

An aerial photograph of a wetland area. The landscape is a mosaic of dark brown and green marshes, light blue water, and white snow. The snow is primarily on the right side, forming a large, irregular shape. Several birds are visible in flight over the water on the right side.

**AVIAN STUDIES IN THE WILLOW PROJECT AREA, 2018**

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## **FINAL REPORT**

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## 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 2018, ABR, Inc., conducted baseline wildlife surveys for selected birds 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, 2018c).

In this report, we present the results of eider and loon surveys that were conducted in the Willow Project area in 2018. 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 is a federally listed threatened species, and the Yellow-billed Loon is listed as a BLM sensitive species (BLM 2010) with a limited breeding range.

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

## STUDY AREA

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 2018 extended approximately 32 km (20 miles) west from the proposed GMT-2 drill site, approximately 19 km (12 miles) north of GMT-2, and 24 km (15 miles) south of GMT-2. The avian study comprised 1 eider survey area (1,468 km<sup>2</sup>)

and 2 slightly overlapping loon survey areas (together comprising 1,142 km<sup>2</sup>) covering all potential Yellow-billed Loon nesting and brood-rearing lakes within 3 miles of proposed facilities in the Willow Project area and the adjacent GMT corridor (Figure 1).

Landforms, vegetation, and wildlife habitats in the Willow Project area were described in Wells et al. (2018, *in prep.*). Johnson et al. (2015) provided the previous habitat map and descriptions for the NE NPR-A, which included the GMT-2 area before the Willow Project area was mapped.

## METHODS

We collected data on eiders in the Willow Project area and on loons in the Willow Project area and in the adjacent GMT corridor. Aerial surveys were used because of the large size of the areas and the short periods of time that each species is at the optimal stage 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 2018, 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 (Malgi, *Gavia pacifica*), Red-throated Loons (Qaqsrmaq, *G. stellata*), and gulls were recorded incidentally during loon surveys. See Table 1 for survey details.

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

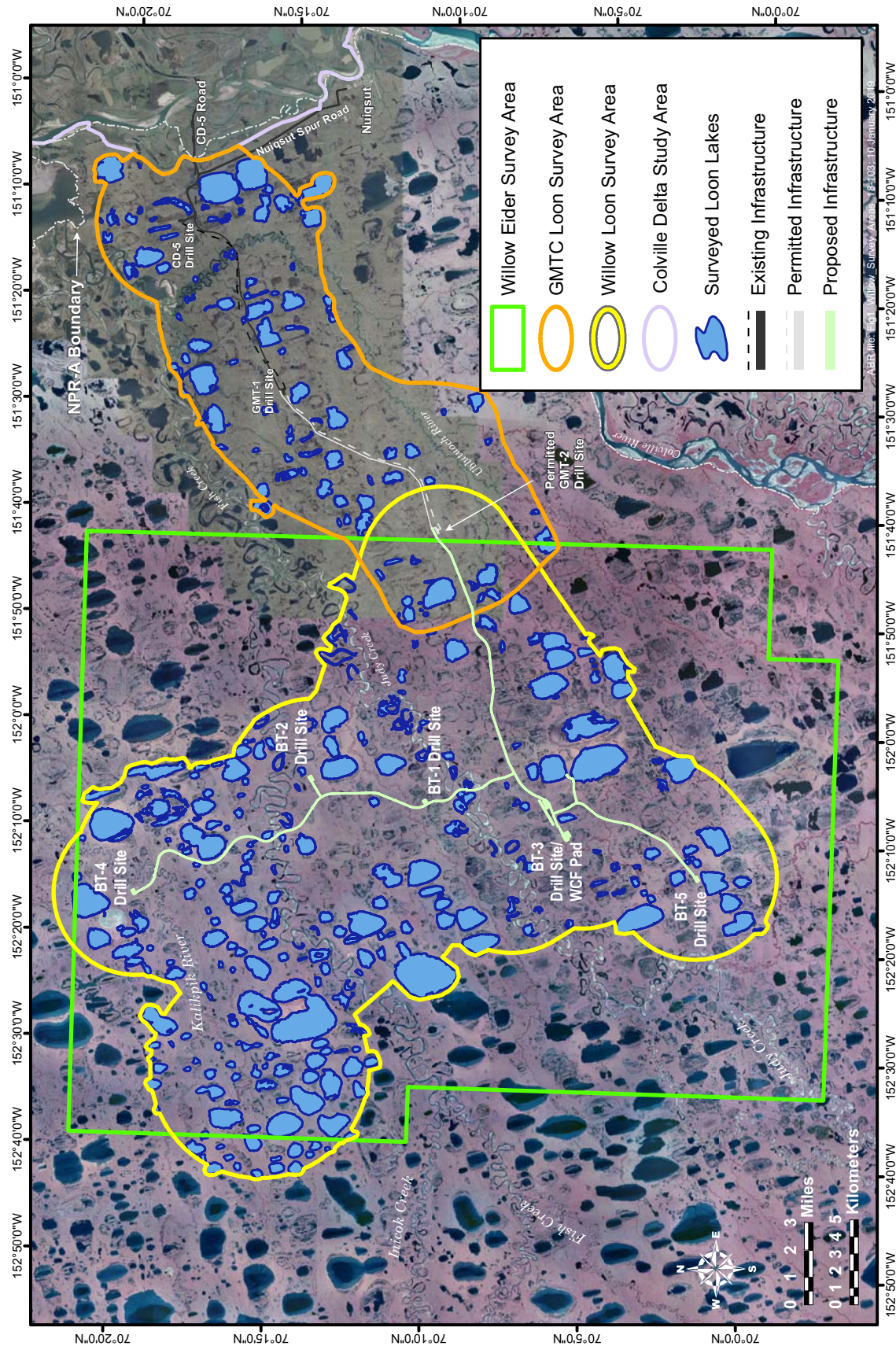


Figure 1. Wildlife survey areas for the Willow and GMT project areas, NE NPR-A, 2017 and 2018.

were present, we diverted the airplane or helicopter to reduce disturbance to hunters.

During the surveys, locations of eiders, loons, and gulls were recorded on digital orthophoto mosaics of 0.75–1 ft resolution natural color imagery 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 of 2.5 m resolution. Habitat mapping for the Willow Project area was prepared using a base map of DigitalGlobe satellite imagery of 1.64 ft resolution in natural color and color infrared acquired 5 July 2015. Bird locations plotted on moving maps on digital tablets were reviewed before they were finalized in a geographical information system (GIS) database.

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

## EIDER SURVEYS

We evaluated the abundance, distribution, and habitat selection of 4 species of eiders—Spectacled, King, Steller’s (Ignitauqtuq, *Polysticta stelleri*), and Common eiders (*Amauligruaq*, *Somateria mollissima*) with data collected on 1 aerial survey flown annually during the pre-nesting

period (Table 1), when male eiders were still present on the breeding grounds. In 2018, we conducted the pre-nesting survey during 17–24 June using 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 (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 approximately 145 km/h. Two observers each counted eiders in a 200 m wide transect on each side of the airplane (400 m total transect width). A Global Positioning System (GPS) receiver was used to navigate east–west transect lines that were spaced 800 m apart achieving 50% coverage.

## LOON SURVEYS

The 2018 loon surveys covered 2 areas, the Greater Moose’s Tooth Corridor (GMTC) and the Willow loon survey areas (Figure 1). Loon survey areas encompassed a 3-mi buffer around existing and proposed roads and drill sites associated with the GMT and Willow developments. In the GMTC loon survey area, we surveyed 105 lakes for nesting and 107 lakes for brood-rearing Yellow-billed Loons (Figure 1, Table 1). In the Willow loon survey area, we surveyed 294 lakes for nesting loons and 291 for brood-rearing loons. The GMTC and Willow loon survey areas overlap near the proposed GMT-2 drill site. Fifteen survey lakes, including 3 Yellow-billed Loon territories, are within the area of overlap. We have previously

Table 1. Avian surveys conducted in the Willow Project area and GMT corridor, NE NPR-A, 2018.

	Pre-nesting Eider Survey <sup>a</sup>	Yellow-billed Loon Surveys <sup>b</sup>	
		Nesting	Brood-rearing
Number of Surveys	1	1	1
Survey Dates	17, 20, and 22–24 June	22–30 June and 1 July	15–21 Aug
Aircraft <sup>b</sup>	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 $\geq$ 5 ha in size	All lakes $\geq$ 5 ha in size

<sup>a</sup> Both Spectacled Eiders and King Eiders were recorded.

<sup>b</sup> Nests and broods of Pacific Loons, Red-throated Loons, Glaucous Gulls, and Sabine’s Gulls were recorded incidentally.

<sup>c</sup> C185 = Cessna 185 fixed-wing airplane; A-Star = Airbus AS 350 B2 helicopter.

conducted surveys for nesting and brood-rearing Yellow-billed Loons in the NE NPR-A area during 2001–2006, 2008–2014, and 2017 (for details, see Johnson et al. [2015, 2018c]).

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, 2018c). All surveys were flown in a helicopter flying in a lake-to-lake pattern at 60–90 m above ground level. 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  $\geq 10$  ha in size in 2001–2006 and most lakes  $\geq 5$  ha in size in 2008–2014, 2017, and 2018. 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. 2018d). Tapped Lakes with Low-water Connections (lakes whose levels fluctuate with changing river levels) were excluded from surveys during all years because Yellow-billed Loons do not use such lakes for nesting (North 1986, Johnson et al. 2003).

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

To make annual comparisons among years when different numbers of territories were surveyed, we calculated territory occupancy by dividing the number of territories with nests, adults, or broods by the number of territories surveyed. We defined a territory as a single lake,

several lakes, or portion of a lake occupied exclusively by 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 occurred and, additionally, by the locations of adults on multi-territory lakes. Territory occupancy was not calculated for the Willow loon survey area for this report because the majority (75%) of those survey lakes had not been surveyed previously. Occupancy will be calculated after more surveys are completed.

#### NEST FATE

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

#### GULLS

Locations of Glaucous Gull (*Nauyasrurugruk*, *Larus hyperboreus*) nests were recorded incidentally during aerial surveys for nesting loons (see survey methods above). Glaucous Gull broods were recorded incidentally during brood-rearing surveys for loons. Colonies of Sabine's Gulls (*Iqirgagiak*, *Xema sabini*) also were recorded during the nesting surveys for loons. The number of nests at each colony was estimated based on the number of adult pairs observed. All locations of gull nests, broods, or colonies were recorded on a tablet computer with a custom Android application.

#### HABITAT MAPPING AND ANALYSIS

A wildlife habitat 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 seasons (e.g.,

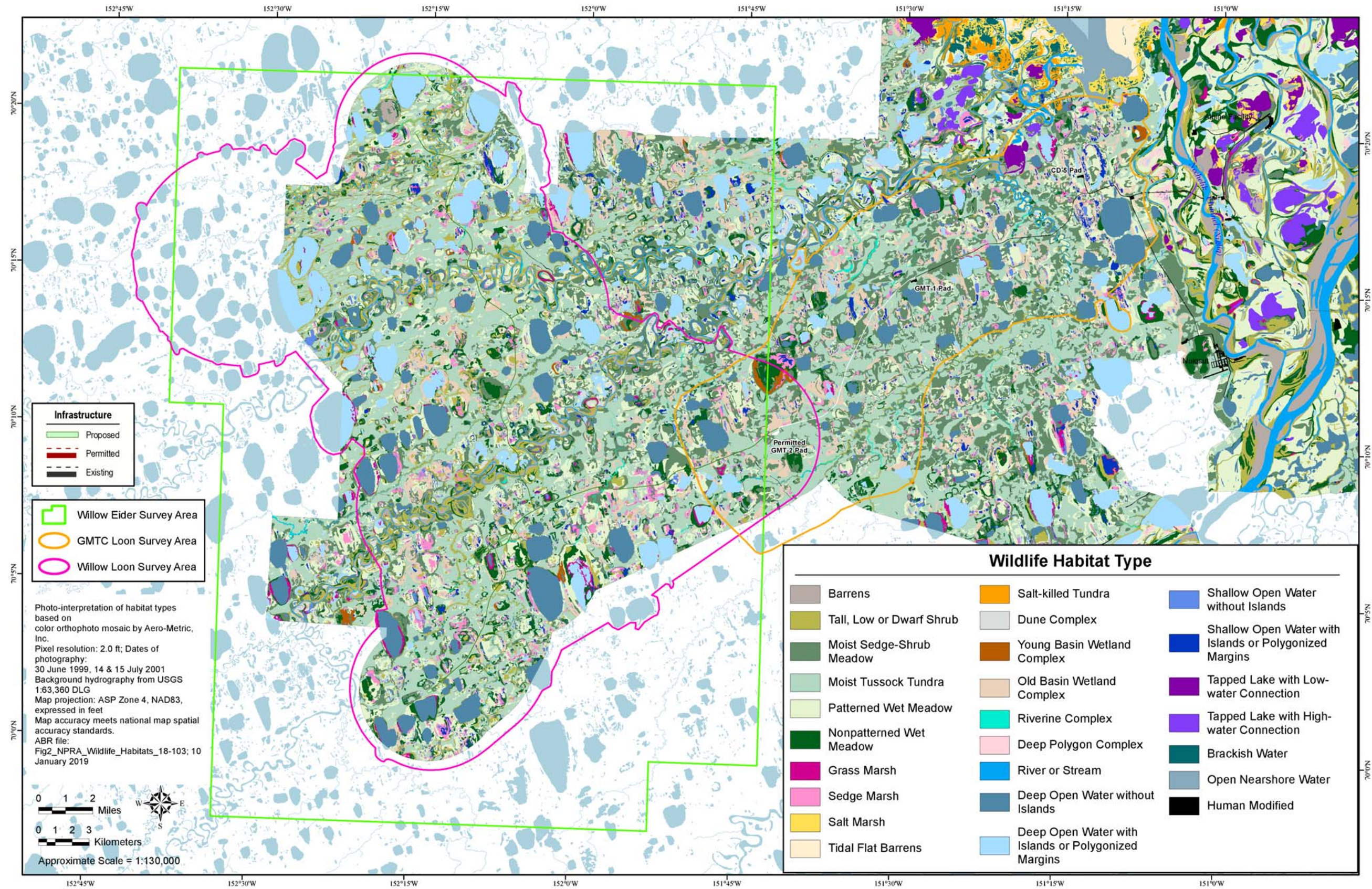


Figure 2. Wildlife habitats in the NE NPR-A area, 2018.



pre-nesting, nesting, and brood-rearing), as appropriate. For each species and season, 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 eider and loon survey areas (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 and GMTC eider and loon survey areas. 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 Eiders, 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 surveys for CPAI were compiled into a centralized database following CPAI's data management protocols (version 10.9, CPAI 2018). All nest, brood, bird, and bird group locations were recorded on Android tablets that could be downloaded into text and GIS

Table 2. Habitat availability in the Willow eider and Willow loon survey areas, Willow Project area, NE NPR-A, 2018.

Habitat	Eider Survey Area		Loon Survey Area	
	Area (km <sup>2</sup> )	Availability (%) <sup>a</sup>	Area (km <sup>2</sup> )	Availability (%) <sup>a</sup>
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 <sup>b</sup>	66.2	7.87	57.0	8.32
Barrens <sup>c</sup>	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	

<sup>a</sup> Percent availability calculated proportion of mapped area.

<sup>b</sup> Tall, Low, or Dwarf Shrub includes Moist Tall Shrub, Dry Tall Shrub, Moist Low Shrub, Moist Dwarf Shrub, and Dry Dwarf Shrub.

<sup>c</sup> Barrens includes Dry Halophytic Meadow and Moist Herb Meadow.

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

In 2018, birds in the Willow Project area experienced the coldest spring in 2 decades. Persistent snow and lake ice probably delayed access to suitable nesting sites for many birds. However, the slow thaw had the positive effect of reduced flooding of nesting areas. We used data from 3 weather stations (Colville Village, Alpine, and Nuiqsut) that span the local CPAI oilfields north to south, observing that the mean daily temperature during the breeding season increases  $\sim 2$  °C southward between weather stations. Although the Alpine and Nuiqsut weather stations might better reflect the weather conditions for the Willow Project area, neither has as long and a complete record of weather data as does Colville Village.

The cold spring followed a record warm winter. The cumulative freezing degree-days (FDD) over the winter of 2017/2018 (6,703 FDD) was the lowest in 20 years of records at Colville Village (Helmericks' homesite), and the fifth consecutive winter with a below average FDD ( $7,725 \pm 153$  FDD, [mean  $\pm$  standard error;  $n = 20$  years]; <http://www.weather.gov/aprfc/FreezingDegreeDays>). Between 15 May and 15 June, when most birds arrive on local nesting grounds annually, only 5.3 cumulative thawing degree-days (TDD) were measured at Nuiqsut in 2018, well below the 19-year mean of  $65 \pm 2$  cumulative TDD. Mean temperatures in Nuiqsut in May 2018 ( $-5.7$  °C) and June 2018 ( $1.8$  °C) were colder than the long-term mean temperatures ( $-4.8 \pm 0.6$  °C,  $n = 18$  years, and  $5.5 \pm 0.5$  °C,  $n = 17$  years, respectively). Mean daily temperatures in June exceeded freezing 9 days earlier at Nuiqsut than at Colville Village.

Low temperatures during spring allowed snow to persist a record length of time in 2018. Snow depth on 15 May was 23 cm at Colville Village, equivalent to the long-term mean ( $23 \pm 2$  cm,  $n = 22$  years). Measureable snow

persisted until 18 June at Colville Village, the latest date in 22 years. Typically, sites south of Colville Village melt out a few days earlier. Alpine reported no measureable snow cover on 7 June. In the Willow Project area, the hydrology crew reported  $\sim 60\%$  snow cover at Judy Creek and the Tiñmiaqsiuġvik bridge on 8–9 June 2018 (Michael Baker International 2018a, b).

Spring floods in 2018 were unremarkable in the Fish Creek basin, the largest drainage in the Willow and GMTC area, as snow melt gradually entered streams over a 3-week period, 4–23 June (Michael Baker International 2018a, b). Water remained in channels resulting in little flooding. Water levels at river mile 13.8 on Judy Creek peaked on 6 June at 37.1 ft BPMSL, higher than the peak stage in 2017. Fish Creek peaked on 23 June after smaller streams and swales peaked a few days earlier (Michael Baker International 2018b). During the loon nest survey, only a few loon lakes near Fish Creek had visible evidence of receiving sediment-loaded flood waters. The nearby Colville River provides a historical perspective on timing and magnitude of breakup because it has been monitored since 1992. In 2018, peak stage water level (15.9 ft) at the head of the Colville River delta (Monument 1 gauge) was below average and occurred on 2 June, later than average. Peak discharge (331,000 cfs) was near average, however (Michael Baker International 2018c).

Open water on Yellow-billed Loon breeding lakes became available later in 2018 than in the previous 4 years. Ice coverage on 20 large lakes ( $>5$  ha) on the Colville delta (estimated visually during nesting surveys for loons on 21–25 June) was more extensive in 2018 (93%) than in the preceding 4 years (range 50–85%).

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

In summary, the timing of the 2018 nesting season was likely delayed for most species. Male



Spectacled Eiders were still present on the nesting grounds in the third week of June, indicating a late nesting season for that species. During other studies in the region, we observed no sign of hatch on the Colville delta and near CD-5 during 19–26 June. Late hatch extends brood rearing later into the year, when snow and ice can reduce fledging success (Cox et al. 2017). Despite the late spring, length of the snow-free period in 2018 (119 d) was near average for Colville Village ( $121 \pm 3$  d,  $n = 22$ ). Below-average to average breeding conditions were reported for most waterfowl in northern Alaska in 2018 (USFWS 2018).

## 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 was listed as “threatened” in 1993 (58 FR 27474–27480) under the Endangered Species Act of 1973, as amended. The nearby Colville River delta is a concentration area for breeding Spectacled Eiders relative to surrounding areas; nonetheless, Spectacled Eiders nest there 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. 2003b; Johnson et al. 2004, 2005, 2018b). 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 Utqiagvik (Barrow). 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 2018, which was consistent with results of previous surveys in this portion of the NE NPR-A (Johnson et al. 2015, 2018c). During the 2018 pre-nesting survey, which sampled 50% of the Willow eider survey area, we recorded only 14 Spectacled Eiders (on the ground and flying) and 10 indicated total Spectacled Eiders (on the ground) (Figure 3, Table 3). Extrapolating to the entire Willow eider survey area produces estimates of 28 observed total and 20 indicated total Spectacled Eiders. Indicated total is a standardized method of counting ducks, which does not count the females, rather it doubles the number of males in singles, pairs, and small groups (no flying birds are included) to compensate for the lower detectability of females (USFWS 1987). In 2018, Spectacled Eiders occurred at the fourth lowest density recorded during 17 years of surveys (Table 3).

Densities of Spectacled Eiders recorded during ABR’s surveys in the NE NPR-A have been consistently low (mean =  $0.03 \pm 0.005$  indicated birds/km<sup>2</sup>; Table 3) since we began surveys in 1999, roughly 25% of the density recorded on the Colville River delta (Johnson et al. 2018a). The distribution of Spectacled Eiders in 2018 was typical of previous years, when densities were highest on the northern Colville River delta (CD North area) and lowest at inland portions of NPR-A, where the Willow eider survey area is located (Figure 4).

Over the 25 years that ABR and others have monitored Spectacled Eiders along the central Beaufort Sea coast, their population trend has been relatively stable (Figure 5). In the NE NPR-A, the annual trend declined at  $-2\%$  ( $\ln(\text{adults}) = -0.024$  (year)  $- 51.54$ ,  $R^2 = 0.03$ ,  $P = 0.54$ ,  $n = 17$  years). The annual growth rate for the adjacent Colville Delta study area was a positive  $2\%$  ( $\ln(\text{adults}) = 0.019$  (year)  $- 34.96$ ,  $R^2 = 0.08$ ,  $P = 0.17$ ,  $n = 25$  years; Johnson et al. *in prep.*). Similar to the trend recorded during surveys by ABR in the NE NPR-A, a slightly negative growth rate ( $-2\%$ ) was estimated from the North Slope eider surveys conducted for Spectacled Eiders across the entire ACP (logarithmic growth rate =  $0.98$ ,  $n = 26$  years; Wilson et al. 2018). However, none of the above growth rates differs significantly from equilibrium (a logarithmic growth rate of 1.0 equals 0% annual

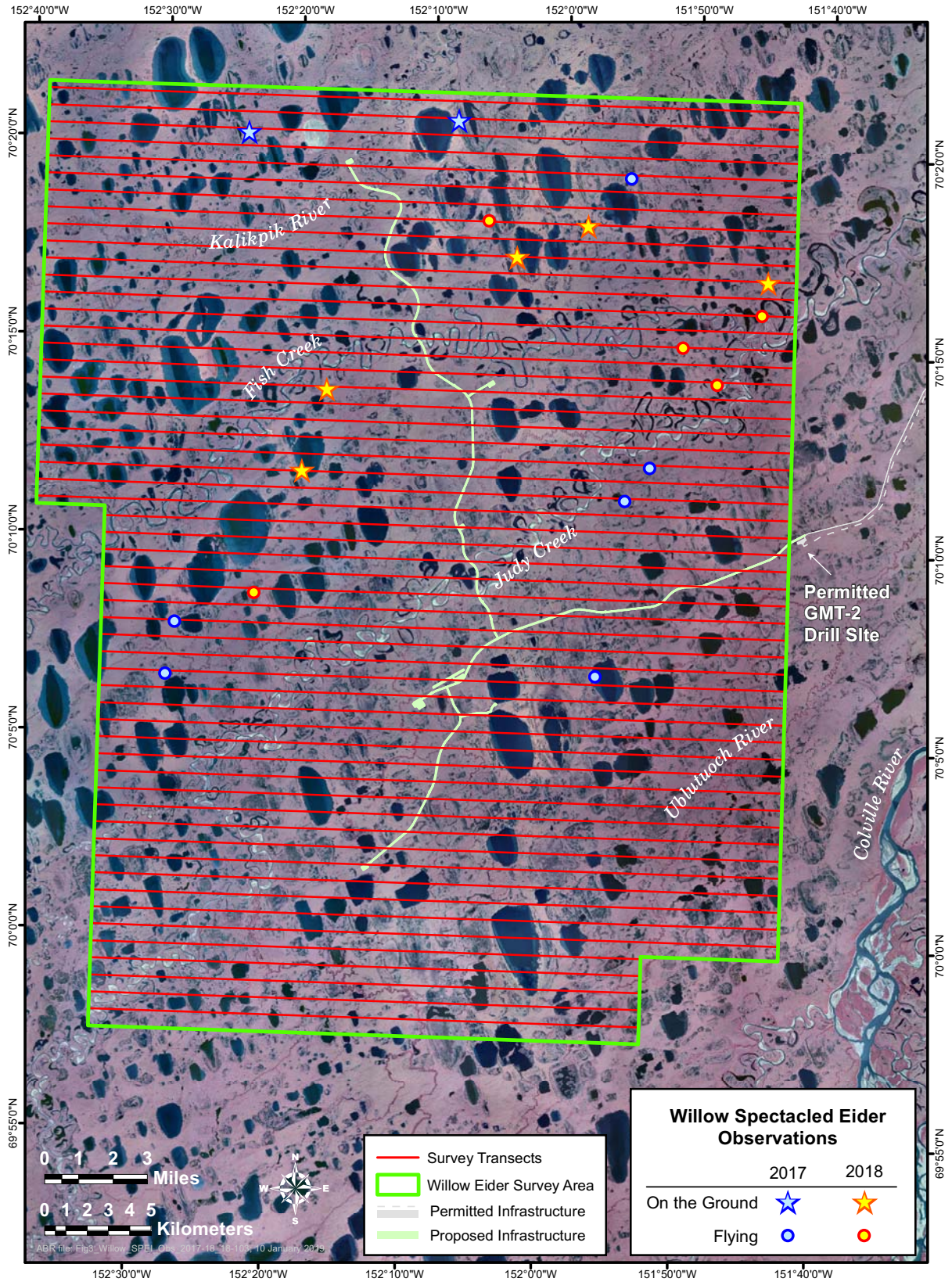


Figure 3. Spectacled Eider locations (flying and non-flying) during pre-nesting, Willow eider survey area, NE NPR-A, 2017 and 2018.

Table 3. Annual number and density (birds/km<sup>2</sup>) of eiders during pre-nesting aerial surveys in the NE NPR-A in 1999–2006, 2008–2014, 2017, and 2018. The Willow eider survey area was surveyed in 2017 and 2018.

Year	Area Surveyed (km <sup>2</sup> )	Spectacled Eider				King Eider			
		Total <sup>a</sup>		Density <sup>b</sup>		Total <sup>a</sup>		Density <sup>b</sup>	
		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
Mean	502.6	–	–	0.034	0.032	–	–	0.446	0.366
SE	57.6	–	–	0.005	0.005	–	–	0.041	0.042

<sup>a</sup> 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  $n = 17$  years.

<sup>b</sup> Numbers not corrected for sightability. Density (birds/km<sup>2</sup>) based on 100% coverage of area in 1999 and 2000 and 50% coverage in all other years. Mean and SE calculated for  $n = 17$  years.

change, or equilibrium), which suggests the population is stable to slightly decreasing.

#### Habitat Use

The Willow eider study area was 1,468 km<sup>2</sup>, of which 842 km<sup>2</sup> (57%) has been mapped for wildlife habitats. Survey coverage was approximately 50% (733 km<sup>2</sup>) and of this 437 km<sup>2</sup> was in the mapped area. Pre-nesting Spectacled Eiders used 15 of 26 available habitats in the NE NPR-A study area over 17 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 also received the greatest use with 18% of the Spectacled Eider locations. Brackish Water, Deep Open Water with Islands or Polygonized

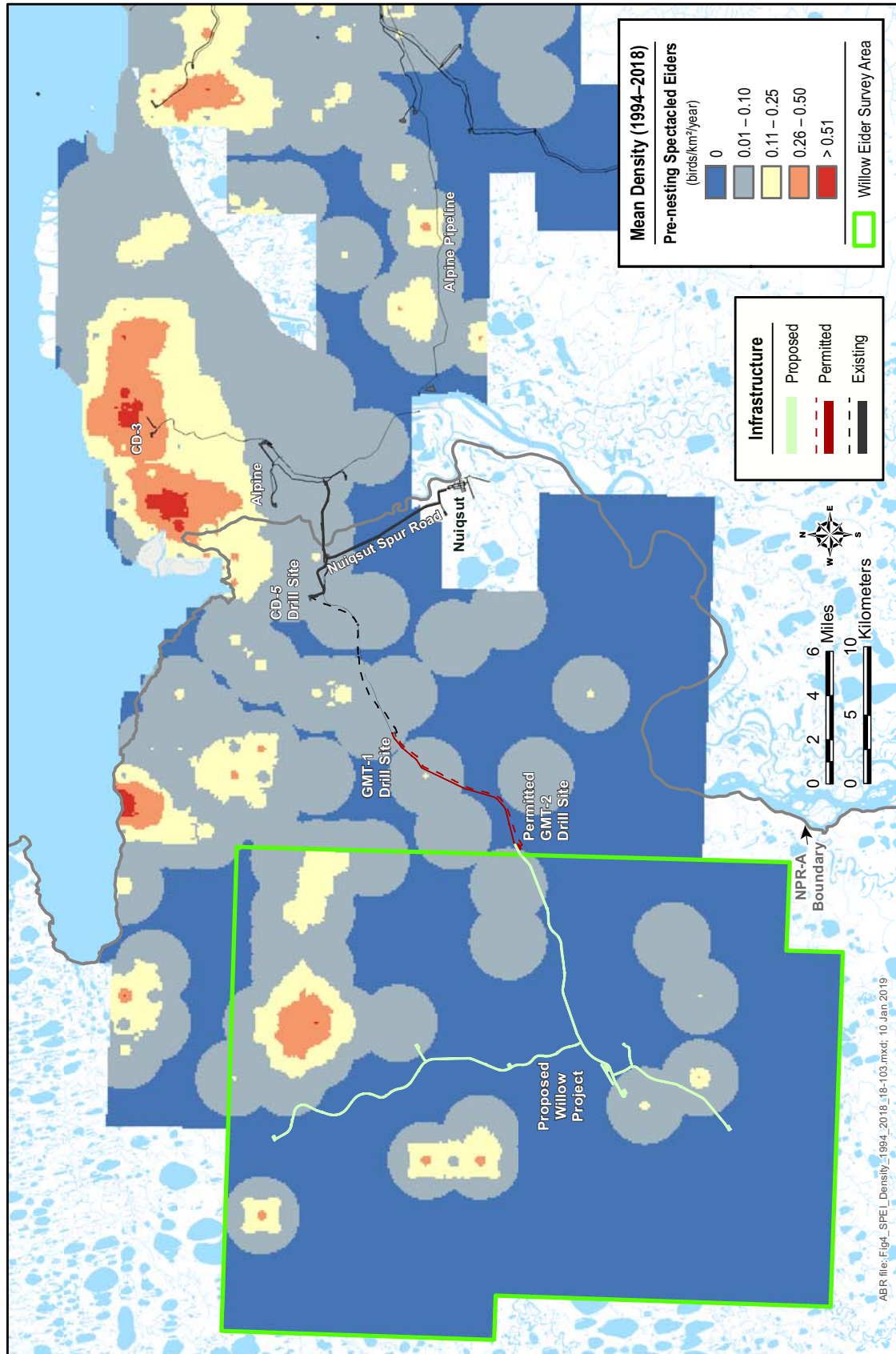


Figure 4. Density distribution of pre-nesting Spectacled Eiders in the Willow eider survey area, NE NPR-A, and the Colville River delta, 1993–2018.

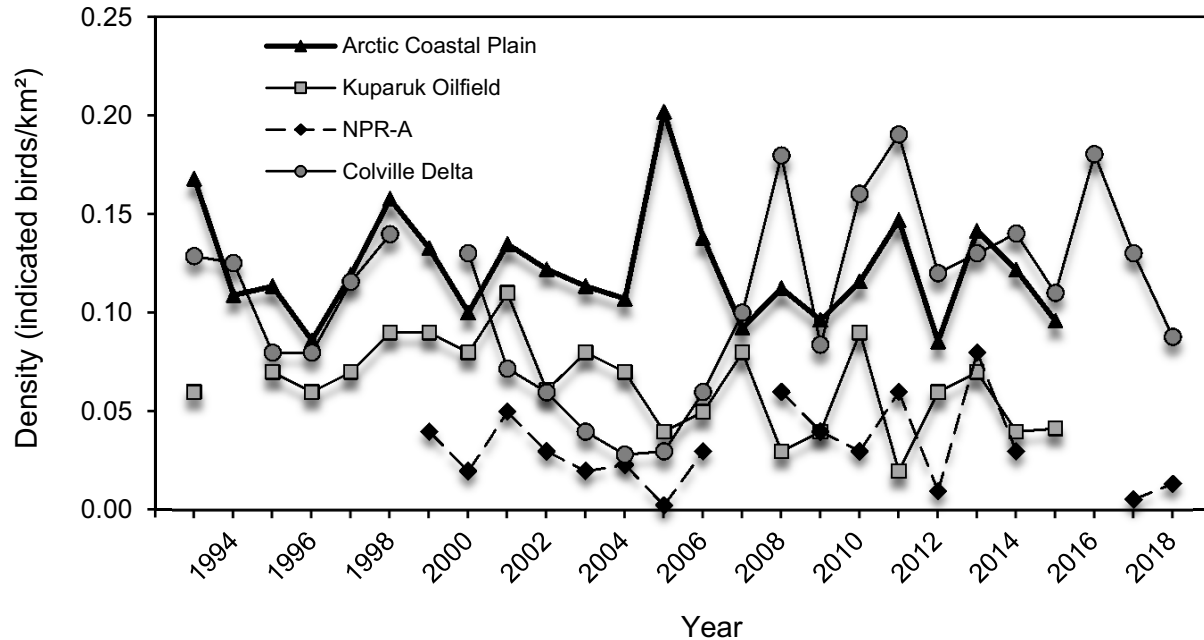


Figure 5. Annual densities of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2018.

Margins, Shallow Open Water with Islands or Polygonized Margins, Shallow Open Water without Islands, and Patterned Wet Meadow each received  $\geq 10\%$  of use by 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 12 of the 16 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 were also the most abundant habitats (19% and 29% 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 2018, we recorded 247 observed (on the ground and flying) and 168 indicated total King Eiders during the pre-nesting aerial survey that sampled 50% of the Willow eider survey area (Figure 6, Table 3). Extrapolating to the entire

survey area, we estimate 594 observed total and 326 indicated total King Eiders. The distribution of King Eiders in 2018 was somewhat 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 7). The indicated density of King Eiders in 2018 (0.23 indicated birds/km<sup>2</sup>) was below the long-term mean of  $0.37 \pm 0.042$  indicated birds/km<sup>2</sup>; Figure 8, Table 3). In contrast, the adjacent Colville Delta study area had its highest indicated density in 2018 (Figure 8) with the highest densities on the East Channel where flocks 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 the 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

Table 4. Habitat selection by Spectacled and King eider groups during pre-nesting in the NE NPR-A in 1999–2006, 2008–2014, 2017, and 2018. Willow was surveyed in 2018.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%) <sup>a</sup>	Availability (%)	Monte Carlo Results <sup>b</sup>	Sample Size <sup>c</sup>
<b>SPECTACLED EIDER</b>						
Open Nearshore Water	2	1	1.7	0.3	ns	low
Brackish Water	14	7	11.7	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	<0.1	ns	low
Salt Marsh	4	2	3.3	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	3.3	8.0	ns	low
Deep Open Water with Islands or Polygonized	15	8	13.3	4.9	prefer	low
Shallow Open Water without Islands	12	7	11.7	1.2	prefer	low
Shallow Open Water with Islands or Polygonized	16	6	10.0	1.4	prefer	low
River or Stream	1	1	1.7	0.9	ns	low
Sedge Marsh	1	1	1.7	2.2	ns	low
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	5	3	5.0	0.4	prefer	low
Young Basin Wetland Complex	0	0	0.0	0.3	ns	low
Old Basin Wetland Complex	20	11	18.3	8.0	prefer	low
Riverine Complex	0	0	0	0.4	ns	low
Dune Complex	2	1	1.7	0.9	ns	low
Nonpatterned Wet Meadow	4	2	3.3	3.9	ns	low
Patterned Wet Meadow	16	7	11.7	12.2	ns	
Moist Sedge-Shrub Meadow	1	1	1.7	19.2	avoid	
Moist Tussock Tundra	0	0	0	28.7	avoid	
Tall, Low, or Dwarf Shrub	0	0	0	4.7	ns	low
Barrens	0	0	0	1.1	ns	low
Human Modified	0	0	0	<0.1	ns	low
Total	117	60	100	100		
<b>KING EIDER</b>						
Open Nearshore Water	4	2	0.3	0.3	ns	low
Brackish Water	18	10	1.5	0.3	prefer	low
Tapped Lake with Low-water Connection	34	10	1.5	0.2	prefer	low
Tapped Lake with High-water Connection	0	0	0.0	<0.1	ns	low
Salt Marsh	44	20	3.0	0.7	prefer	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	257	82	12.2	8.0	prefer	
Deep Open Water with Islands or Polygonized	200	75	11.1	4.9	prefer	
Shallow Open Water without Islands	119	64	9.5	1.2	prefer	

Table 4. Continued.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%) <sup>a</sup>	Availability (%)	Monte Carlo Results <sup>b</sup>	Sample Size <sup>c</sup>
Shallow Open Water with Islands or Polygonized River or Stream	249 32	98 14	14.5 2.1	1.4 0.9	prefer prefer	
Sedge Marsh	86	44	6.5	2.2	prefer	
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	31	10	1.5	0.4	prefer	low
Young Basin Wetland Complex	0	0	0	0.3	ns	low
Old Basin Wetland Complex	239	120	17.8	8.0	prefer	
Riverine Complex	9	4	0.6	0.4	ns	low
Dune Complex	0	0	0	0.9	avoid	
Nonpatterned Wet Meadow	50	30	4.5	3.9	ns	
Patterned Wet Meadow	111	61	9.1	12.2	avoid	
Moist Sedge-Shrub Meadow	41	19	2.8	19.2	avoid	
Moist Tussock Tundra	12	7	1.0	28.7	avoid	
Tall, Low, or Dwarf Shrub	6	4	0.6	4.7	avoid	
Barrens	0	0	0	1.1	avoid	
Human Modified	0	0	0	<0.1	ns	low
Total	1,542	674	100	100		

<sup>a</sup> Use = (groups / total groups) × 100.

<sup>b</sup> Significance calculated from 1,000 simulations at  $\alpha = 05$ ; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

<sup>c</sup> Low = expected value < 5.

(Wilson et al. 2018). Although we have a shorter period over which to measure trend, King Eiders recorded on ABR's surveys in NE NPR-A have increased at a non-significant rate of 4% annually since surveys began in 1999 ( $\ln(\text{adults}) = 0.04$  (year) – 70.7,  $R^2 = 0.17$ ,  $P = 0.10$ ,  $n = 17$  years).

No Steller's or Common eiders were seen in the Willow eider survey area in 2018. 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. 2018b). No records of breeding have been reported in the Willow eider survey area. Common Eiders are 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 17 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 (18%) 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. King Eiders avoided 6 habitats, including the 2 most abundant habitats: Moist Sedge-Shrub Meadow (19% available) and Moist Tussock Tundra (29% available). All other habitats were used in proportion to their availability or had low sample sizes precluding a determination of preference or avoidance.

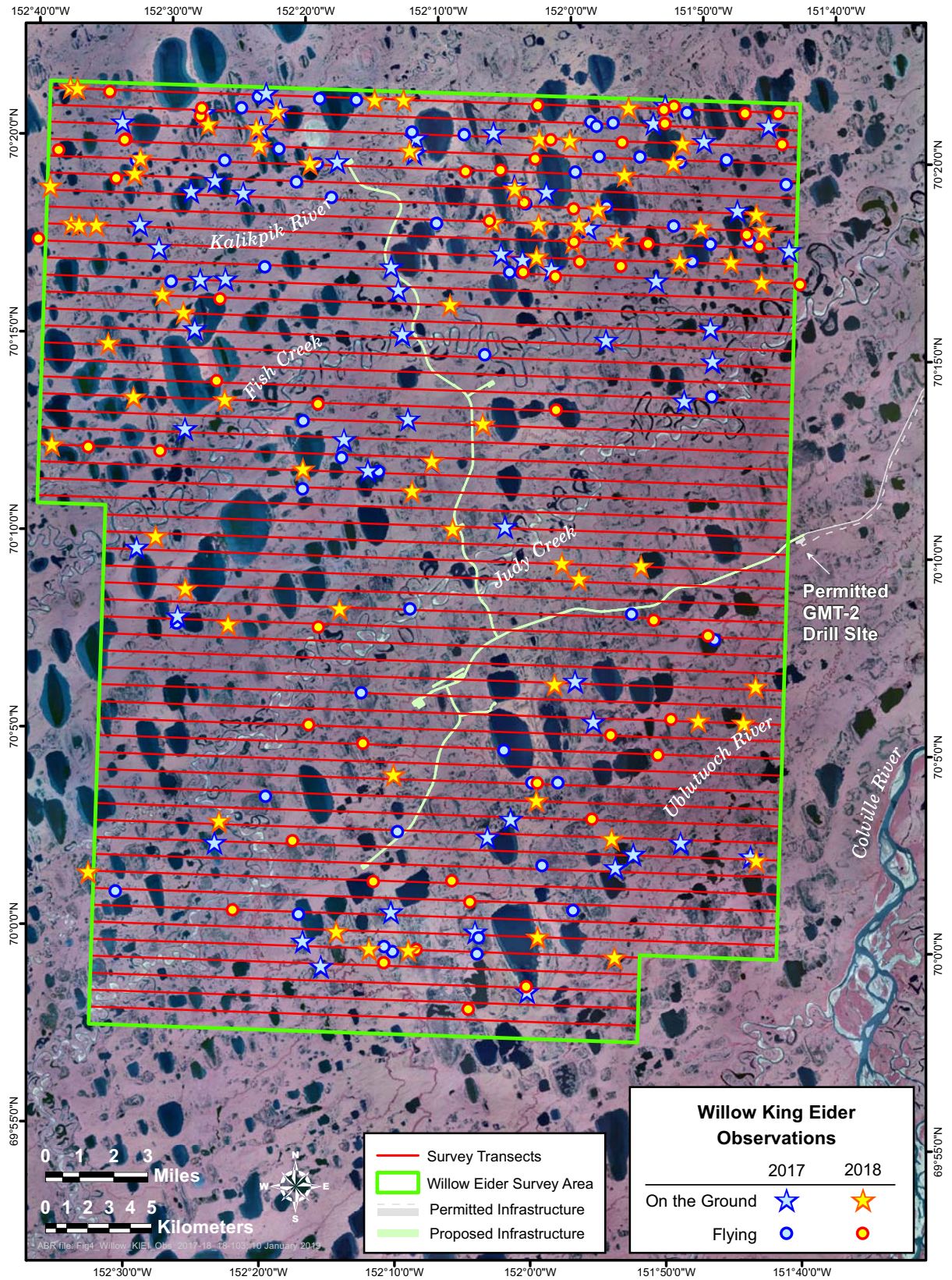


Figure 6. King Eider locations during pre-nesting (flying and non-flying), Willow eider survey area, NE NPR-A, 2017 and 2018.



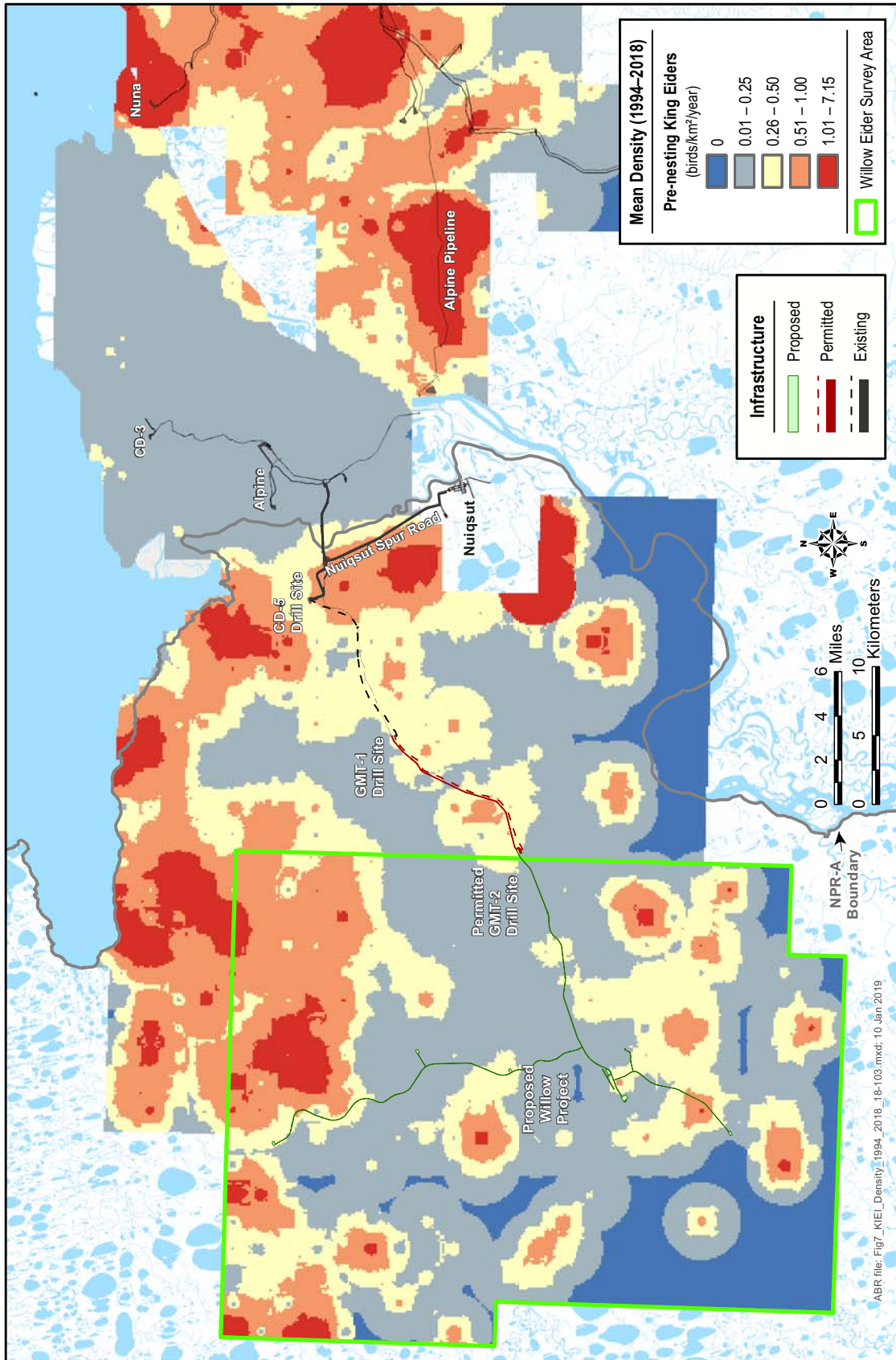


Figure 7. Density distribution of pre-nesting King Eiders in the Willow eider survey area, NE NPR-A, and the Colville River delta, 1993–2018.

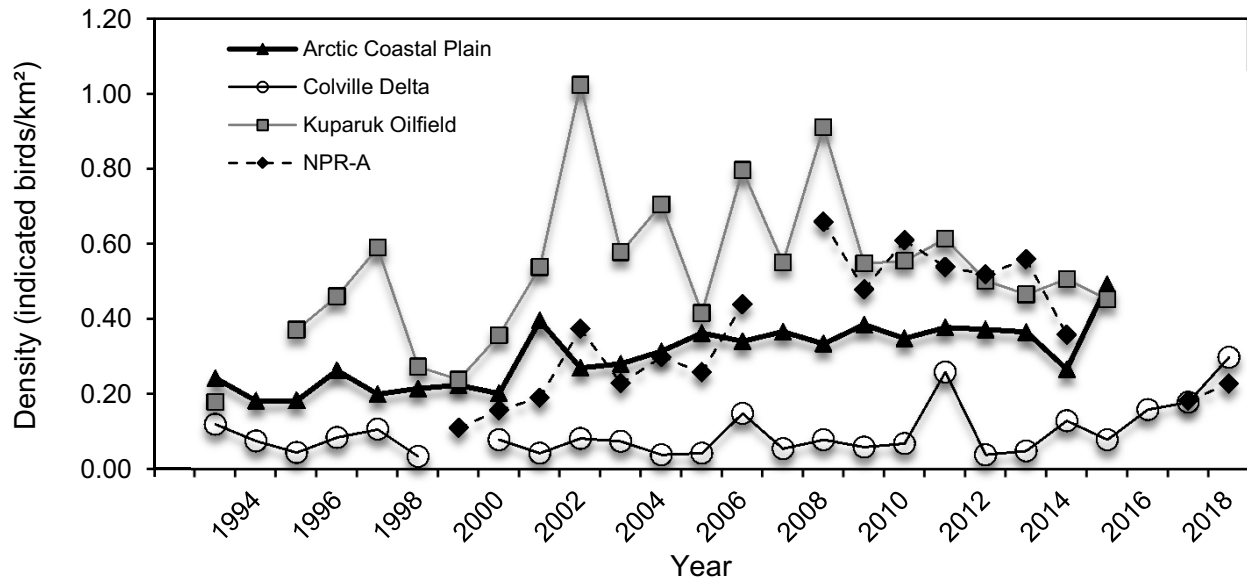


Figure 8. Annual densities of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2018.

## YELLOW-BILLED LOON

### DISTRIBUTION AND ABUNDANCE

#### GMTC Loon Survey Area

Only 3 Yellow-billed Loon nests were found in the GMTC loon survey area during the nesting survey in 2018 (Figure 9, Table 5), fewer nests than were found in 2014 and 2017, the only other years when the entire GMTC loon survey area was surveyed. The count of 24 adults in 2018, however, was the highest of all 3 years (for densities, see Appendix A), indicating that adults were occupying territories but not nesting in high numbers. Incidental records of Pacific and Red-throated loon nests and broods are presented in Appendices B and C.

Survey coverage and effort has varied across the NE NPR-A area since surveys were initiated in 2001. In years when surveys were conducted, annual survey coverage varied from 13 to 51 territories. Because of the annual variation in study area size and survey effort, we did not calculate mean numbers of adults and nests. Although standardized nesting and brood-rearing surveys have been conducted annually, weekly surveys for nests and broods were conducted during 2008–2014 only. Those additional surveys resulted

in higher total nest counts compared to years with a single nesting survey. To adjust for variable coverage and survey effort among years, we used territory occupancy by nests, calculated as the number of nests found only on the nesting survey divided by the number of territories surveyed. Of the 11 territories surveyed during 2018 in the GMTC loon survey area, 27% were occupied by a nest during the nesting survey, which is about half the 13-year mean occupancy calculated for previous ABR surveys in NE NPR-A ( $57.1 \pm 2.4\%$ ; Table 5).

The low nest occupancy in 2018 may have been partly due to the late ice melt on large lakes. Cold spring temperatures delayed formation of moats in lakes compared with previous years. Delayed moat formation can delay or even preclude nesting by preventing access to lakes (North 1986, Johnson et al. 2011, Johnson et al. 2013). Visual estimates of ice cover on large lakes indicated that open water became available later in 2018 compared to previous years. During pre-nesting eider surveys, observers noted that on 18 June, many large lakes were still frozen nearly to their shorelines, especially in northern portions of the Willow loon and eider survey areas. As a result, Yellow-billed Loons likely initiated nests

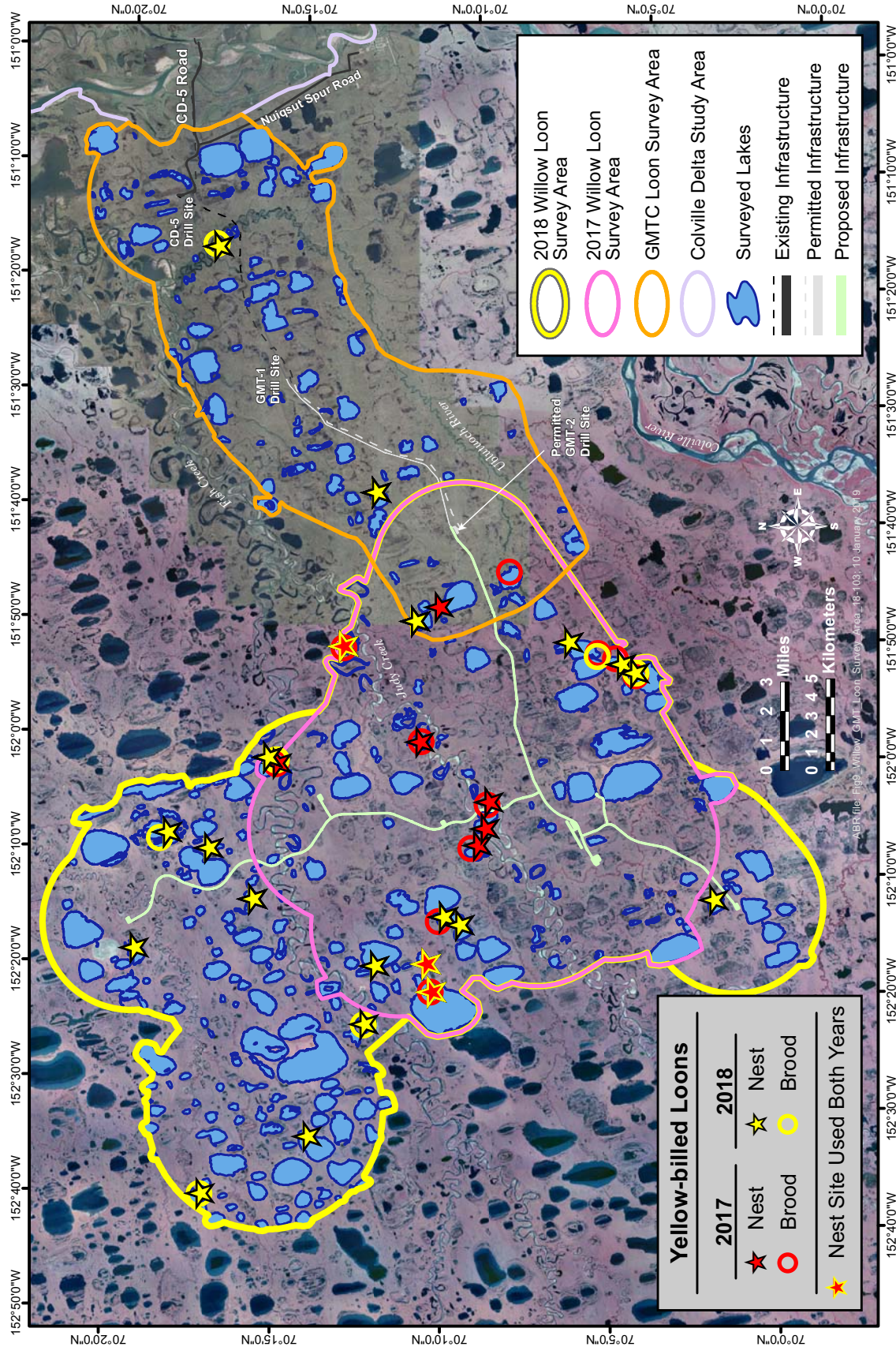


Figure 9. Yellow-billed Loon nest and brood locations, Willow and GMTC loon survey areas, NE NPR-A, 2017 and 2018.

Table 5. Number of Yellow-billed Loons, nests, and territory occupancy by nests in the GMTC, Willow, and other NE NPR-A survey areas in 2001–2006, 2008–2014, 2017, and 2018.

SURVEY AREA	Nesting Survey <sup>a</sup>		All Surveys <sup>b</sup>	No. Territories Surveyed	Nest Occupancy (%) <sup>c</sup>
	Year	No. Adults	No. Nests		
GMTC <sup>d</sup>					
2014	20	8	9 <sup>e</sup>	11	73
2017	11	5	8 <sup>f</sup>	11	45
2018	24	3	3	11	27
Willow <sup>d</sup>					
2017	38	9	14 <sup>f</sup>	18	— <sup>g</sup>
2018	67	19	19	31 <sup>h</sup>	— <sup>g</sup>
NE NPR-A					
2001	44	19	23 <sup>i</sup>	36	53
2002	65	27	27	43	63
2003	53	26	28 <sup>f,i</sup>	42	62
2004	60	23	24 <sup>i</sup>	41	56
2005	24	8	8	13	62
2006	24	8	8	13	62
2008	82	23	29 <sup>e</sup>	51	45
2009	65	27	29 <sup>e</sup>	51	53
2010	75	29	36 <sup>e</sup>	51	57
2011	32	8	13 <sup>e</sup>	21	38
2012	36	15	18 <sup>e</sup>	21	71
2013	39	12	14 <sup>e</sup>	21	57
2014 <sup>j</sup>	47	18	20 <sup>e</sup>	28	64
Mean <sup>k</sup>					57.1
SE					2.4

<sup>a</sup> Nesting survey is limited to a single survey conducted between 19 June and 1 July.

<sup>b</sup> 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.

<sup>c</sup> Calculated as the number of nests found during the nesting survey divided by the number of territories surveyed. Excludes 1 re-nesting in 2003 in the NE NPR-A area.

<sup>d</sup> GMTC and Willow loon survey areas overlap: 3 adults and 1 nest seen during the nesting survey were present at the 3 territories that are within both areas.

<sup>e</sup> Includes nest(s) found during revisit (1996–2002), monitoring (2008–2014), and early nesting (2011, 2012, and 2014) surveys.

<sup>f</sup> Includes nest(s) inferred by the presence of a brood observed on a territory lake during ground or aerial surveys.

<sup>g</sup> Nest occupancy not calculated because the total number of territories in the Willow loon survey area is not known due to lack of historical data.

<sup>h</sup> Twelve territories were identified during surveys in previous years, 8 were first discovered during nesting in 2017 and 8 more were discovered during nesting in 2018. Three territories were identified using the Yellow-billed Loon Geodatabase (USFW 2013).

<sup>i</sup> Includes nest(s) found during ground surveys.

<sup>j</sup> Totals includes observations in the GMTC loon survey area.

<sup>k</sup> Mean numbers of adults and nests not calculated because survey area differed among years.

later than is typical for the area (median start date of incubation = 17 June, range 9–23 June,  $n = 45$  nests over 5 years). Nest surveys began on 22 June and 25 June in the GMTC and Willow loon survey areas, respectively. Opportunistic observations at nests where Yellow-billed Loons were not incubating showed that 6 nests contained only 1 egg (loons lay 2 eggs) as late as 24 June. Those observations suggest nest initiation was still occurring as surveys began and it is possible that some Yellow-billed Loons initiated nests after the survey.

During the brood-rearing survey, 23 Yellow-billed Loons, 1 brood, and 1 young were observed in the GMTC loon survey area (Figure 9, Table 6). As with nests, the total number of broods (1) was well below the numbers observed in 2014 and 2017. The count of 23 adults seen during the brood-rearing survey in 2018 was nearly identical to the number seen during June (for densities, see Appendix A) and higher than the number of adults seen during the brood-rearing surveys in 2014 and 2017.

Similar to occupancy by nests, we used territory occupancy by broods to compare reproductive output among years. Occupancy by broods 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 (see Nest Fate, below) allow us to infer broods at nests where chicks did not survive until the brood-rearing survey. Thus, the total number of broods can be estimated even in the absence of weekly surveys. In the GMTC loon survey area in 2018, only 1 of the 11 (9%) surveyed territories was occupied by a brood, which is well below the long-term mean calculated for other survey areas in NE NPR-A ( $28.1 \pm 3.8\%$ ).

Since surveys began in the NE NPR-A, we have identified 11 Yellow-billed Loon territories composed of 16 lakes in the GMTC loon survey area (Appendix D). No additional territories were detected during 2018 surveys. Three of the 11 territories were occupied by breeding Yellow-billed Loons in 2018.

#### Willow Loon Survey Area

In the Willow loon survey area, 19 Yellow-billed Loon nests and 67 adults were found during the nesting survey in 2018 (Figure 9, Table 5). During the brood-rearing survey in 2018, 89 Yellow-billed Loons and 3 broods comprising 4 young were observed in the Willow loon survey area (Figure 9, Table 6). We inferred 3 additional broods based on eggshell fragments at nests. Incidental records of Pacific and Red-throated loon nests and broods are presented in Appendices B and C.

Forty-five percent of the 282 lakes surveyed during both the nesting and brood-rearing surveys in the Willow loon survey area had been surveyed in previous years. Lakes along parts of Fish and Judy creeks were first surveyed during 2001. Since then, we have identified 28 Yellow-billed Loon territories composed of 32 lakes in the Willow loon survey area. One of those territories was identified only by the presence of a brood during an August survey; however, the Bureau of Land Management (BLM) previously identified a nest site at that lake (BLM, unpublished data). Three additional territories on 3 lakes were identified through the Yellow-billed Loon Geodatabase (USFWS 2013). Using all available data, 31 territories composed of 35 lakes have been identified in the Willow loon survey area (Appendix D). Nineteen of those 31 territories were occupied by breeding Yellow-billed Loons in 2018.

Nine nest sites at 6 territories recorded over multiple years are <1 mile from the proposed Willow project infrastructure (Appendix D). Most of those nest sites (6) are from 3 territories adjacent to the road where it crosses Judy Creek. Four territories have lake shorelines that are <500 m from proposed infrastructure, 2 of which are associated with the proposed Judy Creek road crossing. The 2 other shorelines are from a territory north of the proposed BT-5 Pad and a territory south of the proposed road as it departs the GMT-2 pad.

#### HABITAT USE

The Willow loon survey area was 851 km<sup>2</sup>, 80% (685 km<sup>2</sup>) of which has been mapped for wildlife habitats. Yellow-billed Loons nested in 14 of 26 available habitats during nesting surveys

Table 6. Number of Yellow-billed Loons, broods, and territory occupancy by broods in the GMTC, Willow, and other NE NPR-A survey areas in 2001–2006, 2008–2014, 2017, and 2018.

SURVEY AREA Year	Brood-rearing Survey <sup>a</sup>			All Surveys <sup>b</sup>	No. Territories Surveyed	Brood Occupancy (%) <sup>c</sup>
	No. Adults	No. Young	No. Broods	No. Broods		
GMTC <sup>d</sup>						
2014	16	5	5	5	11	45
2017	21	4	4	5 <sup>e</sup>	11	45
2018	23	1	1	1	11	9
Willow <sup>d</sup>						
2017	39	9	8	11 <sup>e</sup>	19	– <sup>f</sup>
2018	89	4	3	6	31 <sup>g</sup>	– <sup>f</sup>
NE NPR-A						
2001	47	5	5	7 <sup>h</sup>	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 <sup>e,i</sup>	50	38
2009	86	17	12	15 <sup>e</sup>	51	29
2010	70	18	15	16 <sup>e</sup>	49	33
2011	31	5	4	4	21	19
2012	42	14	12	12	21	57
2013	21	0	0	1 <sup>i</sup>	21	5
2014 <sup>j</sup>	29	9	9	11 <sup>e</sup>	28	39
Mean <sup>k</sup>						28.1
SE						3.8

<sup>a</sup> Brood-rearing surveys were conducted between 15 and 27 August.

<sup>b</sup> Includes all broods found on brood-rearing survey and any additional broods found during other types of surveys as footnoted.

<sup>c</sup> Calculated as the number of broods from all surveys divided by the number of territories surveyed.

<sup>d</sup> Willow and GMTC loon survey areas overlap: 4 adults seen during the brood-rearing survey were present at the 3 territories that are within both survey areas.

<sup>e</sup> Includes broods from territories where no brood was seen but presence of a brood was determined from eggshell evidence.

<sup>f</sup> Brood occupancy not calculated because the total number of territories in Willow loon survey area is not known due to lack of historical data.

<sup>g</sup> Twelve territories were identified during surveys in previous years, 8 were first discovered during nesting in 2017 and 8 more were discovered during nesting in 2018. Three territories were identified using the Yellow-billed Loon Geodatabase (USFW 2013).

<sup>h</sup> Includes brood(s) found during ground surveys.

<sup>i</sup> Includes brood(s) found during monitoring surveys.

<sup>j</sup> Totals include observations in the GMTC loon survey area..

<sup>k</sup> Mean numbers not calculated because survey area differed among years.

conducted over 10 years in various ABR survey areas in NE NPR-A (excluding the Fish Creek Delta subarea; Table 7). Six habitats, supporting 152 of 206 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 (146 nests), shorelines (42), peninsulas (10), 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 or adjacent to (<190 m from) a deep lake. Yellow-billed Loons avoided nesting in 4 habitats, which together comprised 60% of the available habitat.

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, Moist Sedge-Shrub Meadow, and Patterned Wet Meadow). However, Patterned Wet Meadow and Moist Sedge-Shrub Meadow together supported ~15% 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 84 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%

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 62 territories in ABR's various survey areas in NE-NPRA (excluding the Fish Creek Delta subarea). Fifty-four territories are comprised of a single lake used for both nesting and brood-rearing, 7 territories are comprised of 2 adjacent lakes, and 1 is comprised of 3 adjacent lakes. Lakes used by breeding Yellow-billed Loons averaged  $77.1 \pm 12.7$  ha in size (range 0.4–694.6 ha,  $n = 66$  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

In total, 21 nests were recorded in the GMTC and Willow loon survey areas. During the brood-rearing survey, 4 of 21 Yellow-billed Loon nests had a brood. Because the absence of a brood does not always indicate nest failure, all 17 nests without broods were visited on the ground to determine nest fate. Three of the 17 nests contained  $\geq 20$  egg fragments (range 40–51 fragments), indicating that at least 1 egg hatched in those nests. Fourteen nests contained  $< 20$  egg fragments (range 0–7 fragments), indicating nest failure. Overall, we determined that 7 of 21 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. 2018a, c). Nests that are missed during the single nesting survey can only be

Table 7. Habitat selection by nesting and brood-rearing Yellow-billed Loons, NE NPR-A, 2001–2004, 2008–2010, 2014, 2017, and 2018. The GMTC and Willow loon survey areas were surveyed in 2017 and 2018.

SEASON Habitat	No. of Nests or Broods	Use (%) <sup>a</sup>	Availability (%)	Monte Carlo Results <sup>b</sup>	Sample Size <sup>c</sup>
<b>NESTING</b>					
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	0.3	ns	low
Tapped Lake with High-water Connection	2	1	<0.1	prefer	low
Salt Marsh	0	0	0.4	ns	low
Tidal Flat Barrens	0	0	0.8	ns	low
Salt-killed Tundra	0	0	<0.1	ns	low
Deep Open Water without Islands	12	5.8	7.8	ns	
Deep Open Water with Islands or Polygonized Margins	84	40.6	5.5	prefer	
Shallow Open Water without Islands	1	0.5	1.1	ns	low
Shallow Open Water with Islands or Polygonized Margins	11	5.3	1.4	prefer	low
River or Stream	0	0	1.1	ns	low
Sedge Marsh	25	12.1	2.0	prefer	low
Deep Polygon Complex	1	0.5	<0.1	ns	low
Grass Marsh	11	5.3	0.4	prefer	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	2	1.0	7.4	avoid	
Riverine Complex	0	0	0.4	ns	low
Dune Complex	5	2.4	1.1	ns	low
Nonpatterned Wet Meadow	20	9.7	3.7	prefer	
Patterned Wet Meadow	16	7.7	12.3	avoid	
Moist Sedge-Shrub Meadow	15	7.2	19.3	avoid	
Moist Tussock Tundra	2	1.0	27.8	avoid	
Tall, Low, or Dwarf Shrub Barrens	0	0	5.1	avoid	
Human Modified	0	0	1.2	ns	low
Total	207	100	100	ns	low
<b>BROOD-REARING</b>					
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	0.3	ns	low
Tapped Lake with High-water Connection	1	1.2	<0.1	ns	low
Salt Marsh	0	0	0.4	ns	low
Tidal Flat Barrens	0	0	0.8	ns	low
Salt-killed Tundra	0	0	<0.1	ns	low
Deep Open Water without Islands	14	16.7	7.8	prefer	
Deep Open Water with Islands or Polygonized Margins	68	81.0	5.5	prefer	low
Shallow Open Water without Islands	0	0	1.1	ns	low



Table 7. Continued.

SEASON Habitat	No. of Nests or Broods	Use (%) <sup>a</sup>	Availability (%)	Monte Carlo Results <sup>b</sup>	Sample Size <sup>c</sup>
Shallow Open Water with Islands or Polygonized					
Margins	1	1.2	1.4	ns	low
River or Stream	0	0	1.1	ns	low
Sedge Marsh	0	0	2.0	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	7.4	avoid	
Riverine Complex	0	0	0.4	ns	low
Dune Complex	0	0	1.1	ns	low
Nonpatterned Wet Meadow	0	0	3.7	ns	low
Patterned Wet Meadow	0	0	12.3	avoid	
Moist Sedge-Shrub Meadow	0	0	19.3	avoid	
Moist Tussock Tundra	0	0	27.8	avoid	
Tall, Low, or Dwarf Shrub	0	0	5.1	avoid	low
Barrens	0	0	1.2	ns	low
Human Modified	0	0	<0.1	ns	low
Total	84	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.

<sup>a</sup> % use = (nests / total nests) × 100 or (broods / total broods) × 100.

<sup>b</sup> 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.

<sup>c</sup> Low = expected number <5.

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 2017 and 2018, 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 single nest surveys and hatching determined from nest fate data and the presence of broods, 7 of the 21 nests found during the nesting survey hatched in 2018 for an apparent nesting success of 33%. This estimate was well below the 9-year mean ( $47.6 \pm 7.4\%$ ) and was the second

lowest 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. Although 7 nests hatched based on nest fate data, only 4 of 21 pairs (19.0%) were observed with young during the brood survey in 2018. Similar to apparent nesting success, the proportion with young during August also is well below the 9-year mean ( $36.4 \pm 6.2\%$ ). On average,  $10 \pm 3.8\%$  (range 0–30.8%) of the broods present at hatch (as indicated by nest fate data) do not survive until the brood survey. Although few pairs were observed with young during the brood survey in 2018, the proportion of broods lost was near average, indicating that low nest survival likely was the biggest contributor to the low productivity observed in 2018.

## GULLS

### DISTRIBUTION AND ABUNDANCE

#### GMTC Loon Survey Area

During 2018, we recorded 35 Glaucous Gull nests on the aerial survey for nesting loons in the GMTC loon survey area (Figure 10). Three colonies in the GMTC loon survey area accounted for 47% of nests found in 2018; all other nests were individual locations. In 2018, we added a new colony named GMT-2 East, which expanded from a single nest in 2014 to 3 nests in 2018 (Table 8). The GMT-1 West colony, located ~3.8 km southwest of the GMT-1 drill site, contained 10 nests in 2018, and the CD-5 East colony, 1.3 km northeast of the CD-5 drill site, contained 3 nests in 2018. Not included in our totals were 9 nests from the CD-5 South colony that lies just south of the survey area (Table 8).

The number of Glaucous Gull nests in the GMTC loon survey area have ranged from 34 to 38 nests, during the 3 years that similar survey methods were employed (Table 8). Nest counts in 2002–2004 (range: 42–51 nests) were collected during aerial surveys for Tundra Swans and loons and during ground-based nest searches, which included a larger area than was covered by the last 3 years of loon surveys.

We did not calculate gull nesting density in 2014, 2017, and 2018, because the loon aerial surveys did not include all potential gull nesting lakes in the survey area. As an example, Shallow Open Water <5 ha in area is not included in the lakes surveyed for loons, but is commonly used as a nesting habitat by gulls. Survey coverage during 2002–2004 included all habitats, resulting in a mean of 0.14 nests/km<sup>2</sup> for the GMTC loon survey area ( $n = 3$  years; 331.1 km<sup>2</sup>), which was almost twice the density of nests in ABR's larger survey area in the NE NPR-A (0.08 nests/km<sup>2</sup>; 1,091.6 km<sup>2</sup> survey area) and the adjacent Colville Delta study area (0.09 nests/km<sup>2</sup>; 363.5 km<sup>2</sup> survey area) (Burgess et al. 2003a, 2003b; Johnson et al., 2005).

Eleven Glaucous Gulls broods were recorded on 11 waterbodies during the survey for brood-rearing loons in 2018 (Figure 10). Brood-rearing gulls included 25 adults and 36 young. In contrast only 9 Glaucous Gull young were observed in 2017

(Johnson et al. 2018c). Typical timing of the loon brood surveys occurs close to when young gulls fledge. In 2018 the plumage on some of the young gulls indicated that fledging period might have been slightly delayed compared to past years, and we may have seen a larger number of young before they became flight capable and moved out of their nesting lakes.

No Sabine's Gull nests were recorded during aerial surveys in the GMTC loon survey area in 2017 or 2018. Sabine's Gulls do use the area: nests were recorded by other studies in the area during 2002–2004 and 2014 (Johnson et al. 2015).

#### Willow Loon Survey Area

Forty-five Glaucous Gull nests were counted at 38 locations on the aerial survey for nesting loons in the Willow loon survey area in 2018 (Figure 10, Table 9). There were 3 small colonies of 3–4 nests, 1 located just north of BT-5, 1 located 15 km west of BT-2, and 1 located in the northwest corner of the loon survey area. Within the area surveyed for Willow in 2017 (the smaller area for the 2 years), the number of active Glaucous Gull nests increased from 12 in 2017 to 21 in 2018. We did not see the same trend in the GMTC loon survey area.

Seven groups of nesting Sabine's Gulls were recorded in the Willow loon survey area during the aerial survey for nesting loons. Group size at nesting sites ranged from 4 to 30 adults (Figure 10). The 3 colonies observed in 2018 were also active in 2017. We detect colonies more readily than single nests during aerial surveys, which probably results in an underestimate of the 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 and colonies were found in 11 different habitats in the GMTC and Willow loon survey areas in 2018 (Table 10). The 3 most commonly used habitats were Shallow Open Water with Islands or Polygonized Margins (35% of all nests), Grass Marsh (13% of all nests), and Deep Open Water with Islands or Polygonized Margins (21% of nests). Colonies were found in Shallow Open Water with Islands or Polygonized Margins, Sedge Marsh, and Grass Marsh. The remaining

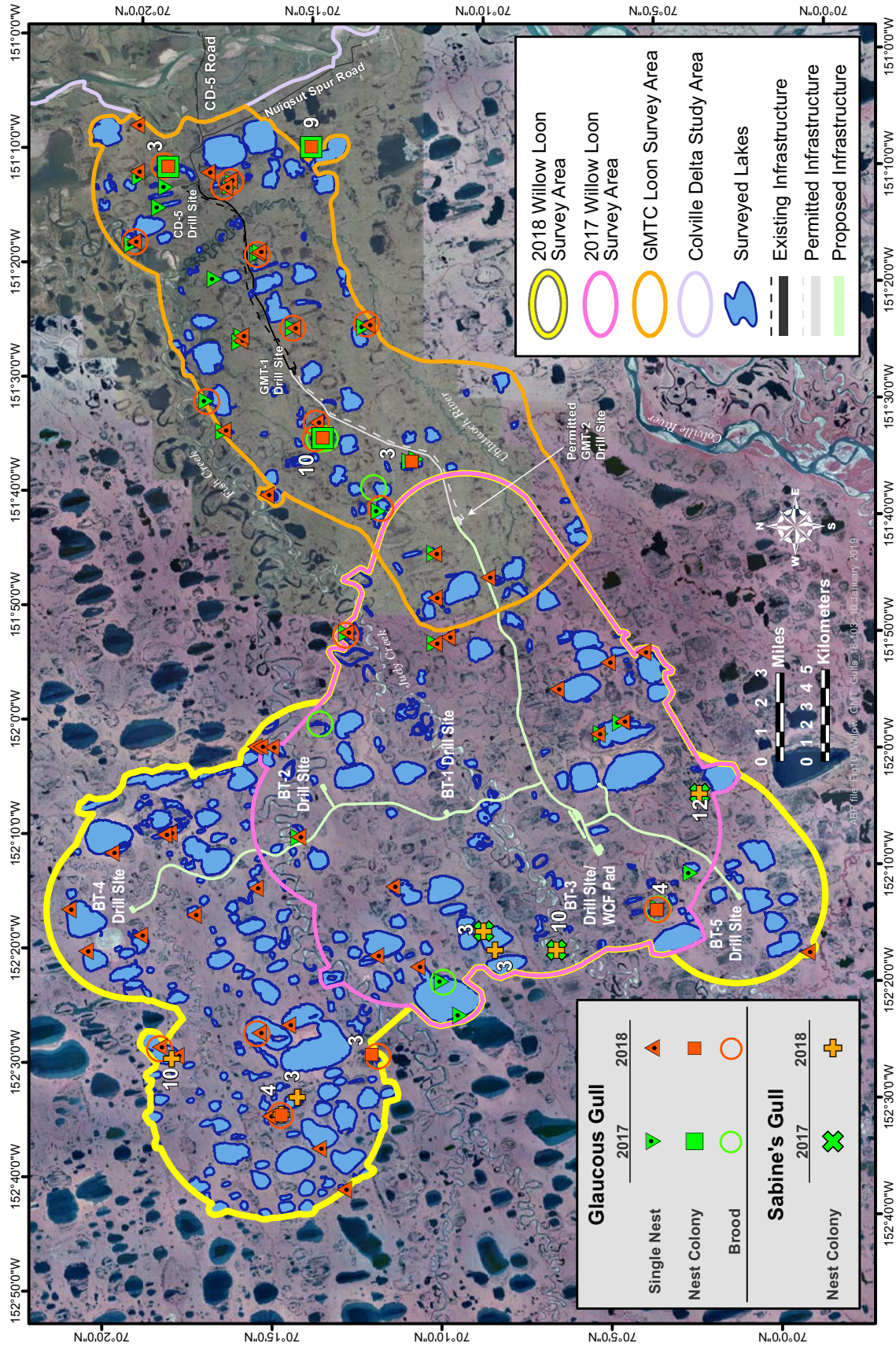


Figure 10. Glaucous Gull and Sabine's Gull nest and brood locations, Willow and GMTC loon survey areas, NE NPR-A, 2017 and 2018.

Table 8. Number of Glaucous Gull nests recorded during aerial surveys for nesting loons in the GMTC loon survey area, NE NPR-A, 2002–2004, 2014, 2017, and 2018.

Method Year	Total Nests	GMT-2 East Colony Nests	GMT-1 West Colony Nests	CD-5 East Colony Nests	CD-5 South Colony Nests <sup>a</sup>	Brood Groups	Total Young
Loon Surveys							
2014 <sup>b</sup>	33	1	9	3	9	11	25
2017 <sup>c</sup>	38	2	10	8	12	4	9
2018 <sup>d</sup>	35	3	10	3	9	11	36
Combined Loon, Swan, and Ground-based Surveys							
2002	42		6	3	4	–	–
2003	51		7	4	7	–	–
2004	42		6	3	6	–	–

<sup>a</sup> Colony CD-5 South lies outside the GMTC loon survey area and is not included in Total Nests counts.

<sup>b</sup> Included in the total is 1 Glaucous Gull nest found by ground nest searcher (Johnson et al. 2015).

<sup>c</sup> GMTC and Willow loon survey areas overlapped in 2017: 1 nest, 1 brood, and 2 young are included in both the Willow and GMTC totals.

<sup>d</sup> GMTC and Willow loon survey areas overlapped in 2018: 3 nests included in both the Willow and GMTC totals.

Table 9. Number of Glaucous Gull nests recorded during aerial surveys for nesting loons in the Willow loon survey area, NE NPR–A, 2017 and 2018.

Year <sup>a</sup>	Total Nests	BT-5 North Colony Nests	BT-2 West Colony Nests	Northwest Colony Nests	Brood Groups	Total Young
2017 <sup>b</sup>	11	2	–	–	4	9
2018 <sup>c</sup>	45	4	3	4	11	36

<sup>a</sup> The 2017 survey area (502 km<sup>2</sup>) is included in the larger 2018 survey area (851 km<sup>2</sup>).

<sup>b</sup> GMTC and Willow loon survey areas overlapped in 2017: 1 nest, 1 brood, and 2 young are included in both the Willow and GMTC totals.

<sup>c</sup> GMTC and Willow loon survey areas overlapped in 2018: 3 nests included in both the Willow and GMTC totals.

Table 10. Habitat use by nesting Glaucous Gulls recorded during aerial surveys for nesting loons in the GMTC and Willow loon survey areas, NE NPR-A, 2014, 2017, and 2018.

Habitat	2014		2017		2018	
	Nests	Use (%)	Nests	Use (%)	Nests	Use (%)
Tapped Lake with High-water Connection	–	0	1	3.2	1	1.6
Deep Open Water without Islands			1	3.2	–	–
Deep Open Water with Islands or Polygonized Margins	6	17.1	5	16.1	13	20.6
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
Sedge Marsh	2	5.7	4	9.8	6	9.5
Grass Marsh	1	2.9	6	19.3	8	12.7
Young Basin Wetland Complex	1	2.9	–	–	–	–
Old Basin Wetland Complex	3	8.5	1	3.2	1	1.6
Riverine Complex	–	–	–	–	1	1.6
Nonpatterned Wet Meadow	–	–	–	–	4	4.8
Patterned Wet Meadow	–	–	–	–	2	3.2
Moist Sedge-Shrub Meadow	1	2.9	–	–	2	3.2
Subtotal of Nests in Mapped Habitat	35	100	47	100	63	100
Subtotal of Nests in Unmapped Habitat	0		2		14	
Total	35		49		77	

nesting Glaucous Gulls in 2017 and 2014, respectively (Table 10). Sabine Gulls nested in Sedge Marsh and Grass Marsh.

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Appendix A. Annual density (number/km<sup>2</sup>) of Yellow-billed Loons, nests, and broods in the GMTC, Willow, and other NE NPR-A survey areas in 2001–2006, 2008–2014, 2017, and 2018.

SURVEY AREA Year	Nesting Survey Adults	Nests <sup>a</sup>	Brood-rearing Survey Adults	Broods <sup>b</sup>
GMTC <sup>c,d</sup>				
2014	0.06	0.02 (0.03)	0.04	0.01 (0.01)
2017	0.03	0.01 (0.02)	0.05	0.01 (0.01)
2018	0.07	0.01 (0.01)	0.07	
Willow <sup>d,e</sup>				
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)
NE NPR-A <sup>f,g</sup>				
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 <sup>h</sup>	0.09	0.03 (0.04)	0.06	0.02 (0.02)

<sup>a</sup> 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.

<sup>b</sup> 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, 2018) that did not survive to the time of the brood-rearing survey.

<sup>c</sup> GMTC loon survey area = 351.8 km<sup>2</sup>.

<sup>d</sup> GMTC and Willow loon survey areas overlap.

<sup>e</sup> Willow loon survey area was 502.3 km<sup>2</sup> in 2017 and 851.2 km<sup>2</sup> in 2018.

<sup>f</sup> Survey area included 5 subareas: Development (617.8 km<sup>2</sup>) surveyed in 2001–2004, Exploration (260.4 km<sup>2</sup>) in 2002–2004, Alpine West (79.7 km<sup>2</sup>) in 2002–2006 and 2008–2013, Fish Creek Delta (130.5 km<sup>2</sup>) in 2005–2006 and 2008–2013, and the Fish and Judy Creek Corridor (255.9 km<sup>2</sup>) in 2008–2010. In 2011–2013, the eastern one-quarter of the Fish and Judy Creek Corridor subarea (41.0 km<sup>2</sup>) was surveyed. In 2014, area surveyed was 525.2.

<sup>g</sup> Mean densities not calculated for NE NPR-A because the study area differed among years.

<sup>h</sup> Totals include observations in the GMTC loon survey area.



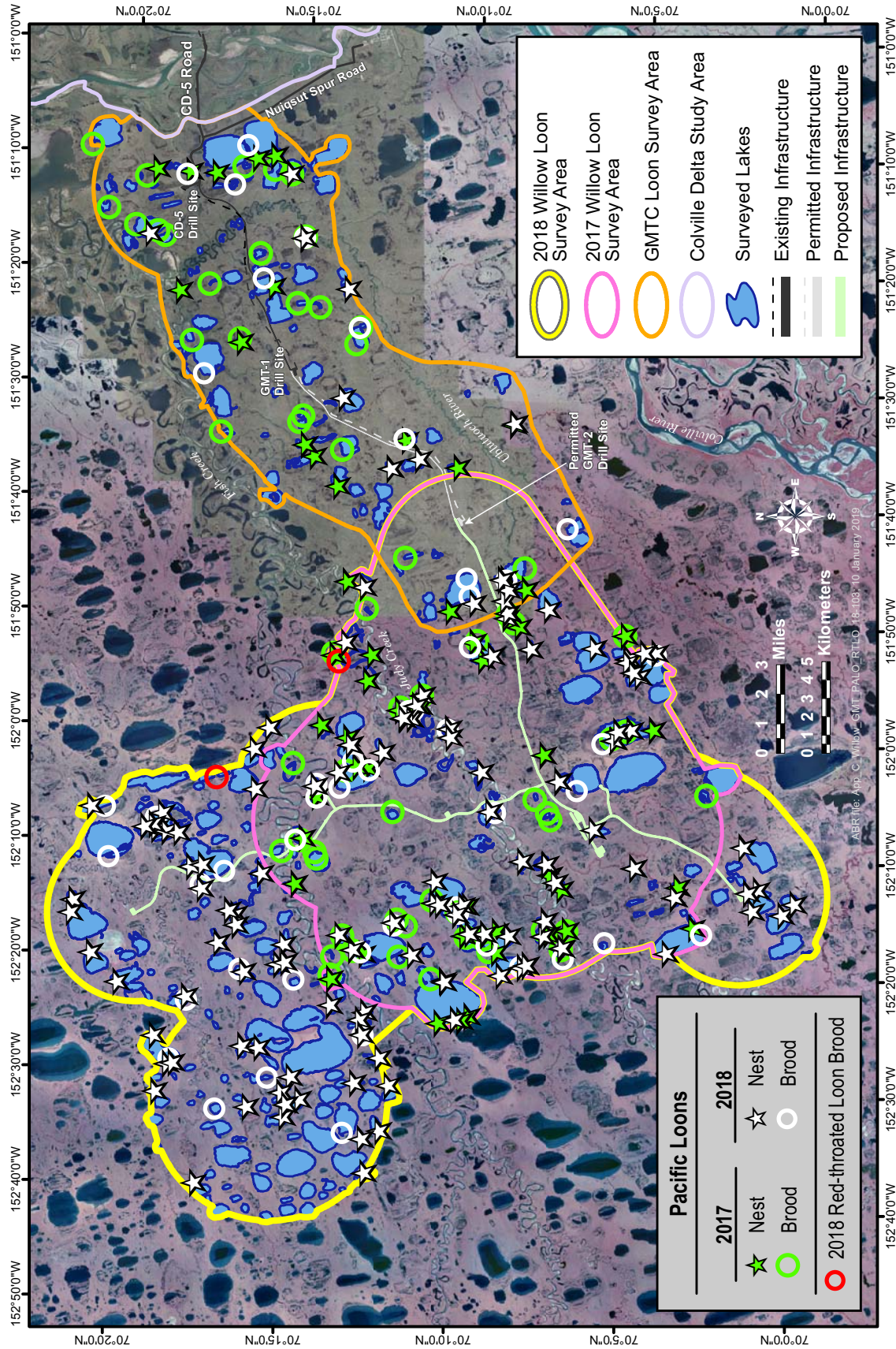
Appendix B. Number of Pacific and Red-throated loons and their nests, broods, and young during aerial surveys, GMTC and Willow loon survey areas, NE NPR-A, 2017 and 2018.

SPECIES Observation Type	Survey Area <sup>a</sup>			
	GMTC		Willow	
	Nesting	Brood-rearing	Nesting	Brood-rearing
<b>PACIFIC LOON<sup>b,c</sup></b>				
Adults				
2017	210	242	251	295
2018	241	198	670	753
Nests/Broods				
2017	19	25	50	39
2018	12	12	117	39
Young				
2017	–	30	–	48
2018	–	15	–	44
<b>RED-THROATED LOON<sup>b,c</sup></b>				
Adults				
2017	10	2	1	0
2018	4	2	1	3
Nests/Broods				
2017	0	0	0	0
2018	0	0	0	2
Young				
2017	–	0	–	0
2018	–	0	–	3

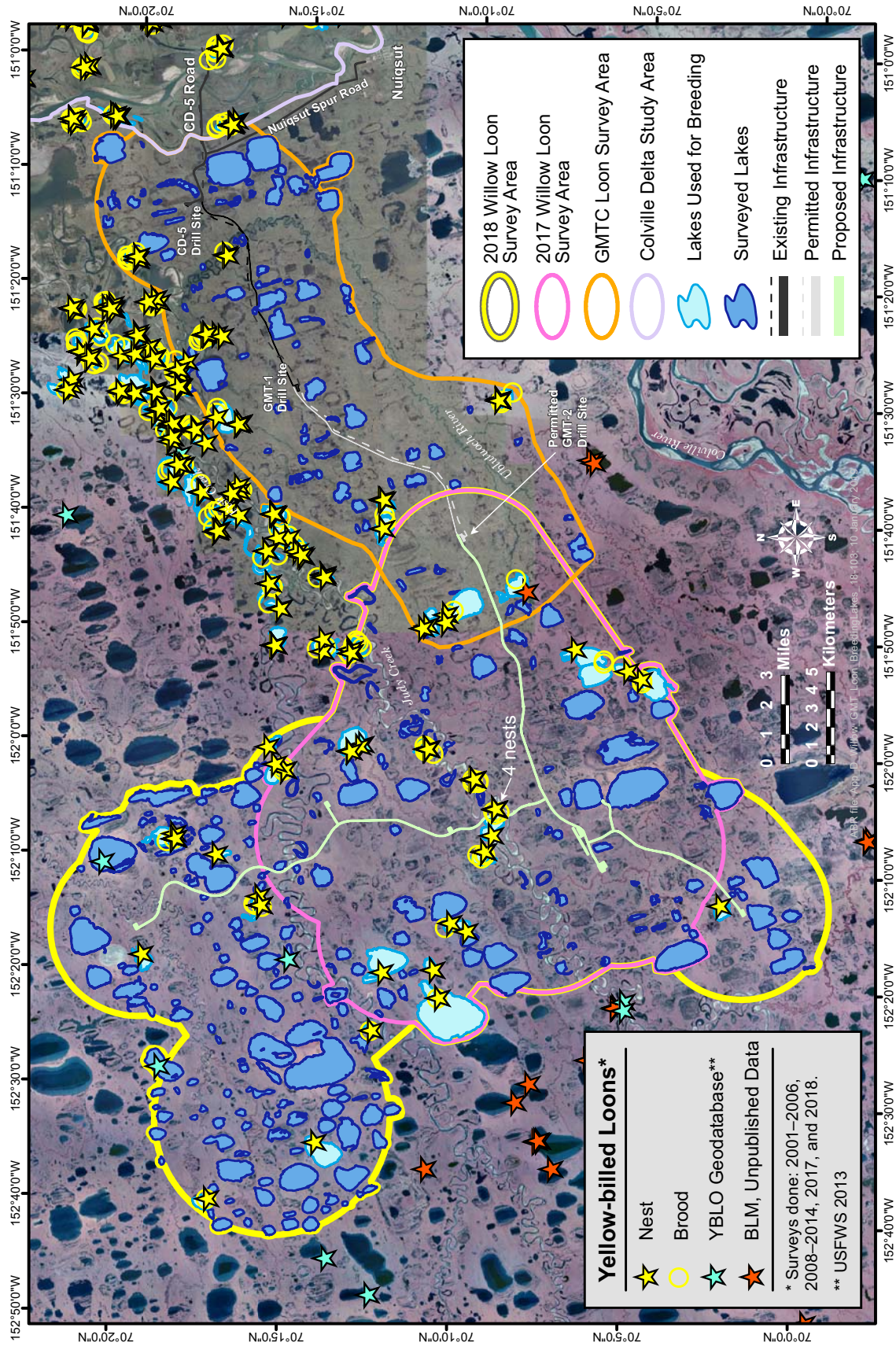
<sup>a</sup> GMTC loon survey area = 351.8 km<sup>2</sup> during both years; Willow loon survey area = 502.3 km<sup>2</sup> in 2017 and 851.2 km<sup>2</sup> in 2018; see Figure 7.

<sup>b</sup> The GMTC and Willow survey areas overlap; for Pacific Loons, 20 adults and 3 nests and 28 adults, 2 broods, and 3 young were in the area of overlap during June and August 2017, respectively; 18 adults and 4 nests and 31 adults, 3 broods, and 3 young were in the area of overlap during June and August 2018, respectively. No Red-throated Loons were seen in the area of overlap.

<sup>c</sup> Densities of Pacific and Red-throated loons were not calculated because surveys did not include smaller lakes (<5 ha) where those species commonly nest.



Appendix C. Pacific Loon nests and broods during aerial surveys, Willow and GMTC loon survey areas, NE NPR-A, 2017 and 2018.



Appendix D. Lakes used by nesting and brood-rearing Yellow-billed Loons, Willow and GMTC loon survey areas, NE NPR-A, 2001–2006, 2008–2014, 2017, and 2018.