p$ = 0.25, $n$ = 10 years). Likewise, the decreasing trend in the number of young has stabilized over the last decade and is near equilibrium (ln(young) = –0.006(year) - 10.5, $R^2$ = -0.05, $p$ = 0.79).

Overall, numbers of Yellow-billed Loon adults, nests, and young appear to fluctuate around an average equilibrium state. Smaller time periods with contrasting trends in adult numbers and measures of productivity suggest that population equilibrium is maintained at least in part by density dependence. Yellow-billed Loons are likely limited by the availability of large, deep lakes suitable for nesting and rearing broods. Time-lapse cameras deployed on nests in the Colville Delta study area (2008–2015) not only documented frequent intraspecific competition over such lakes but also showed that this competition can lower

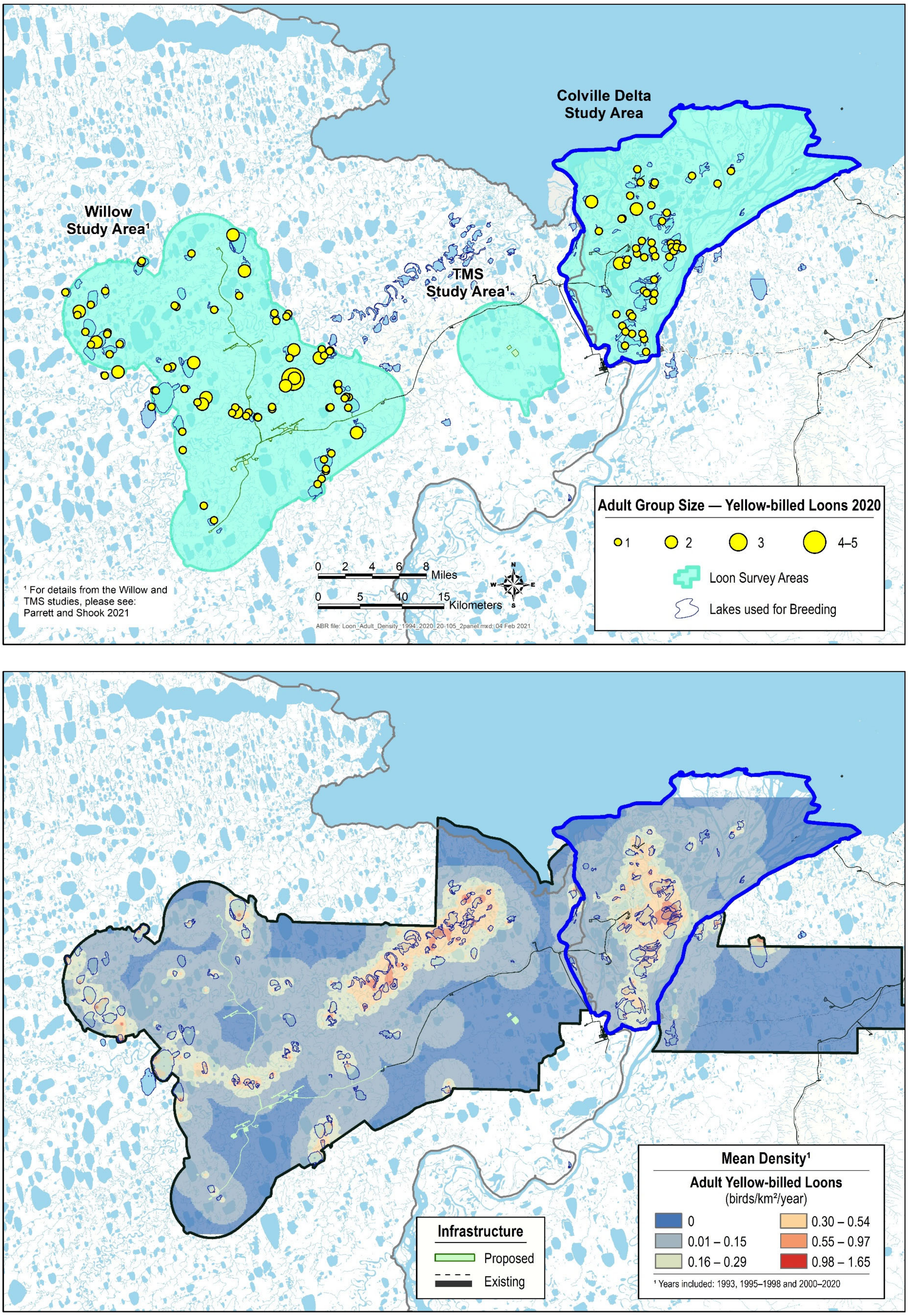


Figure 10. Group size (2020) and mean densities of Yellow-billed Loon adults observed during a single June nesting survey in the Colville Delta (blue outline), NPR-A, and Kuparuk study areas, Alaska, 1993, 1995–1998, 2000–2020.

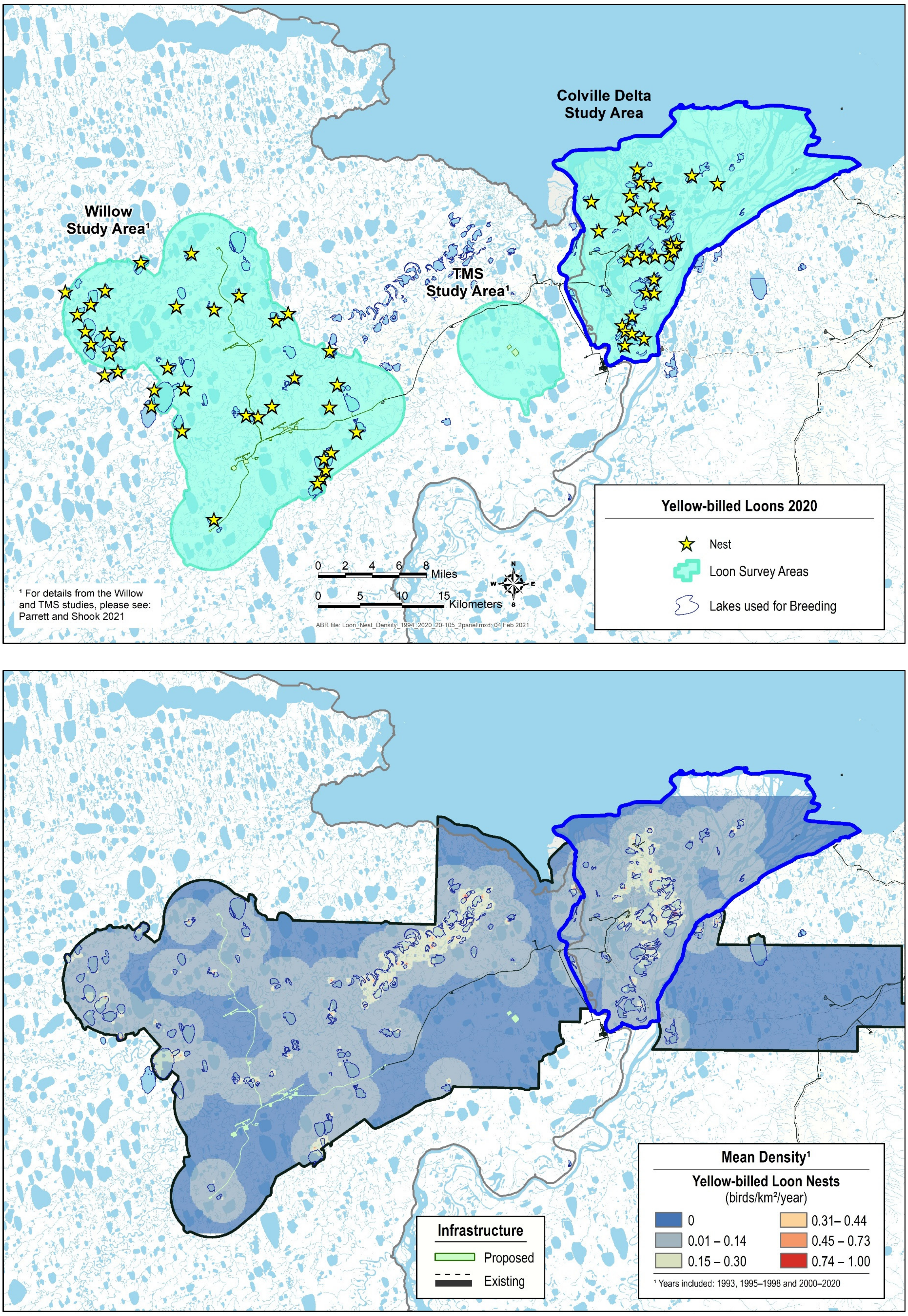


Figure 11. Yellow-billed Loon nest locations and mean annual densities observed during a single June nesting survey in the Colville Delta (blue outline), NPR-A, and Kuparuk study areas, Alaska, 1993, 1995–1998, 2000–2020.

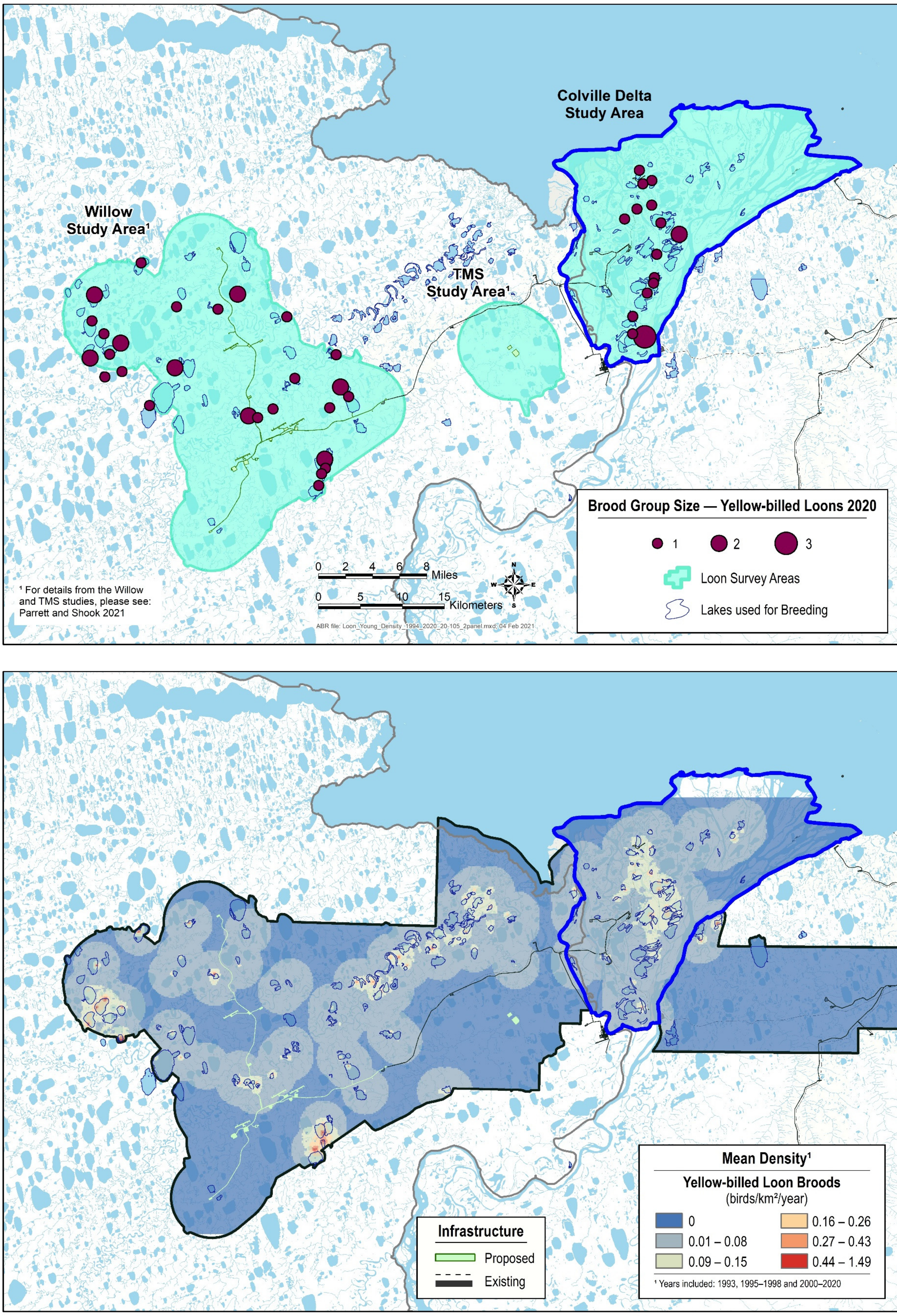


Figure 12. Yellow-billed Loon brood locations and mean annual densities observed during a single August brood-rearing survey in the Colville Delta (blue outline), NPR-A, and Kuparuk study areas, Alaska, 1993, 1995–1998, 2000–2020.

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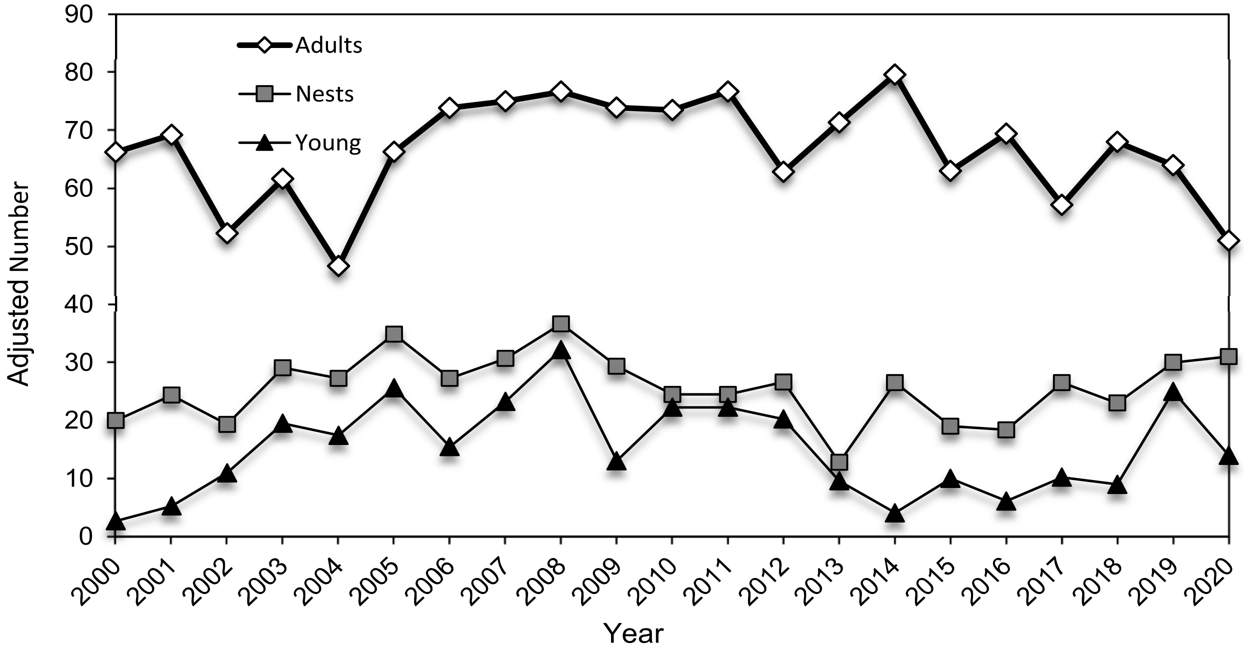


Figure 13. Annual numbers of Yellow-billed Loon adults and nests during the nesting survey and young during the brood-rearing survey, Colville Delta study area, Alaska, 2000–2020.

reproductive output. Incubating loons always left nests to interact with intruding conspecifics (presumably non-breeding, non-territory holding adults). These interactions indirectly caused nest failure by leaving eggs exposed to Glaucous Gulls. In fact, predation by gulls that occurred during intraspecific competition was the main cause of nest failure at camera-monitored nests during 2014, a year with extremely low chick productivity (Figure 13; Johnson et al. 2015). Cameras also documented pairs abandoning newly hatched chicks to fight intruders (Johnson et al. 2016). Although we lack observations during the later stages of brood-rearing, intruding Common Loons have been documented killing young during territorial takeovers (Piper et al. 2000). The proportion of nonbreeders in the adult count in the Colville Delta study area, the source of these nonbreeders, and the degree to which Yellow-billed Loons show natal philopatry are unknown. Common Loons have been documented returning within 20 km of their natal grounds once they reach maturity at 3 to 4 years old (Evers et al. 2020) and nearly half of the floaters in one study were composed of returning young (Piper et al. 2020). If Yellow-billed Loons are similar, a large proportion of non-breeding birds may be those produced within the region and directly contribute to the mechanism for density dependent population growth.

Although Yellow-billed Loon populations dynamics appear to be heavily influenced by adult density, the dynamics are also influenced by stochastic events that independently can depress productivity. For example, some pairs are precluded from nesting during years when the Colville River spills its banks during spring breakup because nest sites may remain under water late into the season (Johnson et al. 2014c). Because Yellow-billed loons are visual underwater hunters, the increased turbidity of flooded lakes may negatively affect hunting success of forage fish, at least early in the breeding season. Lakes without permanent connections to the river typically settle and are clear by the time nests hatch in mid-July (ABR, unpublished data). The effects of temporary turbidity on productivity is not well understood in Yellow-billed Loons. Unseasonably warm weather appears to increase the time loons spend away from their nests, presumably in an attempt to thermoregulate, thereby exposing unattended nests to avian predators (ABR, unpublished data). And, finally, changes in predator composition, primarily red foxes and brown bears, increases nest predation during some years because these mammalian predators can easily flush incubating loons from nests to eat eggs (Johnson et al. 2014c, 2015). The complex interplay between density dependence that occurs over decades and short-term stochastic events underscores the importance of long-term monitoring programs when interpreting population dynamics of Yellow-billed Loons.

Habitat Use

Yellow-billed Loons nested in 12 of 24 available habitats during nesting surveys conducted in the Colville Delta study area over 26 years (Table 6). Seven habitats, supporting 514 of 594 total nests, were preferred for nesting (Tapped Lake with High-water Connection, Deep Open Water without Islands, Deep Open Water with Islands or Polygonized Margins, Sedge Marsh, Deep Polygon Complex, Grass Marsh, and Patterned Wet Meadow). Within these habitats, nearly half (47%, $n$ = 594 nests) of the nests were built on islands but loons also built nests on peninsulas (24%), shorelines (24%), 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). 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. Nesting Yellow-billed Loons avoided nesting in 11 habitats, which together represented 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 (266 broods over 25 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 12% 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 habitat selection analyses highlight the importance of large, deep waterbodies to nesting and brood-rearing Yellow-billed Loons.

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 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 lake has not been used by nesting loons since this change because water has drained from the lake and now fluctuates with the river water level. Yellow-billed Loons do not nest or rear young in such lakes. Thirty-one of the 49 territories were occupied by breeding Yellow-billed Loons in 2020.

Of the 49 Yellow-billed Loon territories, 35 are composed 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. Most lakes were used for both nesting and brood-rearing; the smallest of those lakes was 4.8 ha.

## GLAUCOUS GULL

Distribution and Abundance

Including both systematic and incidental observations, we recorded 85 Glaucous Gull nests during the aerial survey for nesting loons during 2020; 41 of those nests were in the CD North subarea, 38 nests in the CD South subarea, and 6 nests in the Northeast Delta subarea (Figure 14). Fifty-one (60%) nests were found at colonies. We have identified 8 Glaucous Gull colonies in the Colville Delta study area since 2005, the first

Table 6. Habitat selection by nesting (1993, 1995–1998, and 2000–2020) and brood-rearing (1995–1998 and 2000–2020) Yellow-billed Loons, Colville Delta study area[a], Alaska.

| SEASON<br>Habitat type | No. of Nests or Broods | Use (%)[b] | Availability (%) | Monte Carlo Results[c] | Sample Sized |
|---|---|---|---|---|---|
| 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 | 50 | 8.4 | 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 | 60 | 10.1 | 4.7 | prefer | |
| Deep Open Water with Islands or Polygonized | 153 | 25.8 | 2.7 | prefer | |
| Shallow Open Water without Islands | 0 | 0 | 0.3 | ns | low |
| Shallow Open Water with Islands or Polygonized | 2 | 0.3 | 0.1 | ns | low |
| River or Stream | 0 | 0 | 8.7 | avoid | |
| Sedge Marsh | 5 | 0.8 | <0.1 | prefer | low |
| Deep Polygon Complex | 29 | 4.9 | 3.0 | prefer | |
| Grass Marsh | 15 | 2.5 | 0.3 | prefer | low |
| Young Basin Wetland Complex | 0 | 0 | <0.1 | ns | low |
| Old Basin Wetland Complex | 0 | 0 | <0.1 | ns | low |
| Nonpatterned Wet Meadow | 66 | 11.1 | 8.8 | ns | |
| Patterned Wet Meadow | 202 | 34.0 | 24.1 | prefer | |
| Moist Sedge-Shrub Meadow | 7 | 1.2 | 3.2 | avoid | |
| Moist Tussock Tundra | 0 | 0 | 0.9 | avoid | |
| Tall, Low, or Dwarf Shrub | 2 | 0.3 | 6.6 | avoid | |
| Barrens | 0 | 0 | 12.1 | avoid | |
| Human Modified | 0 | 0 | 0.1 | ns | low |
| Total | 594 | 100 | 100 | | |
| BROOD-REARING | | | | | |
| Open Nearshore Water | 0 | 0 | 2 | avoid | |
| Brackish Water | 1 | 0.4 | 1.1 | ns | low |
| Tapped Lake with Low-water Connection | 0 | 0 | 5.9 | avoid | |
| Tapped Lake with High-water Connection | 58 | 21.8 | 5 | prefer | |
| Salt Marsh | 0 | 0 | 2.7 | avoid | |
| Tidal Flat Barrens | 0 | 0 | 3.5 | avoid | |
| Salt-killed Tundra | 0 | 0 | 4.2 | avoid | |
| Deep Open Water without Islands | 118 | 44.4 | 4.1 | prefer | |
| Deep Open Water with Islands or Polygonized Margins | 88 | 33.1 | 3.1 | prefer | |
| Shallow Open Water without Islands | 0 | 0 | 0.3 | ns | low |
| Shallow Open Water with Islands or Polygonized Margins | 0 | 0 | 0.1 | ns | low |
| River or Stream | 0 | 0 | 8.7 | avoid | |
| Sedge Marsh | 0 | 0 | <0.1 | ns | low |
| Deep Polygon Complex | 0 | 0 | 3.4 | avoid | |
| Grass Marsh | 1 | 0.4 | 0.4 | ns | low |

Table 6. Continued.

| SEASON<br>Habitat type | No. of Nests or Broods | Use (%)[b] | Availability (%) | Monte Carlo Results[c] | Sample Size[d] |
|---|---|---|---|---|---|
| BROOD-REARING (continued) | | | | | |
| Young Basin Wetland Complex | 0 | 0 | <0.1 | ns | low |
| Old Basin Wetland Complex | 0 | 0 | <0.1 | avoid | |
| Nonpatterned Wet Meadow | 0 | 0 | 9.2 | avoid | |
| Patterned Wet Meadow | 0 | 0 | 22.9 | avoid | |
| Moist Sedge-Shrub Meadow | 0 | 0 | 3.1 | ns | low |
| Moist Tussock Tundra | 0 | 0 | 1.0 | avoid | |
| Tall, Low, or Dwarf Shrub | 0 | 0 | 7.0 | avoid | |
| Barrens | 0 | 0 | 12.0 | ns | low |
| Human Modified | 0 | 0 | 0.3 | avoid | |
| Total | 266 | 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 10,000 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.

year that 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 (Appendix C). All 8 colonies were active in 2020. 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 2020, which was above the 18-year mean (16.9 ± 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 C). Five of the 8 colonies are located on an index lake. Over the last 16 years, the number of Glaucous Gull nests has increased at these index lakes (Figure 15, Table 7). The annual growth rate for nest numbers on the index lakes was nearly 4% (ln(nests) = 0.036 (year) – 70.33, $R^2 = 0.54$, $p = <0.01$). Despite the increase in gull nests, the number of index lakes used annually shows no trend and varies among years, suggesting that the increase in nests is generally occurring on lakes that are already being used by other nesting pairs. In 2020, 61 nests occupied 23 of the 50 index lakes, which was above the long-term mean (51.5 ± 2.8 nests, range 33–70 nests, $n = 16$ years; Table 7). Annual growth in nest numbers is occurring both among colony-nesting gulls (3.5% annual growth, $R^2 = 0.51$, $p = <0.01$) and those outside of colonies (3.6% annual growth, $R^2 = 0.30$, $p = 0.01$).

Including both systematic and incidental observations, 63 Glaucous Gull chicks were recorded in the Colville Delta study area during the 2020 survey for brood-rearing loons (Figure 14). Broods were present at all 8 of the colonies and accounted for the majority (78%) of the chicks (49) seen during 2020. Some young gulls seen during the survey appeared to be flight capable or had already attained juvenal plumage. The majority, though, were not observed flying.

Glaucous Gull abundance and population trends should be considered when evaluating Yellow-billed Loon productivity in relation to nest attendance because loons experience a high rate of egg loss at unattended nests. Glaucous Gulls were the most commonly-recorded predator at camera-monitored Yellow-billed nests from 2008–2015 and were responsible for nearly a third of the nest failures documented in the Colville Delta study area (Johnson et al. 2016). Gulls, along with Parasitic Jaegers, cannot flush incubating

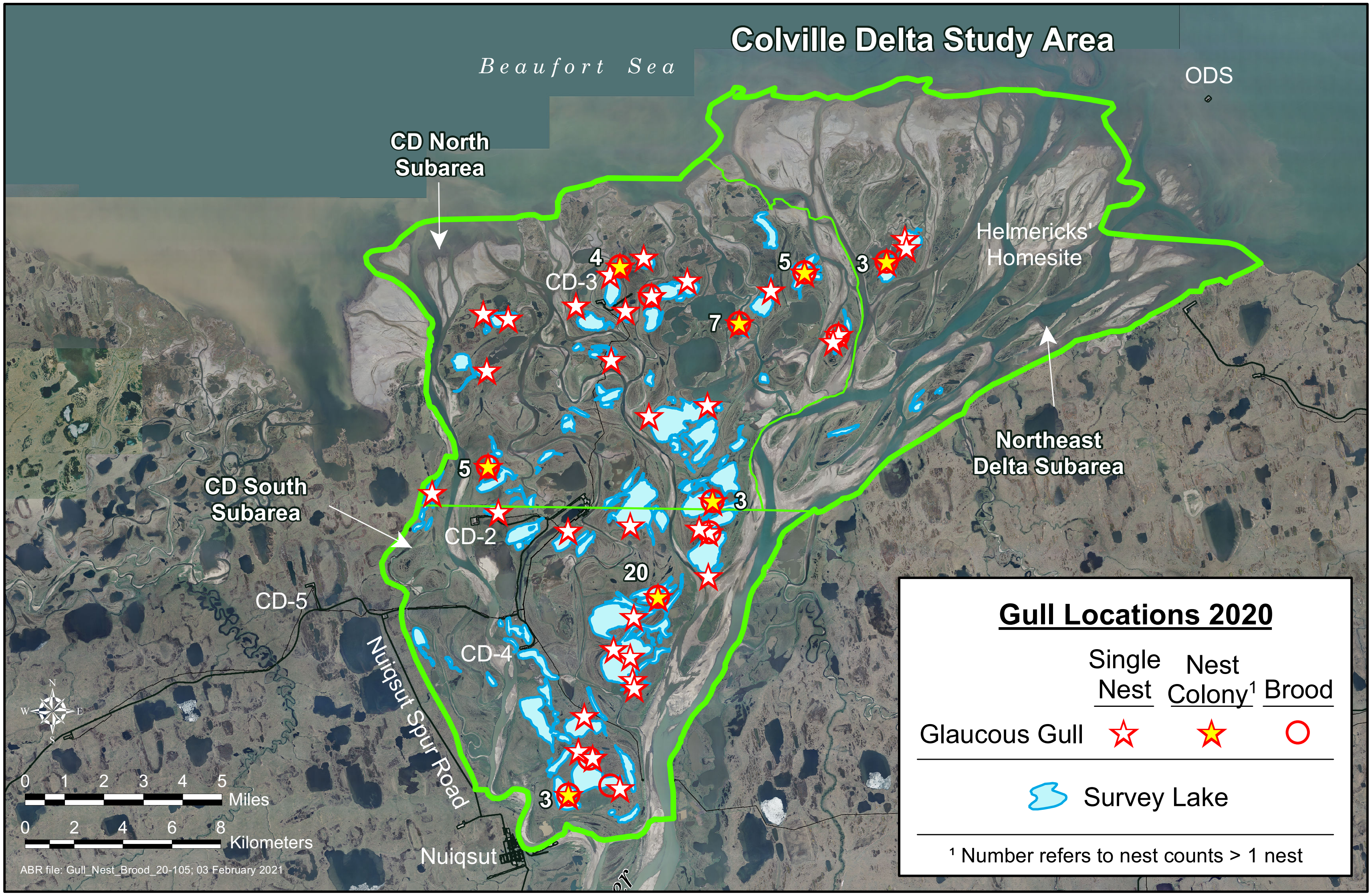


Figure 14. Glaucous Gull nest and brood locations, Colville Delta study area, Alaska, 2020.

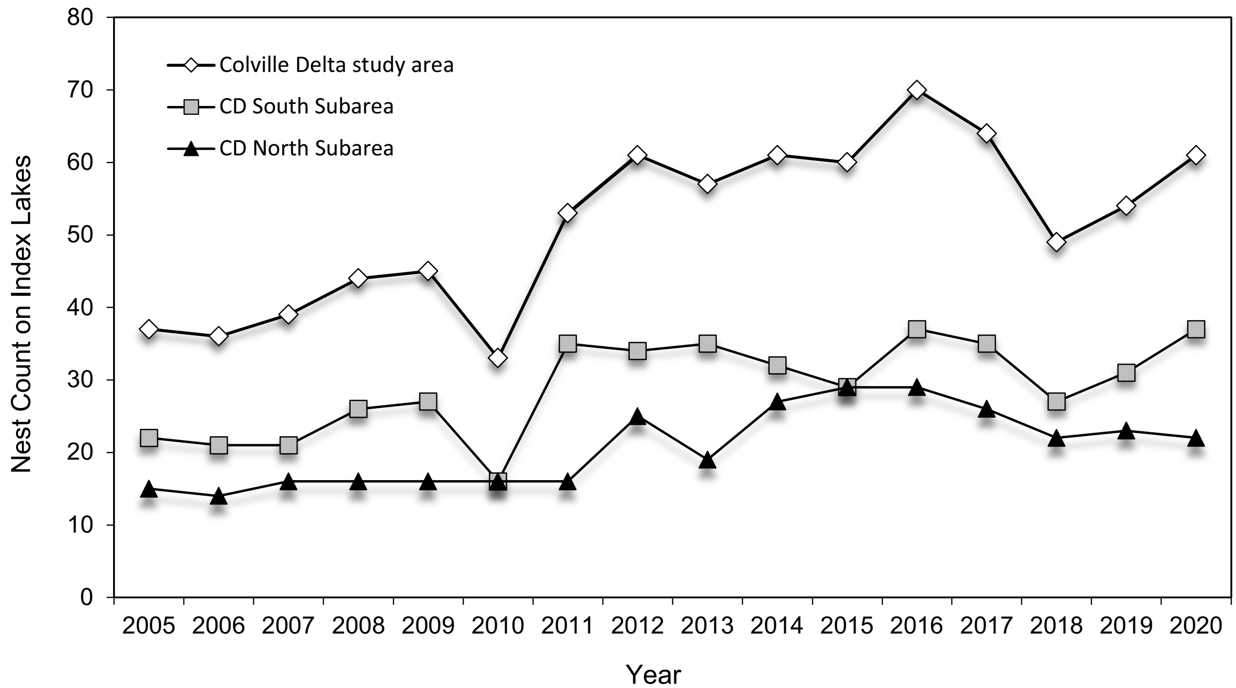


Figure 15. Annual number of Glaucous Gull nests recorded during aerial loon surveys on 50 index lakes, Colville Delta study area, Alaska, 2005–2020.

Yellow-billed Loons from nests and instead, rely on finding unattended nests to steal eggs. Together, gulls and jaegers accounted for 40% of all predation events. The predation risk to unattended Yellow-billed nests likely increases with increasing gull abundance.

### 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 used habitats were Deep Open Water with Islands or Polygonized Margins (34%, $n$ = 85 nests) and Patterned Wet Meadow (24%). The latter habitat contained the largest Glaucous Gull colony (CD-4 Northeast) in the Colville Delta study area. This colony accounted for 18 of the 20 nests found in Patterned Wet Meadow. Within the loon survey area, Glaucous Gulls most commonly nested on islands, which contained 90% of all nests found during 2020 ($n$ = 85 nests).

A habitat selection analysis was not conducted on nesting Glaucous Gulls because the loon survey area did not include small lakes or terrestrial habitats between large lakes where gulls commonly nest. We have observed, however, that Glaucous Gulls and Yellow-billed Loons in the Colville Delta study area use similar habitats for breeding. Both species most commonly nest on islands and use lake habitats with complicated, polygonized shorelines. Further, Yellow-billed Loons and Glaucous Gulls sometimes nest on the same island, placing nests less than a few meters apart. This overlap in habitat use and nest proximity likely increases the predation risk to loon eggs by making it easier for gulls to detect when loon nests are unattended.

Table 7. Number of Glaucous Gull nests recorded on 50 index lakes and associated nesting colonies, Colville Delta study area, Alaska, 2002–2020.

| | CD North Subarea | | | | CD South Subarea | | | Northeast Delta Subarea | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Butterfly Lake Colony | CD-3 North Colony | Alpine East Colony | All Nests[a] | CD-4 Northeast 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 | 15 | 15 | 1 | 22 | 0 | 37 | 15 |
| 2006 | 4 | 1 | 1 | 14 | 16 | 0 | 21 | 1 | 36 | 17 |
| 2007 | 5 | 1 | 1 | 16 | 13 | 2 | 21 | 2 | 39 | 19 |
| 2008 | 5 | 1 | 2 | 16 | 18 | 2 | 26 | 2 | 44 | 18 |
| 2009 | 6 | 1 | 1 | 16 | 19 | 1 | 27 | 2 | 45 | 20 |
| 2010 | 5 | 2 | 1 | 16 | 6 | 2 | 16 | 1 | 33 | 19 |
| 2011 | 5 | 2 | 0 | 16 | 17 | 4 | 35 | 2 | 53 | 22 |
| 2012 | 7 | 5 | 1 | 25 | 17 | 1 | 34 | 2 | 61 | 26 |
| 2013 | 5 | 4 | 1 | 19 | 23 | 0 | 35 | 3 | 57 | 21 |
| 2014 | 6 | 5 | 1 | 27 | 18 | 3 | 32 | 2 | 61 | 26 |
| 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 |
| 2020 | 5 | 4 | 3 | 22 | 20 | 3 | 37 | 2 | 61 | 23 |
| Mean | 5.4 | 3.3 | 1.6 | 20.7 | 17.3 | 2.3 | 29.1 | –[d] | 51.5 | 20.8 |
| SE | 0.3 | 0.5 | 0.2 | 1.3 | 1.0 | 0.3 | 1.6 | –[d] | 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, 2020.

| Habitat type | Nests | Use (%) |
|---|---|---|
| Tapped Lake with High-water Connection | 13 | 15.3 |
| Deep Open Water without Islands | 1 | 1.2 |
| Deep Open Water with Islands or Polygonized Margins | 29 | 34.1 |
| Shallow Open Water with Islands or Polygonized Margins | 1 | 1.2 |
| Sedge Marsh | 1 | 1.2 |
| Deep Polygon Complex | 4 | 4.7 |
| Grass Marsh | 10 | 11.8 |
| Nonpatterned Wet Meadow | 4 | 4.7 |
| Patterned Wet Meadow | 20 | 23.5 |
| Moist Sedge-Shrub Meadow | 2 | 2.4 |
| Total | 85 | 100 |

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Appendix A. Common, Iñupiaq, and scientific names of birds and mammals commonly observed in the Colville Delta and NE NPR-A study areas.

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

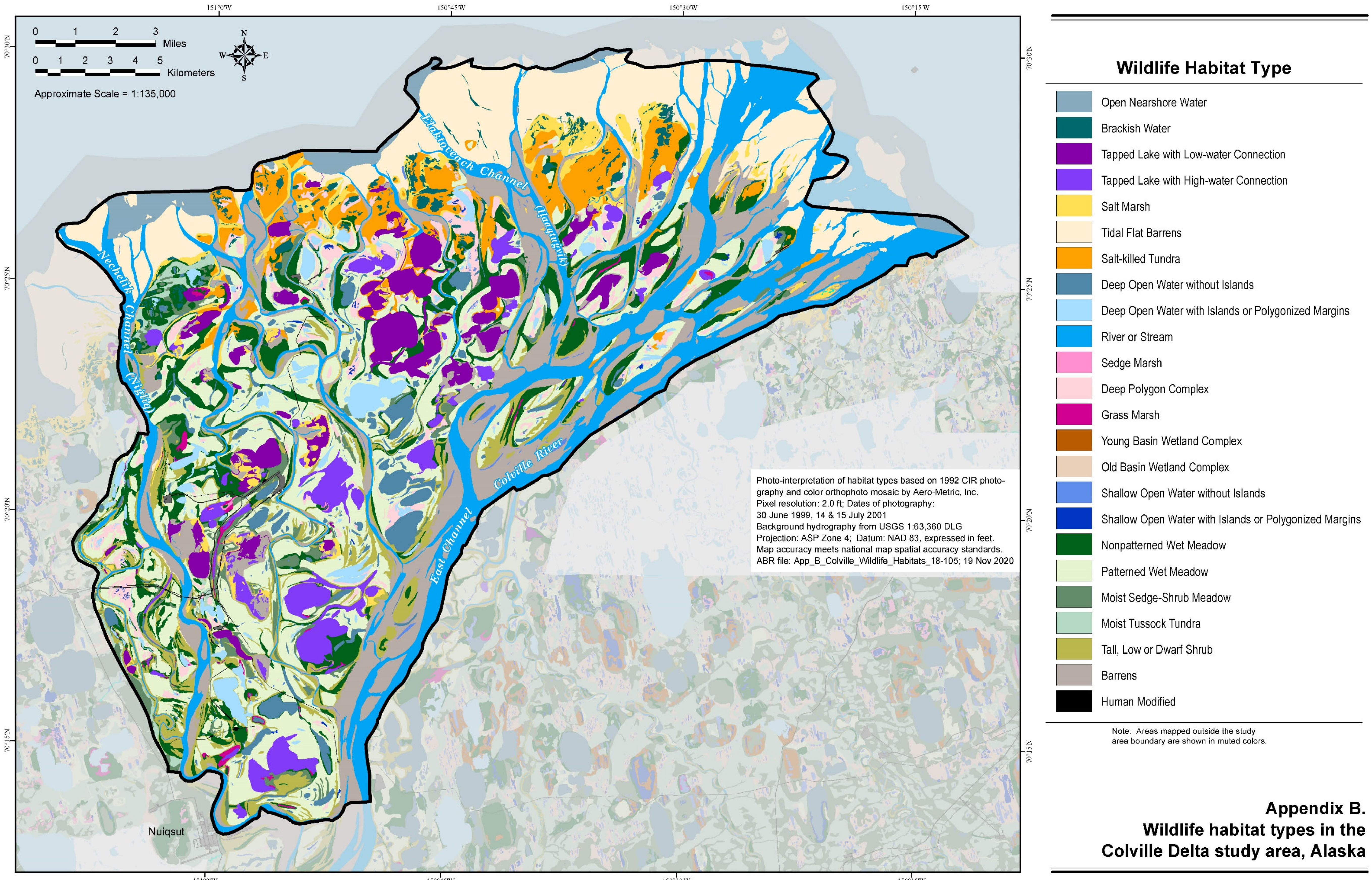


Photo-interpretation of habitat types based on 1992 CIR photography and color orthophoto mosaic by Aero-Metric, Inc.
Pixel resolution: 2.0 ft; Dates of photography: 30 June 1999, 14 & 15 July 2001
Background hydrography from USGS 1:63,360 DLG
Projection: ASP Zone 4; Datum: NAD 83, expressed in feet.
Map accuracy meets national map spatial accuracy standards.
ABR file: App_B_Colville_Wildlife_Habitats_18-105; 19 Nov 2020

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

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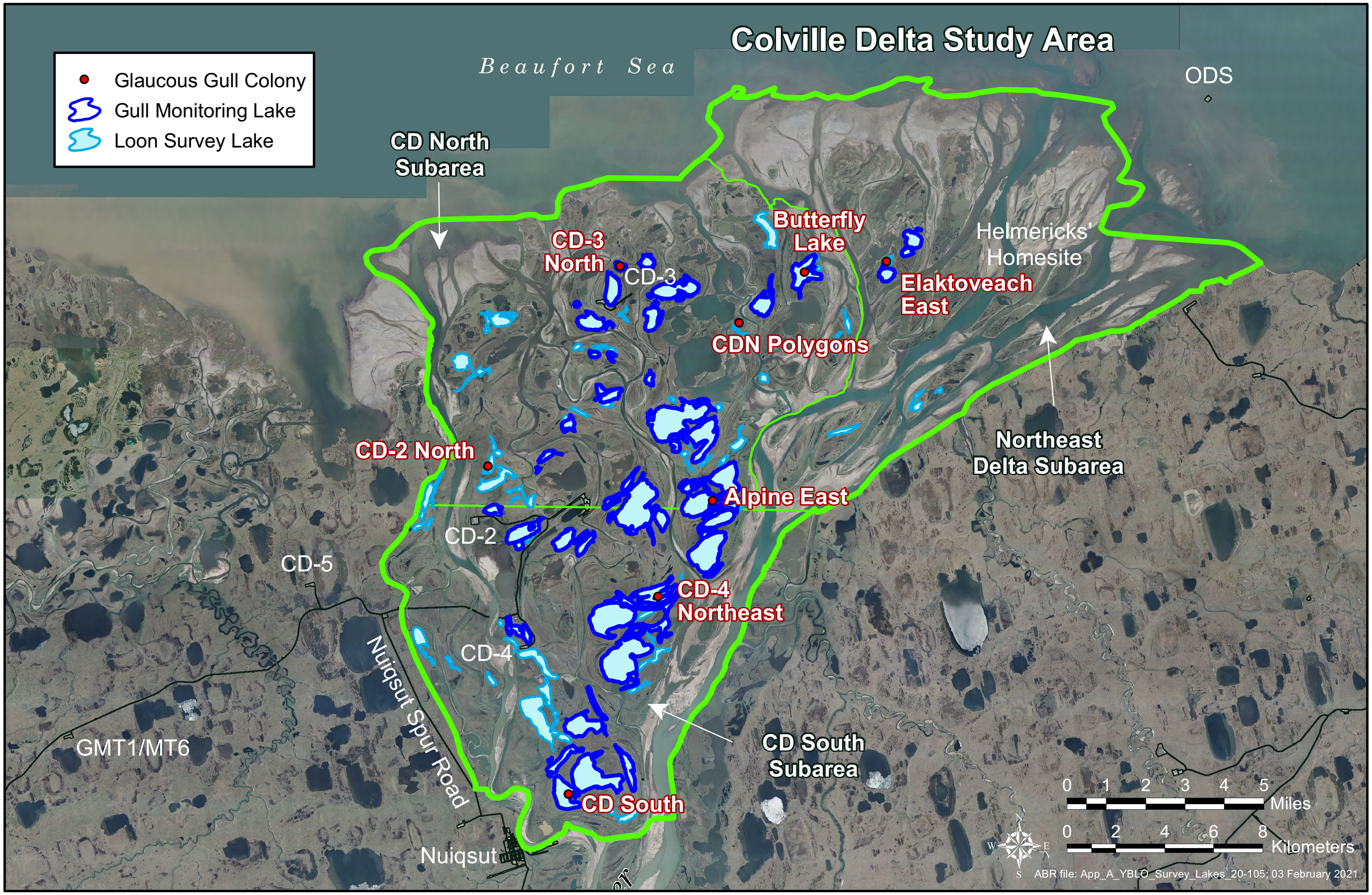



Appendix C. Lakes included in aerial surveys for Yellow-billed Loons, the 50 monitoring lakes systematically surveyed for Glaucous Gulls and gull colony locations, Colville Delta study area, Alaska, 2020.

Appendix D. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2020.

| SPECIES Subarea | Observed Males | Females | Total | Pairs | Indicated Total[a] | Observed Density[b] | Indicated Density[a, b] |
|---|---|---|---|---|---|---|---|
| SPECTACLED EIDER | | | | | | | |
| CD North | | | | | | | |
| On ground | 14 | 8 | 22 | 8 | 28 | 0.11 | 0.14 |
| In flight | 9 | 5 | 14 | 5 | – | 0.07 | – |
| All birds | 23 | 13 | 36 | 13 | – | 0.17 | – |
| Northeast Delta | | | | | | | |
| On ground | 3 | 1 | 4 | 1 | 6 | 0.03 | 0.04 |
| In flight | 2 | 1 | 3 | 1 | – | 0.02 | – |
| All birds | 5 | 2 | 7 | 2 | – | 0.04 | – |
| CD South | | | | | | | |
| On ground | 1 | 0 | 1 | 0 | 2 | 0.01 | 0.01 |
| In flight | 1 | 0 | 1 | 0 | – | 0.01 | – |
| All birds | 2 | 0 | 2 | 0 | – | 0.01 | – |
| Total (subareas combined) | | | | | | | |
| On ground | 18 | 9 | 27 | 9 | 36 | 0.05 | 0.07 |
| In flight | 12 | 6 | 18 | 6 | – | 0.04 | – |
| All birds | 30 | 15 | 45 | 15 | – | 0.09 | – |
| KING EIDER | | | | | | | |
| CD North | | | | | | | |
| On ground | 28 | 26 | 54 | 22 | 56 | 0.26 | 0.27 |
| In flight | 10 | 7 | 17 | 7 | – | 0.08 | – |
| All birds | 38 | 33 | 71 | 29 | – | 0.34 | – |
| Northeast Delta | | | | | | | |
| On ground | 20 | 14 | 34 | 14 | 40 | 0.22 | 0.25 |
| In flight | 3 | 2 | 5 | 2 | – | 0.03 | – |
| All birds | 23 | 16 | 39 | 16 | – | 0.25 | – |
| CD South | | | | | | | |
| On ground | 6 | 4 | 10 | 4 | 12 | 0.07 | 0.09 |
| In flight | 5 | 4 | 9 | 3 | – | 0.07 | – |
| All birds | 11 | 8 | 19 | 7 | – | 0.14 | – |
| Total (subareas combined) | | | | | | | |
| On ground | 54 | 44 | 98 | 40 | 108 | 0.20 | 0.22 |
| In flight | 18 | 13 | 31 | 12 | – | 0.06 | – |
| All birds | 72 | 57 | 129 | 52 | – | 0.26 | – |

[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, 2020.

| | Yellow-billed Loon | | | | | Pacific Loon[a] | | | Red-throated Loon[a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | | | Density (number/km²) | | Number | | | Number | | |
| SUBAREA[b] Survey Type | Adults | Nests/ Brood | Young | Adults | Nests/ Broods | Adults | Nests/ Broods | Young | Adults | Nests/ Broods | Young |
| CD NORTH | | | | | | | | | | | |
| Nesting | 25 | 16 | – | 0.12 | 0.08 | 83 | 16 | – | 8 | 2 | – |
| Brood-rearing | 31 | 8[c] | 8 | 0.15 | 0.04 | 62 | 13 | 14 | 13 | 3 | 3 |
| CD SOUTH | | | | | | | | | | | |
| Nesting | 25 | 15 | – | 0.16 | 0.10 | 53 | 11 | – | 6 | 0 | – |
| Brood-rearing | 32 | 7[d] | 6 | 0.21 | 0.04 | 30 | 3 | 3 | 4 | 0 | 0 |
| NORTHEAST DELTA[e] | | | | | | | | | | | |
| Nesting | 1 | 0 | – | – | – | 8 | 3 | – | 9 | 0 | – |
| Brood-rearing | 1 | 0 | 0 | – | – | 5 | 2 | 2 | 1 | 0 | 0 |
| TOTAL (subareas combined)[f] | | | | | | | | | | | |
| Nesting | 51 | 31 | – | 0.14 | 0.08 | 144 | 30 | – | 23 | 2 | – |
| Brood-rearing | 64 | 15 | 14 | 0.17 | 0.04 | 97 | 18 | 19 | 18 | 3 | 3 |

[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 1.
[c] Number includes 1 brood determined only by eggshell evidence.
[d] Number includes 3 broods determined only by eggshell evidence.
[e] Densities were not calculated for the Northeast Delta subarea because only a portion of the subarea was surveyed.
[f] Total is the sum of all subareas but density calculations included only CD North and CD South for Colville Delta.

Appendix F. Annual density (number/km²) of Yellow-billed Loons, nests, and broods, Colville Delta study area, Alaska, 1993, 1995–1998, and 2000–2020.

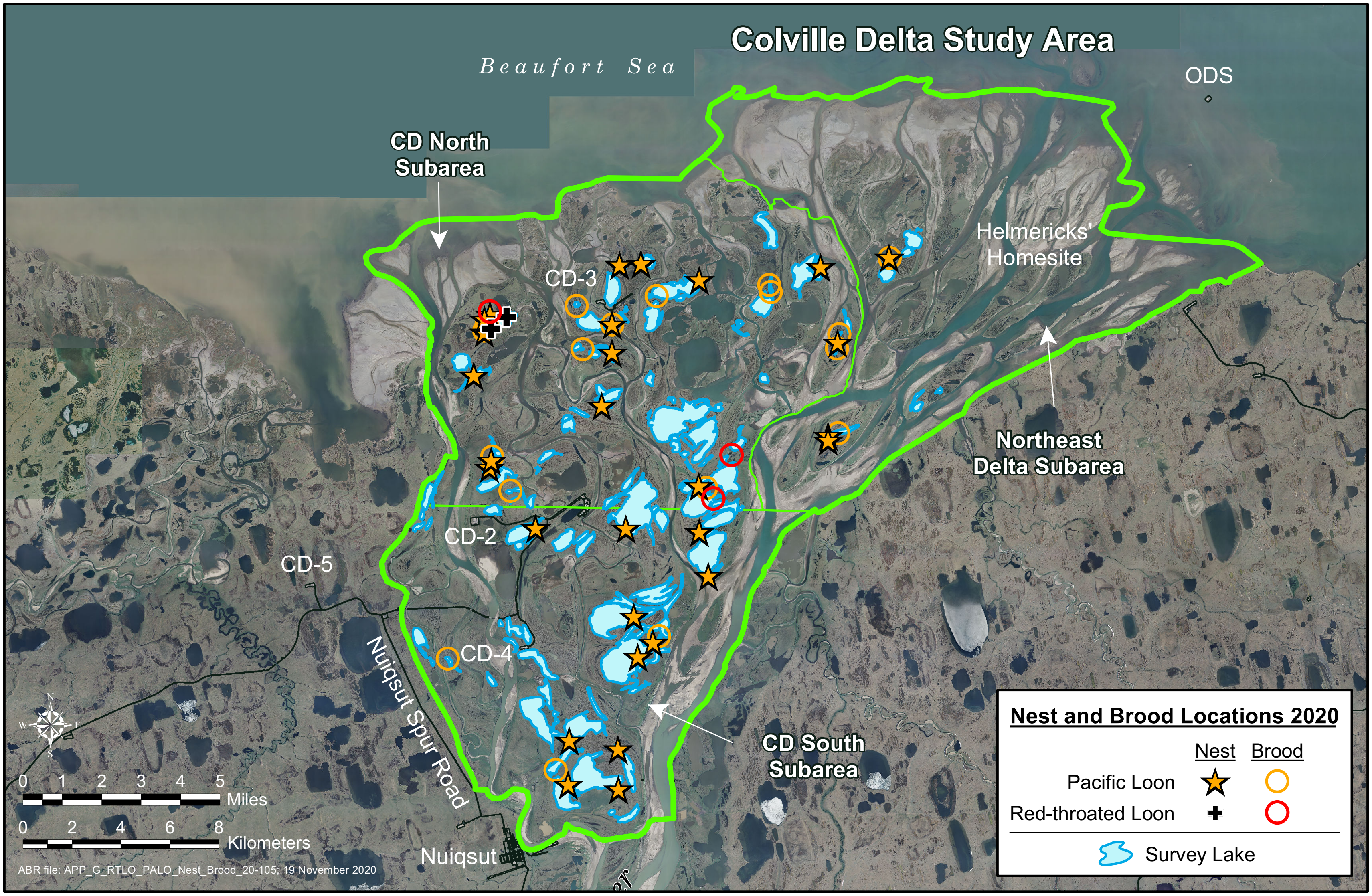
| | Density | | | |
|---|---|---|---|---|
| Year | Nesting Survey Adults | Nests[b] | Brood-rearing Survey Adults | Broods[c] |
| 1993 | 0.13 | 0.02 (0.04) | 0.08 | 0.02 |
| 1995 | 0.10 | 0.03 (0.05) | 0.13 | 0.02 |
| 1996 | 0.12 | 0.03 (0.06) | 0.17 | 0.02 |
| 1997 | 0.13 | 0.03 (0.04) | 0.18 | 0.01 |
| 1998 | 0.09 | 0.04 (0.06) | 0.14 | 0.03 |
| 2000 | 0.15 | 0.04 (0.04) | 0.06 | 0.01 |
| 2001 | 0.15 | 0.05 (0.06) | 0.09 | 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 | 0.21 | 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) |
| 2020 | 0.14 | 0.09 (0.09)[d] | 0.17 | 0.03 (0.04) |
| Mean | 0.15 | 0.06 | 0.14 | 0.03 |
| SE | 0.01 | <0.01 | 0.01 | <0.01 |

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

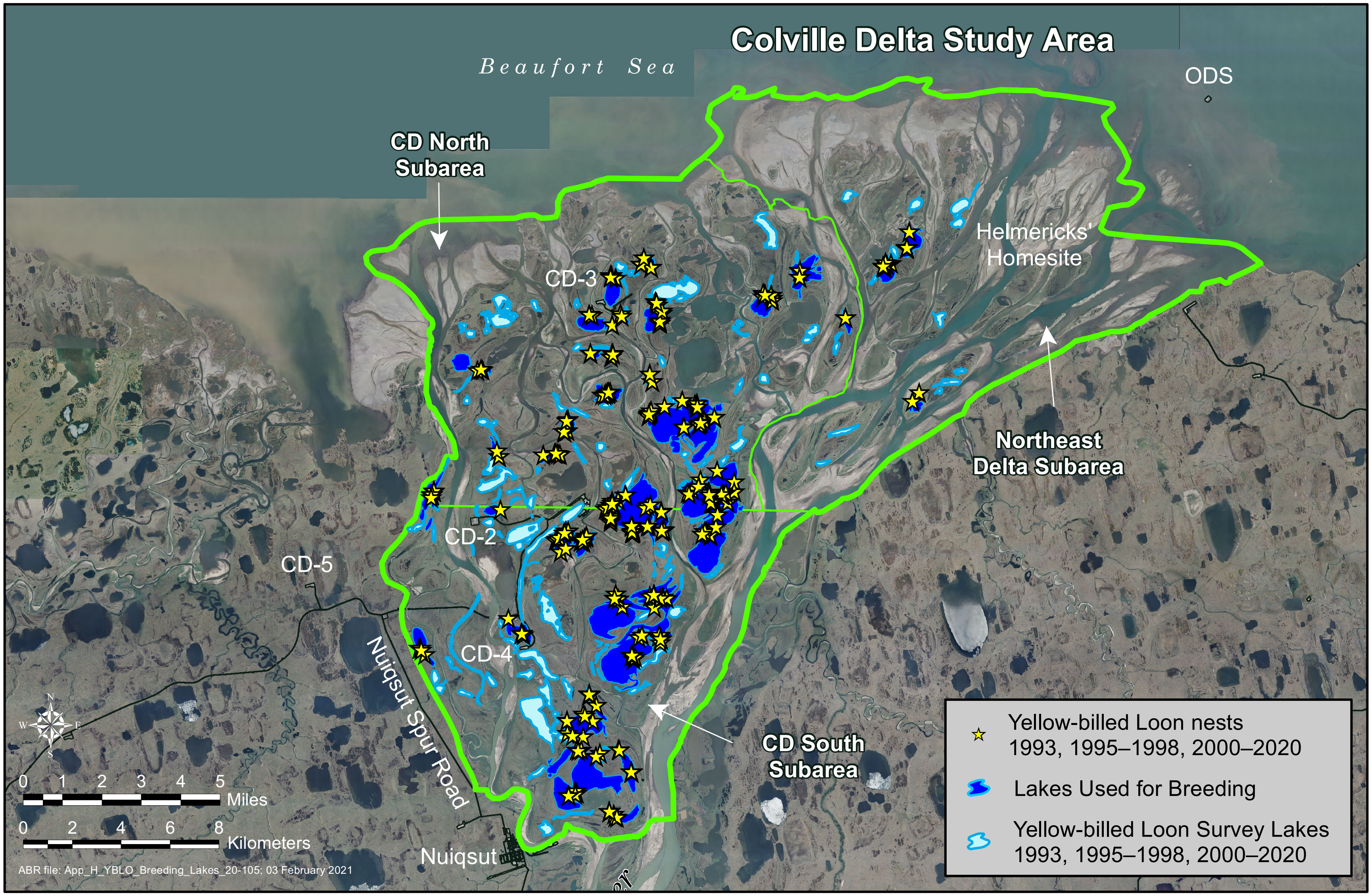
[b] Density of nests found on the nesting survey and, in parentheses, cumulative density including additional nests found during revisit (1996–2002), monitoring (2006–2014), and early nest surveys (2011, 2012, 2014), early camera monitoring (2013–2015), and nests inferred from the presence of broods where no nest was found during other surveys (1993–2020).

[c] Density of broods found on the brood-rearing survey and, in parentheses, cumulative density including additional broods found during monitoring surveys (2005–2014) or inferred from eggshell fragments at the nest (2008–2020).

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




Appendix G. Pacific and Red-throated loon nests and broods, Colville Delta study area, Alaska, 2020.




Appendix H. Lakes used by nesting and brood-rearing Yellow-billed Loons, Colville Delta study area, Alaska, 1993, 1995–1998 and 2000–2020.