AVIAN STUDIES IN THE WILLOW PROJECT AREA, 2019

John E. Shook
Julie P. Parrett
Charles B. Johnson
Joseph Welch

Prepared for
CONOCOPHILLIPS ALASKA, INC.
Anchorage, Alaska

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

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Joseph Welch

ABR, Inc.—Environmental Research & Services

P.O. Box 80410

Fairbanks, AK 99708

January 2020

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ACKNOWLEDGMENTS

Avian surveys in the Willow Project area of the NE NPR-A were conducted by an experienced crew consisting of Tim Obritschkewitsch and co-authors John Shook and Julie Parrett. Chris Swingley programmed the tablets for aerial survey recording. Pam Odom provided travel and publication support, while Joe Welch assisted with analysis and writing. Will Lentz and Tony LaCortiglia supplied equipment and technical assistance. Adrian Gall reviewed the report. We thank the helicopter coordinators, Soloy Helicopters, North River Air, and the staff at Alpine for their assistance. This work was directed by Robyn McGhee, Environmental Studies Coordinator at ConocoPhillips; we appreciate Robyn's and ConocoPhillips' continued support.

INTRODUCTION

The Colville River delta and Northeast Planning Area of the National Petroleum Reserve in Alaska (NE NPR-A) have been focal points of exploration and development for oil and gas since at least the 1990s. During 2019, ABR conducted baseline wildlife surveys for selected bird species in the Willow Project area of the NE NPR-A in support of ConocoPhillips, Alaska, Inc. (CPAI). Previous studies in the area are described by Johnson et al. (2015, 2019a).

In this report, we present the results of eider and loon surveys that were conducted in the Willow Project area in 2019. The surveys were designed to collect data on the distribution, abundance, and habitat use of 2 focal taxa (common names followed in parentheses by Iñupiaq names and scientific names) in support of permit applications: Spectacled Eider (Qavaasuk, *Somateria fischeri*) and Yellow-billed Loon (Tuullik, *Gavia adamsii*). These 2 species were selected because of: 1) threatened or sensitive status; 2) restricted breeding range; and 3) best management practices adopted for NPR-A (BLM 2013). The Spectacled Eider was listed as threatened in 1993 (58 FR 27474–27480) under the Endangered Species Act of 1973, as amended, and the Yellow-billed Loon is listed as a sensitive species by the BLM (BLM 2019).

Required state and federal permits were obtained for all survey activities, including a Scientific Permit (Permit No. 19-161 issued 23 May 2019) 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 Willow Project area is located in the NE NPR-A about 31 km (19 miles) west of Nuiqsut (Figure 1). The area studied for the Willow Project in 2019 extended approximately 32 km west, 19 km north, and 24 km south of the GMT2/MT7 drill site. The avian study was comprised of the Willow eider survey area (1,468 km²), the Willow loon survey area (851 km²) and the Tiŋmiaqsiuġvik Material Site loon survey area (114 km²). The loon survey areas covered all potential Yellow-billed Loon nesting and brood-rearing lakes within 3 miles of proposed facilities in the Willow Project area and the Tiŋmiaqsiuġvik Material Site (TMS) (Figure 1).

Landforms, vegetation, and wildlife habitats in the Willow Project area were described in Wells et al. (2018a, 2018b). Jorgenson et al. 2003 provided the previous habitat map and descriptions for the NE NPR-A, which included the GMT2/MT7 area before the Willow Project area was mapped.

METHODS

We collected data on eiders and loons in the Willow Project area and loons near the Tiŋmiaqsiuġvik Material Site. Aerial surveys were conducted because of the large size of the areas and the short periods of time that each species is at the optimal phase of their annual cycle for data collection. Each survey was scheduled specifically for the period when the focal species was most easily detected or was at an important stage of its breeding cycle (e.g., nesting or raising broods). In 2019, we used a fixed-wing aircraft to conduct 1 aerial survey for eiders during pre-nesting, and we used a helicopter to conduct 2 aerial surveys for Yellow-billed Loons, one during nesting and another during brood-rearing. Nesting and brood-rearing Pacific Loons (Malġi, *Gavia pacifica*), Red-throated Loons (Qaqsrauq, *G. stellata*), and gulls were recorded incidentally during loon surveys.

Concerns about disturbance to local residents and wildlife from survey flights have dictated that we conduct the fewest survey flights necessary and at the highest altitudes possible. Flight altitudes were set at the maximal altitude at which the target species could be reliably detected and counted (Table 1). Daily phone calls with Nuiqsut subsistence representatives were coordinated by the ConocoPhillips Village Outreach group and the Helicopter Coordinator based at Alpine to identify locations with active hunting parties. Additionally, aerial observers looked for people, boats, and off-road vehicles that might indicate presence of subsistence hunters. If hunting parties were present, we diverted the aircraft to reduce disturbance to hunters.

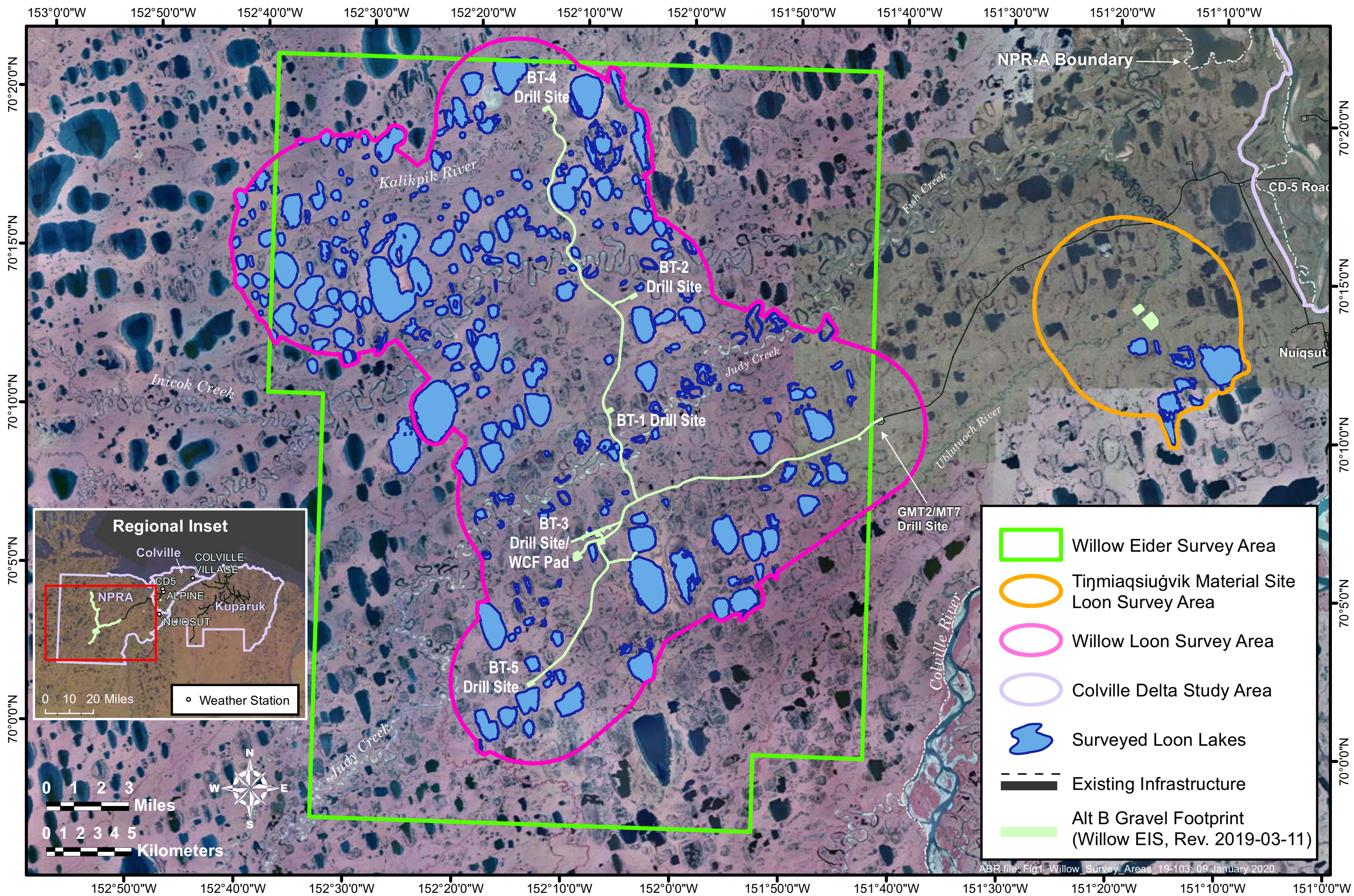

Figure 1. Wildlife survey areas for the Willow project area, NE NPR-A, 2019.

Table 1. Avian surveys conducted in the Willow Project area, NE NPR-A, 2019.

	Pre-nesting Eider Survey[a]	Yellow-billed Loon Surveys[b,c]	
		Nesting	Brood-rearing
Number of Surveys	1	1	1
Survey Dates	11–12 and 14 June	18–24 June	15–19 Aug
Aircraft[d]	C185	A-Star	A-Star
Transect Width (km)	0.4	–	–
Transect Spacing (km)	0.8	–	–
Aircraft Altitude (m)	35–45	60–65	60–65
Notes	50% coverage	All lakes ≥ 5 ha in size	All lakes ≥ 5 ha in size

[a] Both Spectacled Eiders and King Eiders were recorded.
[b] Nests and broods of Pacific Loons, Red-throated Loons, Glaucous Gulls, and Sabine's Gulls were recorded incidentally.
[c] Survey area for loons includes the Tiŋmiaqsiuġvik Material Site.
[d] C185 = Cessna 185 fixed-wing airplane; A-Star = Airbus AS 350 B2 helicopter.

During the surveys, locations of eiders, loons, and gulls were recorded on digital orthophoto mosaics of natural color imagery with 0.22–0.30 m resolution acquired in 2004–2015 by Quantum Spatial (Anchorage, AK). Where recent imagery did not exist, we used BLM's publicly available NPR-A-wide color-infrared ortho-mosaic with 2.5 m resolution. Habitat mapping for the Willow Project area was prepared using a base map of DigitalGlobe satellite imagery with 0.5 m resolution in natural color and color infrared acquired 5 July 2015. Bird locations plotted on moving maps in digital tablet apps were reviewed before they were exported to a geographical information system (GIS) database.

In this report, we present data summaries as means with 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 abundance, distribution, and habitat selection of 4 species of eiders—Spectacled, King, Steller's (Igniqauqtuq, *Polysticta stelleri*), and Common eiders (Amauligruaq, *Somateria mollisima*) with data collected on a single aerial surveys flown annually during the pre-nesting period when male eiders were still present on the breeding grounds. In 2019, we conducted the pre-nesting survey during 11–12 and 14 June (Table 1). This survey followed the same methods that were used during previous surveys conducted by ABR in portions of the NE NPR-A and in the Colville River delta (Johnson et al. 2015). The survey was flown in a Cessna 185 airplane at 35–45 m above ground level (agl) and at ~145 km/h. Two observers, one on each side of the airplane, counted eiders in a 200-m wide transect (400 m total transect width). A Global Positioning System (GPS) receiver was used to navigate east–west transect lines that were spaced 800 m apart, achieving 50% coverage of the survey area.

Results are presented as the total of eiders observed and the indicated total. Indicated total is a USFWS standardized method of counting ducks, which does not count the females; instead, it doubles the number of males in singles, pairs, and small groups observed on the ground or water (no flying birds are included) to compensate for the lower detectability of females (USFWS 1987).

Indicated Total Birds = (lone males × 2) + (flocked males × 2) + (pairs × 2) + (group total ×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 five or more of a mixed-sex grouping of the same species in close association, which cannot be separated into singles or pairs (e.g., one female with three males was considered to be four [a pair plus two males]).

LOON SURVEYS

The 2019 loon surveys covered 2 areas, the Tiŋmiaqsiuġvik Material Site (TMS) and Willow loon survey area (Figure 1, Table 1). Loon survey areas encompassed a 3-mi buffer around proposed roads, drill, and material sites associated with the Willow development. Thirty lakes ≥5 ha are within the TMS loon survey area. We surveyed only 11 of those lakes during nesting and brood rearing because the remaining lakes had already been surveyed for nests and broods during ≥3 years, as required by BMP E-11 (BLM 2013). This reduction in survey effort also was an attempt to reduce air traffic and possible disturbance to the village of Nuiqsut. In the Willow loon survey area, we surveyed 291 lakes for nesting loons and 290 lakes for brood-rearing loons. We have previously conducted surveys for nesting and brood-rearing Yellow-billed Loons in the NE NPR-A area during 2001–2006, 2008–2014, and 2017–2018 (Johnson et al. 2015, 2019a). Each year, the nesting survey was conducted between 19 June and 1 July and the brood-rearing survey between 15 and 24 August. Weekly surveys for nests and broods were conducted during 2008–2014 (Johnson et al. 2015).

All surveys were conducted from a helicopter flying in a lake-to-lake pattern at 60–90 m agl. The perimeter of each lake was circled while 1 observer searched lake surfaces and shorelines for loons and nests during the nesting survey and for loons and young during the brood-rearing survey. Survey lakes were selected before each survey and included most lakes ≥10 ha in size in 2001–2006 and most lakes ≥5 ha in size in 2008–2014, and 2017–2019. We reduced the minimum survey lake size to 5 ha for nesting surveys to detect breeding territories on smaller lakes. During nesting surveys each year, we also surveyed small lakes (1–10 ha) and aquatic habitats adjacent to survey lakes because Yellow-billed Loons sometimes nest on small lakes next to larger lakes that are used for brood-rearing (North and Ryan 1989, Johnson et al. 2019c). Tapped Lakes with Low-water Connections (i.e., 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 types of lakes for nesting (North 1986, Johnson et al. 2003). Although the surveys were designed to maximize detection of Yellow-billed Loons, we recorded incidental observations of Pacific and Red-throated loons during all nesting and brood-rearing surveys.

All locations of loons and their nests were recorded on a tablet computer with a custom-built data collection application. The application used a moving map with an adjustable scale that allowed the user to zoom in on the map features. The scale at its finest level was approximately 1:15,000. Photos were taken of all Yellow-billed Loon nests to ensure maximum accuracy in mapping nest locations. Observation data were entered directly onto the tablet.

We defined a territory as a single lake, several lakes, or portion of a lake occupied exclusively by 1 breeding pair with a nest or brood in 1 or more years. Territories were identified using data from all years; boundaries between territories were determined by locations where nests and broods were recorded and, additionally, by the locations of adults on multi-territory lakes. To make annual comparisons among years when different numbers of lakes were surveyed, we first identified all territories within the surveyed lakes. Then, we calculated territory occupancy by dividing the number of territories with nests, adults, or broods by the number of territories surveyed.

NEST FATE

Absence of broods is not a reliable indicator of nest failure because broods can suffer mortality in the time between hatch and the brood survey. Therefore, we inspected the contents of nests at territories where a brood was not seen during the August survey to determine nest fate (for details, see Johnson et al. 2015). Nests were assumed failed if they contained <20 egg fragments, eggshells had signs of predation (i.e., holes, albumen, yolk, or blood), or if eggs were unattended and cold (Parrett et al. 2008). Nests were assumed successful if a brood was present, or if the nest contained ≥20 egg fragments.

TIME-LAPSE CAMERAS

We previously used time-lapse digital cameras in the NE NPR-A study area in 2010–2014, primarily to reduce helicopter traffic while monitoring nest survival, and secondarily, to record nest attendance patterns and identify causes of nest failures. In 2019, we used 2 models of Silent

Image® Professional cameras: PC85 and PC800 cameras with custom 2.5× and 2× telephoto lenses that take 3.1-megapixel images (Reconyx, Lacrosse, WI). Cameras were installed using the same methods as previous years (Johnson et al. 2015). The cameras were programmed to take images every 30 sec, allowing them to function for 23–28 d without requiring maintenance (i.e., battery or memory card changes).

After completion of the nest survey, we deployed 10 time-lapse cameras (5 PC85 and 5 PC800) at Yellow-billed Loon nests. We attempted to monitor an equal number of nests ≤1 mile from proposed roads or pads and nests >1 mile from roads or pads, in order to have a reference dataset for comparing nesting behavior and nest survival at nests after construction of the Willow project. Cameras were installed at nests within 0–6 days (median = 2.5 d, n = 10) of nest discovery. We removed cameras in mid-August during the brood-rearing survey.

We reviewed digital images on computers with Irfanview software (version 4.51) using the same methods as used in previous years (Johnson et al. 2015). Loon behavior was classified into 3 major types of activity: incubation, break, and recess. Incubation included sitting postures of normal incubation (head up and posture relaxed, or head resting on back), alert incubation (head up in a rigid, attentive posture), concealed incubation (head and body down and flattened in vegetation), and gathering nest material while on the nest. Break activities included brief standing activities at the nest, including changing positions, settling on the nest after changing position, standing over the nest, and egg moving. Exchange activities included behaviors that occurred when the male and female loon traded incubation duties (standing over the nest, sitting or swimming beside the nest, and egg moving). Recess activities were absences from the nest that were not associated with incubation exchanges (gone from view, flying and swimming) and those activities immediately preceding and following the recess. Incubation constancy was calculated by summing the time spent on the nest (incubation minutes, break minutes, and exchange minutes) and dividing by the minutes monitored.

The number of days monitored and incubation parameters (constancy, recess and exchange frequency, and recess length) were calculated for each nest from the time the loon returned to the nest after camera installation to the day before hatch, or to the time of nest failure. Periods of time when images could not be interpreted because of poor weather conditions were excluded. We identified predators in camera view to species, estimated their distance from the nest, and described their behavior.

Day of hatch was defined as occurring when the first chick was seen at the nest or when adults were seen removing egg membranes from the nest, whichever was observed first. If eggshell evidence and/or aerial surveys indicated hatch but no chicks were visible on images, the day of hatch was identified by the increased presence of the non-incubating loon at the nest as it began to feed the hatchlings. If the mate's presence also was obscured on images, then egg flotation data were used to estimate hatch date (described below). We judged a nest to be failed if the loons did not resume incubation after a predator was seen at the nest. The time of failure was taken from the first image containing the predator. Some predation events were not captured on images, and in those cases, we assigned nest failure to the time when the loons stopped incubating the eggs.

The date incubation started was estimated for successful nests by backdating 28 d from the day of hatch. North (1994) reported 27 and 28 d for the incubation period of Yellow-billed Loons, which agrees with our observations at camera-monitored nests (Johnson et al. 2016). For failed nests, we estimated the start of incubation by modeling the relationship between egg flotation angle and known-age eggs at camera-monitored Yellow-billed Loon nests in 2008–2015. Egg flotation methods are presented in Johnson et al. [2015]. Nests with known-age eggs were either nests where we observed the start of incubation in 2013–2015 (n = 10 nests) or where we observed hatching in 2008–2015 (n = 59 nests). At nests where laying dates were observed, the age of each egg in the nest (n = 16 eggs) was calculated by counting the number of days since the egg was laid. At nests where laying dates were unknown and the number of eggs floated in a nest equaled the number of young seen on camera images (n = 34 nests), the age of each egg (n = 61 eggs) was determined by backdating 28 days from the day of hatch. At nests where both eggs were floated but only 1 chick was observed (n = 27 nests), the float angles of the 2 eggs were averaged (n = 54 eggs) and the single hatch date was used to age both eggs. We fit a Gompertz growth curve to the data (Age in days = 15.770*exp(-1.715*0.938^float angle)) and used a Bayesian framework to test how well the model fit the data. The model predicts the age of eggs within ~3 days (ABR, unpublished data). Because we did not revisit active nests after camera installation in June, eggs were floated only once and only in the early stages of incubation, so the model only applies to eggs floated during approximately the first 2 weeks of incubation.

GULLS

Locations of Glaucous (Nauyavasrugruk, *Larus hyperboreus*) and Sabine's gull (Iqirgagiak, *Xema sabini*) nests were recorded incidentally during aerial surveys for nesting loons (see survey methods above). Both species nest singly and in loose aggregations or colonies. We considered a group of 3 or more nests occurring in proximity on the same lake or wetland complex to be a colony. Once a gull colony was identified, we used 1 central location to map all nests, even though some nests may be as far as 350 m apart. Glaucous Gull broods were recorded incidentally during brood-rearing surveys for loons. Unlike Glaucous Gulls, single Sabine's Gull nests are not easily detectable from the air, so only colonially nesting Sabine's Gulls were recorded. Because Sabine's Gulls tend to flush from nests as we survey and their small nests are undetectable from the air, the number of nests at each colony was estimated based on the number of adult pairs observed. Sabine's Gull broods disperse with adults from breeding lakes shortly after hatch (Day et al. 2001), so we are not able to count their broods during August surveys. All locations of gull nests, broods, or colonies were recorded on a tablet computer with a custom-built data collection application.

HABITAT MAPPING AND ANALYSIS

A wildlife habitat type was assigned to each observation of birds, nests, or broods by plotting their coordinates on the wildlife habitat maps (Figure 2). For each bird species, habitat use (% of all observations in each identified habitat type) was determined separately for various stages of the breeding season (e.g., pre-nesting, nesting, and brood-rearing), as appropriate. For each species and stage, we used multi-year data to calculate: 1) the number of adults, flocks, nests, or broods in each habitat; and 2) the percent of total observations in each habitat (habitat use). Habitat use was calculated from group locations for species when birds were in pairs, flocks, or broods and excluded flying birds. Habitat availability was calculated as the percent of each habitat in the Willow eider survey area and the Willow loon survey area separately (Table 2). Observations and habitats from the Alpine West, Development, and Exploration subareas (see Figure 1, Johnson et al. 2015) were combined with those from the Willow eider survey area and the Willow loon survey area. Fish Creek Delta and Fish Creek West subareas (see Figure 1, Johnson et al. 2015) were excluded from the analysis because those areas contained large areas of coastal and deltaic habitat types not available in the Willow Project area. A statistical analysis using a Monte Carlo simulation of habitat selection was used for Spectacled and King eiders and Yellow-billed Loons to evaluate whether habitats were used in proportion to their availability. Methods were explained in more detail by Johnson et al. (2015).

DATA MANAGEMENT

All data collected during eider and loon surveys for CPAI were compiled into a centralized database following CPAI's data management protocols (version 11.3, CPAI 2019). All nest, brood, bird, and bird group locations were recorded on Android tablets that could be downloaded into text and GIS files for data checking. Uniform attribute data were recorded for all observations and proofed after data collection. Survey data were submitted to CPAI in GIS-ready format with corresponding metadata.

RESULTS AND DISCUSSION

SEASONAL CONDITIONS IN THE PROJECT AREA

Weather stations near the Willow Project area include CD5, Nuiqsut, Alpine, and Colville Village (located at Helmericks' homestead). Snow depth data are not collected in Nuiqsut and the datasets

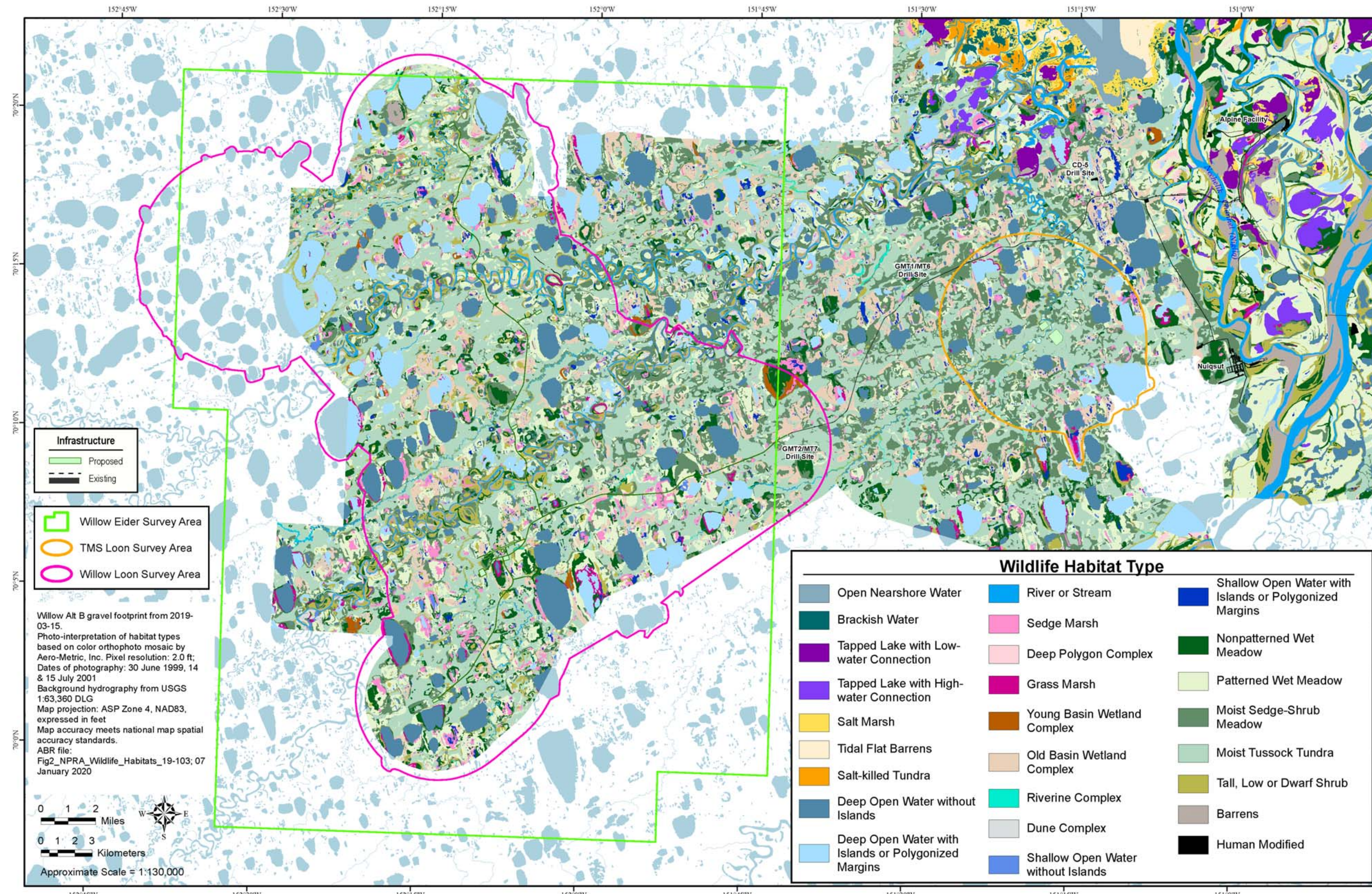

Figure 2. Wildlife habitats in the NE NPR-A area, 2019.

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Table 2. Habitat availability in the Willow eider survey area and Willow loon survey area, Willow Project area, NE NPR-A, 2019.

	Eider Survey Area		Loon Survey Area	
Habitat	Area (km²)	Availability (%)[a]	Area (km²)	Availability (%)[a]
Tapped Lake with High-water Connection	0.1	0.01	0.1	0.01
Deep Open Water without Islands	68.7	8.16	56.0	8.17
Deep Open Water with Islands or Polygonized Margins	63.3	7.51	47.3	6.90
Shallow Open Water without Islands	13.1	1.56	11.3	1.66
Shallow Open Water with Islands or Polygonized Margins	9.1	1.08	6.1	0.89
River or Stream	8.5	1.01	6.3	0.92
Sedge Marsh	21.3	2.53	19.1	2.79
Grass Marsh	5.5	0.65	4.1	0.60
Young Basin Wetland Complex	2.6	0.31	2.2	0.32
Old Basin Wetland Complex	46.2	5.48	34.1	4.97
Riverine Complex	2.3	0.27	1.9	0.28
Dune Complex	6.9	0.82	4.2	0.62
Nonpatterned Wet Meadow	40.4	4.80	34.5	5.03
Patterned Wet Meadow	117.1	13.91	97.9	14.29
Moist Sedge-Shrub Meadow	114.0	13.53	84.7	12.36
Moist Tussock Tundra	246.5	29.28	210.6	30.73
Tall, Low, or Dwarf Shrub[b]	66.2	7.87	57.0	8.32
Barrens[c]	10.0	1.19	7.5	1.10
Human Modified	0.2	0.02	0.2	0.03
Subtotal (total mapped area)	842.0	100	685.2	100
Unknown (unmapped areas)	625.8		166.1	
Total	1,467.8		851.3	

[a] Percent availability calculated proportion of mapped area.
[b] Tall, Low, or Dwarf Shrub includes Moist Tall Shrub, Dry Tall Shrub, Moist Low Shrub, Moist Dwarf Shrub, and Dry Dwarf Shrub.
[c] Barrens includes Dry Halophytic Meadow and Moist Herb Meadow.

for Alpine and CD5 only date back to 2011 and 2013, respectively. The dataset from Helmericks dates back to 1997, and while there are differences in temperatures and snow depths among stations, trends are similar among stations. Therefore, we used the 22-year dataset of temperature and snow depth from Helmericks to describe general weather patterns in the broader region, and supplemented records with snow depth data collected during spring breakup culvert surveys along the GMT1/MT6 and GMT2/MT7 roads (Michael Baker 2019a, 2019b).

During the winter of 2018/2019, total freezing degree days (the sum of average daily temperatures <0 °C) measured at the NPR-A tundra monitoring station were the second lowest on record, indicating a very warm winter (Michael Baker 2019a). Daily average temperatures in May 2019 were at or above the long-term average, but still below freezing for most of the month (Figure 3).

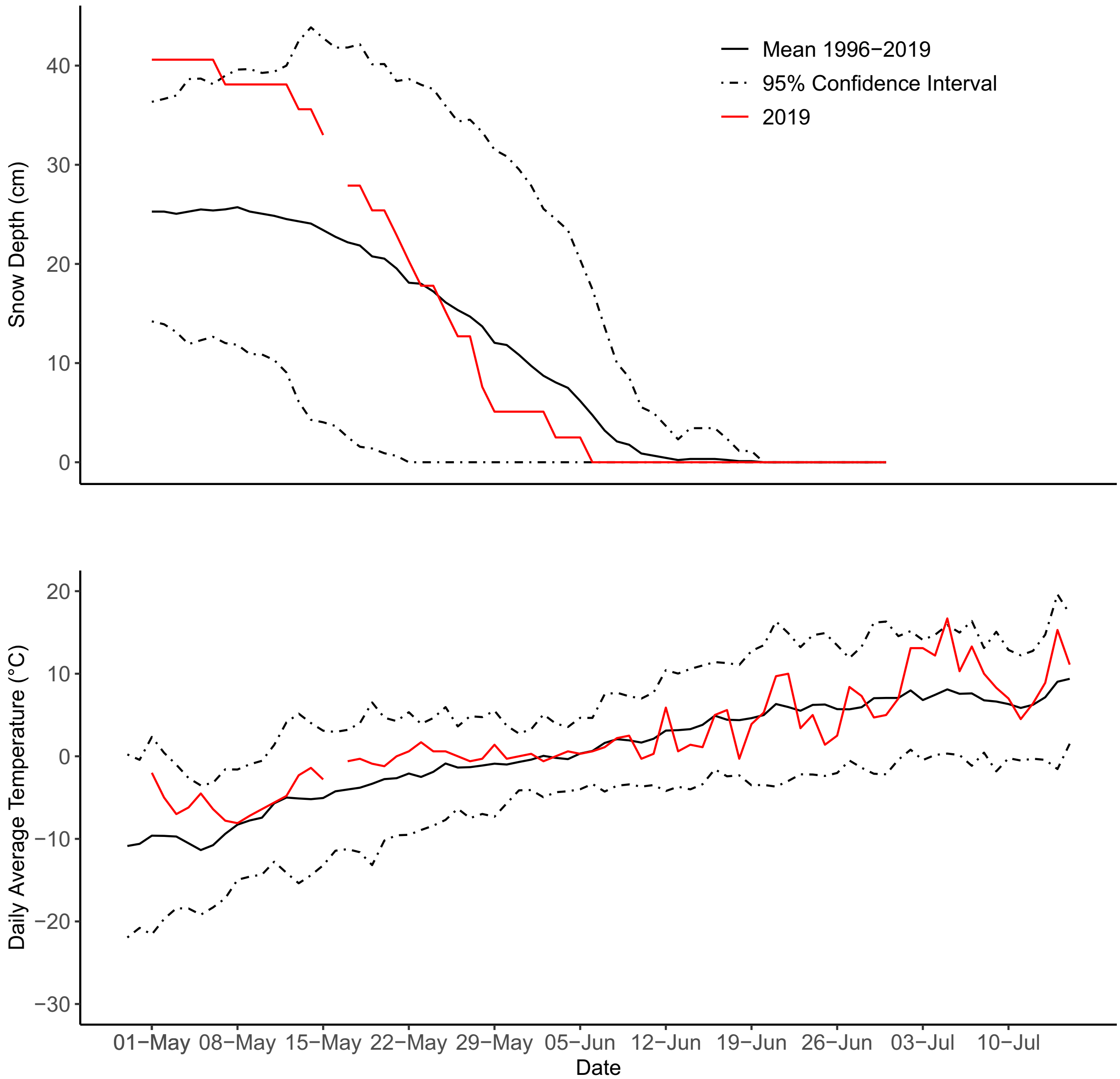

Figure 3. Snow depth and daily average temperature for spring and summer 2019 with mean for 1997–2019, Colville Village, Colville River delta, Alaska.

Total thawing degree-days (the sum of average daily temperatures >0 °C, TDD) for late May were also near average (Figure 4). Snow depth was above average in early May but started melting quickly in mid- and late-May as daily high temperatures were often above freezing. This resulted in near zero snow depths about a week earlier than the long-term mean date at Colville Village (1997–2019; Figure 3). Spring breakup monitoring surveys at GMT2/MT7 road culverts indicated local meltwater first appeared around 27 May when snow cover was ~50% (Michael Baker 2019b). Snow cover declined from ~30% to ~10% from 28 May to 2 June. Peak discharge was estimated to have occurred during that period because water was ponding at almost every monitoring station. Water, however, was not flowing through cross-flow culverts, indicating a low flood event. Breakup was somewhat earlier to the east along the GMT1/MT6 road area (Michael

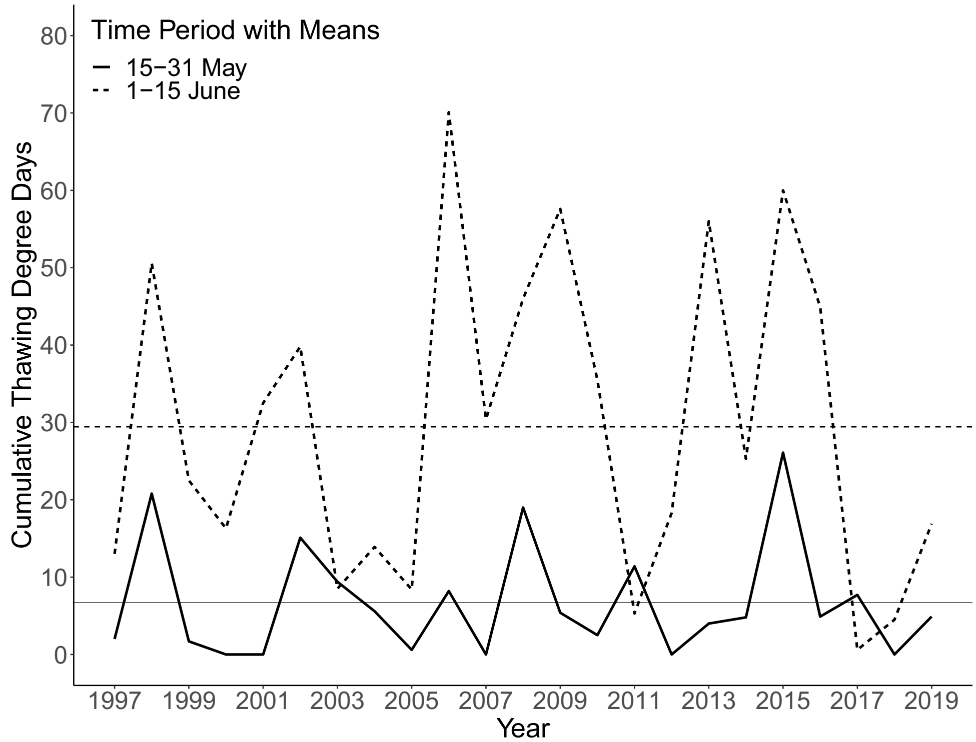

Figure 4. Cumulative number of thawing degree-days and means (horizontal lines) recorded for 15–31 May (6.7 ± 1.52) and 1–15 June (29.4 ± 4.25) recorded at Colville Village, Colville River delta, Alaska, 1997–2019.

Baker 2019a). In early June during snow melt, average daily temperatures remained near the long-term average of 0 °C and the sum of TDD was well below average indicating 2019 had fewer fluctuations of average temperatures above zero in early June compared with the long-term average (Figures 3 and 4). Therefore, breakup was gradual and occurred between the dates of 15 May and 15 June, when most birds arrive on local nesting grounds. Warmer than average temperatures and earlier than average spring break-up conditions were reported during most waterfowl surveys in northern Alaska in 2019 (USFWS 2019). Ice coverage on 180 large lakes (>5 ha) in the Willow loon survey area (estimated visually during nesting surveys for loons on 18–24 June) was less extensive in 2019 (mean = 47%) than previous years (mean = 58% ± 9.6%, *n* = 7 years).

The timing of eider surveys (12 June) was appropriate based on the condition of water bodies; shallow water bodies were thawed as were shallow margins of deep water bodies. The warm winter (indicated by total freezing degree days) may have contributed to thin ice on the deep lakes that Yellow-billed Loons use for breeding. A reduction in ice thickness likely accelerates moat formation during spring, making lakes available for breeding earlier than on average. Long-term lake ice thickness is not available, however, the ice thickness on the Colville River at Colville Village was 45 inches in early May, well below the mean of 60 ± 2.2 inches (*n* = 22 years).

EIDERS

Four species of eiders may occur in the Willow Project area, but only 2 species occur on a regular basis. Of the 2 species of eiders that are most common in the Willow Project area, the Spectacled Eider has received the most attention because it is federally listed as “threatened”. The nearby Colville River delta is a concentration area for breeding Spectacled Eiders relative to surrounding areas; nonetheless, Spectacled Eiders nest in the Willow Project area annually at low densities. Inland areas of the NE NPR-A, such as the Willow eider survey area, support even lower densities (Burgess et al. 2003; Johnson et al. 2004, 2005, 2018a). The King Eider, which is not protected under the Endangered Species Act, is more widespread and generally more numerous than the Spectacled Eider across the Arctic Coastal Plain, although their relative abundance varies geographically. The Steller's Eider was listed as a threatened species in 1997 (62 FR 31748–31757). Steller's Eiders are rare on the Colville River delta, ABR's survey areas in NE NPR-A, and immediate surroundings as these areas are east of their current Alaska breeding range centered near Utqiaġvik. The NE NPR-A is within the range of Common Eiders, which nest primarily on barrier islands and coastlines, but are seen rarely on surveys inland in the NE NPR-A.

SPECTACLED EIDER

Distribution and Abundance

We recorded a low density of Spectacled Eiders in the Willow eider survey area during the pre-nesting period in 2019, which was consistent with results of previous surveys in this portion of the NE NPR-A (Johnson et al. 2015, 2019a). During the 2019 pre-nesting survey, which sampled 50% of the Willow eider survey area, we recorded 6 Spectacled Eiders (on the ground and flying) and 10 indicated total Spectacled Eiders (on the ground) (Figure 5, Table 3). Extrapolating to the entire Willow eider survey area produces estimates of 12 observed total and 20 indicated total Spectacled Eiders.

Densities of Spectacled Eiders recorded during ABR's surveys in the NE NPR-A have been consistently low (mean = 0.031 ± 0.005 indicated birds/km^2; Table 3) since we began surveys in 1999, roughly 25% of the density recorded on the Colville River delta (Johnson et al. 2019a). The distribution of Spectacled Eiders in 2019 was typical of previous years, when densities were highest on the northern Colville River delta, intermediate in the Kuparuk area and lowest at inland portions of NPR-A, where the Willow eider survey area is located (Figure 6).

Over the 26 years that ABR and others have monitored Spectacled Eiders along the central Beaufort Sea coast, their population trend has been relatively stable (Figure 7). The Willow eider survey area appears to support lower densities of Spectacled Eiders compared to other ABR survey areas in the NE NPRA; therefore, we did not include data from 2017–2019 in the population growth rate in order to avoid a potentially negative bias. In the NE NPR-A, a non-significant, positive growth rate near 2% was observed through 2014 (ln(adults) = 0.025 (year) + 47.39, R^2 = 0.02, P = 0.60, n = 15 years). Similarly, the annual growth rate for the adjacent Colville Delta study area also was non-significant and near 2% (ln(adults) = 0.017 (year) – 30.67, R^2 = 0.07 P = 0.19, n = 26 years; Shook et al. *in prep.*). In contrast, Spectacled Eiders in the Kuparuk study area had a negative growth rate of –3% for 1993–2015 (ln(adults) = –0.029 (year) + 62.62, R^2 = 0.22, P = 0.03, n = 22 years; Morgan and Attanas 2016) and this was the only significant trend we detected (2019 data not used because this study area likely biased high). A slightly negative and non-significant growth rate (–2%) was also estimated from the North Slope waterfowl surveys conducted for Spectacled Eiders across the entire Arctic Coastal Plain (ACP; logarithmic growth rate = 0.99, n = 26 years; Wilson et al. 2018). Only the Kuparuk growth rate differs significantly from equilibrium (a logarithmic growth rate of 1.0 equals 0% annual change, or equilibrium), which suggests that, although there is substantial year-to-year variation, the population on the ACP is stable to slightly decreasing.

Habitat Use

The Willow eider study area was 1,468 km^2, of which 842 km^2 (57%) has been mapped for wildlife habitats (Jorgenson et al. 2003, Wells et al. 2018a, 2018b). Survey coverage was approximately 50% (733 km^2) and of this 437 km^2 was in the mapped area. Pre-nesting Spectacled Eiders used 15 of 26 available habitats in the NE NPR-A study area over 18 years of aerial surveys (Table 4). Six habitats were preferred (i.e., use was significantly greater than availability, $P \leq 0.05$) including 1 primarily coastal, salt-affected habitat (Brackish Water), 3 aquatic habitats (Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, and Shallow Open Water without Islands), 1 emergent habitat (Grass Marsh), and 1 complex of mixed terrestrial and aquatic habitat (Old Basin Wetland Complex). Old Basin Wetland Complex was the

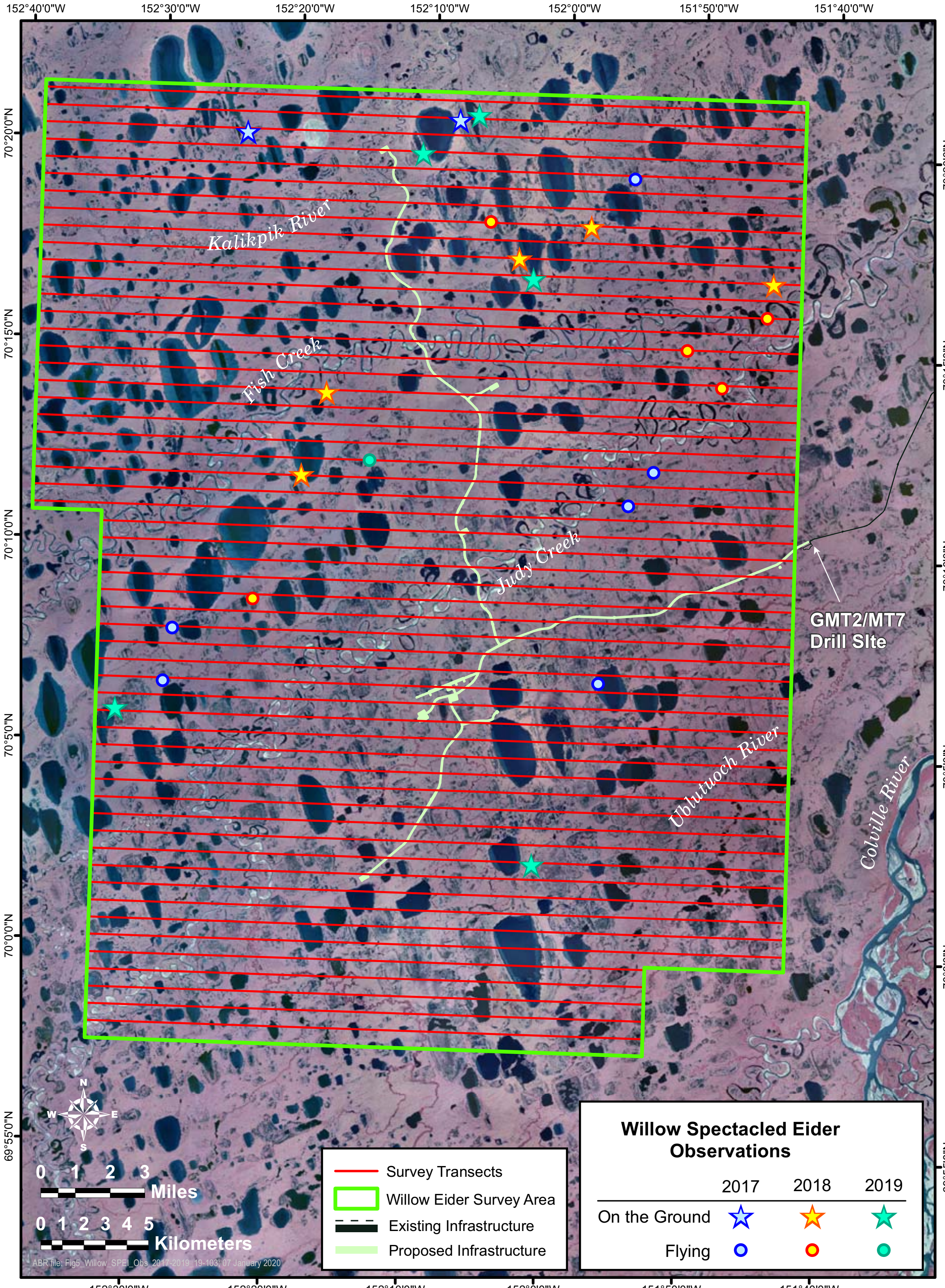

Figure 5. Spectacled Eider locations during pre-nesting, Willow eider survey area, NE NPR-A, 2017–2019.

Table 3. Annual number and density of eiders during pre-nesting aerial surveys in the Willow eider survey area and other NE NPR-A survey areas in 1999–2006, 2008–2014, and 2017–2019.

Year	Area Surveyed (km²)	Spectacled Eider				King Eider			
		Total[a]		Density[b]		Total[a]		Density[b]	
		Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
1999	143.4	4	6	0.03	0.04	41	16	0.29	0.11
2000	278.3	6	6	0.02	0.02	55	38	0.20	0.14
2001	511.0	23	22	0.05	0.04	128	98	0.26	0.19
2002	550.1	12	14	0.02	0.03	182	188	0.39	0.39
2003	557.6	10	12	0.02	0.02	169	114	0.34	0.23
2004	430.3	14	10	0.03	0.02	154	119	0.39	0.30
2005	755.1	9	2	0.01	<0.01	230	166	0.34	0.25
2006	755.1	31	26	0.04	0.03	305	320	0.42	0.44
2008	755.1	41	46	0.05	0.06	468	480	0.65	0.67
2009	755.1	29	30	0.04	0.04	358	330	0.51	0.48
2010	755.1	23	24	0.03	0.03	582	433	0.82	0.61
2011	172.0	9	10	0.05	0.06	93	70	0.69	0.55
2012	172.0	4	2	0.02	0.01	68	76	0.47	0.52
2013	172.0	17	14	0.10	0.08	98	80	0.71	0.57
2014	332.7	8	10	0.02	0.03	102	88	0.43	0.36
2017	706.2	16	4	0.02	0.01	248	132	0.35	0.19
2018	733.2	14	10	0.02	0.01	247	168	0.34	0.23
2019	733.2	6	10	0.01	0.01	196	168	0.27	0.23
Mean		–	–	0.03	0.03	–	–	0.44	0.36
SE		–	–	0.005	0.005	–	–	0.04	0.04

[a] Observed total includes flying and non-flying eiders. Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987). Mean and SE calculated for *n* = 18 years.
[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of area in 1999 and 2000 and 50% coverage in all other years. Mean and SE calculated for *n* = 18 years.

most used habitat with 17.7% of the Spectacled Eiders located there. Brackish Water, Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, Shallow Open Water without Islands, and Patterned Wet Meadow each were used by ≥9.7% of Spectacled Eider groups. Note that Brackish Water does not occur in the Willow eider survey area. Brackish Water was present in the portion of the NE NPR-A north of CD-5 that was included in 15 of the 18 years analyzed for habitat selection (Johnson et al. 2015). Two habitats were avoided (used significantly less than availability): Moist Sedge-Shrub Meadow and Moist Tussock Tundra, which also were the most abundant habitats (18.8% and 28.7% of the area, respectively). All other habitats were used in proportion to their availability or had low sample sizes precluding a determination of preference or avoidance.

OTHER EIDERS

Distribution and Abundance

In 2019, we recorded 196 observed (on the ground and flying) and 168 indicated total King

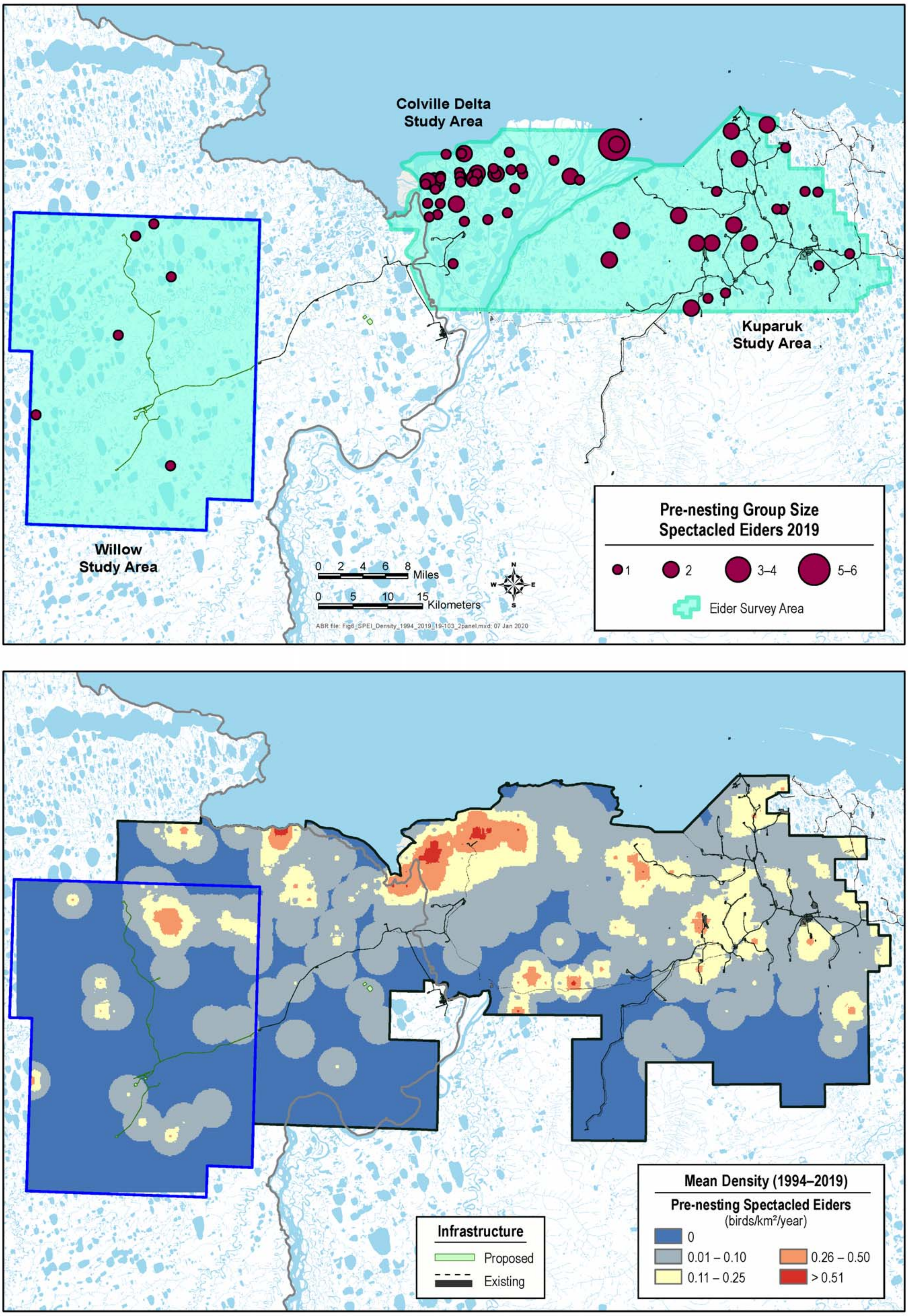

Figure 6. Group locations of pre-nesting Spectacled Eiders (non-flying and flying) in 2019 (above) and density distribution (indicated total birds) of pre-nesting Spectacled Eiders in the Willow eider survey area and the NE NPR-A, Colville River delta, and Kuparuk study areas 1994–2019 (below).

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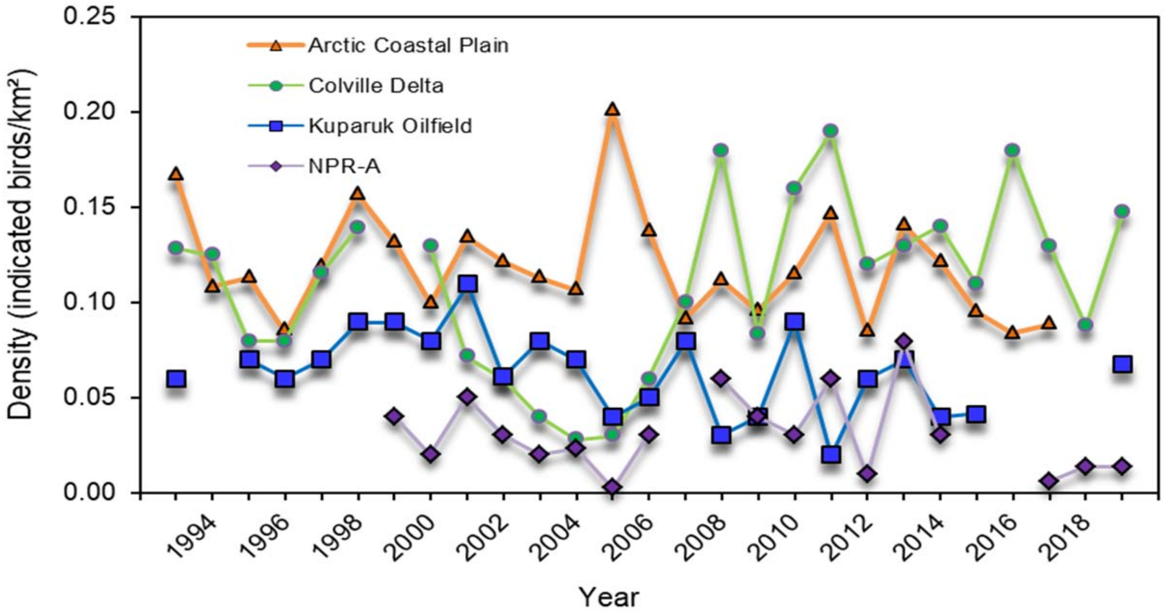


Figure 7. Annual densities of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2019.

Eiders during the pre-nesting aerial survey that sampled 50% of the Willow eider survey area (Figure 8, Table 3). Extrapolating to the entire survey area, we estimate 392 observed total and 336 indicated total King Eiders. The distribution of King Eiders in 2019 was generally uniform throughout the area surveyed, but with more King Eiders north of Fish Creek. Since 1999, when ABR began pre-nesting surveys in NE NPR-A, the highest densities of pre-nesting King Eiders have been in the north (near Fish Creek and Kalikpik River) with some patches of high density in the southern and eastern portions of the Willow eider survey area (Figure 9). The indicated density of King Eiders in 2019 (0.23 indicated birds/km²) was below the long-term mean of 0.36 ± 0.04 indicated birds/km²; Figure 10, Table 3). In contrast, the adjacent Colville Delta study area had the third highest indicated density in 2019 (highest was 2018; Figure 10) with the highest densities on the East Channel where flocks often collect but infrequently nest. We do not know where King Eiders on the Colville River nested, but it is possible that some of these eiders moved inland (e.g., to the NE NPR-A and Kuparuk Oilfield) after the pre-nesting survey was completed.

King Eiders on the ACP have been increasing at a significant rate of 2% annually since 1986 (Wilson et al. 2018). Although we have a shorter period over which to measure trends, King Eiders recorded on ABR's surveys in NE NPR-A have significantly increased at a rate of 9% annually during 1999–2014 (ln(adults) = 0.09 (year) – 176.87, R^2 = 0.65, $P < 0.001$, n = 15 years; 2017–2019 excluded due to potential study area bias). Similarly, King Eiders have a significant, positive growth rate of 3% in the Colville Delta study area for 1993–2019 (ln(adults) = 0.034 (year) – 64.33, R^2 = 0.20, P = 0.02, n = 26 years; Shook et al. in prep.). The Kuparuk area also had a significant, positive growth rate of 3% for 1993–2015 (ln(adults) = 0.027 (year) – 49.16, R^2 = 0.19, P = 0.04, n = 22 years; Morgan and Attanas 2016; 2019 excluded due to potential study area bias).

No Steller's or Common eiders were seen in the Willow eider survey area in 2019. Steller's Eiders have been recorded 4 times during pre-nesting surveys in the vicinity, once each in 1993, 1997, 1998, and 2001 (Johnson et al. 2018a). No records of breeding have been reported in the Willow eider survey area. Common Eiders are

Table 4. Habitat selection by Spectacled and King eider groups during pre-nesting in the NE NPR-A in 1999–2006, 2008–2014, and 2017–2019. Willow was surveyed in 2017–2019.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
SPECTACLED EIDER						
Open Nearshore Water	2	1	1.6	0.3	ns	low
Brackish Water	14	7	11.3	0.3	prefer	low
Tapped Lake with Low-water Connection	0	0	0	0.2	ns	low
Tapped Lake with High-water Connection	0	0	0	<0.1	ns	low
Salt Marsh	4	2	3.2	0.7	ns	low
Tidal Flat Barrens	0	0	0	0.3	ns	low
Salt-killed Tundra	0	0	0	<0.1	ns	low
Deep Open Water without Islands	4	2	3.2	8.0	ns	low
Deep Open Water with Islands or Polygonized	15	9	14.5	5.0	prefer	low
Shallow Open Water without Islands	12	7	11.3	1.3	prefer	low
Shallow Open Water with Islands or Polygonized	15	6	9.7	1.3	prefer	low
River or Stream	1	1	1.6	0.9	ns	low
Sedge Marsh	1	1	1.6	2.2	ns	low
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	5	4	6.5	0.4	prefer	low
Young Basin Wetland Complex	0	0	0	0.3	ns	low
Old Basin Wetland Complex	19	11	17.7	7.8	prefer	low
Riverine Complex	0	0	0	0.4	ns	low
Dune Complex	2	1	1.6	0.9	ns	low
Nonpatterned Wet Meadow	4	2	3.2	4.0	ns	low
Patterned Wet Meadow	16	7	11.3	12.3	ns	
Moist Sedge-Shrub Meadow	1	1	1.6	18.8	avoid	
Moist Tussock Tundra	0	0	0	28.7	avoid	
Tall, Low, or Dwarf Shrub	0	0	0	4.9	ns	low
Barrens	0	0	0	1.1	ns	low
Human Modified	0	0	0	<0.1	ns	low
Total	115	62	100	100		
KING EIDER						
Open Nearshore Water	4	2	0.3	0.3	ns	low
Brackish Water	27	14	1.9	0.3	prefer	low
Tapped Lake with Low-water Connection	34	10	1.4	0.2	prefer	low
Tapped Lake with High-water Connection	0	0	0	<0.1	ns	low
Salt Marsh	47	22	3.0	0.7	prefer	
Tidal Flat Barrens	0	0	0	0.3	ns	low
Salt-killed Tundra	0	0	0	<0.1	ns	low
Deep Open Water without Islands	263	85	11.6	8.0	prefer	
Deep Open Water with Islands or Polygonized	221	85	11.6	5.0	prefer	
Shallow Open Water without Islands	131	70	9.6	1.3	prefer	
Shallow Open Water with Islands or Polygonized	270	112	15.3	1.3	prefer	
River or Stream	33	15	2.1	0.9	prefer	

Table 4. Continued.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
Sedge Marsh	95	48	6.6	2.2	prefer	
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	34	12	1.6	0.4	prefer	low
Young Basin Wetland Complex	0	0	0	0.3	ns	low
Old Basin Wetland Complex	244	124	17.0	7.8	prefer	
Riverine Complex	9	4	0.5	0.4	ns	low
Dune Complex	0	0	0	0.9	avoid	
Nonpatterned Wet Meadow	50	30	4.1	4.0	ns	
Patterned Wet Meadow	114	63	8.6	12.3	avoid	
Moist Sedge-Shrub Meadow	41	19	2.6	18.8	avoid	
Moist Tussock Tundra	19	11	1.5	28.7	avoid	
Tall, Low, or Dwarf Shrub	6	4	0.5	4.9	avoid	
Barrens	0	0	0	1.1	avoid	
Human Modified	0	0	0	<0.1	ns	low
Total	1,642	730	100	100		

[a] Use = (groups / total groups) × 100.
[b] Significance calculated from 1,000 simulations at α = 05; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.
[c] Low = expected value < 5.

more abundant in the nearshore marine waters and barrier islands that are outside the survey area.

Habitat Use

King Eiders used 18 of 26 available habitats during pre-nesting surveys for 18 years of aerial surveys (Table 4). King Eiders preferred 11 habitats, 6 of which were also preferred by Spectacled Eiders in NE NPR-A: Brackish Water, Deep Open Water with Islands or Polygonized Margins, Shallow Open Water without Islands, Shallow Open Water with Islands or Polygonized Margins, Grass Marsh, and Old Basin Wetland Complex. King Eiders also preferred Tapped Lake with Low-water Connection, Salt Marsh, Deep Open Water without Islands, River or Stream, and Sedge Marsh. Old Basin Wetland Complex was the most used habitat (17.0%) followed by Shallow Open Water with Islands or Polygonized Margins, Deep Open Water without Islands, and Deep Open Water with Islands or Polygonized Margins, each with >10% use. Pre-nesting King Eiders avoided 6 habitats, including the 2 most abundant habitats: Moist Sedge-Shrub Meadow (18.8% available) and Moist Tussock Tundra (28.7% available). All other habitats were used in proportion to their availability or had low sample sizes precluding a determination of preference or avoidance.

YELLOW-BILLED LOON

DISTRIBUTION AND ABUNDANCE

No Yellow-billed Loons were observed in the TMS loon survey area during nesting and brood-rearing survey in 2019. In the Willow loon survey area, 30 Yellow-billed Loon nests and 74 adults were found during the nesting survey in 2019 (Figure 11, Table 5; for densities, see Appendix A). Two additional nests were inferred from the presence of broods during August in lakes where nests were not found during the nest survey. Over twice as many nests were found in 2019 compared with 2018, the only other year with the same survey area (Appendix B). The percentage of territories occupied by ≥1 adult, however, was similar between 2018 and 2019 (77% and 81%, respectively), suggesting that adults were occupying territories in 2018 but not nesting in

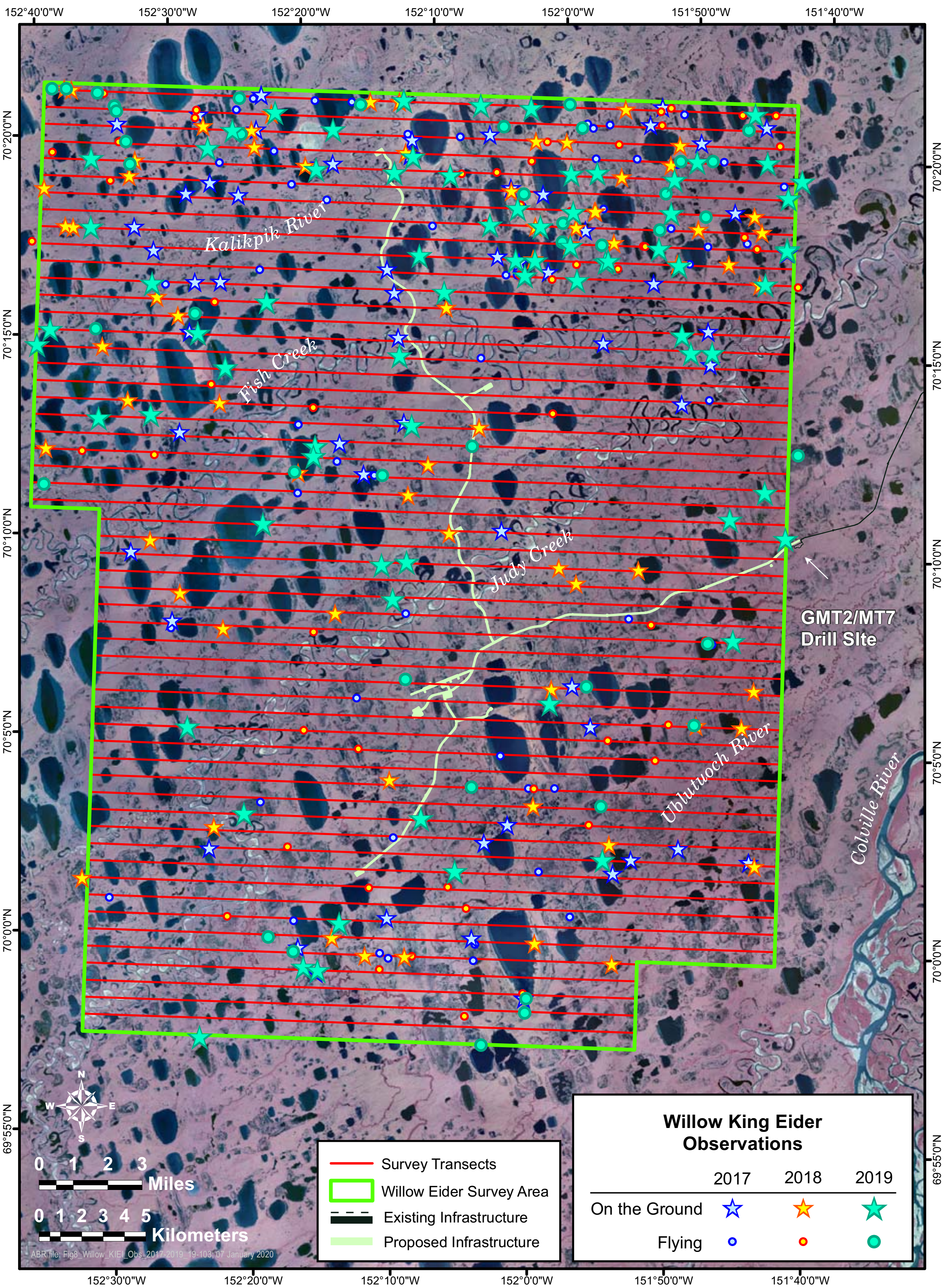
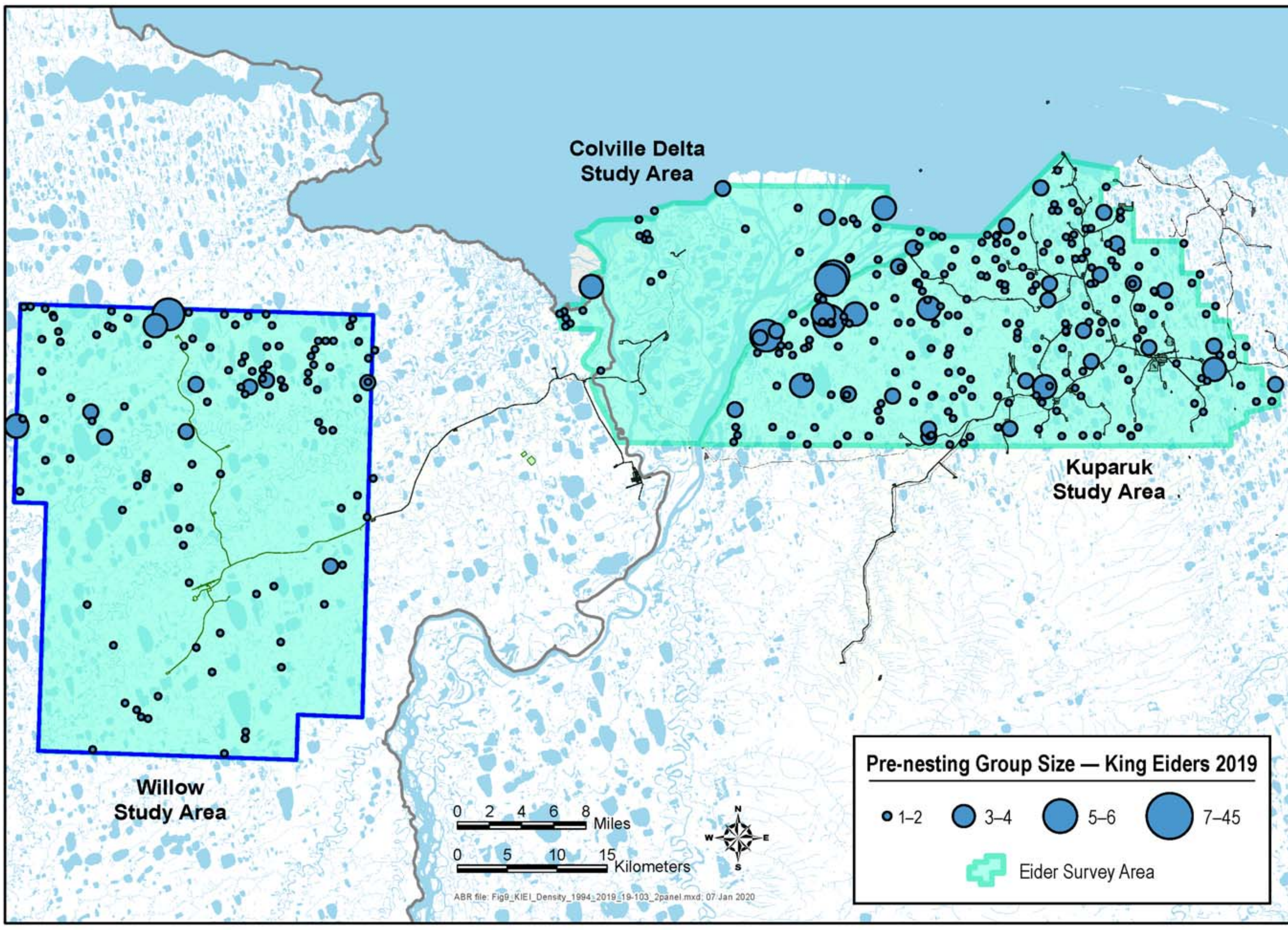


Figure 8. King Eider locations during pre-nesting, Willow eider survey area, NE NPR-A, 2017–2019.



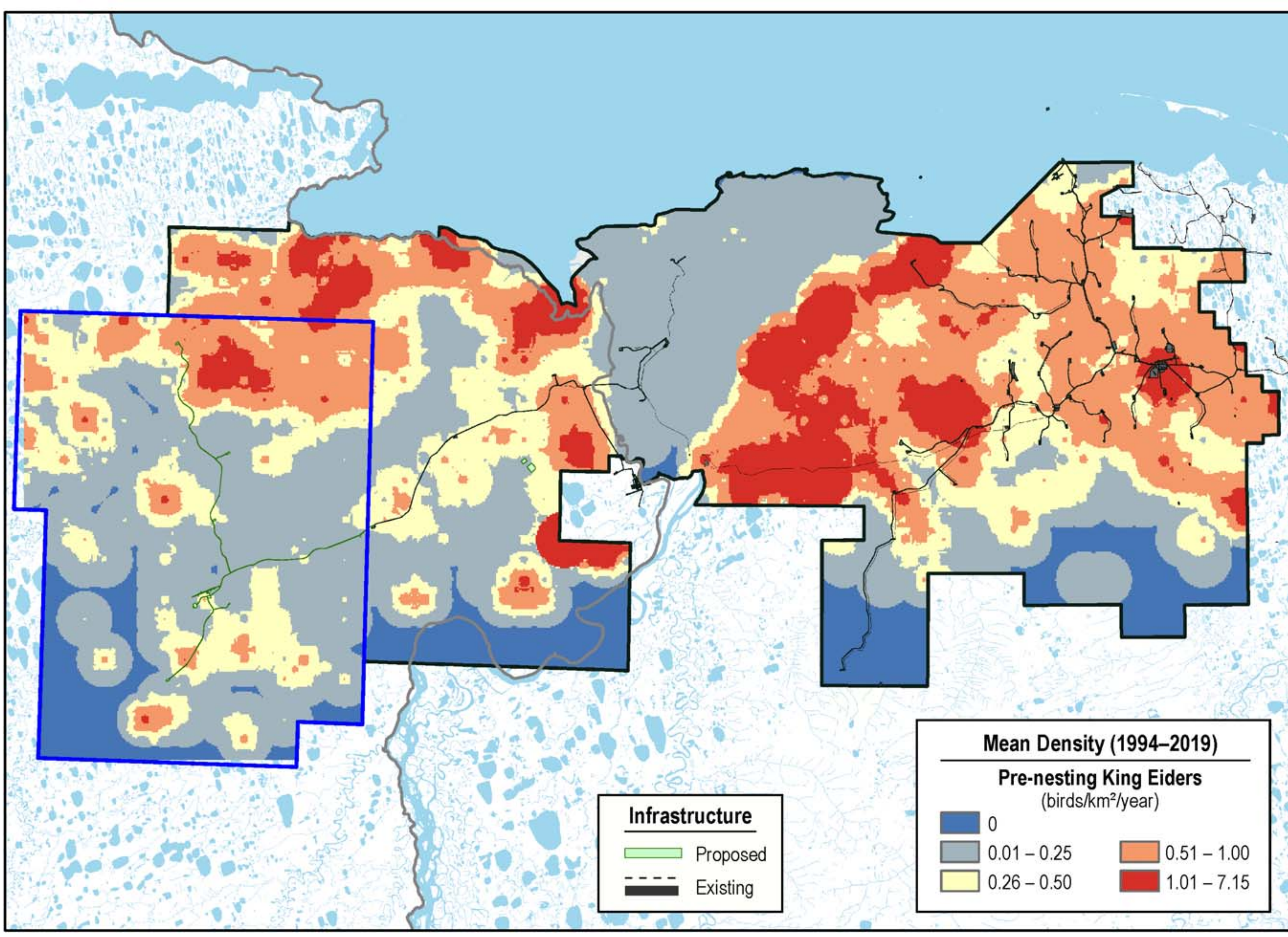


Figure 9. Group locations of pre-nesting King Eiders (non-flying and flying) in 2019 (above) and density distribution of pre-nesting King Eiders (indicated total birds) in the Willow survey area and the NE NPR-A, Colville River delta, and Kuparuk study areas 1994–2019.

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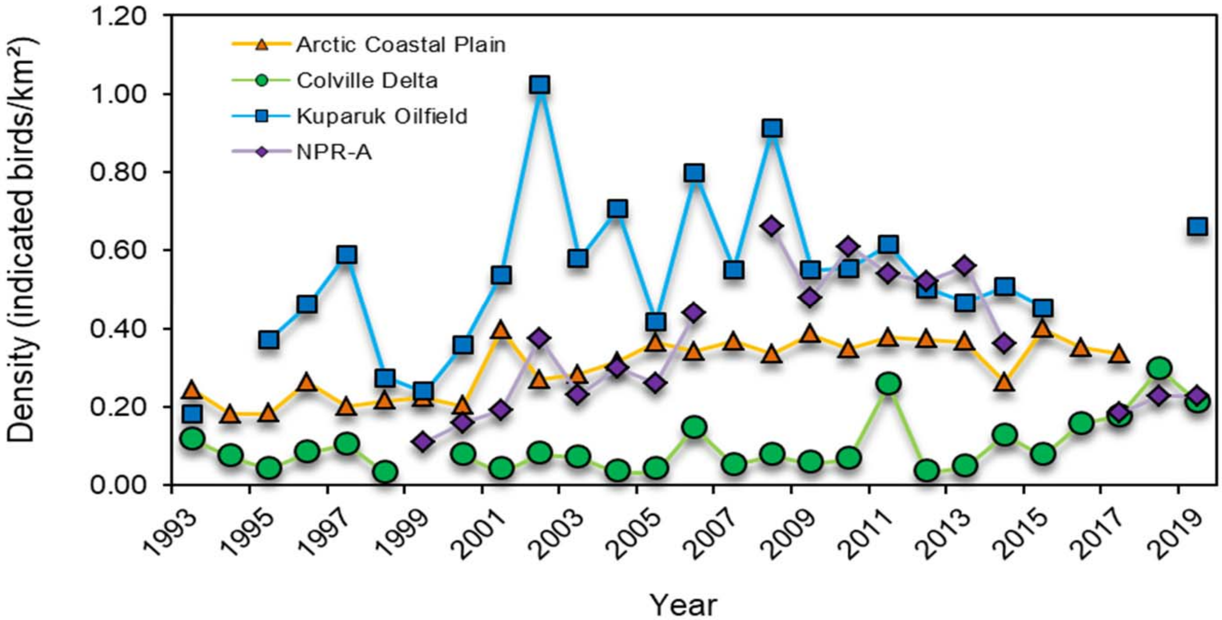

Figure 10. Annual densities of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2019.

high numbers. The number of nests present during the nesting survey likely is influenced by spring phenology and the timing of moat formation on large, deep lakes. Delayed moat formation can delay or even preclude nesting by preventing access to lakes (North 1986, Johnson et al. 2011, Johnson et al. 2013). Percent ice cover on deep lakes, visually estimated during loon surveys, was 47% in 2019 (n = 208 lakes) compared with 73% in 2018 (n = 180 lakes). Earlier open water in 2019 allowed Yellow-billed Loons to begin incubation well before the nesting survey (see Time-Lapse Cameras, below), and as a result, the nesting survey in 2019 was well-timed to the nesting phenology.

Survey coverage and effort has varied across the NE NPR-A area since surveys were initiated in 2001. Because of this annual variation in effort, we did not calculate mean numbers of adults and nests. Instead, we compared the proportion of territories with nests, or nest occupancy, calculated as the number of nests found only on the nesting survey divided by the number of territories surveyed. During the 2019 nest survey in the Willow loon survey area, 70% of 43 territories were occupied by nesting loons, which was higher than the nest occupancy observed in the Willow loon survey area during 2017 (43%) and 2018 (44%). Nest occupancy in 2019 was the second-highest estimate among 15 years of ABR surveys in NE NPR-A and well above the long-term mean (54.3 ± 3.0%, n = 15 years; Table 5).

During the brood-rearing survey in 2019, 98 Yellow-billed Loons and 17 broods comprising 24 young were observed in the Willow loon survey area (Figure 11, Table 6). We inferred 3 additional broods based on eggshell fragments at nests. As with the nesting survey, the number of adults seen during the brood-rearing survey was similar to 2018, but we recorded over 5 times as many broods (20) and 6 times as many young (24) in 2019. Incidental records of Pacific and Red-throated loon nests and broods are presented in Appendices C and D.

Similar to nest occupancy, we used brood occupancy to compare reproductive output among years. Brood occupancy, or the proportion of territories with a brood, was calculated as the total number of broods found during all surveys divided by the number of territories surveyed. We used the total number of broods, as opposed to only those found on the brood-rearing survey, because eggshell data allow us to infer the presence of broods at nests where chicks did not survive until

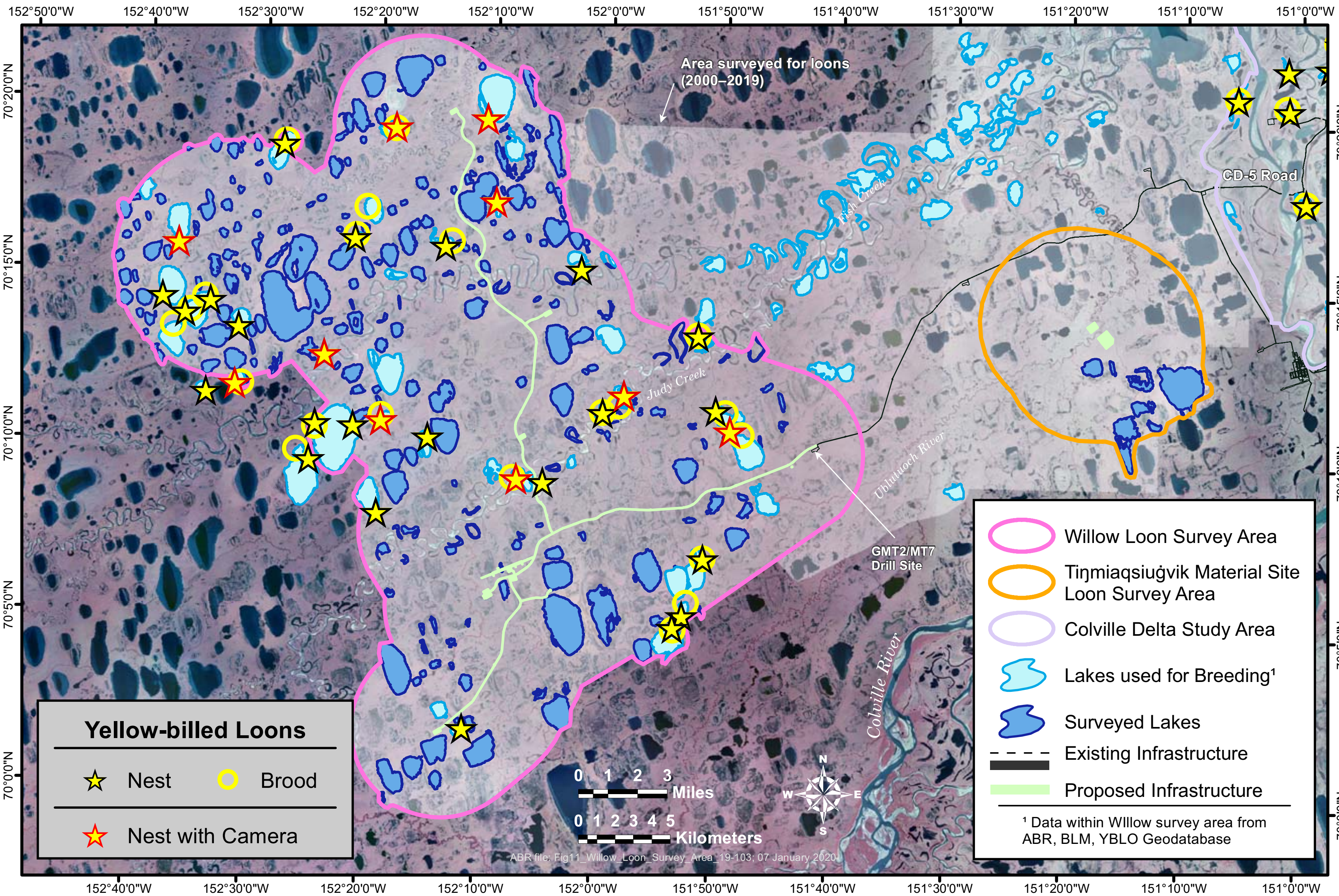

Figure 11. Yellow-billed Loon nest and brood locations, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2019.

Table 5. Number of Yellow-billed Loons, number of nests, and nest occupancy in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017–2019.

Survey Area	Nesting Survey[a]		All Surveys[b]	No. Territories Surveyed	Nest Occupancy (%)[c]
Year	No. Adults	No. Nests	No. Nests		
Willow					
2017	38	9	14[d]	21	43
2018	67	19	19	43[e]	44
2019[f]	74	30	32[d]	43[e]	70
Mean[g]					52.3
SE					8.8
NE NPR-A					
2001	44	19	23[h]	36	53
2002	65	27	27	43	63
2003	53	26	28[d,h]	42	62
2004	60	23	24[h]	41	56
2005	24	8	8	13	62
2006	24	8	8	13	62
2008	82	23	29[i]	51	45
2009	65	27	29[i]	51	53
2010	75	29	36[i]	51	57
2011	32	8	13[i]	21	38
2012	36	15	18[i]	21	71
2013	39	12	14[i]	21	57
2014	47	18	20[i]	28	64
2017[j]	11	5	8[d]	11	45
2018[j]	24	3	3	11	27
Mean[g]					54.3
SE					3.0

[a] Nesting survey is limited to a single survey conducted between 19 June and 1 July.
[b] Observation effort varied among 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.
[c] Calculated as the number of nests found during the nesting survey divided by the number of territories surveyed. Excludes 1 renesting in 2003 in the NE NPR-A area.
[d] Includes nest(s) inferred by the presence of a brood observed on a territory lake during ground or aerial surveys.
[e] Includes 42 territories identified during ABR surveys and 1 territory identified through the Yellow-billed Loon geodatabase (USFWS 2013).
[f] An additional 3 adults and 2 nests were seen outside of the Willow loon survey area.
[g] Mean numbers of adults and nests not calculated because survey area differed among years.
[h] Includes nest(s) found during ground surveys.
[i] Includes nest(s) found during revisit (1996–2002), monitoring (2008–2014), and early nesting (2011, 2012, and 2014) surveys.
[j] Totals include observations at 3 territories within the Willow loon survey area.

Table 6. Number of Yellow-billed Loons, number of broods, and brood occupancy in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017–2019.

SURVEY AREA Year	Brood-rearing Survey[a] No. Adults	Brood-rearing Survey[a] No. Young	Brood-rearing Survey[a] No. Broods	All Surveys[b] No. Broods	No. Territories Surveyed	Brood Occupancy (%)[c]
Willow						
2017	39	9	8	11[d]	22	50
2018	89	4	3	6	43[e]	14
2019[f]	98	24	17	20[d]	43[e]	47
Mean[g]						37
SE						11.5
NE NPR-A						
2001	47	5	5	7[h]	32	22
2002	47	7	6	6	39	15
2003	54	18	16	16	37	43
2004	67	12	10	10	40	25
2005	12	3	3	3	13	23
2006	16	2	2	2	12	17
2008	70	15	12	19[d,i]	50	38
2009	86	17	12	15[d]	51	29
2010	70	18	15	16[d]	49	33
2011	31	5	4	4	21	19
2012	42	14	12	12	21	57
2013	21	0	0	1[i]	21	5
2014	29	9	9	11[d]	28	39
2017[j]	21	4	4	5[d]	11	45
2018[j]	23	1	1	1	11	9
Mean[g]						27.9
SE						3.7

[a] Brood-rearing surveys were conducted between 15 and 27 August.
[b] Includes all broods found on brood-rearing survey and any additional broods found during other types of surveys as footnoted.
[c] Calculated as the number of broods from all surveys divided by the number of territories surveyed.
[d] Includes broods from territories where no brood was seen but presence of a brood was determined from eggshell evidence.
[e] Includes 42 territories identified during ABR surveys and 1 territory identified through the Yellow-billed Loon geodatabase (USFWS 2013).
[f] An additional 4 adults and 1 brood with 2 young were seen outside of the Willow loon survey area.
[g] Mean numbers not calculated because survey area differed among years.
[h] Includes brood(s) found during ground surveys.
[i] Includes brood(s) found during monitoring surveys.
[j] Totals include observations at 3 territories within the Willow loon survey area.

Table 7. Habitat selection by nesting and brood-rearing Yellow-billed Loons in the NE NPR-A in 2001–2004, 2008–2010, 2014, and 2017–2019. The Willow loon survey area was surveyed in 2017–2019.

SEASON Habitat	No. of Nests or Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	0.3	ns	low
Brackish Water	0	0	0.1	ns	low
Tapped Lake with Low-water Connection	0	0	0.2	ns	low
Tapped Lake with High-water Connection	2	0.9	<0.1	prefer	low
Salt Marsh	0	0	0.3	ns	low
Tidal Flat Barrens	0	0	0.7	ns	low
Salt-killed Tundra	0	0	<0.1	ns	low
Deep Open Water without Islands	12	5.3	7.8	ns	
Deep Open Water with Islands or Polygonized Margins	91	40.3	5.7	prefer	
Shallow Open Water without Islands	2	0.9	1.2	ns	low
Shallow Open Water with Islands or Polygonized Margins	12	5.3	1.3	prefer	low
River or Stream	0	0	1.1	ns	low
Sedge Marsh	27	11.9	2.1	prefer	low
Deep Polygon Complex	1	0.4	<0.1	ns	low
Grass Marsh	16	7.1	0.4	prefer	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	2	0.9	7.1	avoid	
Riverine Complex	0	0	0.3	ns	low
Dune Complex	7	3.1	1.0	prefer	low
Nonpatterned Wet Meadow	21	9.3	3.9	prefer	
Patterned Wet Meadow	16	7.1	12.5	avoid	
Moist Sedge-Shrub Meadow	15	6.6	18.6	avoid	
Moist Tussock Tundra	2	0.9	28.2	avoid	
Tall, Low, or Dwarf Shrub	0	0	5.4	avoid	
Barrens	0	0	1.2	ns	low
Human Modified	0	0	<0.1	ns	low
Total	226	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	0.3	ns	low
Brackish Water	0	0	0.1	ns	low
Tapped Lake with Low-water Connection	0	0	0.2	ns	low
Tapped Lake with High-water Connection	1	1.1	<0.1	ns	low
Salt Marsh	0	0	0.3	ns	low
Tidal Flat Barrens	0	0	0.7	ns	low
Salt-killed Tundra	0	0	<0.1	ns	low
Deep Open Water without Islands	18	19.4	7.8	prefer	
Deep Open Water with Islands or Polygonized Margins	73	78.5	5.7	prefer	
Shallow Open Water without Islands	0	0	1.2	ns	low

Table 7. Continued.

SEASON Habitat	No. of Nests or Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
Shallow Open Water with Islands or Polygonized Margins	1	1.1	1.3	ns	low
River or Stream	0	0	1.1	ns	low
Sedge Marsh	0	0	2.1	ns	low
Deep Polygon Complex	0	0	<0.1	ns	low
Grass Marsh	0	0	0.4	ns	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	0	0	7.1	avoid	
Riverine Complex	0	0	0.3	ns	low
Dune Complex	0	0	1.0	ns	low
Nonpatterned Wet Meadow	0	0	3.9	ns	low
Patterned Wet Meadow	0	0	12.5	avoid	
Moist Sedge-Shrub Meadow	0	0	18.6	avoid	
Moist Tussock Tundra	0	0	28.2	avoid	
Tall, Low, or Dwarf Shrub	0	0	5.4	avoid	
Barrens	0	0	1.2	ns	low
Human Modified	0	0	<0.1	ns	low
Total	93	100	100		

Note: Includes the Development, Exploration, Fish and Judy Creek, Alpine West, GMTC, and Willow loon survey areas. See Johnson et al. (2015) for survey areas not described in Figure 1.

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

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

[c] Low = expected number <5.

the brood-rearing survey (see Nest Fate, below). In the Willow loon survey area in 2019, 20 of 43 (47%) territories were occupied by a brood, which is well above the long-term mean calculated for other survey areas in NE NPR-A (27.9 ± 3.7%, *n* = 15 years; Table 6).

Portions of the Willow Project area have been surveyed for Yellow-billed Loons intermittently since 2001, especially the lakes along parts of Fish and Judy creeks. Since then, we have identified 43 Yellow-billed Loon territories composed of 51 lakes in the Willow loon survey area (Appendix E). Twelve of those territories were identified during surveys prior to the initiation of Willow studies in 2017, 8 were first discovered during surveys in 2017, 8 were discovered during surveys in 2018, and 14 were discovered during surveys in 2019. The remaining territory was identified using the Yellow-billed Loon Geodatabase (USFWS 2013).

Eleven nest sites at 7 territories recorded over multiple years are <1 mile from the proposed Willow project infrastructure (Alternative B in the Draft Environmental Impact Statement; BLM, 2019). Seven of those nest sites are in 3 territories adjacent to the road where it crosses Judy Creek, 2 nest sites are in 2 territories adjacent to the BT-5 pad and 2 nest sites at 2 territories are adjacent the BT-4 pad or road (Appendix E). Five territories have lake shorelines that are <500 m from proposed infrastructure; 2 of those territories are associated with the Judy Creek road crossing; 2 with the BT-5 Pad and 1 with the proposed road as it departs the GMT2/MT7 pad.

HABITAT USE

The Willow loon survey area was 851 km^2, 80% (685 km^2) of which has been mapped for wildlife habitats (Jorgenson et al. 2003, Wells et al. 2018a, 2018b). Yellow-billed Loons nested in 14 of 26 available habitats during nesting surveys conducted over 11 years in various ABR survey areas in NE NPR-A (excluding the Fish Creek Delta subarea; Table 7). Seven habitats, supporting 176 of 226 total nests, were preferred for nesting (Tapped Lake with High-water Connection, Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, Sedge Marsh, Grass Marsh, Nonpatterned Wet Meadow). Nests were built on islands (165 nests), shorelines (43), peninsulas (11), or in emergent vegetation (8). Because the minimum size for habitat mapping is 0.5 ha, islands or patches of emergent vegetation (i.e., Grass Marsh or Sedge Marsh) smaller than 0.5 ha were not classified individually. Rather, these small habitat patches were assigned the habitat of the lake in which they occurred. Deep Open Water with Islands or Polygonized Margins was the habitat used most frequently for nesting (40% of all nests), which reflects the high use of small islands by nesting Yellow-billed Loons (Table 7). Although Shallow Open Water with Islands or Polygonized Margins also was a preferred habitat for nesting, only 5% of all Yellow-billed Loons nests occurred there. In all cases, the shallow water habitat used for nests was either connected to or adjacent to (<190 m from) a deep lake. Dune Complex, another preferred habitat for nesting, is found in lakes along river corridors. This habitat contains several vegetation communities that are too small to map individually. Interdune areas include moist and wet habitats such as Sedge Marsh and Nonpatterned Wet Meadow (Wells et al. 2018b) that are used as nest sites by Yellow-billed Loons.

Yellow-billed Loons avoided nesting in 5 habitats, which together comprised 72% of the available habitat across ABR's NE NPR-A survey areas. The 3 most abundant habitats were avoided (Moist Tussock Tundra, Most Sedge-Shrub Meadow, and Patterned Wet Meadow). However, Patterned Wet Meadow and Moist Sedge-Shrub Meadow together supported ~14% of the Yellow-billed Loon nests. Although both habitats received moderate use by nesting loons, those 2 habitats were underutilized compared with their availability.

Yellow-billed Loons were highly selective in their use of brood-rearing habitat. All 93 Yellow-billed Loon broods in various survey areas in the NE NPR-A (excluding Fish Creek Delta subarea) were found in 4 lake habitats, 2 of which were preferred: Deep Open Water with Islands or Polygonized Margins and Deep Open Water (Table 7). Although those habitats occupy only ~13% of the NE NPR-A survey areas, they contained ~98% of all broods. Shallow water with Islands and Polygonized Margins was the only shallow-water habitat used during brood-rearing and was used by 1 brood. That brood, however, was from a territory comprising 2 lakes. The shallow lake had an extensive Sedge Marsh margin that was used for nesting in some years. The other lake is classified as Deep Open Water with Islands and Polygonized Margins and has been used for brood-rearing in most years. The selection analyses for nesting and brood-rearing highlight the importance of large, deep waterbodies to breeding Yellow-billed Loons.

We have identified 76 territories in ABR's various survey areas in NE-NPRA (excluding the Fish Creek Delta subarea). Sixty-seven territories comprised a single lake used for both nesting and brood-rearing, 7 territories comprised 2 adjacent lakes, and 2 comprised 3 adjacent lakes. Lakes used by breeding Yellow-billed Loons averaged 79.5 ± 11.1 ha in size (range 0.4–694.6 ha, n = 80 lakes). The smallest lake (0.4 ha) was used only for nesting; that pair used an adjacent, larger lake (226.5 ha) for brood-rearing. The majority of lakes were used for both nesting and brood-rearing; the smallest of those lakes was 6.0 ha.

NEST FATE

We recorded 32 nests (including 2 nests that were inferred from the presence of broods) in the Willow loon survey area in 2019. During the brood-rearing survey, 17 of 32 Yellow-billed Loon nests had a brood. Because the absence of a brood does not always indicate nest failure, all 15 nests without broods were visited on the ground to determine nest fate. Three of the 13 nests contained ≥20 egg fragments (range 50–85 fragments), indicating that at least 1 egg hatched in those nests. Twelve nests contained <20 egg fragments (range 0–3 fragments), indicating nest failure. Overall, we determined that 20 of 32 nests hatched.

We began visiting inactive nests to verify nest fate in 2008. During 2008–2014, we also conducted weekly nest and brood monitoring surveys, which provide better estimates of the total number of nests and broods. Weekly surveys detect more nests, especially in years when late nesting phenology results in numerous nests being initiated after the nesting survey, as occurred in 2017 (Johnson et al. 2018b, 2018c). Nests that are missed during the single nesting survey can only be detected during the brood-rearing survey if they produce a brood, which would bias estimates of nesting success high because more successful nests would be included in the calculation. Because of lower survey effort in since 2017, nesting success based on the total number of nests detected is not directly comparable to previous years when weekly surveys were conducted. Restricting the annual data to nests found only on nesting surveys and years in which nest fate data were collected allows a standardized comparison of apparent nesting success among years. Based on nests determined from a single nest survey and hatching determined from nest fate data and the presence of broods, 18 of the 30 nests found during the nesting survey hatched in 2019 for an apparent nesting success of 60%. This estimate was well above the 10-year mean of 49.2 ± 6.9% and was the third highest estimate of nest success observed since 2008.

Reproductive success also may be measured by how many pairs retain young until the third week of August. Of the 30 nests found only on the nesting survey in 2019, 18 hatched based on nest fate data and 15 of those pairs (50.0%) were observed with young during the brood survey. Similar to apparent nesting success, the proportion with young during August also was higher than the 10-year mean (37.3 ± 5.3%). Given that both apparent nesting success and the proportion of pairs with young in August were higher than the long-term averages, the high productivity observed in 2019 was likely due to high survival of both nests and broods.

TIME-LAPSE CAMERAS

We monitored 10 of 32 nests in the Willow loon survey area with time-lapse cameras in 2019 (Table 8). Cameras were placed 36–69 m from nests (mean = 49 ± 3.5 m) that were active after the nesting survey. To deploy cameras, 2 researchers were transported to and from nesting lakes by helicopter. Researchers were at nests for 28–60 min (mean = 44 ± 3.3 min). All 10 loons that were incubating left their nests during camera setup: 3 left as the helicopter landed, 5 left as researchers exited the helicopter, and 2 swam away from their nests as researchers approached the camera setup location on foot.

All 10 loons that left their nests during camera installation returned to incubate after installation. Loons returned 4–34 min after we departed (mean = 15 ± 4 min) and, in total, were absent from nests 36–88 min during camera installation (mean = 57 ± 5 min).

Cameras successfully recorded daily nest survival, and we were able to use camera images to identify the day of hatch or failure at all 10 nests (Table 8). Of the 10 camera-monitored nests, 6 hatched and 4 failed for an apparent nesting success of 60%, which was identical to the nesting success for nests without cameras. The median start date for incubation at hatched nests was 6 June (range 5–11 June) and the median hatch date was 4 July (range 3–9 July). Incubation at hatched nests started nearly a week earlier in 2019 than in previous years (median = 14 June, range 6–23 June, n = 6 years; Appendix F), likely an effect of early moat formation on lakes in 2019 granting access to nest sites. The median start date for failed nests in 2019 was 9 June (range 9–18 June), which was also about a week earlier than the long-term median.

Incubation constancy of Yellow-billed Loons in the Willow loon survey area in 2019 (Table 8) was slightly higher than the mean observed since camera monitoring began in 2010 (Appendix F). During camera monitoring in 2019, loons at hatched nests spent 98.8% ± 0.3% of their time incubating. On average, these loons took 1.8 ± 0.4 recesses/day that lasted an average of 8.5 ± 1.6 min/recess. Loons at failed nests had a slightly lower incubation constancy, spending 97.1% ± 0.4% of their time incubating; however, they took more frequent and longer recesses. Loons at failed nests averaged 2.7 ± 0.6 recesses per day, with each recess averaging 14.9 ± 4.9 min.

Since 2010 in the NPR-A, predation of 1 or both eggs has been documented by time-lapse cameras at 33 of 59 nests, including 6 nests where predators were not captured on images. The majority (52%) of identified predators were Glaucous Gulls and Parasitic Jaegers, which take advantage of unattended nests rather than flushing

Table 8. Nest history and incubation activity of Yellow-billed Loon nests monitored by time-lapse digital cameras, Willow loon survey area, NE NPR-A, 2019.

Territory	Fate[a]	Incubation Start Date[b]	Predator	No. Eggs[c]	Date Camera Setup	Date of Hatch or Failure	No. Days Monitored[d]	Incubation Constancy[d] (%)	Exchange Frequency[d] (no/d)	Recess Frequency[d] (no/d)	Recess Length[d] (min/recess)
79	Success	6 June		1	24 June	4 July	9.4	98.5	0.4	2.7	7.8
98	Success	9 June		2	23 June	7 July	13.4	98.3	2.1	2.9	7.2
104	Success	6 June		2	24 June	4 July	9.3	99.6	2.7	0.3	8.5
117	Success	6 June		2	23 June	4 July	10.2	99.5	2.0	1.3	4.2
126	Success	5 June		2	24 June	3 July	8.5	99.1	2.4	1.7	7.4
135	Success	11 June		2	24 June	9 July	14.4	97.7	1.7	1.9	15.9
Median/Mean		6 June			–	4 July		98.8	1.9	1.8	8.5
SE		–			–	–		0.3	0.3	0.4	1.6
115	Failed	9 June	Glaucous Gull	2	24 June	30 June	5.9	98.3	2.9	2.5	8.0
118	Failed	9 June	Red Fox	1	23 June	25 June	1.4	97.0	1.4	2.1	10.3
131	Failed	9 June	Wolverine	2	24 June	1 July	7.5	96.7	2.8	1.6	29.5
134	Failed	18 June	Unknown	1	23 June	5 July	12.2	96.3	1.0	4.5	11.6
Median/Mean		9 June			–	30 June		97.1	2.0	2.7	14.9
SE		–			–	–		0.4	0.5	0.6	4.9

[a] Success = hatched, Failed = failed to hatch.
[b] Incubation start dates for successful nests estimated by subtracting 28 d from date chick first observed on camera images; for failed nests, nest age estimated using egg flotation schedule; if either method resulted in a nest age that was younger than the using the date found, the date found was used as the start of incubation.
[c] Recorded on aerial surveys, during camera setup, or maximum seen on camera images.
[d] Summarized from time loon returned to nest after camera installation to day before hatch, or to time of nest failure; excludes period of time when photo images could not be interpreted because of poor weather conditions.

the incubating loon. Of the 4 nests that failed to hatch in 2019, 1 failure was attributed to predation by a Glaucous Gull, 1 to a red fox, and 1 to a wolverine. The predator at the remaining nest was not captured on images (Table 8). The nest that was lost to a Glaucous Gull was unattended at the time of predation (Figure 12). In contrast, a loon was incubating at both nests that were lost to the red fox (Figure 12) and wolverine. In both cases, the incubating loon left its nest shortly before the appearance of the predator on images.

GULLS

DISTRIBUTION AND ABUNDANCE

Three Glaucous Gull nests and 3 young were observed on the 11 lakes surveyed in the TMS loon survey area during the aerial nesting and brood-rearing surveys for loons in 2019 (Figure 13). An additional 3 nests were recorded on wetlands adjacent to the survey lakes. The same 11 lakes also were surveyed during 2018 and a similar number of gulls were recorded (2 nests and 1 young).

Forty-six Glaucous Gull nests were recorded on 37 waterbodies in the Willow loon survey area during the aerial survey for nesting loons in 2019 (Figure 13, Table 9). Over 75% of the nests were individual nests. Only 3 small colonies of 3–4 nests were identified: 1 located ~4 km north of BT-5, 1 located ~15 km west of BT-2, and 1 located ~9 km west of BT-4. Within the area surveyed for Willow in 2017 (the smallest area of the 3 years), there were 11 Glaucous Gull nests in 2017, 21 nests in 2018 and 16 nests in 2019 (Appendix G).

Twenty-six Glaucous Gull chicks were recorded on 10 waterbodies during the survey for brood-rearing loons in 2019 (Figure 13, Table 9). Individually nesting pairs produced the majority of young (69%). The BT-5 colony was the only colony that produced chicks. Over twice as many chicks were observed in 2019 compared with 2018 despite the similar number of nests found. The loon brood survey occurs close to when young gulls fledge. Many chicks in 2019 were flight capable and it is possible that some chicks were no longer occupying nesting lakes. In contrast, most young gulls in 2018 appeared to be flightless.

Nine Sabine's Gull colonies were recorded in the Willow loon survey area during the aerial survey for nesting loons. Based on estimates of the number of gulls in flight, nest counts at the colonies ranged from 3 to 30 nests (Figure 13). Many of the colonies observed in 2017 and 2018 were also active in 2019 (Appendix G). We detect colonies of Sabine's Gulls more readily than single nests during aerial surveys, which probably results in an underestimate of the number of total nests present. On the Yukon-Kuskokwim Delta, ground-searchers found single nests were as common as colonies of nests (Norment et al 2015).

HABITAT USE

Glaucous Gull nests were found in 9 different habitats in the TMS and Willow loon survey areas in 2019 (Table 10). The most commonly used habitats were Shallow Open Water with Islands or Polygonized Margins (30% of all nests), and Deep Open Water with Islands or Polygonized Margins (15% of nests), Sedge Marsh (15% of all nests) and Grass Marsh (15% of all nests). The remaining nests were found on islands or shorelines in 5 other habitats and in unmapped areas. During 2014, 2017 and 2018, Glaucous Gulls occupied 4 additional habitats; however, the survey area during those years included the GMT2/MT7 road corridor which was not surveyed during 2019 (Table 10, Appendix G). Sabine's Gulls nested in Shallow Open Water with Islands or Polygonized Margins, Sedge Marsh, and Grass Marsh.

Table 9. Number of Glaucous Gull nests and young recorded during aerial surveys for nesting loons in Willow loon survey area, NE NPR–A, 2017–2019.

	BT-5 North Colony		BT-2 West Colony		BT-4 West Colony		Study Area Total	
Year[a]	Nests	Young	Nests	Young	Nests	Young	Nests	Young
2017	2	2	–	–	–	–	11	5
2018	4	2	3	2	1	1	45	10
2019	4	8	3	0	4	0	46	26

[a] The 2017 survey area (502 km^2) is included in the larger 2018 and 2019 survey area (851 km^2).

Figure 12. Time-lapse images of a red fox taking eggs from a Yellow-billed Loon nest after flushing the adult loon from its nest (top) and a Glaucous Gull carrying an egg away from an unattended Yellow-billed Loon nest (bottom), Willow loon survey area, NE NPR-A, Alaska, 2019.

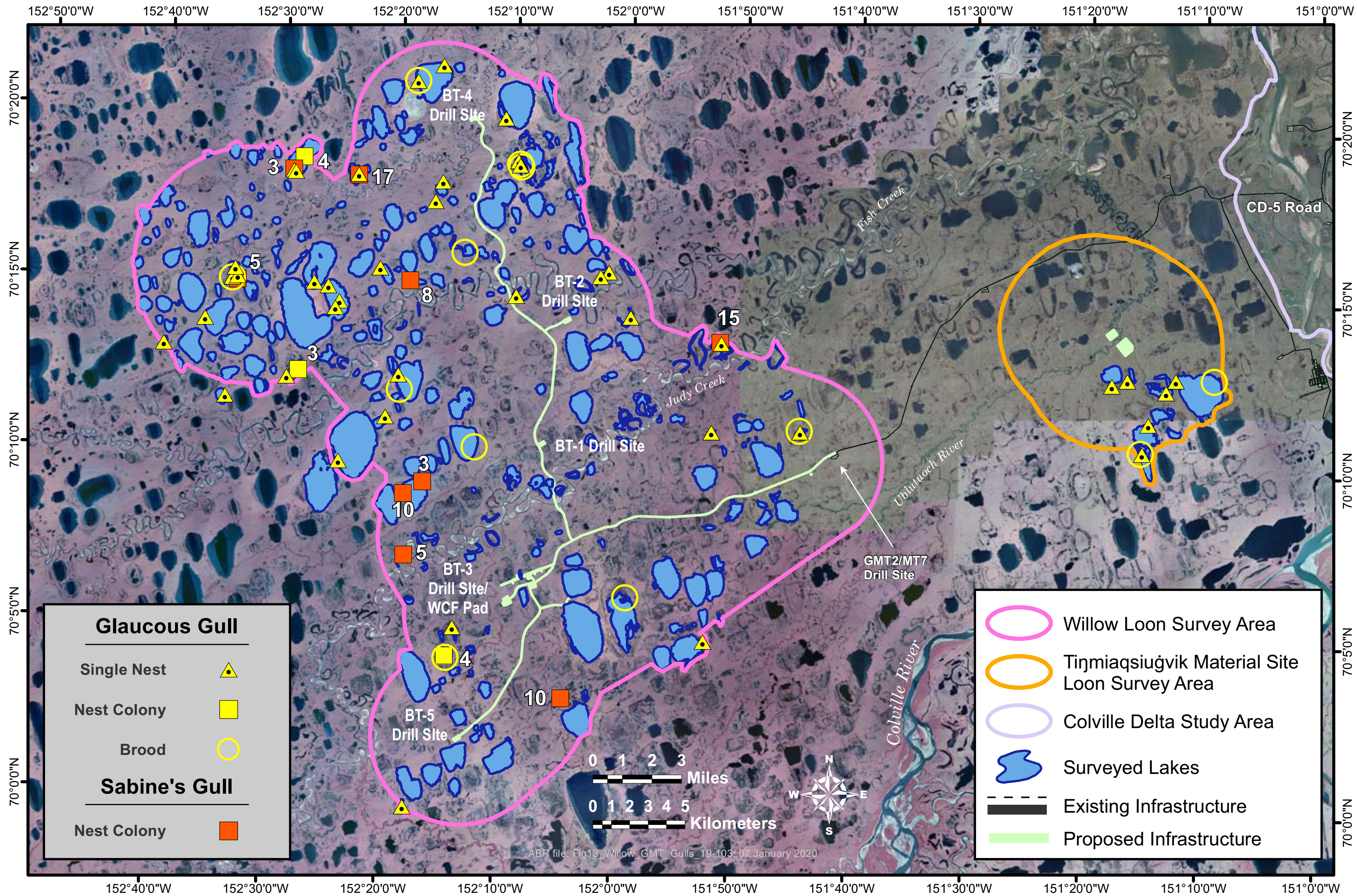

Figure 13. Glaucous Gull and Sabine's Gull nest and brood locations, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2019.

Table 10. Habitat use by nesting Glaucous Gulls recorded during aerial surveys for nesting loons in the Willow and TMS loon survey areas, NE NPR-A, 2014 and 2017–2019.

Habitat	2014[a]		2017[a]		2018[a]		2019	
	Nests	Use (%)	Nests	Use (%)	Nests	Use (%)	Nests	Use (%)
Tapped Lake with High-water Connection	–	–	1	3.2	1	1.6	–	–
Deep Open Water without Islands	–	–	1	3.2	–	–	2	6.0
Deep Open Water with Islands or Polygonized Margins	6	17.1	5	16.1	13	20.6	5	15.2
Shallow Open Water without Islands	–	–	–	–	5	6.3	–	–
Shallow Open Water with Islands or Polygonized Margins	21	60.0	29	45.2	21	34.9	10	30.3
Sedge Marsh	2	5.7	4	9.8	6	9.5	5	15.2
Grass Marsh	1	2.9	6	19.3	8	12.7	5	15.2
Young Basin Wetland Complex	1	2.9	–	–	–	–	–	–
Old Basin Wetland Complex	3	8.5	1	3.2	1	1.6	1	3.0
Riverine Complex	–	–	–	–	1	1.6	–	–
Nonpatterned Wet Meadow	–	–	–	–	4	4.8	–	–
Patterned Wet Meadow	–	–	–	–	2	3.2	1	3.0
Moist Sedge-Shrub Meadow	1	2.9	–	–	2	3.2	2	6.0
Tall, Low, or Dwarf Shrub	–	–	–	–	–	–	2	6.0
Subtotal of Nests in Mapped Habitat	35	100	47	100	63	100	33	100
Subtotal of Nests in Unmapped Habitat	0		2		14		20	
Total	35		49		77		53	

[a] The survey area also included lakes within a 3 mile buffer of the road from the CD-4 bridge to GMT2/MT7 Drill Site.

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Appendix A. Annual density (number/km²) of Yellow-billed Loons, nests, and broods in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017– 2019.

SURVEY AREA Year	Nesting Survey Adults	Nests[a]	Brood-rearing Survey Adults	Broods[b]
Willow[c]				
2017	0.07	0.01 (0.03)	0.08	0.01 (0.02)
2018	0.08	0.02 (0.02)	0.10	<0.01 (0.01)
2019	0.09	0.03 (0.04)	0.12	0.02 (0.02)
NE NPR-A[d]				
2001	0.07	0.03	0.08	0.01
2002	0.07	0.03	0.05	0.01
2003	0.06	0.03	0.06	0.02
2004	0.07	0.03	0.08	0.01
2005	0.11	0.04	0.06	0.01
2006	0.11	0.04	0.07	0.01
2008	0.17	0.05 (0.06)	0.14	0.02 (0.04)
2009	0.13	0.05 (0.06)	0.16	0.03 (0.03)
2010	0.15	0.06 (0.06)	0.14	0.03 (0.03)
2011	0.12	0.03 (0.05)	0.12	0.02 (0.02)
2012	0.14	0.06 (0.07)	0.17	0.05 (0.05)
2013	0.16	0.05 (0.06)	0.08	0 (<0.01)
2014	0.09	0.03 (0.04)	0.06	0.02 (0.02)

[a] Density of nests found on the nesting survey and, in parentheses, cumulative density including additional nests inferred from broods (all years) or found during revisit (1996–2002) and monitoring (2006–2014) surveys.

[b] Density of broods found on the brood-rearing survey and, in parentheses, cumulative density including additional broods found during monitoring surveys (2005–2014) or inferred from egg remains (2017–2019) that did not survive to the time of the brood-rearing survey.

[c] Willow loon survey area was 502.3 km^2 in 2017 and 851.2 km² in 2018 and 2019.

[d] Survey area included 5 subareas: Development (617.8 km²) surveyed in 2001–2004, Exploration (260.4 km²) in 2002–2004, Alpine West (79.7 km²) in 2002–2006 and 2008–2013, Fish Creek Delta (130.5 km²) in 2005–2006 and 2008–2013, and the Fish and Judy Creek Corridor (255.9 km²) in 2008–2010. In 2011–2013, the eastern one-quarter of the Fish and Judy Creek Corridor subarea (41.0 km²) was surveyed. In 2014, area surveyed was 525.2.

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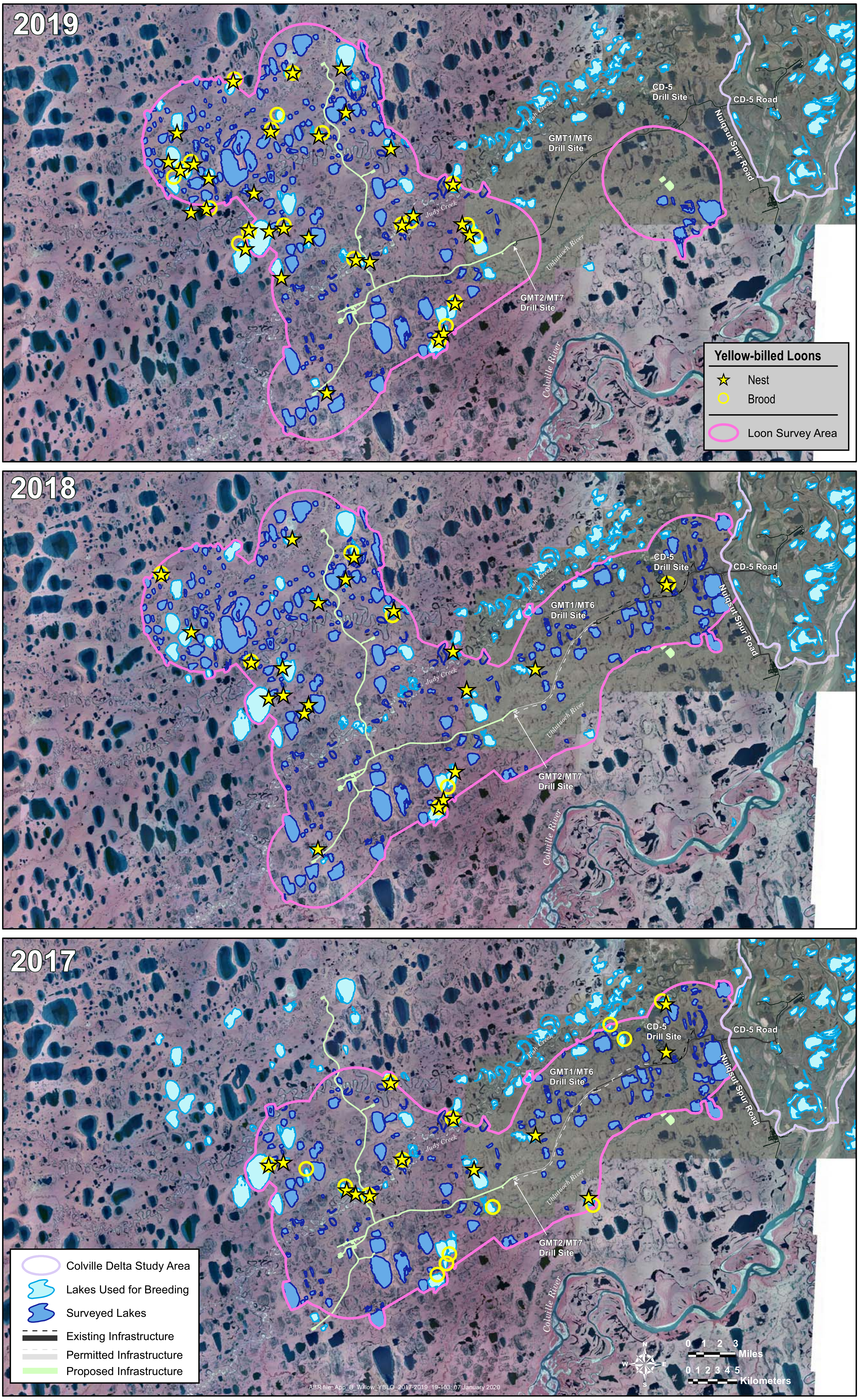

Appendix B. Yellow-billed Loon nests and broods during aerial surveys in the Willow loon survey area, NE NPR-A, 2017–2019.

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Appendix C. Number of Pacific and Red-throated loons and their nests, broods, and young during aerial surveys in the Willow and Tiŋmiaqsiuġvik Material Site (TMS) loon survey areas, NE NPR-A, 2017–2019. Densities were not calculated because surveys did not include smaller lakes (<5 ha) where those species commonly nest.

	Survey Area[a]			
SPECIES	Willow		TMS[b]	
Observation Type	Nesting	Brood-rearing	Nesting	Brood-rearing
PACIFIC LOON				
Adults				
2017	251	295	–	–
2018	670	753	29	30
2019	697	711	26	22
Nests/Broods				
2017	50	39	–	–
2018	117	39	3	5
2019	134	105	7	8
Young				
2017	–	48	–	–
2018	–	44	–	6
2019	–	140	–	11
RED-THROATED LOON				
Adults				
2017	1	0	–	–
2018	1	3	0	0
2019	4	8[c]	0	0
Nests/Broods				
2017	0	0	–	–
2018	0	2	0	0
2019	0	0[c]	0	0
Young				
2017	–	0	–	–
2018	–	3	–	0
2019	–	0[c]	–	0

[a] TMS loon survey area = 113.9 km² during 2018 and 2019 but only 11 of the 30 lakes in the survey area are included in totals; Willow loon survey area = 502.3 km² in 2017 and 851.2 km² in 2017; see Appendix D.
[b] The TMS loon survey area was not surveyed during 2017
[c] One brood with 1 adult and 1 young was seen outside the Willow loon survey area.

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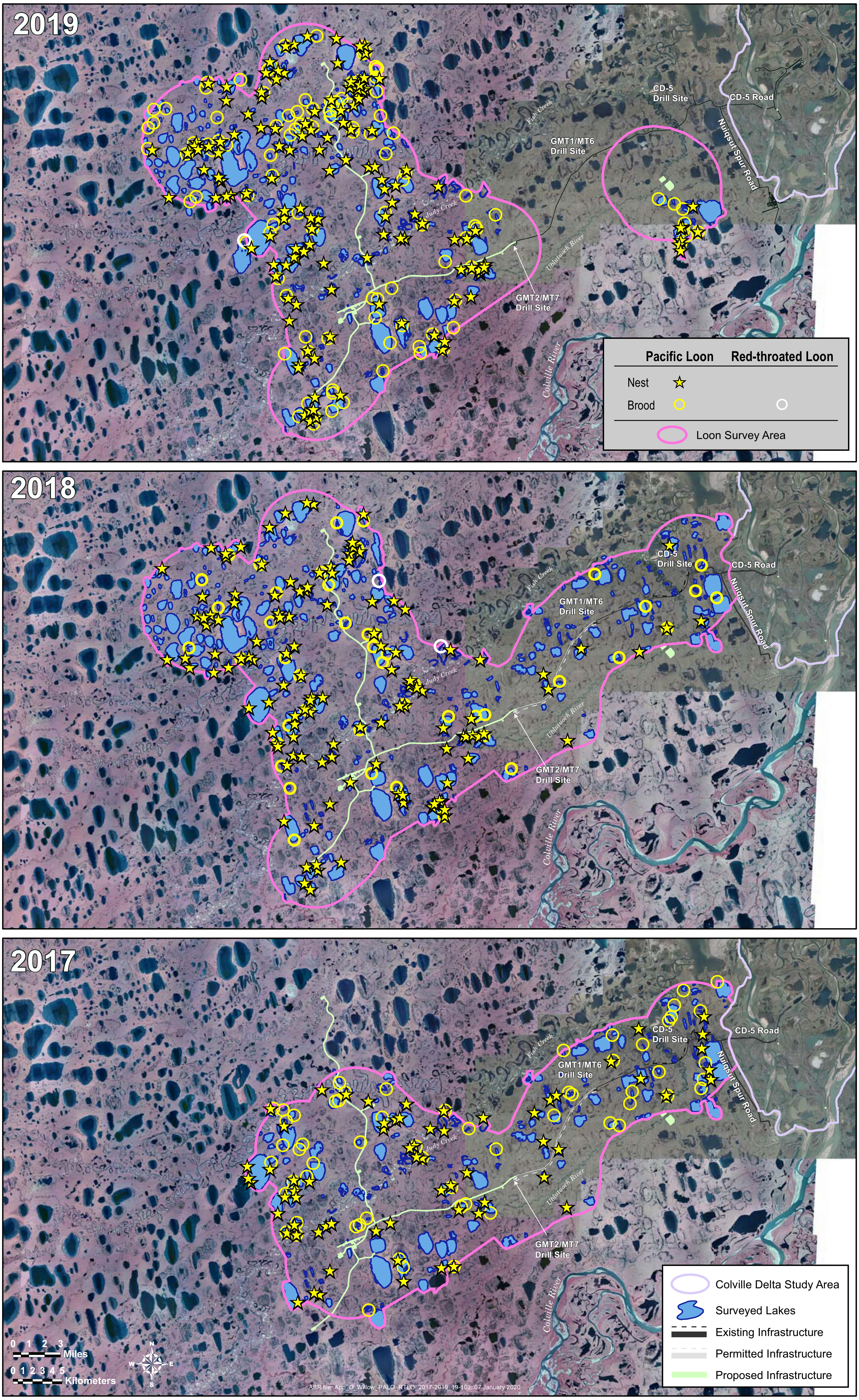

Appendix D. Pacific Loon nests and broods and Red-throated Loon broods during aerial surveys, NE NPR-A, 2017–2019.

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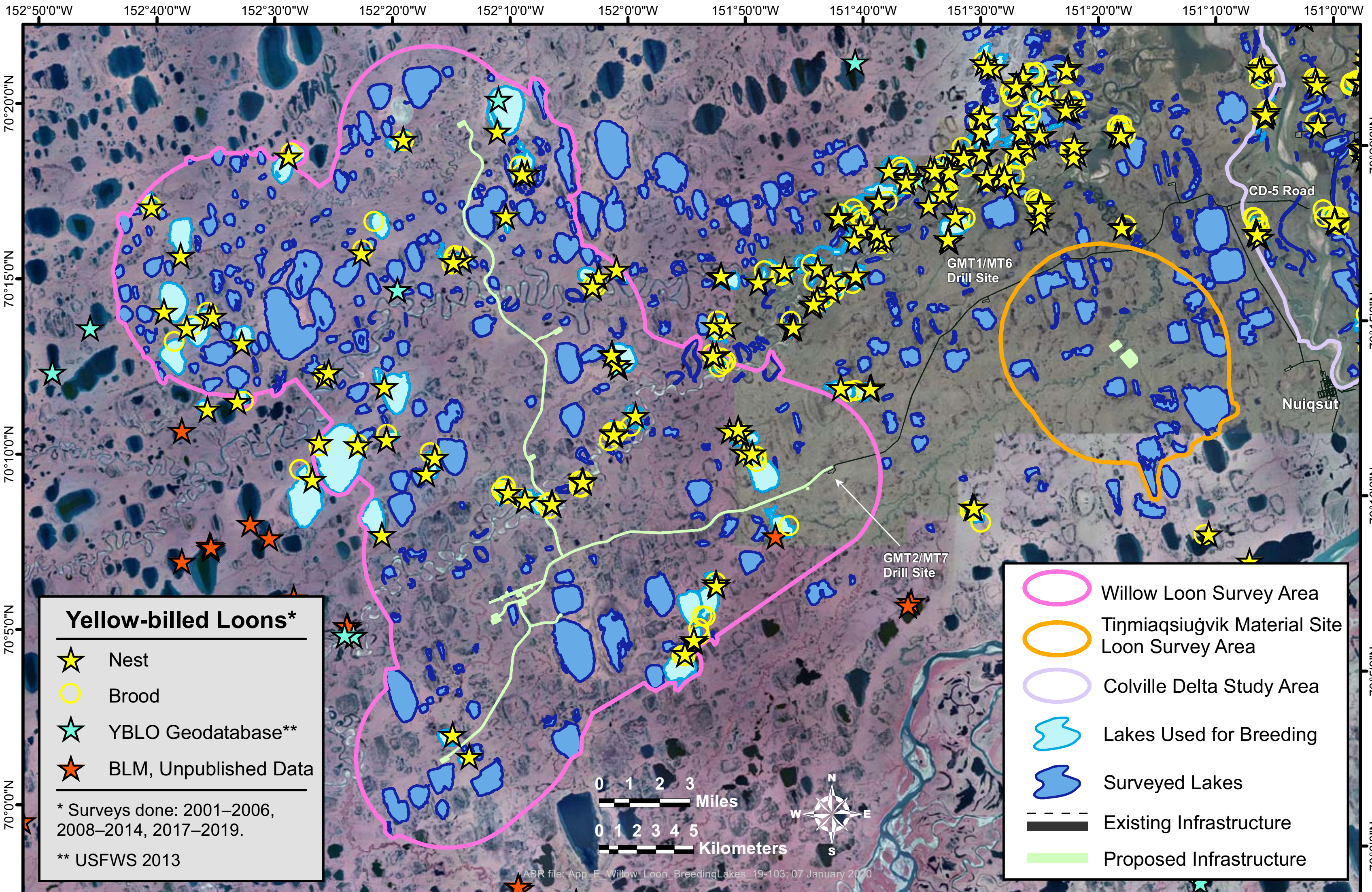


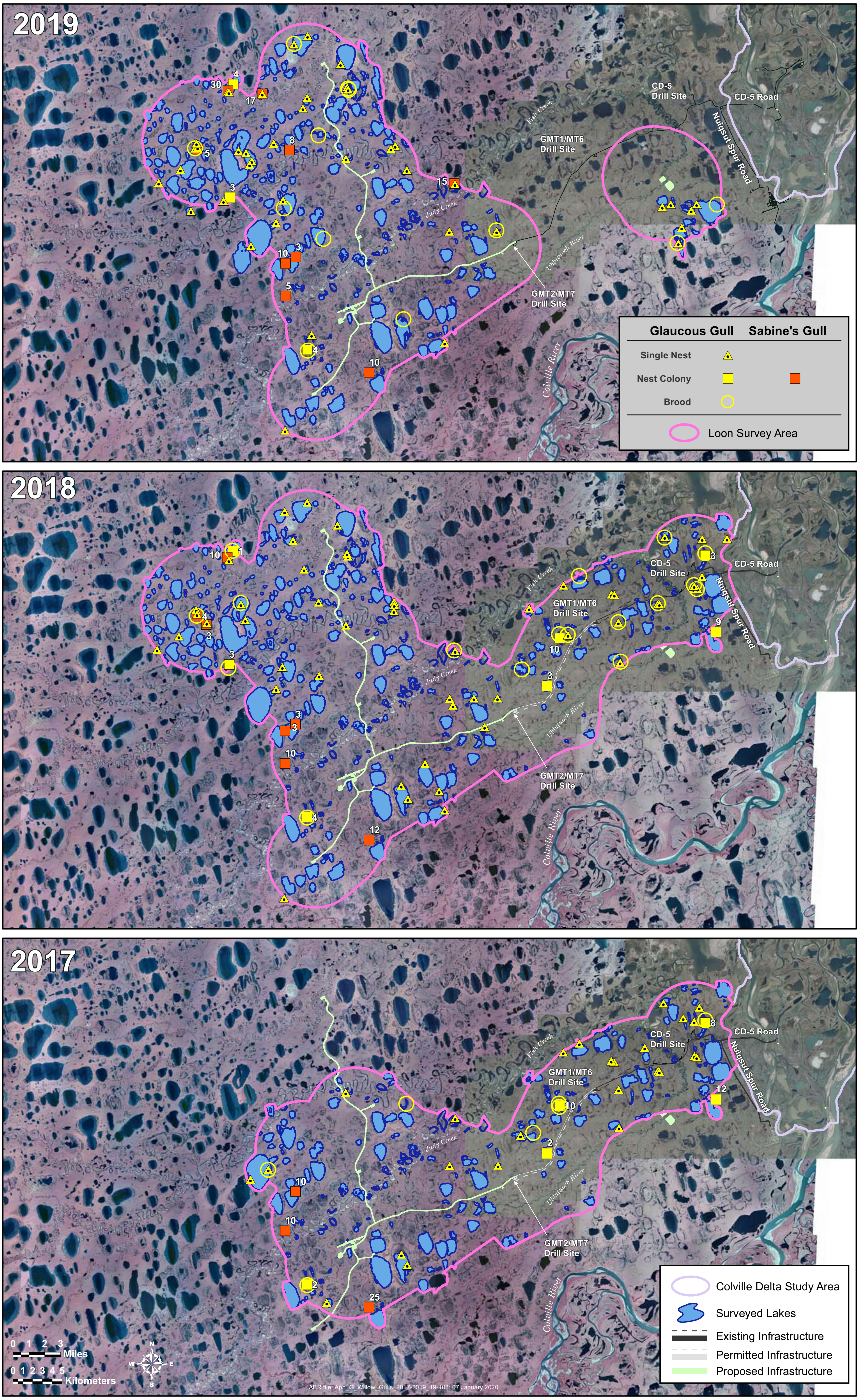
Appendix E. Lakes used by nesting and brood-rearing Yellow-billed Loons, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2001–2006, 2008–2014, and 2017–2019.

Appendix F. Nest history and incubation activity of Yellow-billed Loon nests monitored by time-lapse digital cameras, NE NPR-A, Alaska, 2008–2014 and 2019.

Year/ Fate	Median				Average				
	Start of Incubation	*n*	Hatch or Failure	*n*	Incubation Constancy[d] (%)	Exchange Frequency[a] (no/d)	Recess Frequency[a] (no/d)	Recess Length[a] (min/recess)	*n*
2010									
Hatched	19 June	6	18 July	5	97.2 ± 0.5	1.2 ± 0.2	3.5 ± 0.2	11.0 ± 1.3	6
Failed	18 June	2	5 July	4	94.4 ± 1.8	1.4 ± 0.2	3.6 ± 0.5	30.9 ± 9.6	4
2011									
Hatched	14 June	2	12 July	2	98.4 ± 0.2	1.3 ± 0.5	1.8 ± 0.1	12.4 ± 1.8	2
Failed	19 June	3	25 June	4	95.2 ± 0.4	1.6 ± 0.4	4.9 ± 0.4	20.5 ± 5.6	2
2012									
Hatched	14 June	9	12 July	8	97.9 ± 0.4	1.4 ± 0.2	2.4 ± 0.3	11.2 ± 1.2	9
Failed	16 June	2	4 July	2	95.8 ± 0.8	0.9 ± 0.9	4.0 ± 0.4	16.8 ± 1.8	2
2013									
Hatched	23 June	1	21 July	1	94.0	1.4	4.0	16.4	1
Failed	17 June	7	29 June	8	93.2 ± 0.9	1.1 ± 0.1	3.6 ± 0.3	58.6 ± 22.7	7
2014									
Hatched	15 June	7	13 July	7	98.0 ± 0.5	1.3 ± 0.3	2.5 ± 0.6	9.4 ± 1.3	6
Failed	17 June	6	6 July	5	93.6 ± 1.0	1.0 ± 0.1	4.6 ± 1.0	22.7 ± 6.6	5
2019									
Hatched	6 June	6	4 July	6	98.8 ± 0.3	1.9 ± 0.3	1.8 ± 0.4	8.5 ± 1.6	6
Failed	9 June	4	30 June	4	97.1 ± 0.4	2.0 ± 0.5	2.7 ± 0.6	14.9 ± 4.9	4
Total									
Hatched	14 June[b]	6	12 July[b]	6	97.8 ± 0.3	1.4 ± 0.1	2.5 ± 0.2	10.5 ± 0.7	30
Failed	17 June[b]	6	2 July[b]	6	94.5 ± 0.5	1.3 ± 0.1	3.8 ± 0.3	32.6 ± 4.5	24

[a] Summarized from time loon returns to nest after camera installation to day before hatch, or to time of nest failure; excludes period of time when photo images could not be interpreted because of poor weather conditions and loon nests that were monitored for <1 day.

[b] Overall median calculated across yearly medians.



Appendix G. Glaucous and Sabine's Gull nest and brood locations in the Willow loon survey area, NE NPR-A, 2017–2019.