Nesting Greater White-fronted Goose Study at CD-5, 2015

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Anchorage, Alaska

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Anadarko Petroleum Corporation
Anchorage, Alaska

Prepared by
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Fairbanks, Alaska

NESTING GREATER WHITE-FRONTED GOOSE STUDY AT CD-5, 2015

FINAL REPORT

Prepared for

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INTRODUCTION

The first oil development in the Northeast Planning Area of the National Petroleum Reserve in Alaska (NE NPR-A) was constructed during 2014 and 2015 by ConocoPhillips Alaska, Inc., (CPAI) as part of the Alpine Satellites Development Project (BLM 2004). The new development, named CD-5, consists of an all-season gravel road and pipeline connected to the Alpine Facility on the Colville River delta, where oil will be processed. Wildlife surveys for selected birds and mammals in the Colville River delta and NE NPR-A have been conducted since 1992 in support of the Alpine Satellite Development Project (ASDP). For a review of previous studies conducted in the area see Johnson et al. (2015).

Niġlivik, the Iñupiaq name for Greater White Fronted Goose (*Anser albifrons*), is a major subsistence species for local Iñupiaq people. At the request of the North Slope Borough, CPAI is conducting a multi-year study of Greater White-fronted Geese (henceforth, White-fronted Geese) out of concern for potential development effects. ABR, Inc. (ABR) was contracted in 2013 to conduct this study. The pre–post construction study design for CD-5, approved by the North Slope Borough, includes collection of nesting data during 1 year of the pre-construction period (2013), during 2 years of the construction period (2014 and 2015), and during 2 years of the operation period (2017 and 2020). The goal of the study is to evaluate the effects of the 3 phases of development on the abundance, distribution, and nesting success of White-fronted Geese nesting in the CD-5 area.

In this report, we present the 2015 results of the White-fronted Goose nesting study at CD-5 with brief comparisons of results from 2013 and 2014. Required state and federal permits were obtained for all survey activities, including a Scientific or Educational Permit (Permit No. 15-146) from the State of Alaska and a Federal Fish and Wildlife Permit—Native Threatened Species Recovery–Threatened Wildlife; Migratory Birds (Permit No. TE012155-4 issued under Section 10(a)(1)(A) of the Endangered Species Act [58 FR 27474-27480]).

STUDY AREA

The CD-5 drill pad (0.04 km²) is located approximately 7 km west of the Niġliq Channel in the NE NPR-A (Figure 1). An all-season road (9.6 km long and with a 0.23 km² footprint) and 4 bridges connect CD-5 to the CD-4 road on the Colville River delta. Construction of the CD-5 pad, all-season road, and bridges began in 2014 and, along with the pipeline, was completed in 2015. The Nuiqsut Spur Road (9.3 km, 0.16 km²) was constructed in 2014 and completed in 2015 by the Kuukpik Corporation from Nuiqsut to the CD-5 road, but it was open primarily to construction equipment during summer 2015. A laydown pad (0.04 km²) also was built in 2014 at the intersection of the CD-5 and Spur roads.

Landforms, vegetation, and wildlife habitats in the NE NPR-A study area were described in the Environmental Impact Statement for the lease area and the ASDP (BLM 2004) and in Jorgenson et al. (2003, 2004). Coastal plain and riverine landforms dominate the NE NPR-A study area. On the coastal plain, lacustrine processes, basin drainage, and ice aggradation are the primary geomorphic factors that modify the landscape. In riverine areas along Fish and Judy creeks, fluvial processes predominate, although eolian and ice-aggradation processes also contribute to ecological development (Jorgenson et al. 2003).

Sixteen wildlife habitats occur on the 10 ha plots searched for nests. The most abundant wildlife habitats were Patterned Wet Meadow (28%), Moist Sedge-Shrub Meadow (25%), Old Basin Wetland Complex (23%), and Moist Tussock Tundra (13%). Only 2 other habitats had >1% coverage: Shallow Open Water with Islands or Polygonized Margins (5%) and Sedge Marsh (2%).

METHODS

NEST PLOT SELECTION

We established 40 permanently fixed plots in 2013 to be searched for White-fronted Goose nests in each of the 5 years of the study (Figure 1). We randomly selected plot locations from a 6 × 6 km grid centered on the CD-5 drill site. The grid contained 3,600 points spaced 100 m apart, of which 60 points were randomly selected. Each point was used to locate the start of a 100 m × 1,000 m (10 ha or 0.1 km²) plot, oriented parallel to the nearest proposed road or pad. Plots were discarded if they overlapped a previously selected plot or had more than 25% of area in lakes. During

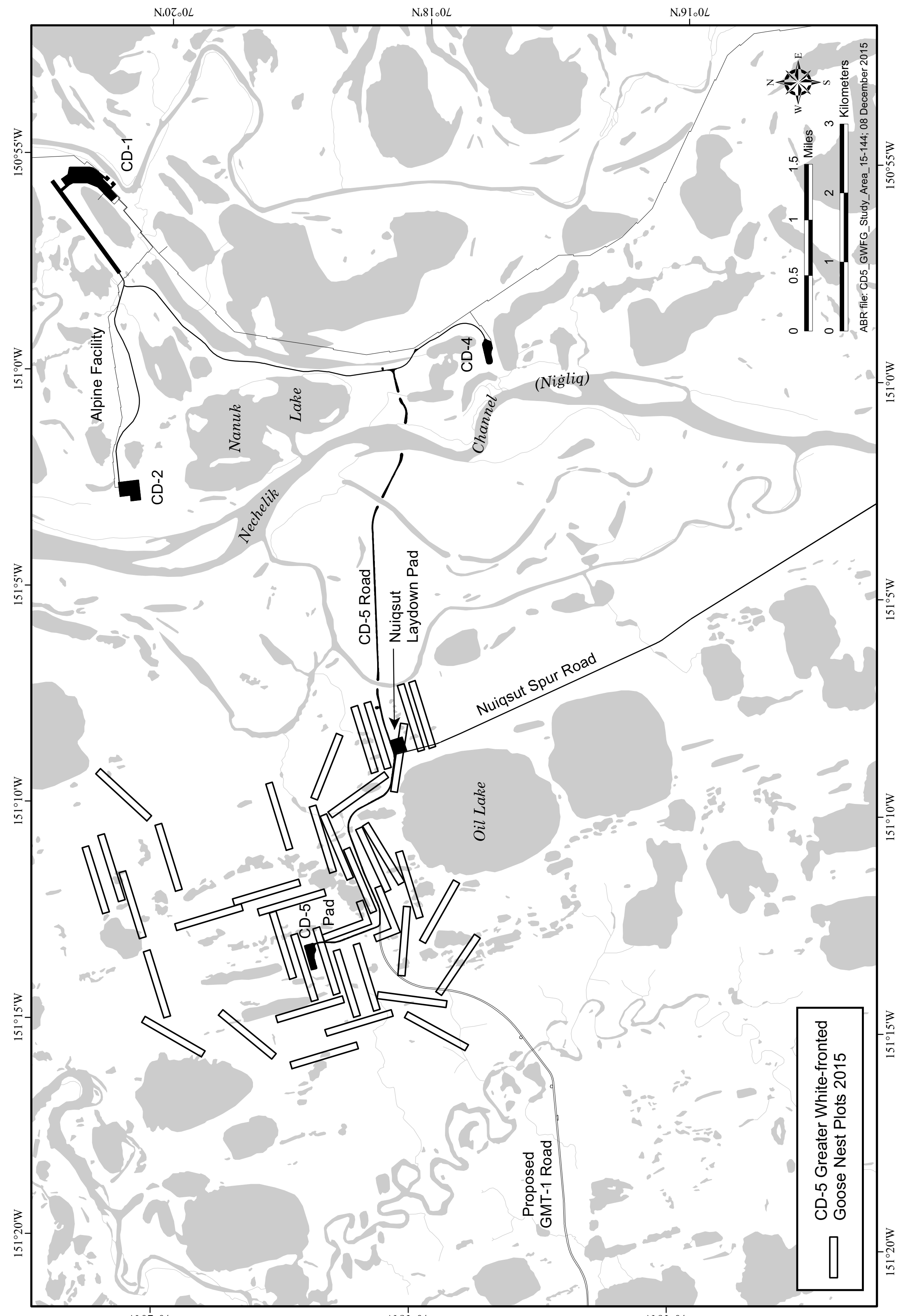

Figure 1. Forty plot locations (10-ha plots) for ground-based surveys of nesting Greater White-fronted Geese at CD-5, NE NPR-A study area, Alaska, 2013–2015.

nest searches, we completed a cluster of 1–5 plots each day, all within walking distance (<2 km from the end of one to the start of another). Each successive day we alternated between clusters of plots that were near the proposed facility locations and those that were far from facility locations. Plots were searched in the same order each year within a 10-day period, to avoid introducing a timing effect that might influence annual comparisons among plots. Unless stated otherwise, means are presented with standard errors (mean ± SE).

NEST SEARCHING

In 2015, we conducted the second of 2 construction-period nest searches of plots for White-fronted Geese. This was also the first year the CD-5 road and pad were actively used during the breeding season. Methods were the same as those in 2013 and 2014 (Johnson et al. 2014, 2015). Nests of other large waterbirds were recorded as they were encountered. We conducted 1 complete nest search covering 3.97 km² in 40 plots during 8–17 June, commuting by truck or by helicopter from Alpine each day. The total nest searching area in 2014 and 2015 was 0.03 km² smaller than in 2013 due to the Nuiqsut Spur Road and Nuiqsut Laydown Pad, which intersected several study plots (Figure 1). A crew of 4 people spaced 20 m apart searched for nests by walking a zigzag pattern, to achieve total coverage of the tundra within each plot's boundaries. Plot boundaries were displayed on a moving map on handheld GPS units. Crew members searched for nests of large birds including Bar-tailed Godwits, waterfowl, ptarmigan, and larids (gulls, terns, and jaegers); all other shorebird and songbird nests were not recorded. Nest searchers communicated with hand-held radios when nests other than of White-fronted Geese were spotted, to avoid flushing incubating birds. For each nest found, we recorded the species, location (GPS coordinates in WGS 84), status (defined below), distance to nearest water (ephemeral or permanent water), distance to nearest waterbody (permanent water ≥0.25 ha in area), waterbody class, whether or not the bird flushed, the distance at which it flushed, the number of eggs, and the float angle of eggs for nests that were unoccupied or where the incubating bird flushed. Nest status was recorded as active (nest attended or eggs were warm), or inactive (unattended and without eggs). We floated 1–3 eggs in a small clear container of water (Westerkov 1950, Mabee et al. 2006) from all nests of White-fronted Geese (intentionally flushed) and Cackling/Canada Geese (only those inadvertently flushed) and recorded the float angle and position to estimate age of eggs and incubation start dates (see NESTING SUCCESS below for details). Nest data were recorded on a GPS and downloaded to a database at the end of the day.

Unattended nests were identified to species or species group based on the size and color pattern of contour feathers, down, or eggs in the nest (Anderson and Cooper 1994, Bowman 2004). Some nests were unidentified because too few feathers were in the nest or feathers were not clearly definitive in determining species. Wooden survey stakes (45 cm high) were placed ≥15 m from active nest sites to assist in relocating the nest. Before we departed from waterfowl nests where the incubating bird was absent, eggs were covered with nest material and additional vegetation to conceal the nest from predators.

TEMPERATURE-SENSING EGGS

Artificial temperature-sensing eggs and data loggers were installed in 43 White-fronted Goose nests to record incubation activity and data on daily nest survival using the same methods as in 2014. The eggs were constructed from plastic "Easter" eggs that were painted white. The thermistor (TMC1-HD, TMC6-HD, and TMC6-HA cables; Onset Computer Corporation, Bourne, MA) consisted of a 2.5 cm temperature sensor taped to the inside of each egg. The thermistor cable (connected to the temperature sensor) exited the temperature-sensing egg where the egg was attached to a 15 cm threaded toggle-bolt (sheetrock wall anchor). The thermistor cable was connected to a small data logger (HOBO® models H8-002-02, U12-006, and U12-013, Onset Computer Corporation, Bourne, MA) external to the egg. Loggers were programmed to record nest temperature every 5 minutes. One thermistor was attached to a nest stake at ground level to record ambient temperatures every 15 minutes.

All eggs were removed from nests before installing temperature sensors. The thermistor cable was hidden in a shallow trench (2–3 cm deep) leading to the data logger, which was sealed in a waterproof bag and buried 3–5 cm under the vegetation mat. To prevent the removal of equipment by geese or nest predators, the toggle-bolt on the temperature-sensing egg was pressed into a hole in the center of the nest bowl so that the wings of the bolt could act as barbs and hinder removal. After installation, the eggs were returned to the nest and covered with down and vegetation. After the nesting season, artificial eggs and data loggers were retrieved and the temperature data were exported using BoxCar Pro version 4.0.7.0 or HOBOware version 3.7.1, depending on the model of the data logger used.

Classifications of incubation activity were made using temperature data collected from the artificial eggs, applying rules of interpretation developed for White-fronted Geese in a previous multi-year study, which used time-lapse cameras in conjunction with temperature sensing eggs (Johnson et al. 2003). Incubation classification was based on the minimum egg temperature during incubation (28.3° C) and on the temperature changes between 2 consecutive 5 minute recording intervals. See Johnson et al. (2015) for detailed methods of temperature interpretation and calculation of incubation activity.

NESTING SUCCESS

We revisited all nests on 6–9 July to determine nest fates. A nest was considered successful if evidence suggested that at least 1 egg hatched. Hatch was determined by the presence at the nest of detached egg membranes, eggshells with thickened membranes that peeled easily from the shell, eggshell pipping fragments (less than 5 mm), and eggshell tops or bottoms. The presence of yolk, blood, eggshells with holes, egg fragments with attached membranes, or the total absence of egg remains was recorded as nest failure. Any evidence of predation (fox scent, fox scat, or a disturbed nest site) was recorded.

Temperature data from nests with installed thermistors also were reviewed for indications of hatch or failure. Temperature records during hatch showed a long period of nest attendance followed by an increasing frequency of breaks 24–36 h before the female and brood left the nest (Johnson et al. 2003). The increase in break frequency is apparent in the graph of nest temperature against time as a gradual cooling of the nest temperature. The female and brood were judged to have departed the nest when 5 consecutive records had an average nest temperature <9° C, or when temperature appeared to track ambient temperatures. After brood departure, nest temperature cycles with ambient temperature. In contrast, temperatures from failed nests usually drop more abruptly before tracking ambient temperatures. The hatch date of a nest was recorded as the day before the female and brood departed the nest.

Apparent nesting success was estimated by dividing the number of nests that hatched by the number of nests found, including nests that were inactive at discovery. Apparent nesting success is generally acknowledged to overestimate success because it does not take into the account the length of time nests are exposed to predators and other risk factors (Mayfield 1961). We report apparent nesting success for all nests found, because it is easily calculated for large numbers of nests without the added disturbance or expense of periodic visits or monitoring devices. We also calculated nesting success for the sample of nests containing temperature sensing eggs with daily survival rates (DSR). DSR can be used to calculate unbiased estimates of nesting success, but they require periodic monitoring of nests to determine status. DSRs were estimated in program MARK (White and Burnham 1999), which we used to examine competing models with covariates of year, nest age, and date using Akaike Information Criteria corrected for finite sample size (AIC_c). We constructed 6 models: constant (assuming non-varying DSR), year, age, date, year + age, and year + date.

Nesting success over the incubation period was calculated by raising the DSR to the exponent of the number of days of incubation. The incubation period for White-fronted Geese on the North Slope of Alaska is reported to be 22–27 d (Ely and Dzubin 1994). We used 24 d for the incubation period for White-fronted Geese, which was the modal incubation length for nests at CD-5 in 2015. We estimated incubation start dates and nest initiation dates for White-fronted Geese and

Canada Geese using egg-flotation data or back-dating in the case of nests with known hatch dates. Each floated egg was assigned an age from a float schedule based on the angle and position of the egg in the water column (Jerry Hupp, USGS, unpublished data). The float schedule provided estimates of ages in 2–4 d increments; we used the midpoint of the age range or the earlier date in the case of 2 d ranges. We used the youngest (last-laid) egg sampled in each nest to arrive at the start date for incubation. The date of nest initiation was calculated by multiplying the clutch size by the estimated laying interval (1.33 d/egg; Ely and Dzubin 1994, Mowbray et al. 2002, Burgess et al. 2013) and backdating from the incubation start date.

PREDATOR SCANS

We conducted predator scans visually on all of our plots to determine the types and numbers of potential nest predators in the CD-5 area. Binoculars were used to search for avian predators (i.e., jaegers, gulls, raptors, ravens, and owls) and mammalian predators (i.e., foxes and bears) during each scan. On each plot, we conducted 2 scans of 10 min each for predators within plot boundaries and ≤300 m outside plot boundaries. Predator scans were conducted on the center line of each plot at the beginning and again at the end of the nest-search effort (1 km apart): 10 min before the start and 10 min after the end of the nest-searching effort for each plot. Level of predator activity in the area was represented by the number of predator observations per 10 min scan. Observations of predators seen incidentally during nest searches also were recorded.

HABITAT MAPPING AND ANALYSIS

A wildlife habitat was assigned to each observation of a nest by plotting its coordinates on the wildlife habitat map. For each bird species, habitat use (% of all nests in each identified habitat type) was determined. We also calculated habitat availability as the percent of each habitat in the total area on the 40 plots.

We conducted a statistical analysis of habitat selection of White-fronted Goose nests to evaluate whether habitats were used in proportion to their availability. We combined 3 years of nest search data in the analysis of habitat selection. We inferred selection (preference or avoidance) from comparisons of observed habitat use with random habitat use by means of Monte Carlo simulations (1,000 iterations). We defined habitat preference (i.e., use > availability) as observed habitat use greater than the 95% confidence interval of simulated random use. 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 with Microsoft® Excel. More complete details are provided by Johnson et al. (2015).

DATA MANAGEMENT

All data collected during nest searches were compiled into a centralized database following CPAI's data management protocols (version 9.3, CPAI 2015). Locations of nests were recorded on a GPS receiver with decimal-degree coordinates in the WGS 84 map datum and later transferred into the NAD 83 map datum. Uniform attribute data were recorded for all observations and proofed after data collection and proofed again during data entry. Survey data were submitted in GIS-ready format with corresponding metadata.

RESULTS AND DISCUSSION

SEASONAL CONDITIONS IN THE STUDY AREAS

Birds arriving to the North Slope during mid- to late-May 2015 experienced unseasonably warm temperatures and a few days of extreme flood conditions along major rivers. On 18 May, melt water from the Brooks Range reached the head of the Colville River delta (Monument 1) at the same time high temperatures across the delta were causing local snow melt. The highest peak water level recorded at Monument 1 (7.15 m above sea level) was recorded on 21 May, 10 days earlier than the average date for peak level. Peak discharge at Monument 1 occurred on 22 May and was the fourth highest in 19 years of records (Michael Baker Jr. 2015). Ice jams on the Niġliq Channel near the village of Nuiqsut and on the East Channel near the Tamayayak Channel resulted in flooding around the Alpine CD-2 and CD-4 roads. Areas west of the Colville River, such as the area around the CD-5 drill pad were relatively unaffected by river flooding, although snow melt may have caused some isolated local high water.

The period of peak nest initiation for waterfowl (15 May–15 June), had warmer than average temperatures in 2015. Eighty-six cumulative thawing degree-days were measured at Colville Village, well above the long-term mean of 40 cumulative thawing degree-days (SE = 8 thawing degree-days, n = 19 years [see Figure 2 in Johnson et al. 2016]). The mean temperature in May (–1.4° C) was almost 4° C warmer than the 19-year mean (–5.3 ± 0.6° C), as was the mean temperature in June (7.6° C compared to the 19-year mean = 3.8 ± 0.4° C). Daily mean temperatures at Alpine (24 km southwest of Colville Village) averaged 1.8° C warmer than at Colville Village on the outer delta, indicating an earlier thaw in the CD-5 area.

Snow depth in the spring of 2015 was fairly typical but snow cover at the station near CD-5 was gone earlier than usual. On 15 May, snow depth was 30 cm at Colville Village compared to the 19-year average of 24 ± 2 cm. At both locations, snow had disappeared by 20 May, 12 days earlier than the long-term average (2 June ± 1 d).

Warm weather in June promoted early emergence of midges and mosquitos. In most years, mosquitoes have not emerged in great numbers before late June or early July. In 2015, average daily temperatures reached 10° C before mid-June, and by 20 June mosquitoes were more abundant in the CD-5 area than in previous years of this study.

DISTRIBUTION AND ABUNDANCE

Three species of geese nested on the 40 10-ha plots in the CD-5 area in 2015, and their combined nests accounted for 93% of all nests recorded (Figure 2, Table 1). White-fronted Geese were the most abundant nesting waterfowl in 2015 (30.2 nests/km²) with nesting densities that have increased annually through our study (21.8 nests/km² in 2013, 28.7 nests/km² in 2014). In 2015, Cackling/ Canada Geese were second in abundance (5.5 nests/km²), and Brant had only 1 nest though not on a plot). White-fronted and Cackling/Canada Goose nests were widely distributed among the plots. The mean number of White-fronted Goose nests found was 3.0 ± 0.27 nests/plot (Table 2). We found the greatest number of White-fronted Goose nests on plots 20 (7 nests) and 49 (6 nests). Three plots contained no White-fronted Goose nests.

HABITAT USE

White-fronted Geese nested in 6 habitats, though 84% of these nests were in just 3 habitats: Old Basin Wetland Complex, Patterned Wet Meadow, and Moist Sedge-Shrub Meadow (Figure 3, Table 3). White-fronted Goose nests were the only nests for which sample size was adequate to test for habitat selection. A Monte Carlo analysis of habitat selection using 321 White-fronted Goose nests from 3 years of this study found nesting White-fronted Geese used all habitats in proportion to availability except for Shallow Open Water with Islands or Polygonized Margins, which they avoided. No habitats were preferred by White-fronted Geese (Table 4). Cackling/Canada Geese nested in 4 habitats, with most nests located in in the wetter habitats near waterbodies (Figure 3, Table 3).

NEST INITIATION AND INCUBATION

We floated eggs from 150 White-fronted Goose nests and 11 Cackling/Canada Goose nests in 2015 to estimate nest age and the start of incubation. By the time nest searching began on 8 June, we estimate 99% of the White-fronted Geese had initiated incubation. The median start date of incubation for White-fronted Geese in 2015 was 3 June (range 27 May–11 June, n = 150 nests), 6 d earlier than in 2014 and 11 d earlier than 2013 (Figure 4). Most incubation was initiated 3–7 June 2015, with 51% of all nest incubation beginning between these dates (Figure 4). The median date of nest initiation (first egg laid) for White-fronted Geese in 2015 was 30 May (range 20 May–9 June, n = 150 nests). Mean clutch size for nests with complete clutches (eggs >3 d old) was 4.0 eggs (±0.14, n = 148 nests), an increase from the means in 2013 (3.8 ± 0.18 eggs/nest, n =55 nests) and 2014 (3.8 ± 0.17 eggs/nest, n = 88 nests).

The median incubation start date for Cackling/Canada Geese was 1 June (range 27 May–9 June, n = 11 nests), 2 days earlier than for Greater White-fronted Geese. Mean clutch size for nests with complete clutches was 5.0 eggs (SE =

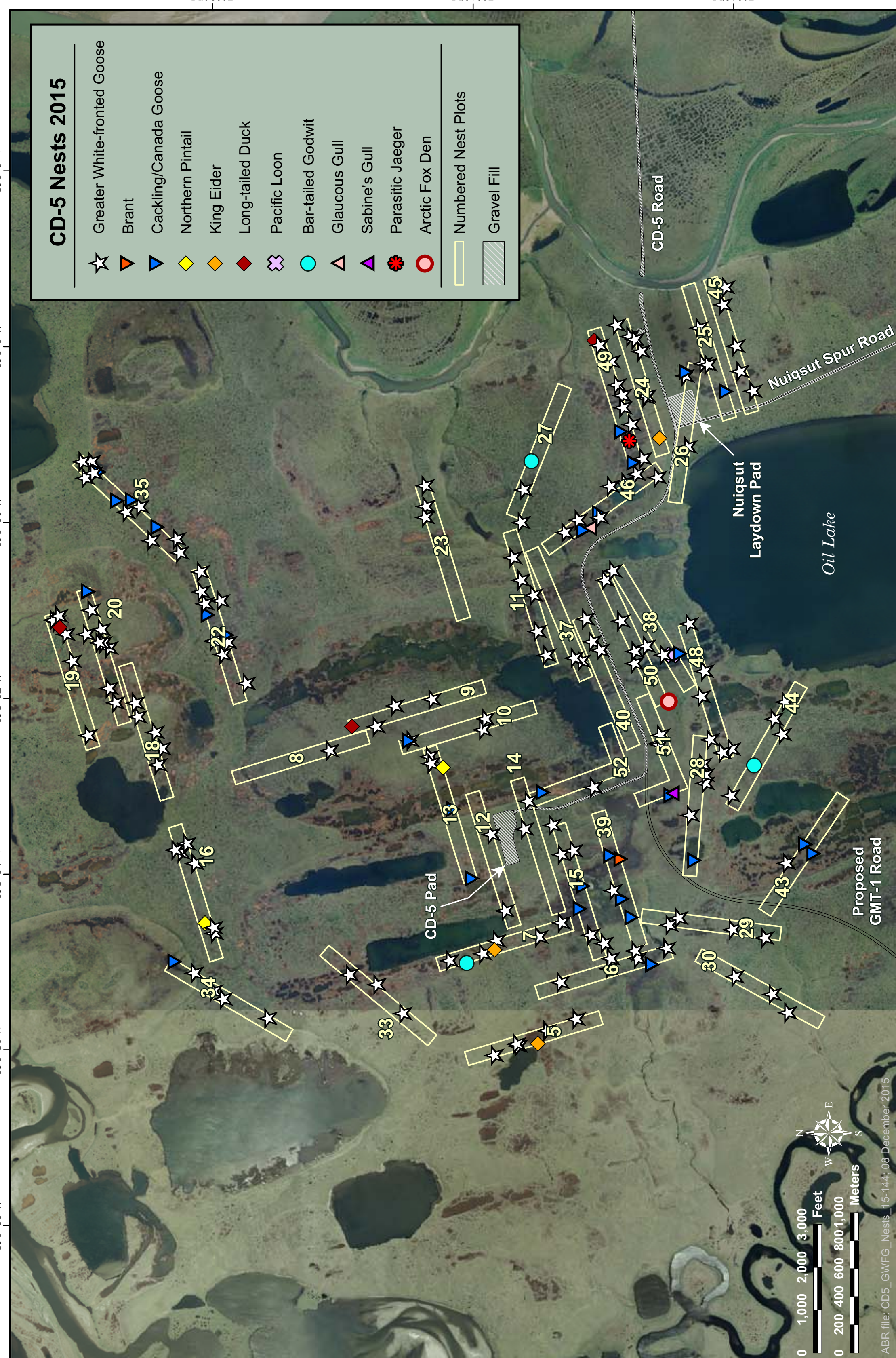

Figure 2. Nest locations of Greater White-fronted Geese and other species on nest plots at CD-5, NE NPR-A, Alaska, 2015.

Table 1. Number and density of nests and apparent nesting success for birds at CD-5, NE NPR-A, Alaska, 2015.

	Nests on Plot		All Nests[a]				
Species	Total	Density (nests/km²)[b]	Total	Successful	Failed	Unknown	Apparent Nesting Success (%)[c]
Greater White-fronted Goose	120	30.2	162	135	27	–	83
Brant	–	–	1	1	–	–	100
Cackling/Canada Goose[d]	22	5.5	29	21	5	3	81
Northern Pintail	2	0.5	2		2	–	0
King Eider	3	0.8	3	1	2	–	33
Long-tailed Duck	3	0.8	3	1	1	1	50
Pacific Loon	1	0.3	1	1	–	–	100
Bar-tailed Godwit	3	0.8	3	1	–	2	100
Sabine's Gull	1	0.3	1	–	–	1	–
Glaucous Gull	–	–	1	1	–	–	100
Parasitic Jaeger	1	0.3	1	–	–	1	–
Total	154	38.8	207	162	37	8	

[a] Includes nests located outside plot boundaries
[b] Density calculations based on 3.97 km² search area
[c] Apparent nesting success = no. nests successful/(no. successful + no. failed) × 100; successful nests hatched ≥1 egg
[d] Nest belonging to either Cackling or Canada goose

0.55, *n* = 11 nests). The dates of nest initiation for Cackling/Canada Geese ranged from 20 May to 27 May, and the median date was 25 May (*n* = 11 nests).

TEMPERATURE-SENSING EGGS

Of the 43 thermistors installed in White-fronted Goose nests, 40 produced temperature data that could be used to quantify incubation behaviors (Tables 5 and 6). Thirty-seven nests were monitored to day of hatch and brood departure and 5 nests were monitored to day of failure. Only 3 data-loggers failed to provide useful data. One data-logger had a thermistor cord that became disconnected during setup, and 2 thermistors recorded a normal temperature pattern except for a regular occurrence of spikes in temperature, which may be the result of condensation in the data-logger (Tim Cater, ABR, personal communication). In 2015, no data loggers were lost to predators. A total of 38 nests instrumented with thermistors were successful (88% apparent nesting success) and 5 nests failed.

INCUBATION BEHAVIOR

Excluding the days of instrumentation, hatch, and failure, temperature-sensing eggs monitored nest temperature in 36 successful nests for 3–23 d (mean = 11.1 ± 0.5 d) and in 5 failed nests for 3–12 d (mean = 9.8 ± 1.7 d). When egg thermistors were deployed in White-fronted Goose nests, the incubating birds were flushed from their nests, and the length of time females at successful nests took to return to incubate after installing an egg thermistor averaged 85 ± 6.4 min (range 35–205 min, *n* = 18 nests; Table 5). Females from nests that later failed took slightly longer to return to nests after instrumentation (mean = 94 ± 3.3 min, range 85–105 min, *n* = 5 nests; Table 6). However, nesting success does not appear to be related to the time required to resume incubation. In 2014, successful nesters took almost twice as long to return to nests (mean = 152.8 ± 31.6 min, *n* = 18 nests) as did failed nesters (mean = 80 ± 13.8 min, *n* = 7 nests; Johnson et al. 2015). Incubation constancy for all nests was high in 2015, with females spending 99.3 ± 0.2% (*n* = 35 nests) of the time incubating at hatched nests and 99.1 ± 0.5%

Table 2. Number of nests and apparent nesting success of Greater White-fronted Geese by nest plot at CD-5, NE NPR-A, Alaska, 2015.

	Number of Nests			
Plot	Total	Successful	Failed	Apparent Nesting Success (%)[a]
5	5	4	1	80
6	4	4	0	100
7	5	5	0	100
8	1	1	0	100
9	2	2	0	100
10	3	2	1	67
11	5	3	2	60
12	2	2	0	100
13	2	0	2	0
14	1	1	0	100
15	3	3	0	100
16	4	2	2	50
18	3	3	0	100
19	5	4	1	80
20	7	4	3	57
22	5	4	1	80
23	2	1	1	50
24	4	4	0	100
25	2	2	0	100
26	1	1	0	100
27	1	1	0	100
28	3	3	0	100
29	4	3	1	75
30	2	2	0	100
33	3	2	1	67
34	4	4	0	100
35	4	4	0	100
37	2	2	0	100
38	1	1	0	100
39	0	0	0	–
40	3	2	1	67
43	0	0	0	–
44	2	2	0	100
45	4	3	1	75
46	4	3	1	75
48	5	3	2	60
49	6	6	0	100
50	3	3	0	100
51	3	3	0	100
52	0	0	0	–
Total	120	99	21	
Mean	3.0			85
SE	0.27			4
n (plots)	40			37

[a] Apparent nesting success = no. nests successful/(no. successful + no. failed) × 100; successful nests hatched ≥1 egg

Table 3. Habitat use (%) by nesting birds on nest plots at CD-5, NE NPR-A, Alaska, 2015.

Habitat	Greater White-fronted Goose[a]	Cackling/Canada Goose[b]	Northern Pintail	King Eider[a]	Long-tailed Duck	Pacific Loon	Bar-tailed Godwit	Sabine's Gull	Parasitic Jaeger	Total Nests	Habitat Use (%)
Shallow Open Water without Islands	0	0	0	0	0	100	0	0	0	1	1
Shallow Open Water with Islands or Polygonized Margins	1	14	0	0	0	0	0	100	0	5	3
Sedge Marsh	2	9	0	0	0	0	0	0	0	4	3
Old Basin Wetland Complex	22	59	0	67	0	0	33	0	100	43	27
Patterned Wet Meadow	31	18	50	0	0	0	67	0	0	45	29
Moist Sedge-Shrub Meadow	31	0	50	33	67	0	0	0	0	41	26
Moist Tussock Tundra	13	0	0	0	33	0	0	0	0	17	11
Total Nests	120	22	2	3	3	1	3	1	1	156	100

[a] Includes nests identified to species from feather and down samples
[b] Nest belonging to either Cackling or Canada goose

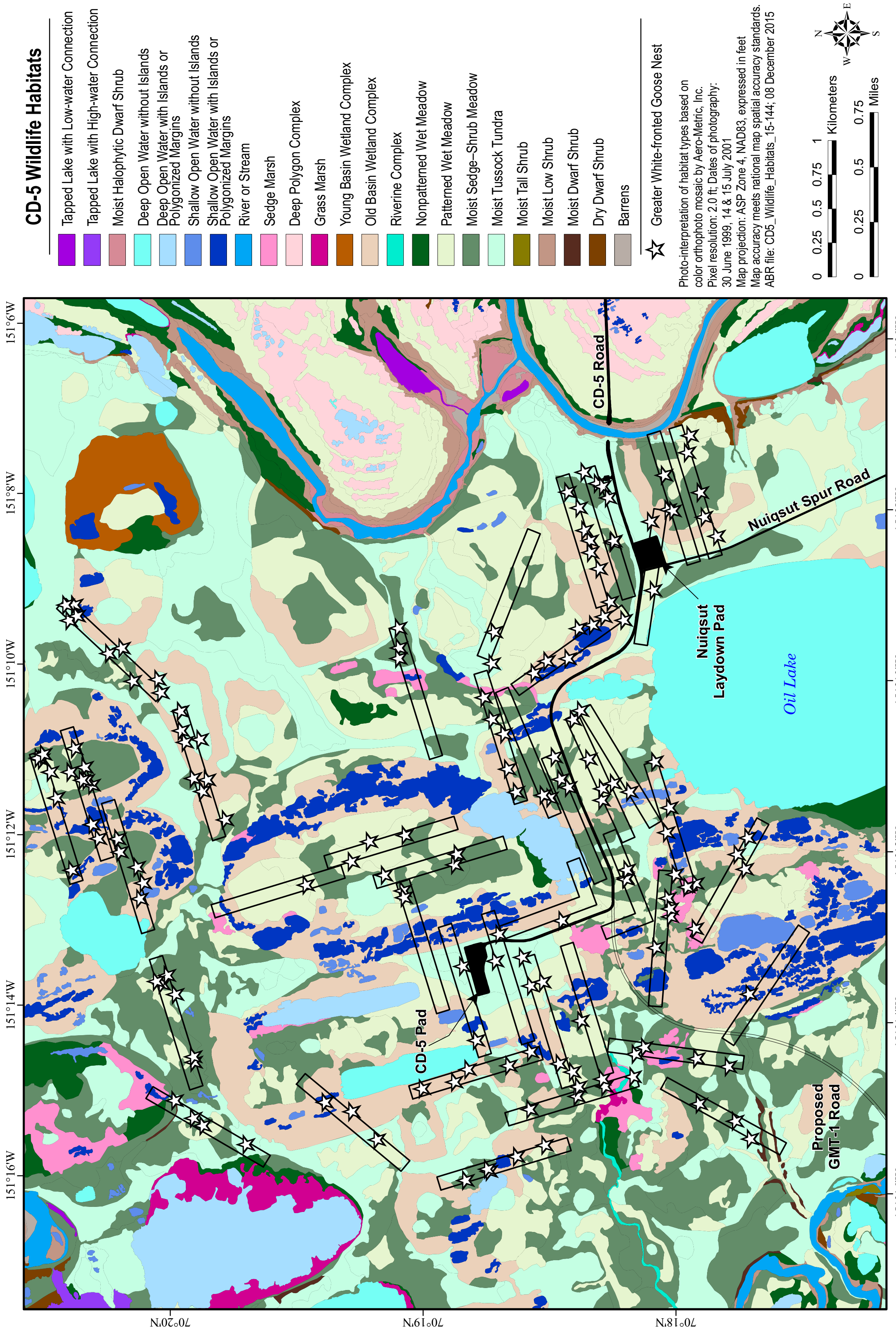

Figure 3. Nest locations of Greater White-fronted Geese and habitats in the area of nest plots at CD-5, NE NPR-A, Alaska, 2015.

Table 4. Habitat selection by nesting Greater White-fronted Geese on nest plots at CD-5, NE NPR-A, Alaska, 2015.

Habitat	Area (km^2)	No. of Nests	Use[a] (%)	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
Deep Open Water without Islands	0.01	0	0	0.2	ns	low
Deep Open Water with Islands or Polygonized Margins	0.02	0	0	0.5	ns	low
Shallow Open Water without Islands	0.03	0	0	0.7	ns	low
Shallow Open Water with Islands or Polygonized Margins	0.21	3	0.9	5.3	avoid	
River or Stream	<0.01	0	0	<0.01	ns	low
Sedge Marsh	0.08	7	2.2	2.0	ns	
Grass Marsh	<0.01	0	0	<0.01	ns	low
Old Basin Wetland Complex	0.93	80	24.9	23.3	ns	
Riverine Complex	<0.01	0	0	0.1	ns	low
Nonpatterned Wet Meadow	0.01	0	0	0.2	ns	low
Patterned Wet Meadow	1.13	104	32.4	28.3	ns	
Moist Sedge-Shrub Meadow	1.02	87	27.1	25.5	ns	
Moist Tussock Tundra	0.52	40	12.5	13.2	ns	
Tall, Low, Dwarf Shrub	0.01	0	0	0.2	ns	low
Barrens	<0.01	0	0	<0.01	ns	low
Human Modified	0.03	0	0	0.5	ns	low
Total	4.00	321		100		

[a] Use (%) = (nests / total nests) × 100
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, and avoid = significantly less use than availability
[c] Low has expected number <5, all others have expected number ≥5

(n = 5 nests) at failed nests. Only 5 nests had incubation constancies <99%, and only 1 of these was a nest that failed. At hatched nests, White-fronted Goose females took 0.7 ± 0.2 incubation recesses/day (n = 35 nests), and only 2 females left the nest more than twice per day. Recess durations at hatched nests ranged from 0 to 31.3 min (mean = 11.8 ± 1.0 min; Table 5). Females at nests that failed took an average of 1.0 ± 0.6 recesses/day that ranged from 0 to 17.5 min (mean = 10.4 ± 2.9 min; Table 6). The day of nest hatch or failure was not included in summaries, because the exact time could not always be discerned from temperature records and partial days of incubation are not adequate for measuring recess frequency and time off nest. Females at failed nests might have lower nest attendance on the final day of incubation than successful nests, but these data do not allow that comparison.

NESTING SUCCESS

In 2015, 94% of the 162 White-fronted Goose nests were active when found. Our methods do not account for partial predation (loss of less than the entire clutch of eggs) but we did find evidence of partial predation at 1 active nest during the nest search. Seven inactive nests were found with all eggs crushed or otherwise damaged or nest contents were missing. Apparent nesting success (the percentage of nests hatching ≥1 egg) for all White-fronted Goose nests, including those outside plots, was 83% (Table 1), which was substantially higher than the apparent nesting success in both 2013 (53%, n = 110 nests) and 2014 (58%, n = 147

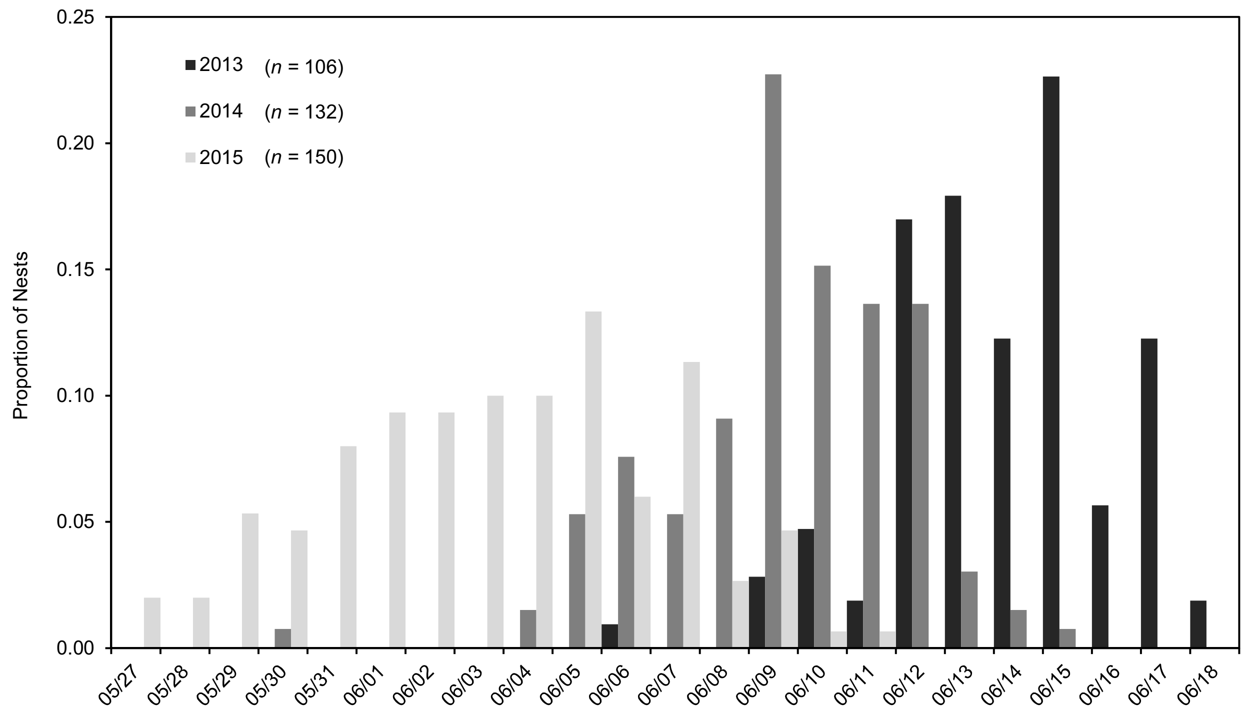

Figure 4. Incubation start dates (% of nests) estimated by egg flotation for Greater White-fronted Goose nests at CD-5, NE NPR-A, Alaska, 2013–2015.

nests. Among the other geese nesting in the CD-5 nest search area in 2015, 81% (21 of 29 nests) of Cackling/Canada Goose nests hatched, and the single Brant nest was also successful (Table 1).

We compared 6 models of daily survival rates (DSR, probability of a nest surviving 1 d) for monitored White-fronted Goose nests, including the models containing the constant (no covariates), year, date, clutch age, and the additive models of year + date, and year + clutch age. Each of the models was plausible given the data with none clearly superior (AICc weights = 0.01–0.19), thus the date of failure and clutch age did not improve the model predictions over that of the top model containing only year (AICc weight = 0.19). The second best model (AICc weight = 0.10), included year + clutch age, but the coefficient for clutch age was not significantly different from 0. Here we report on the highest ranked model, which included year as a covariate. As with apparent nesting success, nest survival has improved through each of the 3 years of study. The DSR for monitored nests in 2015 was 0.99 ± 0.004, compared with 0.969 ± 0.008 in 2013 and 0.982 ± 0.004 in 2014. The estimated probability a nest would survive a 24 d incubation period in 2015 was 0.79 (95% CI = 0.642–0.937), compared with 0.465 (95% CI = 0.29–0.640) in 2013 and 0.653 (95% CI = 0.534–0.773) in 2014. Contrary to expectations, the apparent nesting success for nests with temperature sensors in 2015 (88%, n = 42 nests) was higher than the apparent nesting success for White-fronted Geese without sensors (81%, n = 119). Apparent nesting success was also substantially higher than estimates of nest success from DSR, but as discussed in the methods, apparent nesting success tends to be biased high relative to DSR estimates that account for time of exposure. We did not calculate DSR for other species of geese or waterfowl.

OTHER NESTING BIRDS

DISTRIBUTION AND ABUNDANCE

We found a total of 207 nests belonging to 11 species of birds on and near nest plots in 2015 (Figure 2, Table 1). Only 22% of these nests belonged to species other than geese. Among the

Table 5. Nest history and incubation activity of Greater White-fronted Geese at successful nests monitored by thermistors at CD-5, NE NPR-A, Alaska, 2015.

Nest	Date Instrumented	Incubation Start Date[a]	No. Eggs	Date of Hatch	No. Days Monitored[b]	Initial Time Off Nest (min)[c]	Incubation Constancy (%)[b]	Recess Frequency (no/d)[b]	Mean Recess Length (min/recess)[b]
100	9 June	1 June	3	24 June	14	105	99.9	0.1	15.0
104	9 June	2 June	3	25 June	15	130	99.5	0.5	15.7
110	10 June	31 May	3	23 June	12	80	99.7	0.4	12.0
111	10 June	30 May	4	22 June	11	85	99.5	0.6	10.7
118	11 June	1 June	3	24 June	12	165	99.6	0.6	10.7
119	11 June	2 June	6	25 June	13	90	99.8	0.2	15.0
121	12 June	31 May	2	23 June	10	130	99.8	0.2	12.5
123	12 June	31 May	5	23 June	10	40	99.9	0.2	10.0
126	12 June	1 June	5	24 June	11	75	99.5	0.4	18.8
129[c]	13 June		2						
130	13 June	1 June	6	24 June	10	85	96.7	1.5	31.3
137	14 June	31 May	2	23 June	8	85	99.9	0.1	10.0
141[c]	14 June		4						
142	14 June	3 June	4	26 June	11	135	100	0.0	0.0
203	9 June	3 June	2	26 June	16	80	100	0.0	0.0
205	10 June	30 May	7	22 June	11	205	99.5	0.6	10.7
208	10 June	30 May	5	22 June	11	70	99.1	1.1	12.5
215	12 June	31 May	3	23 June	10	65	95	3.8	19.0
217	13 June	31 May	4	23 June	9	80	99.7	0.4	11.3
218	13 June	28 May	4	20 June	6	35	99.8	0.2	15.0
224[d]	15 June	3 June		26 June	10	90	99.3	1.1	8.6
300	8 June	5 June	3	28 June	19	40	99.3	0.8	13.0
307	10 June	2 June	2	25 June	14	55	96.2	4.1	13.4
310	11 June	1 June	2	24 June	12	45	99.1	0.9	14.6
318	14 June	1 June	2	24 June	9	90	99.8	0.2	15.0
330	16 June	30 May	4	22 June	5	90	99.9	0.2	10.0
333	16 June	31 May	5	23 June	6	45	100	0.0	0.0
412	9 June	30 May	5	22 June	12	100	99.7	0.4	10.0
413	9 June	29 May	2	21 June	11	60	99.5	0.6	10.7
414	10 June	31 May	1	23 June	12	110	99.6	0.3	21.7
416[c]	11 June	2 June	5	25 June	13				
417	11 June	2 June	7	25 June	13	40	98.5	1.5	13.8
421	12 June	13 June	2	6 Jul	23	40	99.6	0.5	10.8
424	13 June	31 May	3	23 June	9	40	99.6	0.6	10.0
425	13 June	1 June	2	24 June	10	100	99.7	0.5	10.0
434	14 June	2 June	2	25 June	10	115	99.4	0.8	11.3
437	14 June	1 June	6	24 June	9	110	100	0.0	0.0
454	16 June	28 May	5	20 June	3	65	98.8	1.7	10.0
Median/ Mean[f]	12 June	1 June	3.6	24 June	11.1	85	99.3	0.7	11.8
SE			0.3		0.6	6.4	0.2	0.2	1.0
n	38	36	37	36	36	35	35	35	35

[a] Calculated by subtracting 24 d from day before hatch date
[b] Excludes day of instrumentation, hatch, or fledging
[c] Amount of time female was off nest following instrumentation
[d] Thermistor data could not be used because data-logger was damaged or thermistor detached from data-logger
[e] Egg and float data not recorded
[f] Median dates, mean numerical values

Table 6. Nest history and incubation activity of Greater White-fronted Geese at failed nests monitored by thermistors at CD-5, NE NPR-A, Alaska, 2015.

Nest	Date Instrumented	Incubation Start Date[a]	No. Eggs	Date of Failure	No. Days Monitored[b]	Initial Time Off Nest (min)[c]	Incubation Constancy (%)[b]	Recess Frequency (no/d)[b]	Recess Length (min/recess)[b]
146	15 June	3 June	4	27 June	11	95	97	3.2	13.3
211	11 June	31 May	1	24 June	12	85	99.7	0.5	10.0
214	12 June	31 May	3	24 June	11	90	99.3	0.9	11.1
302	15 June	29 May	4	22 June	12	105	99.6	0.4	17.5
401	8 June	19 May	7	12 June	3	95	100	0.0	0.0
Median/ Mean[d]	12 June	6 June	3.8	24 June	9.8	94	99.1	1.0	10.4
SE	–	–	1.0	–	1.7	3.3	0.5	0.6	2.9
n	5	5	5	5	5	5	5	5	5

[a] Calculated using egg-float data
[b] Excludes day of instrumentation and failure
[c] Amount of time female was off nest following instrumentation
[d] Median dates, mean numerical values

large waterbirds nesting on plot, we found 3 King Eider nests, 3 Long-tailed Duck nests, 2 Northern Pintail nests, and 1 Pacific Loon nest. Other species nesting on or off plot included Glaucous Gull (1 nest), Sabine's Gull (1 nest), Parasitic Jaeger (1 nest), and Bar-tailed Godwit (3 nests).

With 3 nests each, King Eiders (0.8 nests/km²) were tied with Long-tailed Duck as the third most common large waterbirds nesting on plots in 2015 (Figure 2, Table 1). The same number of nests of these species was found in 2014. In 2015, 2 of the 3 eider nests failed to hatch (apparent nesting success = 33%). A Pacific Loon nest was found in 2015 for the first time in the 3 years of this study and the nest attempt was successful. Several Red-throated Loons were observed in lakes near study plots or flying overhead in 2015, but we did not locate any Red-throated Loon nests. No Yellow-billed Loons or Spectacled Eiders or their nests were seen in or near study plots in 2015.

HABITAT USE

Nests of species other than geese were located in the same 6 habitats used by geese (Table 3). King Eider nests were found in Old Basin Wetland complex and Moist Sedge-Shrub Meadow. Long-tailed Duck was the only species other than White-fronted Goose to nest in Moist Tussock Tundra, and the other waterfowl nests were found in Patterned Wet Meadow and Moist Sedge-Shrub Meadow. The greatest species diversity was found in Old Basin Wetland Complex (5 species, including goose species), followed by Patterned Wet Meadow (4 species). Pacific Loon was the only species recorded in Shallow Open Water without Islands.

NEST PREDATORS

In 2015, jaegers and gulls were the most abundant and widespread nest predators observed during predator scans and incidental observations on nest plots (Appendix A), similar to predator scans in 2013 and 2014. Potential nest predators seen on plots during predator scans included jaegers (57% of 103 sightings; 0.74 ± 0.16 jaegers/scan), Glaucous Gulls (40%; 0.53 ± 0.13 gulls/scan), Common Raven (<1%; 0.01 ± 0.02 ravens/scan), and mammals (<1% arctic fox; 0.01 ± 0.03 foxes/scan). Parasitic Jaegers accounted for 81% of the jaeger observations (n = 63 jaegers), followed by Long-tailed Jaegers (14%) and Pomarine Jaegers (5%). Similar abundances and proportions of the avian predators were observed outside plots (within 300 m of plot boundaries) as on-plots during predator scans. Only 2 mammalian predators were recorded, an arctic fox on plot and a brown bear off plot (Appendix A). During predator scans, jaegers were seen on 27 of 40 plots and Glaucous Gulls were seen on 24 of 40 plots (Appendix A). The average number of predators observed per plot in 2015 (1.29 ± 0.21) was similar to observations in 2013 (1.28 ± 0.10) and less than half the number of predators recorded during predator scans in 2014 (2.83 ± 0.53).

The number and species composition of predators seen incidentally during nest searching was similar to during predator scans, though no mammals were observed during incidental observations (Appendix A). Jaegers were also the most common predators (48% of 93 sightings) on plot during incidental observations, followed by Glaucous Gulls (41%; Appendix A). This year was the only year we did not record avian predators other than jaegers, gulls, and ravens. Ravens were sighted flying over plots and only occasionally landing on plot, but most often were seen on or near the pads, or pipeline.

During nest fate visits in July, an arctic fox den with 3–5 pups was located on top of a pingo at the corner of plot 50, approximately 250 m south of the CD-5 road (Figure 2). Despite its proximity to many of our plots, we only saw adults in the vicinity of the den a couple of times from the road and only once during predator scans. Red foxes were notably absent from predator observations in 2015 and 2014. In 2014, red foxes were observed in the NE NPR-A study area at camera-monitored loon nests only, but no loon nests were monitored in the NE NPR-A in 2015. Mammalian predators are likely less abundant than avian predators, but some species such as arctic foxes may be more active at night, when we are not on nesting plots, or they may avoid humans. Daytime predator scans likely are biased against observing mammalian predators, therefore the mammalian component of nest predators was under-represented using this technique.

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PERSONAL COMMUNICATIONS

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Appendix A. Number of nest predators observed in and near 40 10-ha nest plots in the CD-5 study area, NE NPR-A, Alaska, 2015. Predators include Long-tailed, Parasitic, and Pomarine jaegers (jaeger); Glaucous Gull (gull); Common Raven (raven); arctic fox and brown bear (mammal).

	Predator Scans										Incidental Observations[a]									
	On Plot					Outside Plot[b]					On Plot					Outside Plot[b]				
Plot	Jaeger	Gull	Raven	Mammal	Total	Jaeger	Gull	Raven	Mammal	Total	Jaeger	Gull	Raven	Mammal	Total	Jaeger	Gull	Raven	Mammal	Total
5	1	3	0	0	4	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0
6	0	2	0	0	2	2	0	0	0	2	0	2	0	0	2	2	2	0	0	4
7	0	1	0	0	1	0	1	0	0	1	0	2	0	0	2	0	0	0	0	0
8	1	1	0	0	2	1	2	0	0	3	2	0	2	0	4	2	0	1	0	3
9	2	1	0	0	3	0	7	0	0	7	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	1	7	0	0	8	2	1	0	0	3	0	0	0	0	0
11	2	2	0	0	4	3	0	1	0	4	0	0	0	0	0	6	0	0	0	6
12	4	1	0	0	5	0	0	1	0	1	2	0	2	0	4	0	0	0	0	0
13	3	0	0	0	3	0	1	0	0	1	4	2	0	0	6	0	0	0	0	0
14	0	1	0	0	1	4	0	0	0	4	3	1	2	0	6	0	3	0	0	3
15	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
16	0	0	0	0	0	2	2	1	0	5	0	0	0	0	0	0	0	1	0	1
18	3	4	0	0	7	0	3	0	0	3	0	1	0	0	1	0	6	0	0	6
19	1	0	0	0	1	1	1	0	1	3	2	1	0	0	3	0	0	0	0	0
20	4	1	0	0	5	0	1	0	0	1	3	1	0	0	4	0	0	0	0	0
22	2	3	0	0	5	9	2	0	0	11	4	5	0	0	9	0	0	0	0	0
23	2	1	0	0	3	0	6	0	0	6	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	3	1	0	0	4	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	2	0	0	2	2	1	0	0	3	0	0	1	0	1
26	0	1	0	0	1	0	0	0	0	0	0	1	2	0	3	0	0	0	0	0
27	1	0	0	0	1	0	2	0	0	2	2	0	1	0	3	1	0	0	0	1
28	3	0	0	0	3	0	0	1	0	1	0	1	0	0	1	0	1	2	0	3
29	4	0	0	0	4	1	0	0	0	1	2	0	0	0	2	0	0	0	0	0
30	0	3	0	0	3	0	0	0	0	0	2	2	0	0	4	0	1	0	0	1
33	1	2	0	0	3	17	0	0	0	17	1	1	0	0	2	3	0	0	0	3
34	1	1	0	0	2	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0
35	3	2	0	0	5	0	0	1	0	1	2	1	0	0	3	0	0	0	0	0
37	2	2	0	0	4	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0
38	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	1	0	0	0	1	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0

Appendix A. Continued.

	Predator Scans										Incidental Observations[a]									
	On Plot					Outside Plot[b]					On Plot					Outside Plot[b]				
Plot	Jaeger	Gull	Raven	Mammal	Total	Jaeger	Gull	Raven	Mammal	Total	Jaeger	Gull	Raven	Mammal	Total	Jaeger	Gull	Raven	Mammal	Total
40	0	1	0	0	1	1	0	0	0	1	1	1	0	0	2	0	0	0	0	0
43	1	1	1	0	3	0	0	0	0	0	1	3	0	0	4	0	0	0	0	0
44	3	0	0	0	3	0	2	0	0	2	2	1	0	0	3	0	0	0	0	0
45	2	0	0	0	2	0	3	0	0	3	3	1	0	0	4	0	1	0	0	1
46	0	1	0	0	1	1	0	0	0	1	0	3	0	0	3	0	0	0	0	0
48	0	3	0	0	3	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
49	3	1	0	0	4	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0
50	5	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
51	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
52	2	3	0	0	5	1	3	0	0	4	0	0	0	0	0	0	0	1	0	1
Total	59	42	1	1	103	49	48	5	1	103	45	39	9	0	93	14	15	6	0	35
Mean	0.74	0.53	0.01	0.01	1.29	0.61	0.60	0.06	0.01	1.29	1.13	0.49	0.11	0	1.16	0.18	0.19	0.08	0	0.44
SE	0.16	0.13	0.02	0.02	0.21	0.34	0.21	0.04	0.02	0.38	0.20	0.17	0.10	0	0.31	0.18	0.17	0.07	0	0.25
n [c]	80	80	80	80	80	80	80	80	80	80	40	40	40	40	40	40	40	40	40	40

[a] Predator scans included (two 10-min scans per plot); incidental observations were made during nest-searching
[b] Predators observed outside plot but ≤300 m from plot boundary
[c] *n* = total number of 10-min scans for predators (predator scans) on and outside plots, and for incidental observations *n* = number of plots visited