AVIAN STUDIES IN THE WILLOW PROJECT AREA, 2020

Julie P. Parrett
John E. Shook

Prepared for

CONOCOPHILLIPS ALASKA, INC.
Anchorage, Alaska

Prepared by

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

COVER
A Yellow-billed Loon on a nest at the edge of the peninsula. Photograph by ABR.

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ConocoPhillips Alaska, Inc.
P.O. Box 100360
Anchorage, AK 99510

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Julie P. Parrett
John E. Shook

ABR, Inc.—Environmental Research & Services
P.O. Box 80410
Fairbanks, AK 99708

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EXECUTIVE SUMMARY

- We used a helicopter to survey 301 lakes in the Willow Project area for nesting and brood-rearing Yellow-billed Loons. Glaucous and Sabine's gulls and Pacific and Red-throated loons were recorded incidentally.
- We completed the 3 years of prenesting Spectacled Eider surveys required by the Bureau of Land Management in areas associated with the Willow Project in 2019; therefore, Spectacled Eider surveys were not included in the Willow Avian studies in 2020.
- During the nesting survey in June, we searched for Yellow-billed Loon adults and nests whereas during the brood-rearing survey in August we searched for adults and young. Nests were also visited on the ground during the brood-rearing survey to verify nest fate.
- No Yellow-billed Loons were seen in lakes near the Tiŋmiaqsiuġvik Material Site.
- In the Willow loon survey area, we found 91 Yellow-billed Loon adults and 35 nests. During the brood-rearing survey, we saw a record-high number of broods (20) and chicks (28).
- Apparent nest success for Yellow-billed Loons during 2020 was 69%, which was well above the mean in the Willow loon survey area (55.5 ± 10%, n = 4 years). Abundant nests, high hatching success, and a large proportion of pairs fledging 2 chicks all contributed to a record-high fledging rate (0.77 chicks/nest) in 2020, which was well above the mean (mean = 0.53 ± 0.14 chicks/nest, n = 4 years).
- Yellow-billed Loons preferred 7 of 26 wildlife habitats for nesting. These habitats contained islands, complex shorelines with low relief, and lake margins with aquatic habitats that thaw by early June. Brood-rearing loons preferred only 2 habitats, both of which were characterized by deep lakes.
- In lakes near the Tiŋmiaqsiuġvik Material Site, we recorded 25 Pacific Loon adults and 9 nests during the nesting survey and 33 adults, 5 broods, and 7 chicks during the brood-rearing survey. In the Willow loon survey area, we recorded 705 Pacific Loon adults and 157 nests during the nesting survey and 612 adults, 83 broods, and 101 chicks during the brood-rearing survey.
- No Red-throated Loons were seen near the Tiŋmiaqsiuġvik Material Site. In the Willow loon survey area, we recorded 4 adults and 1 nest. No Red-throated Loons were seen during the brood-rearing survey. Red-throated Loon use small, shallow lakes for breeding. These lakes are not a focus of Yellow-billed Loon surveys because, unless near a large, deep lake, Yellow-billed Loons do not use such small lakes for breeding.
- In the Tiŋmiaqsiuġvik Material Site survey area, 2 Glaucous Gull nests and 1 chick were observed on the 11 lakes surveyed during the aerial nesting and brood-rearing surveys for loons in 2020.
- In the Willow loon survey area, 50 Glaucous Gull nests were recorded on 40 waterbodies and 38 chicks were recorded on 22 waterbodies during the aerial surveys for nesting and brood-rearing loons in 2020.

TABLE OF CONTENTS

Executive Summary iii
List of Figures v
List of Tables vi
List of Appendices vi
Acknowledgments vii
Introduction 1
Study Area 1
Methods 3
  Loon Surveys 3
    Distribution and Abundance 3
    Nest Fate 5
    Density Maps 5
  Gull Surveys 5
  Habitat Mapping and Analysis 5
  Data Management 10
Results 10
  Seasonal Conditions in the Project Area 10
  Yellow-billed Loon 10
    Distribution and Abundance 10
    Nest Fate 16
    Density Maps 18
    Habitat Use 18
  Gulls 24
    Distribution and Abundance 24
    Habitat Use 26
Discussion 26
Literature Cited 29

LIST OF FIGURES

Figure 1. Wildlife survey areas for the Willow Project area, NE NPR-A, 2020 2
Figure 2. Wildlife habitats in the NE NPR-A area, 2020 7
Figure 3. Mean daily temperature at CD-5 for spring and summer 2020 with mean for 2011–2020 and snow depth at Alpine, Colville River delta and NE NPR-A, Alaska 11
Figure 4. Cumulative number of thawing degree-days and means recorded for 15–31 May and 1–15 June at Alpine, Colville River delta, Alaska, 2011–2020 12
Figure 5. Yellow-billed Loon nest and brood locations, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2020 13
Figure 6. Yellow-billed Loon nest locations and mean annual densities observed during a single June nesting survey in the Willow loon and Tiŋmiaqsiuġvik Material Site loon survey areas, Colville Delta, and Kuparuk study areas, Alaska, 1993, 1995–1998, 2000–2020 20

Figure 7. Yellow-billed Loon brood locations and mean annual densities observed during a single August brood-rearing survey in the Willow loon and Tiŋmiaqsiuġvik Material Site loon survey areas, Colville Delta, and Kuparuk study areas, Alaska, 1993, 1995–1998, 2000–2020 21
Figure 8. Glaucous and Sabine's gull nest locations and Glaucous Gull brood locations, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2020 25

LIST OF TABLES

Table 1. Avian surveys conducted in the Willow Project area, NE NPR-A, 2020 3
Table 2. Habitat availability in the Willow loon survey area, Willow Project area, NE NPR-A, 2020 9
Table 3. Numbers of Yellow-billed Loons and nests, and nest occupancy in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017–2020 14
Table 4. Numbers of Yellow-billed Loons, chicks, and broods, and brood occupancy in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017–2020 15
Table 5. Number of Yellow-billed Loon nests, apparent nesting success, fledging rate, and proportion of two-chick broods associated with nests found during the nesting survey in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017–2020 17
Table 6. Habitat selection by nesting and brood-rearing Yellow-billed Loons in the NE NPR-A in 2001–2004, 2008–2014, and 2017–2020 23
Table 7. Number of Glaucous Gull nests and chicks recorded during aerial surveys for nesting loons in Willow loon survey area, NE NPR–A, 2017–2020 26
Table 8. Habitat use by nesting Glaucous and Sabine's gulls recorded during aerial surveys for nesting loons in the Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2020 27

LIST OF APPENDICES

Appendix A. Annual density 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 2017–2020 33
Appendix B. Number of Pacific and Red-throated loons and their nests, broods, and young during aerial surveys, in the Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2017–2020 34
Appendix C. Pacific and Red-throated loon nest locations and Pacific Loon brood locations, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2020 35
Appendix D. 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 2017–2020 36

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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. In 2017, ABR began conducting Spectacled Eider prenesting surveys and Yellow-billed Loon nest and brood surveys in the Willow Project area of the NE NPR-A in support of ConocoPhillips, Alaska, Inc. (CPAI; Johnson et al. 2018, Johnson et al. 2019a, and Shook et al. 2020). Previous studies in the NE NPR-A area are described by Johnson et al. (2015).

In this report, we present the results of Yellow-billed Loon surveys that were conducted in the Willow Project area in 2020. The surveys were designed to collect data on the distribution, abundance, and habitat use of Yellow-billed Loons in support of permit applications. The Yellow-billed Loon (common names followed in parentheses by Iñupiaq names and scientific names; Tuullik, *Gavia adamsii*) is listed as a sensitive species by the Bureau of Land Management (BLM 2019) and is the subject of required operating procedures (ROPs) under BLM's Integrated Activity Plan (IAP), as revised in 2020 (BLM 2020a). Under ROP E-9, 3 years of paired Yellow-billed Loon nest and brood surveys are required in areas subject to permanent infrastructure. The ROP also addresses disturbance, requiring a 0.5-mile buffer, up to 1 mile where feasible, around all nest sites and a minimum 1,625-foot buffer (300 m) around the shoreline of all lakes containing Yellow-billed Loons, regardless of breeding status. The ROP generally prohibits development within these buffers but would consider modifications if no other possible option exists (BLM 2020a). ABR has surveyed portions of the NE NPR-A for Yellow-billed Loons since 2001 and has conducted surveys annually in the Willow Project area since 2017. In 2018, however, additional lakes were added to the 2017 loon survey area to accommodate the project area, making 2020 the third year for these additional lakes and the fourth year for the rest of the lakes in the survey area.

The Spectacled Eider (Qavaasuk, *Somateria fischeri*) was listed as threatened in 1993 (58 FR 27474–27480) under the Endangered Species Act of 1973, as amended. Spectacled Eiders also are addressed in ROP E-9, which requires 3 years of site-relevant prenesting eider surveys (BLM 2020a). The ROP for eiders was satisfied in 2019 (Shook et al. 2020). As a result, eider surveys were not included in the Willow avian studies in 2020. Eider prenesting surveys were flown, however, across an area spanning Greater Mooses Tooth (GMT2)/Mooses Tooth (MT7) and a portion of the Willow Project area as part of an eider study required by the North Slope Borough GMT2 rezone ordinance (Rozell et al. 2021).

Glaucous Gull (Nauyavasrugruk, *Larus hyperboreus*) and Sabine's Gull (Iqirgagiak, *Xema sabini*) nests and broods were recorded incidentally during both Yellow-billed Loon surveys. Glaucous Gulls are effective egg predators and are one of the primary causes of failure at Yellow-billed Loon nests (Johnson et al. 2015). Glaucous Gulls also are a subsidized predator, meaning that they potentially benefit from human development (Liebezeit et al. 2009, Wieser and Powell 2010). Monitoring gull distribution and abundance is important because of the potential for increased predation at nests. Sabine's Gulls are not major egg predators, but we monitor colonies because they can be identified during aerial surveys without additional survey effort.

All required permits were obtained for the Yellow-billed Loon surveys, including a Scientific Permit (Permit No. 20-130 issued 10 June 2020) from the State of Alaska.

STUDY AREA

The Willow Project area is located in the NE NPR-A about 31 km (19 miles) west of Nuiqsut (BLM 2020b). The area studied for the Willow Project in 2020 extended approximately 32 km west, 19 km north, and 24 km south of the GMT2/MT7 drill site (Figure 1). The area surveyed for loons comprised the Willow loon survey area (851 km²) and the Tiŋmiaqsiuġvik Material Site (TMS) 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 associated with the Willow Project and material site.

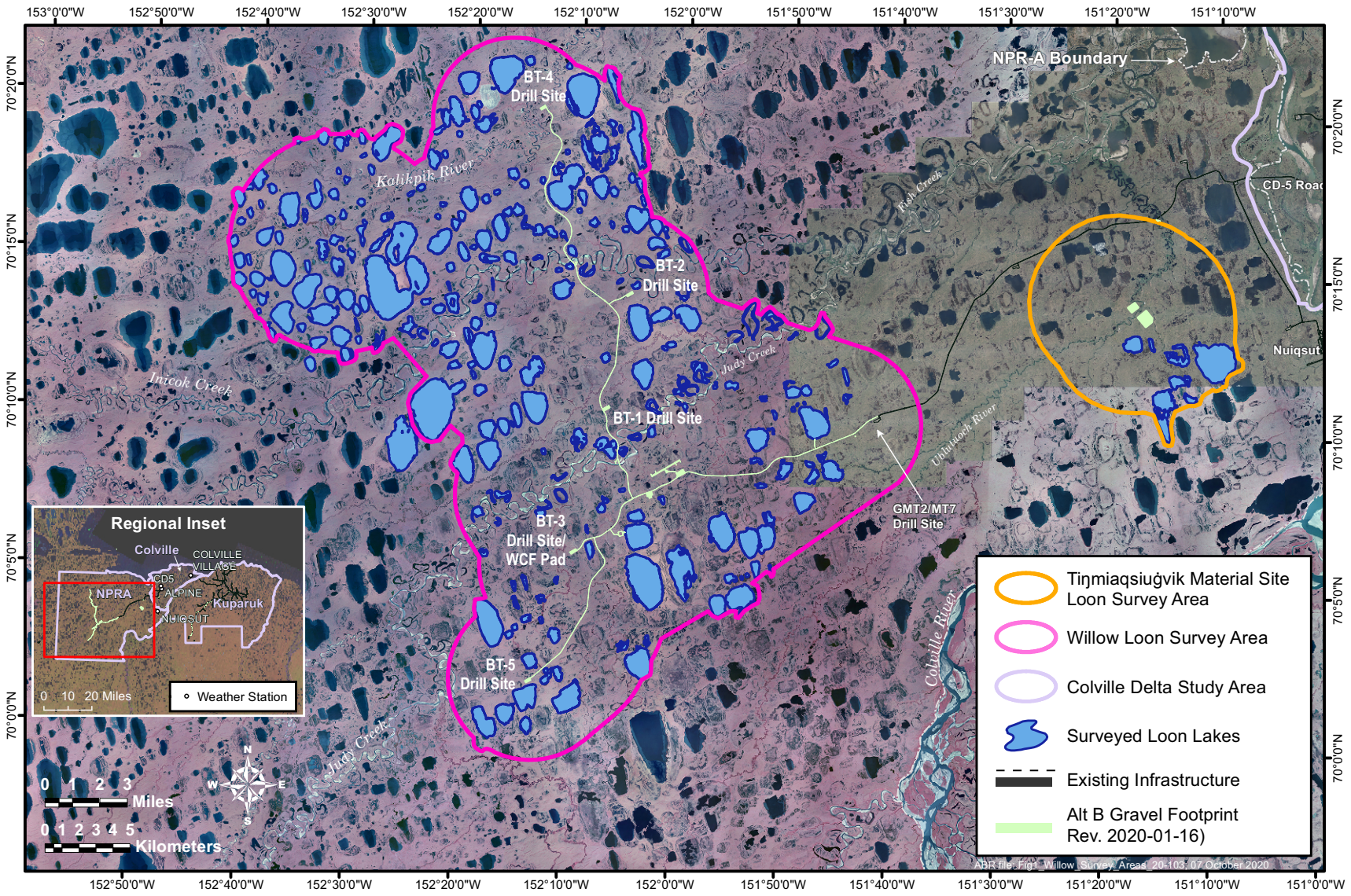

Figure 1. Wildlife survey areas for the Willow Project area, NE NPR-A, 2020.

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

In 2020, we used a helicopter to conduct 2 aerial surveys for Yellow-billed Loons, 1 during nesting and 1 during brood-rearing. Nests were also visited on the ground during the brood-rearing survey to verify nest fate. Aerial surveys were conducted because of the large area and the short period of time that Yellow-billed Loons are at the optimal phase of their annual cycle for data collection. Surveys were scheduled for mid- to late June and mid- to late August, corresponding to the periods when Yellow-billed Loon nests and broods are most easily detected. These time periods also follow guidelines as specified in the IAP (BLM 2020). Nesting and brood-rearing Pacific Loons (Malġi, *Gavia pacifica*), Red-throated Loons (Qaqsrauq, *G. stellata*), Glaucous Gulls, and Sabine's Gulls were recorded incidentally during loon surveys.

Concerns about disturbance to local residents and wildlife from survey flights require that we conduct the fewest survey flights necessary and at the highest altitudes possible. Flight altitudes were set at the maximal altitude at which loon nests and broods 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 and avoid locations with active hunting parties. Additionally, aerial observers looked for people, boats, and off-road vehicles that might indicate the presence of subsistence hunters. If hunting parties were present, we diverted the aircraft to reduce disturbance to hunters.

During the surveys, locations of 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 were plotted on tablet computers with a custom application that employed moving maps based on this aerial imagery (see Data Management, below).

In this report, we present data summaries as means with standard errors (mean ± SE), unless noted otherwise. Statistical significance is assigned at $P \leq 0.05$ unless otherwise stated.

LOON SURVEYS

DISTRIBUTION AND ABUNDANCE

The 2020 loon surveys covered 2 areas, the TMS and Willow loon survey area (Figure 1, Table 1). Loon survey areas encompassed a 3-mi buffer

Table 1. Avian surveys conducted in the Willow Project area, NE NPR-A, 2020.

	Yellow-billed Loon Surveys[a]	
	Nesting	Brood-rearing
Number of Surveys	1	1
Survey Dates	18–24 June	15–19 Aug
Aircraft[b]	A-Star	A-Star
Aircraft Altitude (m)	60–70	60–70
Notes	All lakes ≥ 5 ha in size	All lakes ≥ 5 ha in size

[a] Nests and broods of Pacific Loons, Red-throated Loons, Glaucous Gulls, and Sabine's Gulls were recorded incidentally.
[b] A-Star = Airbus AS 350 B2 helicopter.

around proposed roads, drill sites, and material sites associated with the Willow development. Thirty lakes ≥5 ha are within the TMS loon survey area. In 2019 and 2020, we surveyed 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 ROP E-9 (BLM 2020a). This reduction in survey effort was an attempt to reduce air traffic and possible disturbance to the village of Nuiqsut. In the Willow loon survey area, we surveyed 290 lakes during both nesting and brood-rearing. 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 2017–2019. In all years, the nesting survey was conducted between 18 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 (see Johnson et al. 2015 for details).

All surveys were conducted from a helicopter flying in a lake-to-lake pattern at 60–70 m above ground level (agl). The perimeter of each lake was circled while an observer searched lake surfaces and shorelines for loons and nests during the nesting survey and for loons and chicks during the brood-rearing survey. A nest was defined by the presence of an incubating adult or by seeing a nest with ≥1 egg. Adults were assumed to be incubating eggs when seen on a shoreline or island in concealment posture. Although less common, nests with eggs sometimes were detected after scanning the shoreline next to a swimming adult. After the nesting survey, we revisited lakes containing only non-incubating Yellow-billed Loon adult(s) to verify the presence or absence of a nest. Likewise, during the brood-rearing survey, we revisited lakes with hatched nests (see Nest Fate, below) and no young to verify the presence or absence of broods. For resurveyed lakes, the total number of adults or chicks was calculated by taking the maximum number seen during a single lake visit.

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 2017–2020. 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. 2019b). Yellow-billed Loons have been observed nesting along stream inlets/outlets to lakes (Uher-Koch et al. 2018), so we began including these channels in surveys in 2018. 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). We also recorded the landform (e.g., island, shoreline, peninsula, or emergent) associated with all nests. 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.

We defined a territory as a single lake, several lakes, or portion of a lake occupied exclusively by 1 breeding pair with a nest or brood (Johnson et al. 2019b). Territories were identified using data from all years; boundaries between territories were determined by locations where nests and broods were recorded and, additionally, by the locations of adults on multi-territory lakes. When we identified a new territory (i.e., when nests or broods were found in a lake not previously known to support breeding Yellow-billed Loons), we assumed that territory was available but unoccupied by breeding pairs in years before discovery. To make comparisons among years when different numbers of territories were surveyed, we first identified all territories within the survey area. Then, we calculated nest or brood occupancy by dividing the number of territories with nests or broods by the number of territories surveyed.

The number of chicks surviving to at least 6 weeks of age has been used as an estimator of fledging in Common Loons because chick mortality is minimal after 6 weeks of age (Evers et al. 2020). Yellow-billed Loon chicks appear to have similar survival. Most Yellow-billed Loon chick mortality occurs during the first 2 weeks following hatch and is less common thereafter (Uher-Koch et al. 2020a, ABR unpublished data). Yellow-billed Loon chicks in the Willow loon survey area are ~6 to 8 weeks old during the

brood-rearing survey (based on hatch dates observed during camera monitoring in previous years; see Johnson et al. 2015), so chicks/nest serves as an approximation of the fledging rate. Fledging rate was defined as the number of chicks seen on the brood survey divided by the number of nests. Because the denominator is the number of nests, survey effort must be standardized among years; therefore, we limited these data to only those chicks seen during the brood-rearing survey at nests detected on the nesting survey.

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. 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.

DENSITY MAPS

To summarize the mean annual distribution and abundance of Yellow-billed Loons, we used the inverse distance-weighted (IDW) interpolation technique of the Spatial Analyst extension of ArcMap software (Environmental Systems Research Institute, Inc. [ESRI], Redlands, CA) on a GIS platform. We mapped Yellow-billed Loon adults, nests, and young (1993, 1995–1998 and 2000–2020) in ABR's Colville Delta and NE NPR-A study areas. We calculated annual mean density from the total number of adults and nests seen on the nesting survey and the number of young seen on the brood survey within 1 km × 1 km grid cells.

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

GULL SURVEYS

Locations of Glaucous and Sabine's gull 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 nests occurring in proximity on the same lake or wetland complex to be a colony. Some wetlands or lakes contained <3 nests for years prior to attaining colony status; however, once an area supported a colony in any year, we consider it a colony in all years. Colony locations within the study area were checked systematically for activity, whereas nests outside of traditional locations were recorded incidentally as they were encountered. 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 as they were encountered during the loon brood-rearing survey.

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 after hatch (Day et al. 2020), so we are unable to count their broods during August surveys.

HABITAT MAPPING AND ANALYSIS

A wildlife habitat was assigned to observations of nests and broods by plotting their location on the wildlife habitat map (Figure 2). Habitat use (% of all observations in each identified habitat type) was determined separately for nesting and brood-rearing Yellow-billed Loons. For Glaucous and Sabine's gulls, habitat use was only determined during nesting. For each species, we calculated 1) the number of nests or broods in each habitat, and 2) the percent of total

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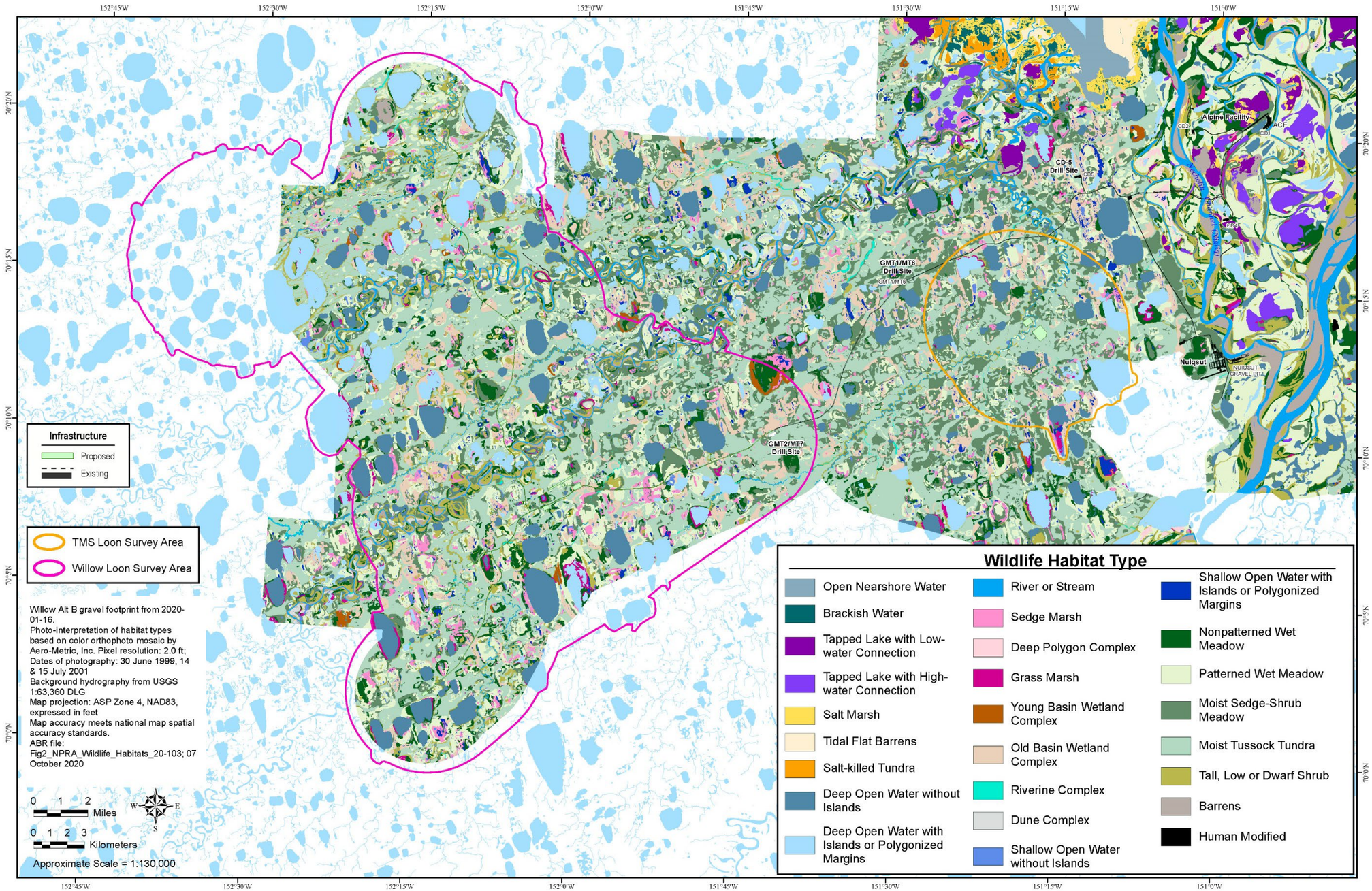

Figure 2. Wildlife habitats in the NE NPR-A area, 2020.

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observations in each habitat. Habitat use was calculated from individual locations of Yellow-billed Loons, Glaucous and Sabine's gull nests and group locations for Yellow-billed Loon broods. Habitat availability was calculated as the percent of each wildlife habitat in the Willow loon survey area and ABR's other NE NPR-A surveys areas (Table 2).

For Yellow-billed Loons, we evaluated whether or not habitats were used in proportion to their availability. Multiple years of comparable survey data were used in the analysis of habitat selection. We calculated the number of observations and the area (km²) for each wildlife habitat in all survey years (2001–2004, 2008–2014, and 2017–2020) to represent the total habitat use and availability, respectively. We excluded the Fish Creek Delta subarea from habitat selection analyses for Yellow-billed Loons because that area contained large areas of coastal and deltaic habitat types not available in the Willow Project area.

We inferred habitat selection by comparing observed habitat use to random habitat use. Monte Carlo simulations (10,000 iterations) were used to calculate a frequency distribution of random habitat use, with the sample sizes in each simulation equaling the number of observed nests or groups of birds in that season. The resulting distribution was used to compute 95% confidence intervals around the expected value of habitat use (Haefner 1996, Manly 1997). We defined habitat preference (i.e., use > availability) as observed habitat use greater than the 95% confidence interval of simulated random use, which represents

Table 2. Habitat availability in the Willow loon survey area, Willow Project area, NE NPR-A, 2020.

Habitat	Area (km²)	Availability (%)[a]
Tapped Lake with High-water Connection	0.1	0.01
Deep Open Water without Islands	56.0	8.17
Deep Open Water with Islands or Polygonized Margins	47.3	6.90
Shallow Open Water without Islands	11.3	1.66
Shallow Open Water with Islands or Polygonized Margins	6.1	0.89
River or Stream	6.3	0.92
Sedge Marsh	19.1	2.79
Grass Marsh	4.1	0.60
Young Basin Wetland Complex	2.2	0.32
Old Basin Wetland Complex	34.1	4.97
Riverine Complex	1.9	0.28
Dune Complex	4.2	0.62
Nonpatterned Wet Meadow	34.5	5.03
Patterned Wet Meadow	97.9	14.29
Moist Sedge-Shrub Meadow	84.7	12.36
Moist Tussock Tundra	210.6	30.73
Tall, Low, or Dwarf Shrub[b]	57.0	8.32
Barrens[c]	7.5	1.10
Human Modified	0.2	0.03
Subtotal (total mapped area)	685.2	100
Unknown (unmapped areas)	166.1	
Total	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.

an alpha level of 0.05 (2-tailed test). Conversely, we defined habitat avoidance (i.e., use < availability) as observed habitat use below the 95% confidence interval of simulated random use. The simulations and calculations of confidence intervals were conducted in the program R (version 4.0.3; R Core Team 2020).

DATA MANAGEMENT

All locations of loons and gulls 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. Bird locations were recorded with decimal-degree coordinates in the WGS 84 map datum and later transferred into the NAD 83 map datum. Photos were taken of all Yellow-billed Loon nests showing the surrounding habitat and lake topography to ensure maximum accuracy in nest locations.

Uniform attribute data were recorded for all observations and proofed after data collection. Data were checked for quality with a series of scripts created in the program R and exported into a centralized PostgreSQL database. All photos of loon nests were reviewed by digitally marking nests and labeling them according to territory and observation number. Final nest locations were assigned by consulting the photos. Survey data were submitted to CPAI in GIS-ready format with corresponding metadata following CPAI's data management protocols (version 11.4, CPAI 2020).

RESULTS

SEASONAL CONDITIONS IN THE PROJECT AREA

Multiple weather stations are located in the general vicinity of the Willow Project area including near the proposed Willow airstrip, at CD-5, Alpine, Nuiqsut, and Colville Village (Helmerick's homestead). Colville Village has the longest dataset in the region, but the station stopped recording data in 2019. We used temperature data from the nearest station at CD-5 and snow depth data from Alpine to describe general 2020 weather patterns. Additionally, we used spring breakup and hydrological data reported by Michael Baker International (Michael Baker 2020).

Compared to the previous 5 years of data at CD-5, temperatures were generally low for the first few weeks of May (with the exception of a warm period on 9–10 May), average in late-May and early-June, and high in mid-June (Figure 3, top). The sum of thawing degree days (the sum of average daily temperatures >0 °C, TDD) was below average during the last 2 weeks of May when the first migratory birds begin to arrive, and was above average during the first 2 weeks of June when the majority of birds are arriving on the breeding grounds (Figure 4). Snow was deeper than in any of the previous 5 years at Alpine for the first week of May, but steadily decreased throughout the month. On 24 May, snow cover on the tundra along the GMT2/MT7 road was about 90% but localized meltwater was observed (Michael Baker 2020). Culverts began to convey flow by 30 May and snow continued to melt through early June. By late May and early June, snow depth was unmeasurable at Alpine (Figure 3, bottom). Therefore, breakup started gradually in late May and accelerated in early June when most birds arrive on local nesting grounds.

The proportion of water to ice on deep lakes was estimated visually during the loon nesting survey. During 2020, mean ice coverage on deep lakes (>5 ha) was 35% (n = 177 lakes), which was lower than in any of the preceding 6 years (mean = 62 ± 6%, range 47–80% ice). Yellow-billed Loons rely on moats of open water in order to access nesting sites on lakes. The high proportion of open water on lakes during the nesting survey in 2020 likely meant that loons were not delayed in accessing nest sites, and, as a result, surveys were well timed for the conditions. All of the lakes used by breeding loons in the Willow area had clear water, unlike on the Colville River delta where extensive flooding resulted in murky water (Parrett et al. 2021).

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 2020. We have not documented Yellow-billed Loons using the 11

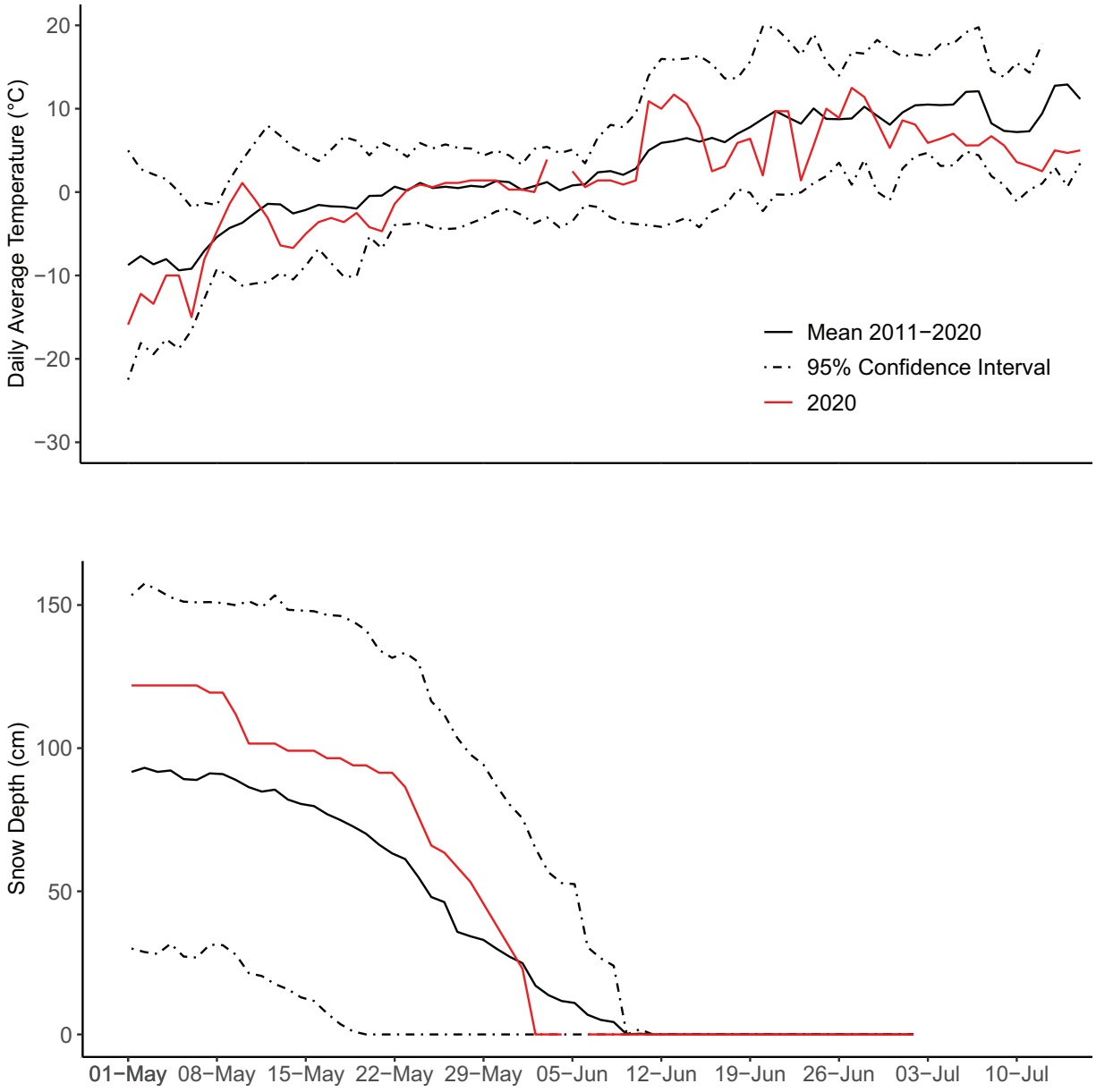

Figure 3. Mean daily temperature at CD-5 for spring and summer 2020 with mean for 2011–2020 (top) and snow depth at Alpine (bottom), Colville River delta and NE NPR-A, Alaska.

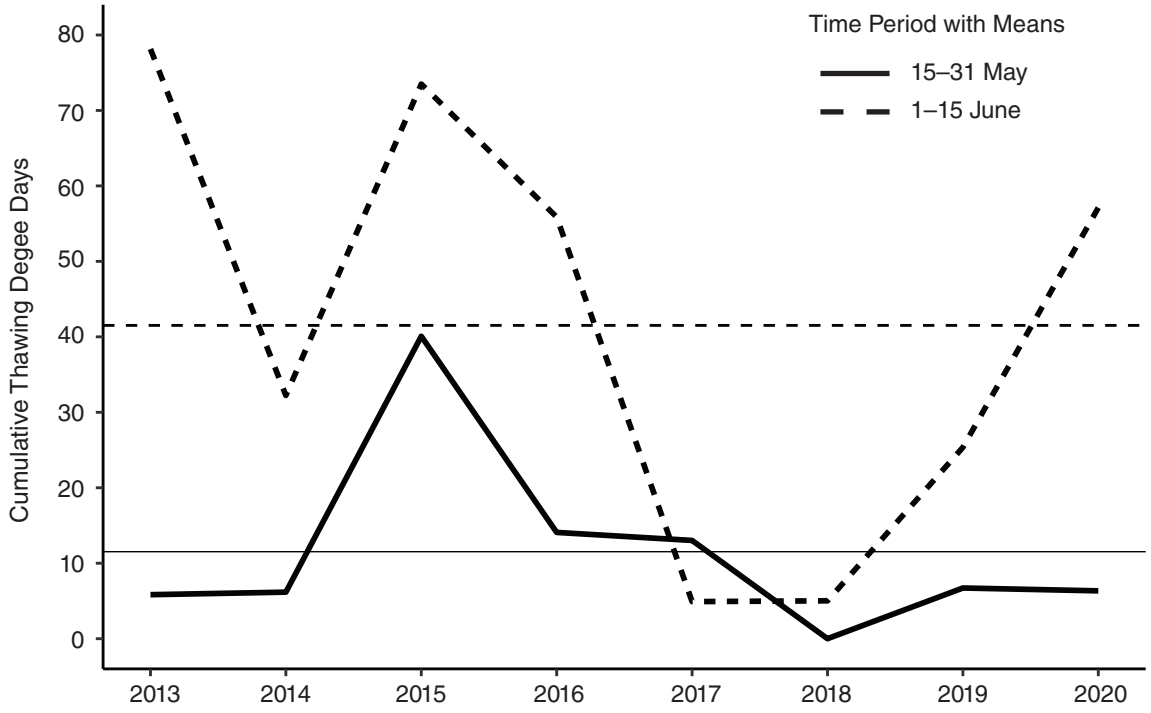

Figure 4. Cumulative number of thawing degree-days and means (horizontal lines) recorded for 15–31 May and 1–15 June at Alpine, Colville River delta, Alaska, 2011–2020.

lakes surveyed since 2018 nor have we documented any on the remaining 19 lakes in the TMS that were surveyed prior to 2018.

In the Willow loon survey area, 91 Yellow-billed Loon adults and 35 nests were found during the nesting survey in 2020 (Figure 5, Table 3; for densities, see Appendix A). One additional nest was inferred from the presence of a brood during August in a lake where a nest was not found during the nesting survey and 2 more nests were found in lakes outside the survey boundary. The numbers of adults and nests were both well above the numbers found in the same survey area during 2018 and 2019.

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 nest occupancy, or the proportion of territories with nests because it is a metric that is not sensitive to survey effort. During the 2020 nesting survey in the Willow loon survey area, 35 of 51 territories (69%) were occupied by nesting loons, which is the highest nest occupancy observed in the Willow loon survey area since surveys began there in 2017. Compared to other ABR survey areas in NE NPR-A, nest occupancy in 2020 was second only to 2012 and well above the long-term mean (52.6 ± 3.2%, n = 15 years; Table 3).

During the brood-rearing survey in 2020, 88 Yellow-billed Loons, 20 broods, and 28 chicks were observed in the Willow loon survey area; 2 broods and 2 chicks were seen in lakes adjacent to the survey area (Figure 5, Table 4). We inferred that 5 additional nests hatched chicks based on eggshell fragments at nests but the chicks did not survive until the brood-rearing survey (see Nest Fate, below). Including these additional broods, a total of 25 broods were produced by breeding Yellow-billed Loons in 2020. Incidental records of Pacific and Red-throated loon nests and broods are presented in Appendices B and C.

Similar to nest occupancy, we used brood occupancy, or the proportion of territories with a brood, to compare reproductive output among

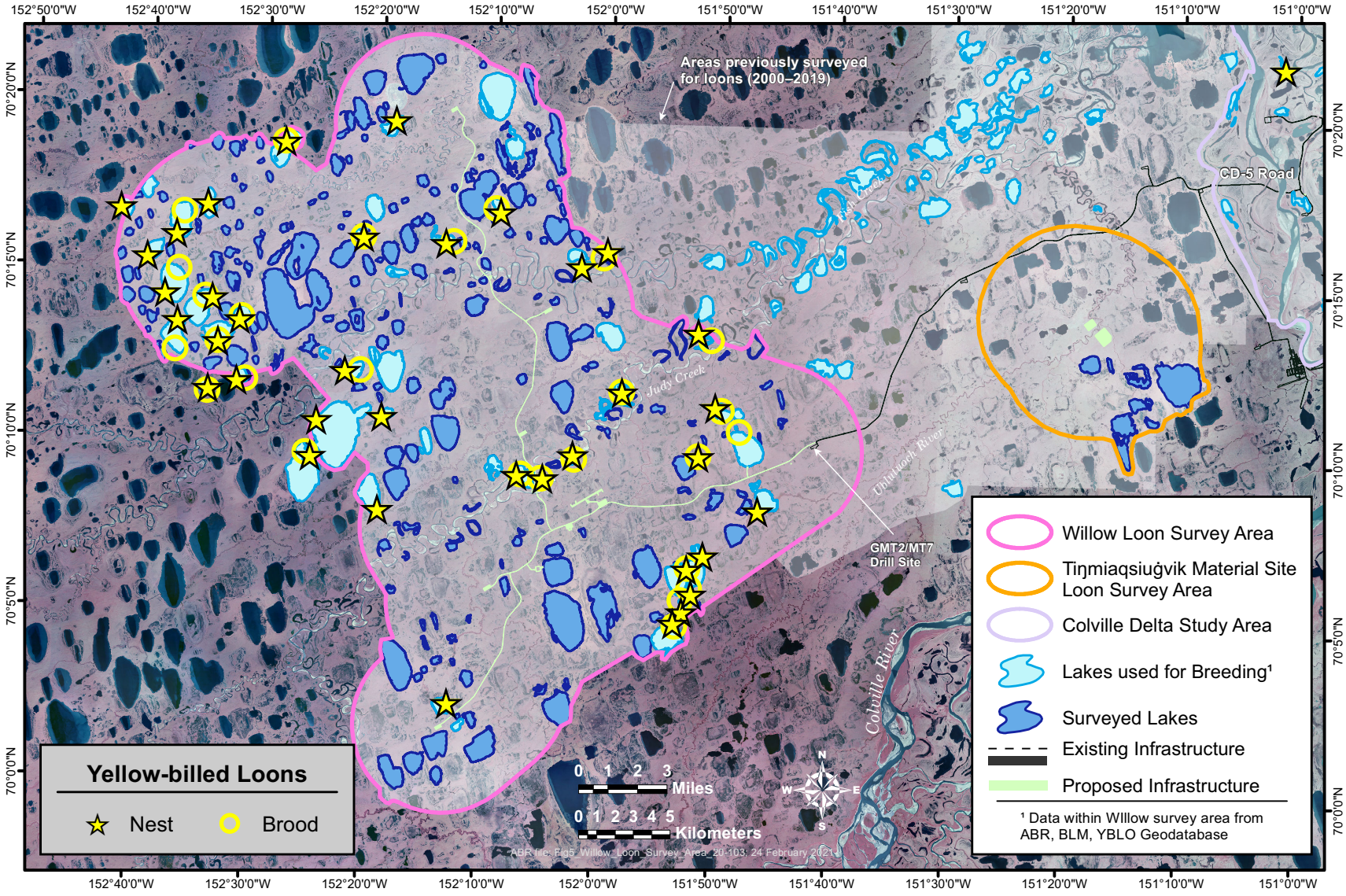

Figure 5. Yellow-billed Loon nest and brood locations, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2020.

Table 3. Numbers of Yellow-billed Loons and nests, and nest occupancy in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017–2020.

SURVEY AREA	Nesting Survey[a]		All Surveys[b]	No. Territories Surveyed[c]	Nest Occupancy (%)[d]
Year	No. Adults	No. Nests	No. Nests		
WILLOW[e]					
2017	38	9	14[f]	24	38
2018	65	19	20[f]	50	38
2019[g]	69	30	32[f]	50	60
2020[h]	91	35	36[f]	51	69
Mean[i]					51.3
SE					7.9
NE NPR-A					
2001	44	19	23[j]	37	51
2002	65	27	27	46	59
2003	53	26	28[f,j]	45	58
2004	60	23	24[j]	44	52
2005	24	8	8	13	62
2006	24	8	8	13	62
2008	82	23	29[k]	53	43
2009	65	27	29[k]	53	51
2010	75	29	36[k]	53	55
2011	32	8	13[k]	21	38
2012	36	15	18[k]	21	71
2013	39	12	14[k]	21	57
2014	46	18	20[k]	28	64
2017[l]	11	5	8[f]	11	45
2018[l]	24	3	3	11	27
Mean[i]		—			52.6
SE					3.2

[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] Includes 1 territory identified only through the Yellow-billed Loon geodatabase (USFWS 2013).
[d] 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.
[e] Willow loon survey area was 502.3 km^2 in 2017 and 851.2 km^2 in 2018–2020.
[f] Includes nest(s) inferred by the presence of a brood observed on a territory lake during ground or aerial surveys.
[g] An additional 3 adults and 2 nests were seen outside of the Willow loon survey area.
[h] An additional 2 adults and 2 nests were seen outside of the Willow loon survey area.
[i] Mean numbers of adults and nests not calculated because survey area differed among years.
[j] Includes nest(s) found during ground surveys.
[k] Includes nest(s) found during revisit (1996–2002), monitoring (2008–2014), and early nesting (2011, 2012, and 2014) surveys.
[l] Totals include observations at 3 territories within the Willow loon survey area.

Table 4. Numbers of Yellow-billed Loons, chicks, and broods, and brood occupancy in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017–2020.

SURVEY AREA	Brood-rearing Survey[a]			All Surveys[b]		Brood
Year	No. Adults	No. Chicks	No. Broods	No. Broods	No. Territories Surveyed[c]	Occupancy (%)[d]
WILLOW[e]						
2017	39	9	8	11[f]	25	44
2018	89	4	3	6	50	12
2019[g]	98	24	17	20[f]	50	40
2020[h]	88	28	20	25[f]	51	49
Mean[i]						36.3
SE						8.3
NE NPR-A						
2001	47	5	5	7[j]	33	21
2002	47	7	6	6	41	15
2003	54	18	16	16	37	43
2004	67	12	10	10	42	24
2005	12	3	3	3	13	23
2006	16	2	2	2	12	17
2008	70	15	12	19[f,k]	52	27
2009	86	17	12	15[f]	53	28
2010	70	18	15	16[f]	51	31
2011	31	5	4	4	21	19
2012	42	14	12	12	21	57
2013	21	0	0	1[k]	21	5
2014	29	9	9	11[f]	28	39
2017[l]	21	4	4	5[f]	11	45
2018[l]	23	1	1	1	11	9
Mean[i]						27.5
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] Includes 42 territories identified during ABR surveys and 1 territory identified through the Yellow-billed Loon geodatabase (USFWS 2013).
[d] Calculated as the number of broods from all surveys divided by the number of territories surveyed.
[e] Willow loon survey area was 502.3 km² in 2017 and 851.2 km² in 2018–2020.
[f] Includes broods from territories where no brood was seen but presence of a brood was determined from eggshell evidence.
[g] An additional 4 adults and 1 brood with 2 chicks were seen outside of the Willow loon survey area.
[h] An additional 3 adults and 2 broods with a total of 2 chicks were seen outside of the Willow loon survey area.
[i] Mean numbers not calculated because survey area differed among years.
[j] Includes brood(s) found during ground surveys.
[k] Includes brood(s) found during monitoring surveys.
[l] Totals include observations at 3 territories within the Willow loon survey area.

years. 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 the brood-rearing survey (see Nest Fate, below). In the Willow loon survey area in 2020, 25 of 51 territories (49%) contained a brood. Like nest occupancy, compared 15 years of surveys in other areas in NE NPR-A, brood occupancy in 2020 was second only to 2012 and well above the long-term mean (27.5 ± 3.7%, n = 15 years; Table 4).

One goal of brood-rearing surveys is to estimate how many chicks survive to fledging. The fledging rate differs from measures of brood occupancy and apparent nest success in that the fledging rate incorporates nesting effort, nest and brood survival, and brood size into one metric. The fledging rate of 0.77 chicks/nest in 2020 is the highest on record in the Willow loon survey area (Table 5). The fledging rate was also the highest estimate compared to other ABR survey areas in NE NPR-A and well above that long-term mean (mean = 0.40 ± 0.06 chicks/nest, n = 15 years). In addition, the number of pairs that fledged 2 chicks (23%) was above the mean for the Willow loon survey area (15.7 ± 4.5%) and was the second-highest estimate compared to other NE NPR-A survey areas (range 0–33%). High nest occupancy, high hatching success (see Nest Fate, below), and a large proportion of pairs fledging 2 chicks all combined to create the record-high fledging rate observed during 2020.

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 51 Yellow-billed Loon territories composed of 59 lakes in the Willow loon survey area (Appendix D). Of those territories, 12 (24%) were identified during surveys prior to the initiation of Willow studies in 2017, 8 (16%) were first discovered during surveys in 2017, 8 (16%) were discovered during surveys in 2018, 14 (27%) were discovered during surveys in 2019, and 8 (16%) were discovered during 2020. The remaining territory was identified using the Yellow-billed Loon Geodatabase (USFWS 2013). Of the territories discovered in 2020, 1 was discovered incidentally on a lake that had not been included in surveys because it was <5 ha. Although the nest at this territory hatched, the brood did not survive and it is unknown whether the pair would have used the same lake for brood-rearing or moved to a larger, adjacent lake. The territories discovered in 2020 had been included in surveys since 2017 or 2018 and all had previously contained adult Yellow-billed Loons without evidence of breeding.

Nine nest sites at 3 territories recorded over multiple years are <0.5 miles from the proposed Willow Project infrastructure (Appendix D; BLM 2020b). Six of those nest sites are in 1 territory adjacent to the proposed road where it crosses Judy Creek and 3 nest sites are in 2 territories adjacent to the proposed BT-5 drill site. Yellow-billed Loons have been found in 9 lakes with shorelines that are <495 m from proposed infrastructure; 6 of those lakes are associated with nesting or brood-rearing loons.

NEST FATE

We found 36 nests (including one nest that was inferred from the presence of a brood) in the Willow loon survey area in 2020. During the brood-rearing survey, 20 of 36 Yellow-billed Loon nests had adults that were seen with a brood. Because the absence of a brood does not always indicate nest failure, 15 of 16 nests without broods were visited on the ground to determine nest fate. Ten nests failed to hatch (1 nest contained a broken egg and 9 nests contained no egg fragments). Five nests contained ≥20 egg fragments (range 41–52 fragments) and, therefore, hatched at least 1 chick that did not survive. One nest could not be inspected for nest fate because the nest was submerged in water. We assumed that this nest failed during breakup as water levels increased via a stream inlet conveying local runoff. Including broods that did not survive, we determined that 25 of 36 nests hatched.

We began visiting inactive nests in ABR's NE NPR-A survey areas to verify nest fate in 2008. During 2008–2014, we also conducted weekly nest and brood monitoring surveys, which provided more accurate 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

Table 5. Number of Yellow-billed Loon nests, apparent nesting success, fledging rate, and proportion of two-chick broods associated with nests found during the nesting survey in the Willow loon survey area and other NE NPR-A survey areas in 2001–2006, 2008–2014, and 2017–2020.

				Mid-August	
SURVEY AREA Year	No. Territories Surveyed[a]	No. Nests[a]	Nesting Success (%)[b,c]	Fledging Rate (chicks/nest)[d]	Two-chick Broods (%)
WILLOW[e]					
2017	24	9	67	0.44	11
2018	50	19	26	0.16	5
2019	50	30	60	0.73	23
2020	51	35	69	0.77	23
Mean[f]	–	–	55.5	0.53	15.7
SE	–	–	10.0	0.14	4.5
NE NPR-A					
2001	37	19	–	0.16	0
2002	46	27	–	0.26	4
2003	45	25	–	0.64	8
2004	44	23	–	0.48	9
2005	13	8	–	0.38	0
2006	13	8	–	0.13	0
2008	53	21	77	0.48	5
2009	53	24	52	0.67	21
2010	53	26	48	0.54	8
2011	21	8	37	0.50	12
2012	21	15	67	0.73	13
2013	21	12	0	0	0
2014	28	18	56	0.44	0
2017[g]	11	5	40	0.20	20
2018[g]	11	3	30	0.33	33
Mean[f]	–	–	41.3	0.40	8.9
SE	–	–	7.2	0.06	2.5

[a] Limited to a single nesting survey flown annually between 19 June and 1 July.
[b] Apparent nesting success calculated using nests found only during the nesting survey; successful nests determined by nest fate data and the presence of broods.
[c] Apparent nesting success not available prior to 2006 because nest fate data were not collected during those years.
[d] Total number of chicks seen during the brood rearing survey/number of nests found during the nesting survey.
[e] Willow loon survey area was 502.3 km^2 in 2017 and 851.2 km^2 in 2018–2020.
[f] Mean numbers of nests not calculated because survey areas differed among years.
[g] Totals include observations at 3 territories within the Willow loon survey area.

(Johnson et al. 2018a, 2018b). Nests that are missed during the single nesting survey can only be detected during the brood-rearing survey if they produced 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 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 nesting survey and hatching determined from nest fate data and the presence of broods, 24 of 35 nests (excluding data at the nest inferred from presence of a brood) found during the nesting survey hatched in 2020 for an apparent nesting success of 69% (Table 5). This estimate was the highest observed in Willow since surveys began there in 2017 and well above the mean observed in other ABR survey areas in NE NPR-A (mean = 41.3 ± 7.2%, n = 9 years).

DENSITY MAPS

The distribution of Yellow-billed Loon adults, nests, and chicks in the Willow loon survey area during 2020 was typical of previous years. The adult count during June contains both breeding adults and a proportion of non-breeding adults as indicated by territories with >2 adults or adult(s) on lakes with no history of breeding by loons. The highest densities of adults occur in lakes near 4 main areas—adjacent to Fish and Judy creeks, east of the proposed BT-4 drill site, between Fish Creek and the Kilikpik River in northwestern Willow, and southwest of the GMT2/MT7 drill site which was still under construction in 2020 (Figure 6). Nest density is also high in those areas indicating that adults generally are concentrated near areas with suitable breeding habitat and other breeding loons (Figure 7). The density of chicks, however, is more protracted and is highest primarily in the latter two areas near the northwestern edge of the Willow loon survey area and southwest of the GMT2/MT7 drill site (Figure 8).

HABITAT USE

The Willow loon survey area was 851 km^2, 80% (685 km^2) of which has been mapped for wildlife habitats (Table 2; Jorgenson et al. 2003, Wells et al. 2018a, 2018b). Yellow-billed Loons nested in 15 of 26 available habitats during nesting surveys conducted over 15 years in various ABR survey areas in NE NPR-A (excluding the Fish Creek Delta subarea; Table 6). Seven habitats, supporting 207 of 266 total nests, were preferred for nesting. In general, habitats preferred for nesting occurred on lakes that contained islands, complex shorelines with low relief, and aquatic habitats along margins that thaw by early June (Wells et al. 2018a, 2018b). Nests were built on islands (191 nests), shorelines (49), peninsulas (20), or in emergent vegetation (9).

Yellow-billed Loons avoided nesting in 6 habitats, which together comprised 79% of the available habitat across ABR's NE NPR-A survey areas. The 3 most abundant habitats were underutilized compared with their availability (Moist Tussock Tundra, Most Sedge-Shrub Meadow, and Patterned Wet Meadow). They were not entirely avoided, however: Patterned Wet Meadow and Moist Sedge-Shrub Meadow together supported ~14% of the Yellow-billed Loon nests.

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 6). Although those habitats occupy only ~13% of the NE NPR-A survey areas, they contained ~98% of all broods. Only one shallow-water habitat (Shallow water with Islands and Polygonized Margins) was 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.

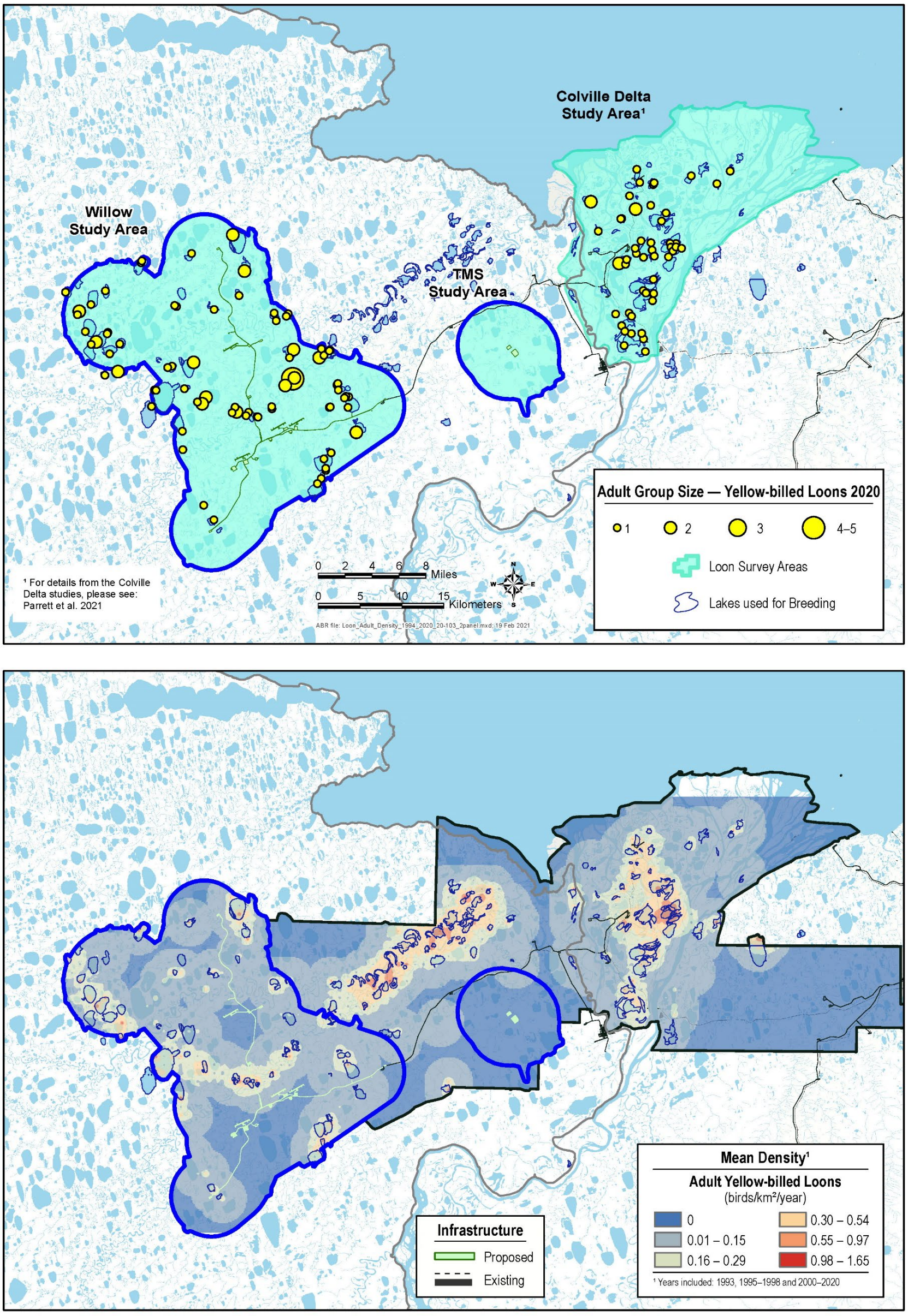

Figure 6. Group size (2020) and mean densities of Yellow-billed Loon adults observed during a single June nesting survey in the Willow and Tiŋmiaqsiuġvik Material Site loon survey areas (blue outline), Colville Delta, and Kuparuk study areas, Alaska, 1993, 1995–1998, 2000–2020.

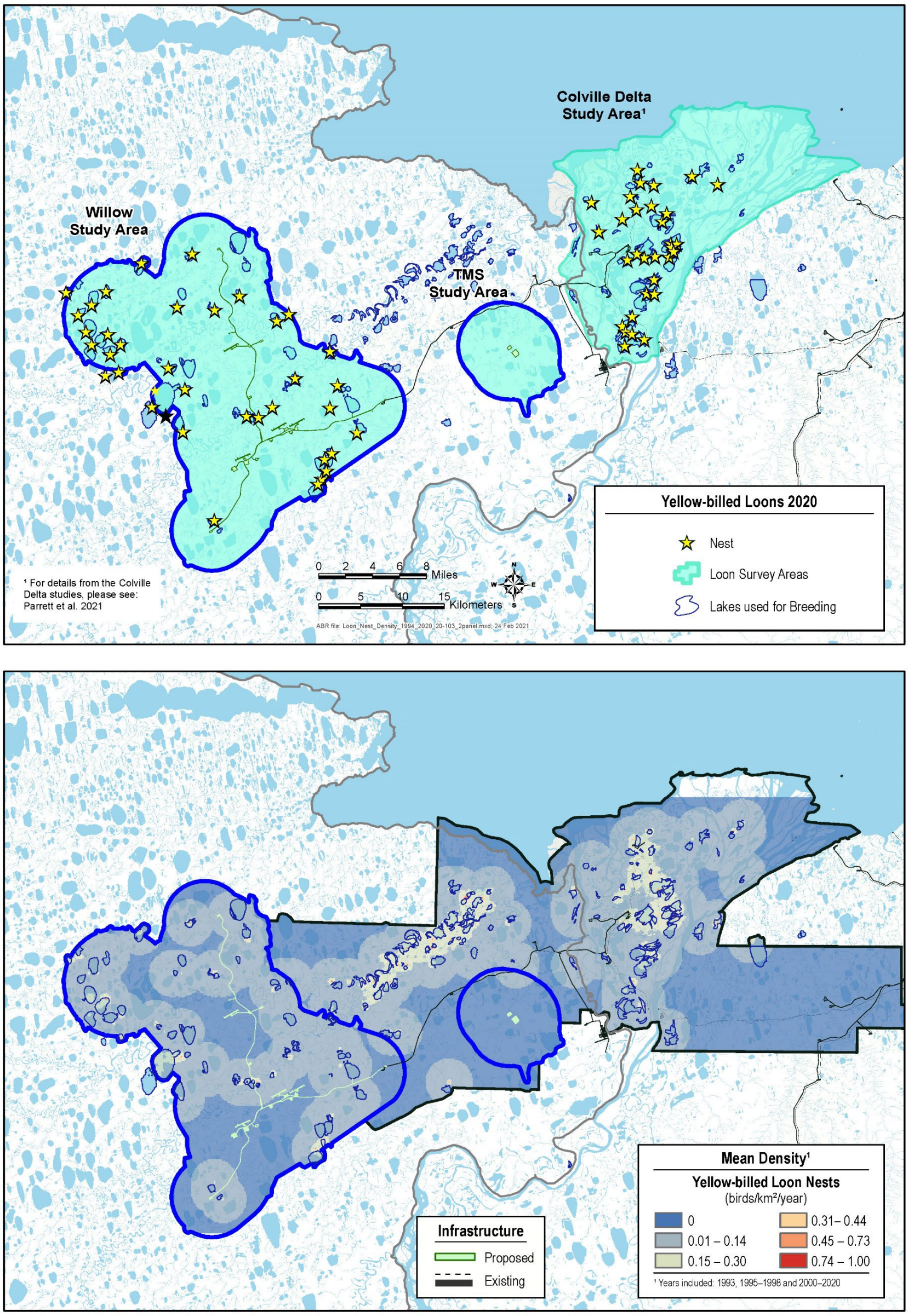

Figure 7. Yellow-billed Loon nest locations and mean annual densities observed during a single June nesting survey in the Willow loon and Tiŋmiaqsiuġvik Material Site loon survey areas (blue outline), Colville Delta, and Kuparuk study areas, Alaska, 1993, 1995–1998, 2000–2020.

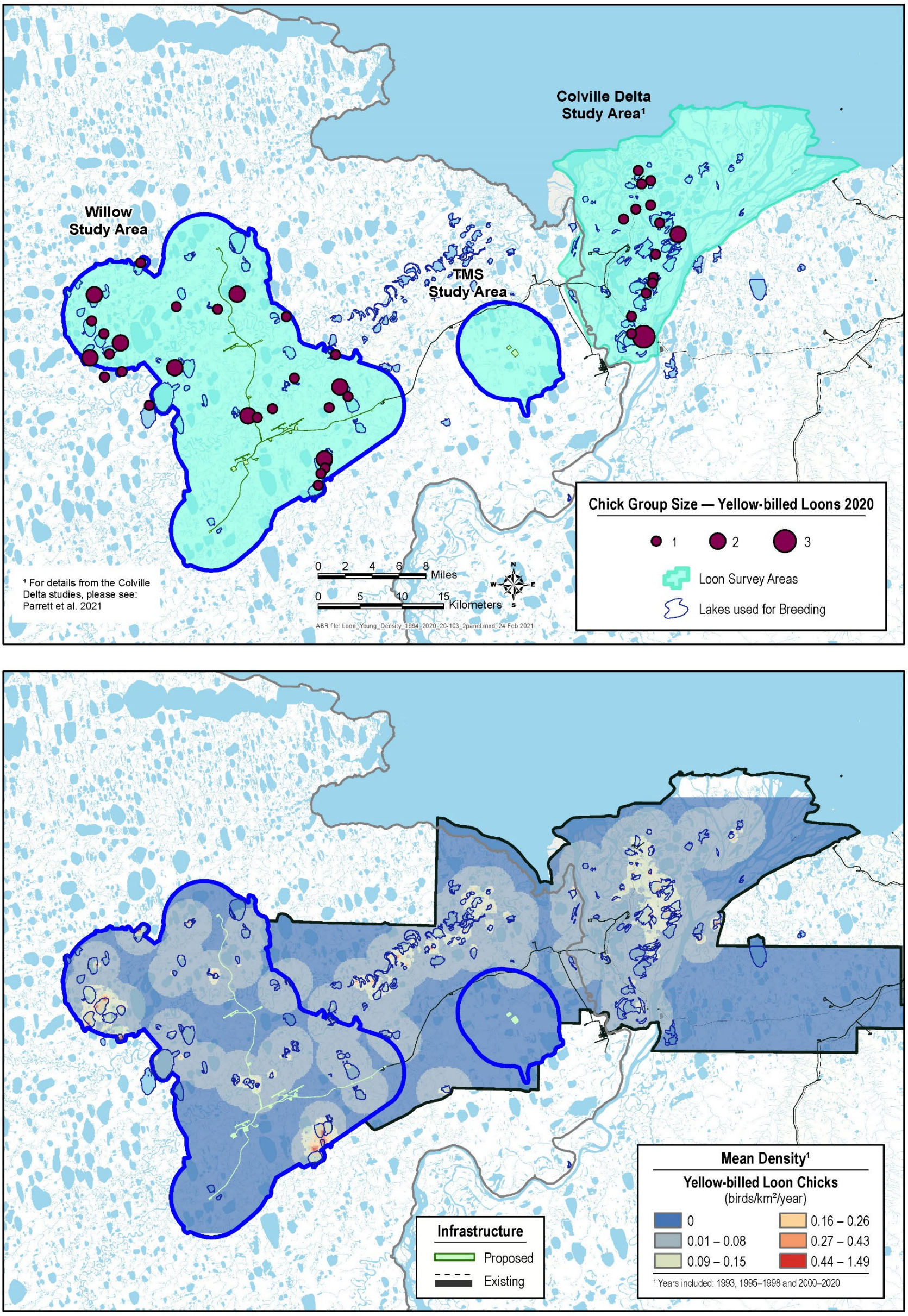

Figure 8. Yellow-billed Loon brood locations and mean annual densities observed during a single August brood-rearing survey in the Willow loon and Tiŋmiaqsiuġvik Material Site loon survey areas (blue outline), Colville Delta, and Kuparuk study areas, Alaska, 1993, 1995–1998, 2000–2020.

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Table 6. Habitat selection by nesting and brood-rearing Yellow-billed Loons in the NE NPR-A[2] in 2001–2004, 2008–2014, and 2017–2020. The Willow loon survey area was surveyed in 2017–2020.

SEASON Habitat	No. of Nests or Broods	Use (%)[b]	Availability (%)	Monte Carlo Results[c]	Sample Size[d]
NESTING					
Open Nearshore Water	0	0	0.4	ns	low
Brackish Water	0	0	0.2	ns	low
Tapped Lake with Low-water Connection	0	0	0.3	ns	low
Tapped Lake with High-water Connection	0	0	<0.1	ns	low
Salt Marsh	0	0	0.4	ns	low
Tidal Flat Barrens	0	0	0.9	ns	low
Salt-killed Tundra	0	0	<0.1	ns	low
Deep Open Water without Islands	9	3.4	7.9	avoid	
Deep Open Water with Islands or Polygonized Margins	109	41	5.8	prefer	
Shallow Open Water without Islands	3	1.1	1.2	ns	low
Shallow Open Water with Islands or Polygonized Margins	10	3.8	1.3	prefer	low
River or Stream	0	0	1.1	ns	low
Sedge Marsh	31	11.7	2.0	prefer	
Deep Polygon Complex	4	1.5	<0.1	prefer	low
Grass Marsh	19	7.1	0.4	prefer	low
Young Basin Wetland Complex	1	0.4	0.3	ns	low
Old Basin Wetland Complex	2	0.8	7.1	avoid	
Riverine Complex	0	0	0.3	ns	low
Dune Complex	9	3.4	1.0	prefer	low
Nonpatterned Wet Meadow	25	9.4	3.9	prefer	
Patterned Wet Meadow	22	8.3	12.5	avoid	
Moist Sedge-Shrub Meadow	20	7.5	18.5	avoid	
Moist Tussock Tundra	1	0.4	27.8	avoid	
Tall, Low, or Dwarf Shrub	1	0.4	5.3	avoid	
Barrens	0	0	1.2	ns	low
Human Modified	0	0	0.1	ns	low
Total	266	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	0.4	ns	low
Brackish Water	0	0	0.2	ns	low
Tapped Lake with Low-water Connection	0	0	0.3	ns	low
Tapped Lake with High-water Connection	0	0	<0.1	ns	low
Salt Marsh	0	0	0.4	ns	low
Tidal Flat Barrens	0	0	0.9	ns	low
Salt-killed Tundra	0	0	<0.1	ns	low
Deep Open Water without Islands	22	19.3	7.9	prefer	
Deep Open Water with Islands or Polygonized Margins	90	78.9	5.8	prefer	

Table 6. Continued.

SEASON Habitat	No. of Nests or Broods	Use (%)[b]	Availability (%)	Monte Carlo Results[c]	Sample Size[d]
Shallow Open Water without Islands	0	0	1.2	ns	low
Shallow Open Water with Islands or Polygonized Margins	1	0.9	1.3	ns	low
River or Stream	1	0.9	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	7.1	avoid	
Riverine Complex	0	0	0.3	ns	low
Dune Complex	0	0	1.0	ns	low
Nonpatterned Wet Meadow	0	0	3.9	avoid	low
Patterned Wet Meadow	0	0	12.5	avoid	
Moist Sedge-Shrub Meadow	0	0	18.5	avoid	
Moist Tussock Tundra	0	0	27.8	avoid	
Tall, Low, or Dwarf Shrub	0	0	5.3	avoid	
Barrens	0	0	1.2	ns	low
Human Modified	0	0	0.1	ns	low
Total	114	100	100		

[a] 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.
[b] % use = (nests / total nests) × 100 or (broods / total broods) × 100.
[c] Significance calculated from 10,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.
[d] Low = expected number <5.

We have identified 84 territories in ABR's various survey areas in NE-NPRA (excluding the Fish Creek Delta subarea). Of those territories, 74 comprised a single lake used for both nesting and brood-rearing, 8 comprised 2 adjacent lakes, and 2 comprised 3 adjacent lakes. Lakes used by breeding Yellow-billed Loons averaged 78.4 ± 10.3 ha in size (range 0.39–694.6 ha, $n = 87$ lakes). Ten percent of the lakes used by breeding loons ($n = 87$ lakes) were <5 ha. All of those small lakes were used only for nesting, with pairs moving young into larger, adjacent lakes for brood-rearing. The majority of lakes were used for both nesting and brood-rearing; the smallest of those lakes was 6.0 ha.

GULLS

DISTRIBUTION AND ABUNDANCE

In the TMS loon survey area, 2 Glaucous Gull nests and 1 chick were observed on the 11 lakes surveyed during the aerial nesting and brood-rearing surveys for loons in 2020 (Figure 9). An additional 2 nests and 1 brood were recorded on wetlands adjacent to the survey lakes. A similar number of nests and broods have been observed in the TMS loon survey area since 2018.

In the Willow loon survey area, 50 Glaucous Gull nests were recorded on 40 waterbodies during the aerial survey for nesting loons in 2020, which is similar to the numbers found since 2018 (Figure 9, Table 7). Nearly 75% of the nests were individually nesting pairs whereas 25% were part of a colony. Three small colonies, each with 4 to 7

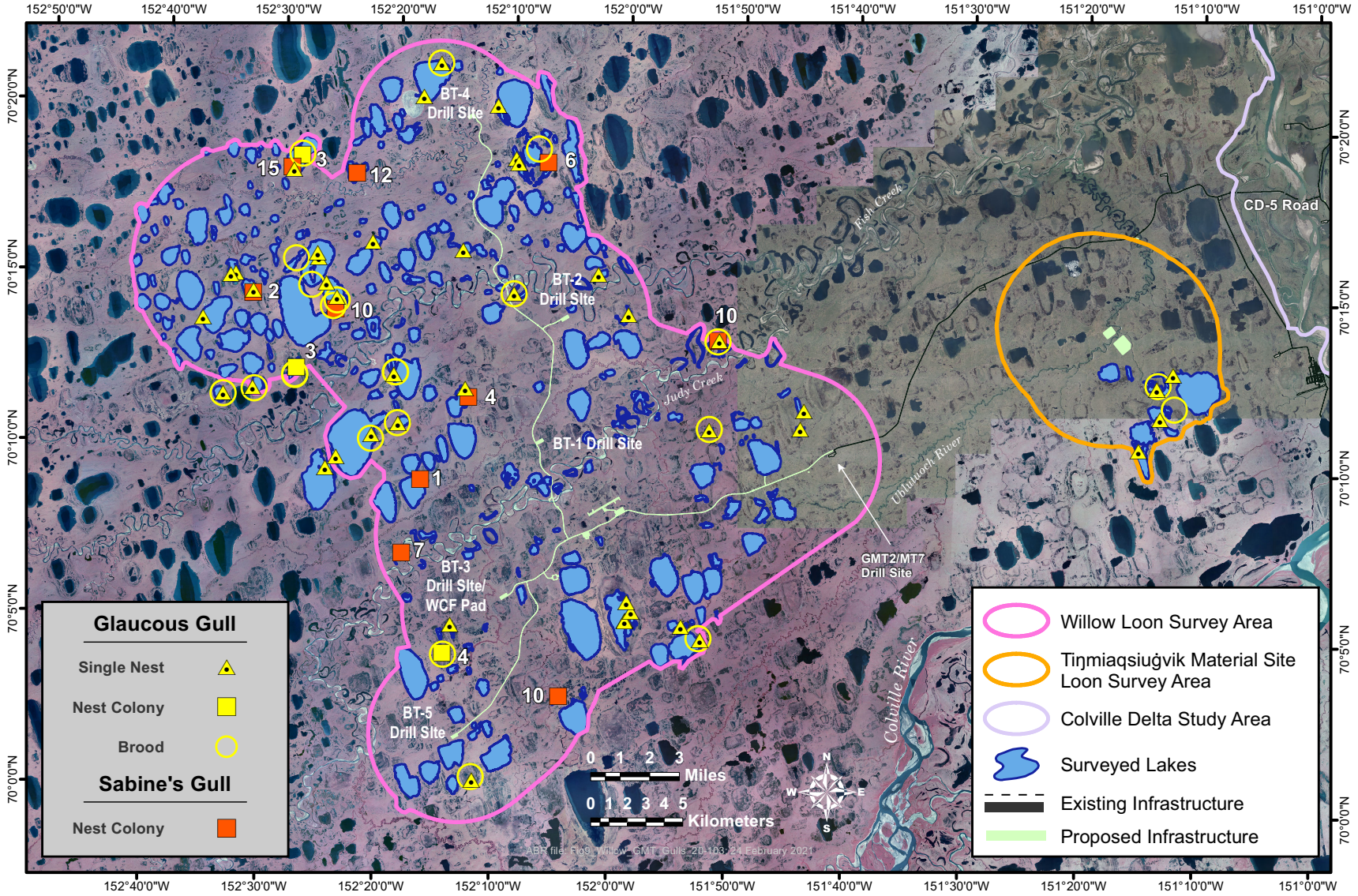

Figure 9. Glaucous and Sabine's gull nest locations and Glaucous Gull brood locations, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2020. Numbers at colony sites indicate the estimated number of nests in the colony.

Table 7. Number of Glaucous Gull nests and chicks recorded during aerial surveys for nesting loons in Willow loon survey area, NE NPR–A, 2017–2020.

	BT-5 North Colony		BT-2 West Colony		BT-4 West Colony		Study Area Total	
Year[a]	Nests	Chicks	Nests	Chicks	Nests	Chicks	Nests	Chicks
2017	2	2	–[b]	–[b]	–[b]	–[b]	11	5
2018	4	2	3	2	1	1	45	10
2019	4	8	3	0	4	0	46	26
2020	7	5	3	2	3	3	50	38

[a] The 2017 survey area (502 km^2) is included in the larger 2018–2020 survey area (851 km^2).
[b] Colony was outside of the survey area.

nests, have been found in the Willow Loon survey area: 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. Gulls nested at all 3 of the colonies in 2020.

A total of 38 Glaucous Gull chicks were recorded on 22 waterbodies during the survey for brood-rearing loons in 2020 (Figure 9, Table 7). All 3 colonies produced chicks but individually nesting pairs produced the majority of chicks (74%). The BT-5 colony is the largest colony and gulls at this colony produced 5 chicks.

We have identified 13 Sabine's Gull colonies in the Willow loon survey area. Of those, 10 contained nests during the aerial survey for nesting loons in 2020. Based on estimates of the number of gulls in flight and those seen on nests, a total of 74 nests were observed at 10 colonies. On average, colonies contained 7 ± 1.4 nests (range 1–15 nests).

HABITAT USE

Glaucous Gull nests were found in 6 different habitats in the TMS and Willow loon survey areas in 2020 (Table 8). The most commonly used habitats were Grass Marsh (28% of all nests), Shallow Open Water with Islands or Polygonized Margins (26% of all nests), Sedge Marsh (21% of all nests), and Deep Open Water with Islands or Polygonized Margins (18% of nests). The remaining nests were found on islands or shorelines in 2 other habitats and in unmapped areas.

Sabine's Gull colonies were found in 5 different habitats in the TMS and Willow loon survey areas (Table 8). The most commonly used habitat was Grass Marsh, which contained 4 colonies and over half (56%) of the nests. Nonpatterned Wet Meadow was the second most commonly used habitat and contained 1 colony with 10 nests.

DISCUSSION

The distribution and density of Yellow-billed Loon adults during the nesting survey shows that non-breeding adults (i.e., as indicated by territories with >2 adults or adult(s) on lakes with no history of breeding by loons) are concentrated in and near lakes that host breeding adults. Although the distribution of adults may differ during periods outside of the nesting survey, the concentration of non-breeding adults near territories supports the idea that Yellow-billed Loons may be habitat-limited during the breeding season, leading to competition over suitable lakes. The opportunity to take over a territory likely requires conspecifics (i.e., members of the same species) to remain close to occupied territories. Conspecifics have been observed intruding into occupied Yellow-billed Loon territories causing breeding adults to leave nests or chicks to evict the intruders (Johnson et al. 2012, 2013, 2014, 2015, 2016, Uher-Koch et al. 2019). In Common Loons, the rate of territorial intrusions by conspecifics is related to the presence of chicks during the previous breeding season. Territories that produce chicks experience a higher rate of territorial intrusions the following year than less productive territories (Piper et al. 2006). This relationship is less clear, however, in Yellow-billed Loons but small sample sizes may have limited the ability to detect a similar association (Uher-Koch et al. 2019).

Table 8. Habitat use by nesting Glaucous and Sabine's gulls recorded during aerial surveys for nesting loons in the Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2020.

	Glaucous Gull		Sabine's Gull[a]	
Habitat	Nests	Use (%)	Nests	Use (%)
Deep Open Water without Islands	1	2.6	–	–
Deep Open Water with Islands or Polygonized Margins	7	17.9	–	–
Shallow Open Water with Islands or Polygonized Margins	10	25.6	–	–
Sedge Marsh	8	20.5	1	2.1
Grass Marsh	11	28.2	27	56.3
Patterned Wet Meadow	–	–	10	20.8
Nonpatterned Wet Meadow	–	–	6	12.5
Moist Sedge-Shrub Meadow	2	5.1	4	8.3
Subtotal of Nests in Mapped Habitat	39	100	48	100
Subtotal of Nests in Unmapped Habitat	15		26	
Total	54		74	

[a] Only colonially nesting (≥ 3 nests) Sabine's Gulls were detectable on aerial surveys.

Within the NE NPR-A survey area, nesting density of Yellow-billed Loons is highest in lakes along the confluence of Fish and Judy creeks. These riverine lakes are often connected to the river during high-water events in the spring, which provides an influx of fish species into lakes (Jorgenson et al. 2003, Jason MacFarland, Owl Ridge Natural Resource Consultants, Inc., personal communication). Lake characteristics that promote persistent fish populations, such as connectivity to streams, are an important characteristic of Yellow-billed Loon breeding habitat in the NE NPR-A (Uher-Koch et al. 2020b, Earnst et al. 2006). Consistent access to forage fish in these lakes along Fish and Judy creeks may contribute to the high density of nests on lakes in this area.

The average annual density of Yellow-billed Loon chicks in the study area is low but reflective of this species' life history traits. Yellow-billed Loons are long-lived birds with low annual reproductive output. Adults likely reach breeding age around 3 years old but failure to acquire a territory may prevent them from breeding for several more years (Uher-Koch et al. 2020a). Adults have high survival rates and are capable of living for over 20 years (Uher-Koch et al. 2020a, Evers et al. 2020). Little is known about lifetime reproductive success in Yellow-billed Loons but Common Loon populations have been extensively studied (Grear et al. 2009, Piper et al. 2020). Assuming average productivity for 24 years, a Common Loon female will fledge approximately 12 chicks, only 4 of which will survive to maturity (Evers et al. 2020). If Yellow-billed Loons are similar, low annual densities of chicks can be expected and are reflective of a long-lived species that requires decades to achieve its lifetime reproductive success.

One of the main objectives of the Yellow-billed Loon surveys is to identify individual lakes used for breeding (e.g., nesting and/or brood-rearing). These data are required for species management under BLM's IAP (BLM 2020). Density maps, however, summarize mean annual distribution and are useful in displaying productivity at a landscape level. Within the Willow loon survey area, density of chicks is highest in northwestern Willow and southwest of the GMT2/MT7 drill site. High densities occur here in part because both areas have a high concentration of territories, including single lakes with multiple loon territories, in a fairly small area. The high density of chicks in those areas, however, could also be because we only have

3 years of data at those lakes and productivity was well above average during 2 of those years. Additional years of survey data will help determine whether those areas in Willow consistently contain high densities of chicks, even in years of low productivity.

Overall annual productivity can be measured by the number of chicks produced per nest, or fledging rate. Since surveys began in 2017, fledging rates of Yellow-billed Loons in the Willow survey area have ranged from 0.16 chicks/nest in 2018 to 0.77 chicks/nest in 2020, a nearly 4-fold difference between the lowest and highest year. The fledging rate is influenced by the relationships between nest occupancy, nesting success, brood survival, and brood size in August, all of which have varied in the Willow loon survey area. Low nest occupancy contributed to the 2 years with the lowest productivity (2017 and 2018). During both years, lakes retained a high percentage of ice cover well into mid-June, which is typically when most Yellow-billed Loons begin nesting (Johnson et al. 2018, 2019a, Shook et al. 2020). Delayed moat formation can delay or even preclude nesting by preventing access to lakes (North 1986, Johnson et al. 2011, Johnson et al. 2013). Although nest occupancy was similar, the fledging rate was much higher in 2017 than 2018 due to higher nesting success and higher proportion of pairs with 2 chicks. The years with the highest productivity (2019 and 2020) were characterized by above-average nest occupancy and nesting success and a high proportion of broods with 2 chicks (Shook et al. 2020). This high inter-annual variation in Yellow-billed Loon productivity underscores the importance of long-term monitoring in estimating average productivity rates.

The habitat selection analyses for nesting and brood-rearing Yellow-billed Loons highlights their affinity for deep lakes with complex shorelines. Deep Open Water with Islands or Polygonized Margins was used most frequently by nesting Yellow-billed Loons, which reflects the high use of small islands that are not only typical of those lakes but also too small to be mapped separately from the lake. Yellow-billed Loons also place nests on the shorelines of Deep Open Water without Islands and this habitat is a preferred habitat for rearing broods. Shoreline nests are assigned the terrestrial habitat along the lakeshore rather than to Deep Open Water without Islands which masks the use of lake types without islands by nesting Yellow-billed Loons.

Despite a clear preference for deep lake habitats, shallow Open Water with Islands or Polygonized Margins also was a preferred habitat for nesting; however, only ~4% 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 that was used for brood-rearing. 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. The preference of these habitat types demonstrates that Yellow-billed Loons are capable of using fairly small patches of suitable habitat for nesting and shallow lakes and as long as those occur near deep lakes that support fish for rearing broods.

The number of Glaucous Gull nests recorded annually in the Willow loon survey since 2018 has been fairly consistent. Glaucous Gulls are highly philopatric to nest sites (Weiser and Gilchrist 2020). We have observed gulls breeding annually on the same lakes and wetlands in the Willow Project area. The number of Glaucous Gull nests on the Colville River delta has grown 4% annually since 2005 (Parrett et al. 2021). Gulls are the most-frequent predator of Yellow-billed Loon eggs in both the Colville River delta and NE NPR-A study areas and only take eggs from unattended loon nests (Johnson et al. 2015). Monitoring trends in gull numbers may help understand the predation risk to Yellow-billed Loon nests, especially when loons are away from their nests. Our survey areas in NE NPR-A have varied since surveys began there in 2001, which limits our ability to conduct population trend analyses; however, we have 3 years of gull survey data in the Willow loon survey area. Additional years of consistent data collection in this area will allow us to investigate trends in the numbers of Glaucous Gull nests.

Although the number of Glaucous Gull chicks recorded annually in the Willow loon survey area

has steadily increased since 2018, comparisons of productivity based on the number of gull chicks seen during mid-August is difficult. Nest initiation, or when gulls begin building nests and laying eggs, is highly dependent on spring phenology (Weiser and Gilchrist 2020). The loon brood survey occurs close to when young gulls fledge and flight-capable chicks may move away from survey lakes by that time. Small differences in nesting timing among years likely influences the proportion of flight-capable chicks present during the mid-August loon surveys, causing differences in detectability of gull chicks among years. Regardless, the number of chicks counted during 2020 suggests that Glaucous Gulls were highly productive.

Sabine's Gulls are not a major egg predator and primarily feed on insects, crustaceans, and small fish (Day et al. 2020). We report on Sabine's Gulls because we are able to monitor colonies during the aerial loon surveys without extra effort. 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). Sabine's Gull populations are thought to be globally stable, but few data exist from their breeding grounds (Day et al. 2020).

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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 2017–2020.

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	0.08	0.03 (0.04)	0.12	0.02 (0.02)
2020	0.11	0.04 (0.04)	0.10	0.02 (0.03)
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 (2017–2020) that did not survive to the time of the brood-rearing survey.

[c] Willow loon survey area was 502.3 km² in 2017 and 851.2 km² in 2018–2020.

[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 km².

Appendix B. 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, 2017–2020. Densities were not calculated because surveys did not include smaller lakes (<5 ha) where those species commonly nest.

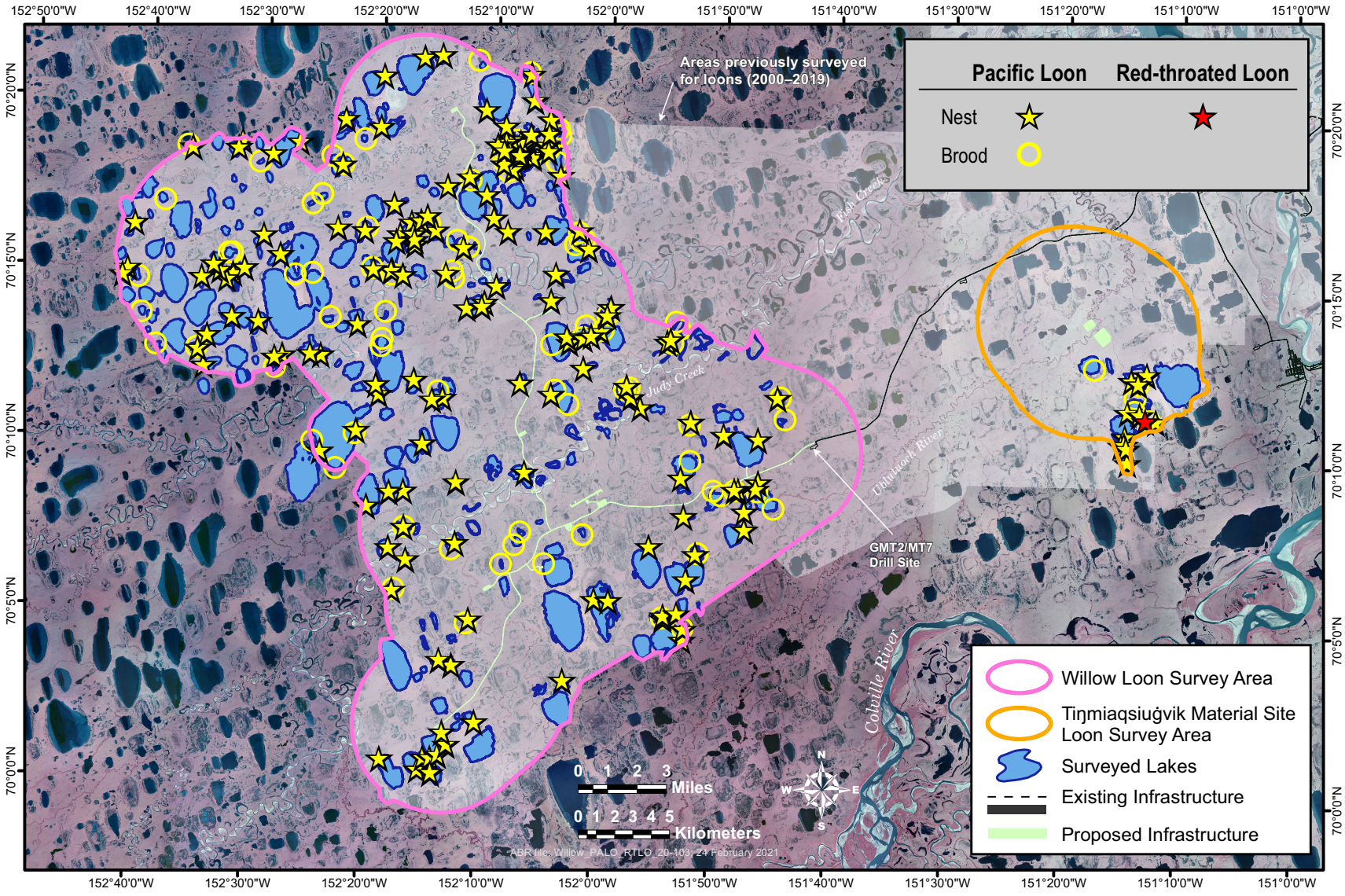
SPECIES	Survey Area[a]			
	Willow		TMS[b]	
Observation Type	Nesting	Brood-rearing	Nesting	Brood-rearing
PACIFIC LOON				
Adults				
2017	251	299	–	–
2018	670	753	29	30
2019	698	711	25	22
2020	705	612	35	33
Nests/Broods				
2017	50	39	–	–
2018	117	39	3	5
2019	131	105	7	8
2020	157	83	9	5
Young				
2017	–	48	–	–
2018	–	44	–	6
2019	–	140	–	11
2020	–	101	–	7
RED-THROATED LOON				
Adults				
2017	1	0	–	–
2018	1	3	0	0
2019	4	8[c]	0	0
2020	4[d]	1	0	0
Nests/Broods				
2017	0	0	–	–
2018	0	2	0	0
2019	0	0[c]	0	0
2020	0	0	0	0
Young				
2017	–	0	–	–
2018	–	3	–	0
2019	–	0[c]	–	0
2020	–	0	–	

[a] TMS loon survey area = 113.9 km²; Although all lakes were surveyed in 2018, only 11 of the 30 lakes in the survey area are included in totals because of the reduction in survey effort beginning in 2019; Willow loon survey area = 502.3 km² in 2017 and 851.2 km² in 2018–2020.

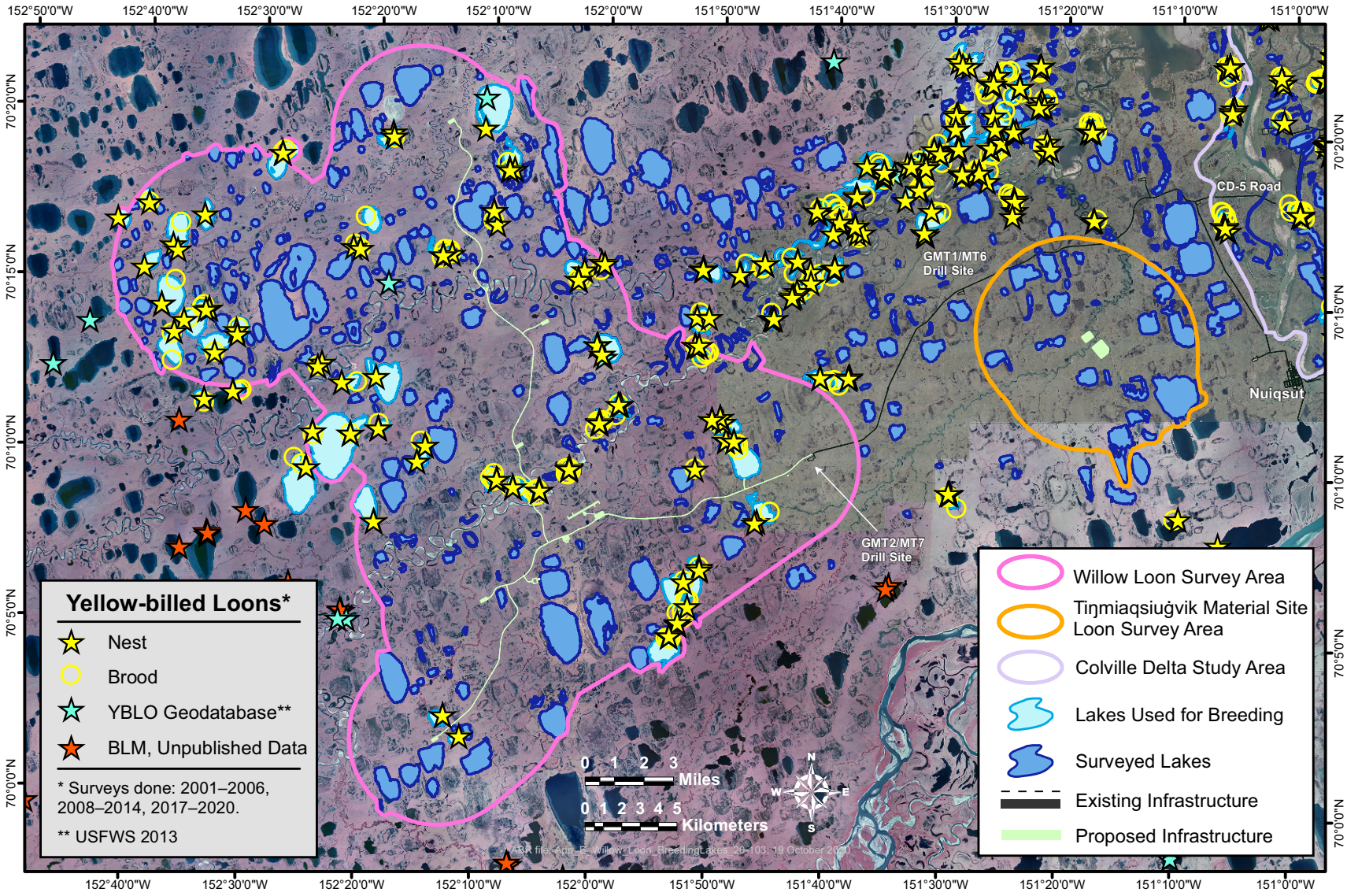
[b] The TMS loon survey area was not surveyed during 2017.

[c] An additional brood with 1 adult and 1 young was seen outside the Willow loon survey area.

[d] An additional adult was seen outside the Willow loon survey area.



Appendix C. Pacific and Red-throated loon nest locations and Pacific Loon brood locations, Willow and Tiŋmiaqsiuġvik Material Site loon survey areas, NE NPR-A, 2020.



Appendix D. 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, 2017–2020.