Eider Surveys in the Kuparuk Oilfield, Alaska, 2019

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Prepared for
ConocoPhillips Alaska, Inc.
Anchorage, Alaska

and

The Kuparuk River Unit

Prepared by
ABR, Inc.—Environmental Research & Services
Fairbanks, Alaska

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February 2020

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ACKNOWLEDGMENTS

We thank Robyn McGhee, Environmental Studies Coordinator, ConocoPhillips Alaska, Inc., for her support of the Kuparuk avian studies and Wendy Mahan and Nathan Visser, Kuparuk environmental staff, for their help with logistical and field support. Bob Eubanks of North River Air expertly flew our aerial survey. Many ABR employees assisted with this project. Thanks to Bob Burgess, Caitlin Forster, Robert McNown, Mette Møeller, and Forrest Rosenbower for the many hours spent walking the tundra in search of nesting eiders; to Tim Obritschkewitsch for his aerial survey expertise and effort; to Chris Swingley and Tawna Morgan for app development; to Dorte Dissing for GIS map preparation; to Joe Welch for weather data analysis and summaries; to Will Lentz and Tony LaCortiglia for their logistic support; to Adrian Gall for review of the draft report; and to Pamela Odom for report production and travel coordination.

We would also like to acknowledge the years of dedication, expertise, humor, and hard work that Bob Burgess has contributed to this and many other North Slope projects. Congratulations on your retirement, Bob, and best of luck in your future endeavors.

INTRODUCTION

Spectacled Eiders (*Somateria fisheri*) are listed by the U.S. Fish and Wildlife Service (USFWS) as a threatened species, and their population status on the North Slope is being monitored in support of the population recovery effort (U.S. Fish and Wildlife Service 1996, 2007). Annual surveys for Spectacled Eiders began in the Kuparuk Oilfield in 1993 and have included searches for King Eiders (*Somateria spectabilis*) which nest in similar habitats and are frequently encountered while searching for Spectacled Eiders. ABR, Inc.—Environmental Research & Services (ABR) was hired by ConocoPhillips Alaska, Inc., to conduct surveys focused on eider nest distribution, habitat use, and productivity in the Kuparuk Oilfield. This report summarizes the results of these surveys for Spectacled and King eider pre-nesting and nest distribution, habitat use, and productivity during 2019.

Spectacled and King eiders are 2 of 4 species of eiders that breed in arctic Alaska (Bellrose 1978), and 2 of 3 species known to nest in the oilfields on Alaska's North Slope (Johnson and Herter 1989). The other 2 species, Common Eider (*Somateria mollissima*) and Steller's Eider (*Polysticta stelleri*), are rarely seen on Kuparuk avian surveys. Common Eiders nest predominately in coastal habitats (barrier islands, beaches, and sand spits), which are rare in the Kuparuk Oilfield (Roth et al. 2007). Steller's Eiders nest in tundra habitats primarily in northern and western Alaska—most notably around Utqiaġvik. Although there are no definitive historical breeding records of Steller's Eiders east of Cape Halkett, historical and recent records indicate the species has occurred as far east in Alaska as Demarcation Point (Quakenbush et al. 2002).

Spectacled Eiders have undergone severe declines in abundance, particularly on the Yukon–Kuskokwim Delta in western Alaska (Kertell 1991; Stehn et al. 1993). Because of their decline in abundance, Spectacled Eiders were listed by the USFWS as a threatened species under the Endangered Species Act in 1993 (58 FR 27474-27480). The USFWS has developed a recovery plan and a recovery task list for the Spectacled Eider (U.S. Fish and Wildlife Service 1996, 2007) that outline the research needs for promoting the recovery of the species. Research needs for Spectacled Eiders are being addressed by annual aerial surveys for eiders conducted on the North Slope by the USFWS, by USFWS-sponsored research on nesting ecology and reproduction conducted on the Yukon–Kuskokwim Delta, and by industry-sponsored research on the North Slope (including this study, studies on the Colville River delta, and studies in the National Petroleum Reserve–Alaska [NPR–A]).

The King Eider was listed by the USFWS as a Species of Management Concern in 2011 and by ADFG in 2006 as a Species of Greatest Conservation Need because of population declines and susceptibility to impacts from both climate change and resource extraction activities (Alaska Department of Fish and Game 2006; U.S. Fish and Wildlife Service 2011). In 2015, ADFG refined their listing of the King Eider as a highest-priority Species of Conservation Need due to small population size and decline (Alaska Department of Fish and Game 2015). Monitoring of King Eiders has included the annual aerial surveys for eiders conducted by the USFWS, a University of Alaska study on non-breeding King Eiders (Phillips 2005), and various industry-sponsored surveys that have had the Spectacled Eider as the focal species (this study and studies on the Colville River delta and NPR–A).

METHODS

CONDITIONS IN THE STUDY AREA

The weather station nearest to the Kuparuk study area is located at the Kuparuk airstrip. We used temperature and snow depth data from 1993–2019 that we obtained from the National Oceanic and Atmospheric Administration (NOAA). Data were summarized and plotted using the R software package ggplot2 (R Core Team 2019; Wickham 2016).

PRE-NESTING AERIAL SURVEY

The study area for the 2019 aerial pre-nesting survey was 1,008 km², and at 50% coverage the area surveyed was 505 km², which was 135 km² less than the area surveyed in 2007–2015. In 2019, we eliminated transects located south of the Spine Road and extended the survey area to the west in order to incorporate the Nuna project area (Figure 1; Morgan and Attanas 2016). The general procedures for the aerial survey were similar to those used since 1993 (Anderson and Cooper 1994). The survey team consisted of 2 observers (in addition to the pilot) in a fixed-wing aircraft (Cessna 185). The pilot used a Global Positioning System (GPS) to navigate the 400-m wide transects, which were oriented east–west and spaced 800 m apart. Observers counted eiders in a fixed-width strip (200 m on each side of the aircraft) along each transect. The transects were flown at ~145 km/hour and at an altitude of 35–45 m above ground level (agl). During the surveys, observers recorded locations of eiders on digital orthophoto mosaics of natural color imagery with 0.22- to 0.30-m resolution acquired in 2004–2015 by Quantum Spatial (Anchorage, AK) using a tablet computer loaded with a custom application. They also recorded on a digital voice recorder the species of eider, number of each sex, number of identifiable pairs, and whether the birds were flying or on the ground. Observers reviewed bird locations plotted on digital moving maps before committing them to a geographical information system (GIS).

Results are presented as the total of eiders observed and the indicated total. Indicated total is a standardized calculation in which the observed number of males is doubled to compensate for the lower detectability of females (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987). Only males observed in singles, pairs, and small groups on the ground are included in the indicated total; flying birds are excluded.

Indicated Total Birds = (lone males × 2) + (flocked males × 2) + (pairs × 2) + (group total ×1)

Lone males are single, isolated males without a visible associated female; flocked males are 2–4 males in close association (no females in the flock); a pair is a male and female in close association; and a group is five or more of a mixed-sex cluster of the same species in close association, which cannot be separated into singles or pairs (e.g., one female with three males was considered to be four [a pair plus two males]).

We calculated average annual distribution and density throughout the Kuparuk study area from 1994–2015 and 2019 using an inverse distance-weighted (IDW) interpolation of Spectacled and King eider indicated totals. (No aerial pre-nesting surveys were conducted during 2016–2018.) Mean density values were calculated for each 2-km transect segment and were assigned to the segment centroid. IDW interpolation calculated the density of a location based on the distance-weighted values of the nearest centroids for each 152-m grid cell in the study area.

To analyze population trends, we delineated a trend analysis area which only includes portions of the study area that were surveyed every year during 1995–2015 and 2019 (Figure 1). This was done because the study area changed substantially in 2019 and no longer included the southernmost transects which have low densities of pre-nesting eiders. Annual population growth rates for pre-nesting Spectacled and King eiders in this trend analysis area were calculated with log-linear regression for the period from 1995 to 2015 and 2019 using a standardized total number of birds that was calculated using the annual density (birds/km²) multiplied by a standard study area (385.1 km²) as the dependent variable.

HABITAT SELECTION ANALYSIS

We determined the habitats (Roth and Loomis 2008; Roth et al. 2007) used by pre-nesting Spectacled and King eiders at the time of the aerial surveys using a GIS. A habitat map for the Kuparuk study area was developed using a base map of DigitalGlobe satellite imagery with 0.5 m resolution in natural color and color infrared acquired 5 July 2015. A wildlife habitat type was assigned to each observation of pre-nesting Spectacled and King eiders by plotting their coordinates on the wildlife habitat map. For both eider species, habitat use (% of adults or groups in each identified habitat type) was determined for the 2019 pre-nesting season and compared to habitat availability (Table 1). Habitat availability was calculated as the percent of each habitat within the 400-m wide transects in the eider pre-nesting survey area. A statistical analysis using a Monte Carlo simulation of habitat selection was used for Spectacled and King eiders to evaluate whether or not habitats were used in proportion to their availability. Methods are explained in more detail by Johnson et al. (2015). We present data

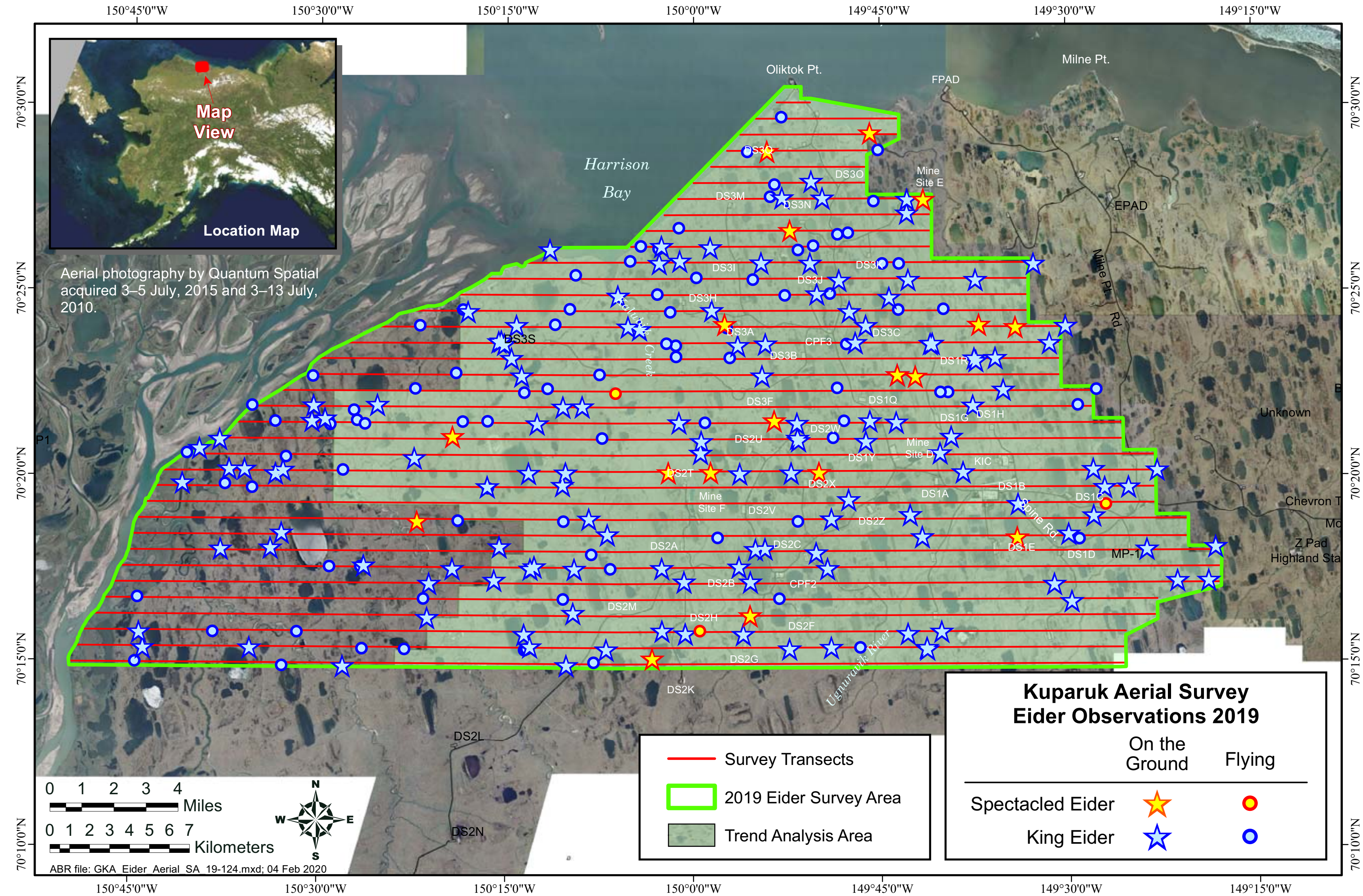

Figure 1. Locations of pre-nesting aerial survey study area, trend analysis area, survey transects, and Spectacled and King eider observations in the Kuparuk Oilfield, Alaska, 2019.

Table 1. Habitat availability in the pre-nesting eider survey area, Kuparuk Oilfield, 2019.

	Eider Survey Area	
Habitat	Area (km²)	Availability (%)[a]
Open Nearshore Water	6.0	0.74
Brackish Water	0.3	0.04
Tapped Lake with Low-water Connection	0.5	0.06
Tapped Lake with High-water Connection	0.1	0.01
Salt Marsh	2.5	0.30
Tidal Flat Barrens	0.3	0.04
Salt-killed Tundra	1.5	0.18
Deep Open Water without Islands	40.6	4.97
Deep Open Water with Islands or Polygonized Margins	42.0	5.13
Shallow Open Water without Islands	26.8	3.27
Shallow Open Water with Islands or Polygonized Margins	32.7	3.99
River or Stream	4.3	0.53
Sedge Marsh	15.2	1.86
Deep Polygon Complex	0.1	0.01
Grass Marsh	2.2	0.27
Young Basin Wetland Complex	13.5	1.64
Old Basin Wetland Complex	92.0	11.24
Riverine Complex	3.5	0.42
Nonpatterned Wet Meadow	61.1	7.47
Patterned Wet Meadow	78.9	9.64
Moist Sedge-Shrub Meadow	128.6	15.71
Moist Tussock Tundra	223.7	27.33
Tall, Low, or Dwarf Shrub	19.6	2.39
Barrens	4.1	0.50
Human Modified	18.5	2.26
Subtotal (total mapped area)	819	100
Unknown (unmapped areas)	189	
Total	1,008	

[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.

summaries as means with standard errors (mean ± SE), unless noted otherwise. Where appropriate, we report median values. Statistical significance is assigned at $P \leq 0.05$ unless otherwise stated.

GROUND NEST SEARCH

In 2013, we identified 6 core study sites within the Kuparuk Oilfield to be searched annually regardless of pre-nesting observations or nest history during the previous year. These sites are identified by their closest facility as DS-1E, DS-2C, DS-2F, DS-2T northern basin complex (hereafter, 2T [N]), DS-2T southern basin complex (hereafter, 2T [S]), and Mine Site E (Figure 2). These core sites were selected because of nearly annual use by nesting Spectacled Eiders since ABR began conducting ground-based nest searches in 1993. Our consistent and repeated search effort in these areas allows us to differentiate between annual variation in nest distribution and habitat use and longer term trends in distribution. In June 2019, we searched these 6 core sites, as well as 8 additional sites where Spectacled Eiders nests had been found during the last 10 years. In late July, we re-visited the sites and determined nest fates for all accessible Spectacled and King eider nests located within the study area.

Observers walked the sites and searched for all eider nests, regardless of whether nests were active or failed. Most Spectacled Eiders nest within 25 m of waterbodies, but searches extended out to at least 50 m beyond the perimeters of waterbodies to ensure adequate coverage. Effort was made to avoid flushing incubating birds, and eiders were never intentionally flushed from nests. We classified nests as active if females were present and incubating, or failed if nest scrapes or bowls contained no eggs and were unattended. Observers estimated the distance of each nest to the nearest water and noted the water type (e.g. seasonal standing water, pond, lake, or river/stream). Using a custom application installed on Android smart-phones, observers mapped nest locations and recorded nest characteristics at the nest site so that habitat type, distance to the nearest oilfield facility (road or pad), and distance to nearest waterbody could also be calculated after the field effort using a GIS. Samples of contour feathers were collected from all failed nests and from active nests if the bird was unintentionally flushed at discovery or if the nest was empty during fate checks. In addition, we recorded clutch size if a bird flushed from an active nest, or a description of egg shells and indications of predation (e.g., peck holes in egg shells, fox scent or scat, scattered nest contents) from failed nests. ABR is authorized to disturb nesting female Spectacled Eiders (≤20) during nest searches and collect nest materials, including egg shells, membranes, feathers, and down under ADFG Scientific Permit No. 19-161 and USFWS Native Threatened Species Recovery Permit No. TE012155-7, and to collect nest materials from King Eider nests under USFWS Migratory Bird Management Salvage permit no. MB106033-0.

NEST MONITORING

We deployed cameras and egg thermistors to monitor eider nest attendance, incubation constancy, nest survival, and predation. During 2008–2018, a subset of Spectacled Eider nests was monitored with Reconyx digital time-lapse cameras (Rapidfire model PM-75 or Hyperfire model PC800) to capture information on nest behavior, predation, and timing of failure or hatching. Cameras were located 25–50 m from the nest and were programmed to record 1 image every 30 seconds. We retrieved cameras during fate checks and downloaded digital images for later review in the office. Reviewers documented the behavior of the incubating hen, as well as occurrences of predators and other nest visitors. If predators appeared in images, the type of predator, evidence of harassment or predation of eggs, length of interaction, and any observable reactions of the eider on the nest were recorded. The most common nest predators in the Kuparuk Oilfield are Glaucous Gulls (*Larus hyperboreus*), jaegers (*Stercorarius* spp.), Common Ravens (*Corvus corax*), arctic foxes (*Vulpes lagopus*), and red foxes (*Vulpes vulpes*). Wolverines (*Gulo gulo*) and brown bears (*Ursus arctos*) are potential nest predators but have never been observed depredating eider nests during this study.

Time-lapse camera images were also reviewed to determine the behavior of the nesting hen. Three types of behaviors were distinguished from the images based on definitions used by Hawkins (1986) for Tundra Swans: incubation, breaks, and recesses. Time on the nest includes incubation, when the female is sitting on the nest, and breaks, when the female stands above the nest and rearranges the eggs or nesting material or changes position. Recesses are periods off the nest, when the female is standing, swimming, or sitting beside the nest, or when she is out of the camera view completely. In this report we present camera data collected in 2018; no cameras were deployed in 2019. Camera data collected during 2004–2015 were summarized and presented in Morgan and Attanas (2016).

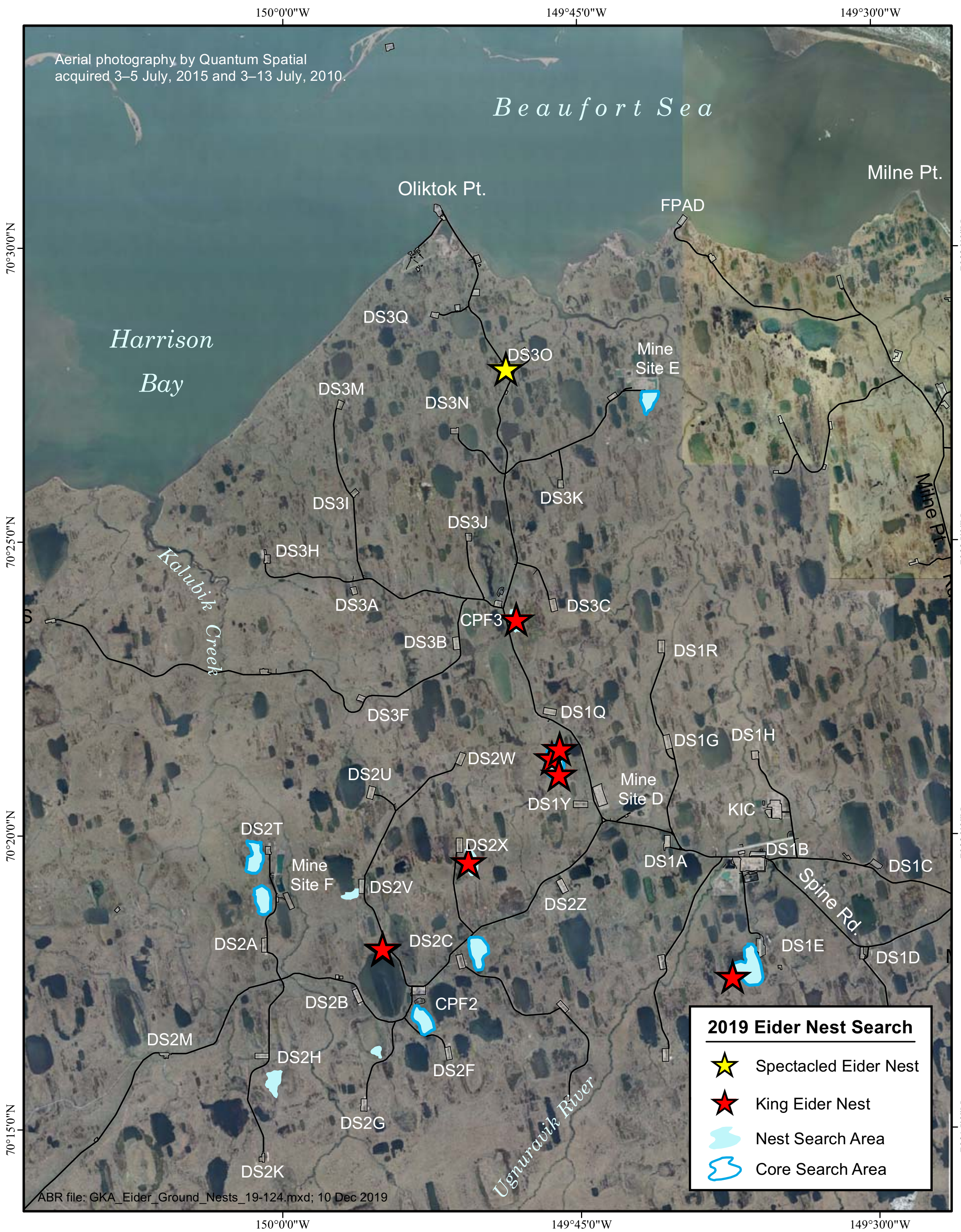

Figure 2. Locations of ground nest search areas and Spectacled and King eider nests in the Kuparuk Oilfield, Alaska, 2019.

During 2004–2018, we installed HOBO H-8 thermistors (Onset Computer Corporation, Bourne, MA) at some eider nests to monitor incubation constancy and timing of failure or hatching. Thermistors only were installed if the female was accidentally flushed upon discovery of the nest. A detailed description of thermistor installation and data analysis methods is available in Morgan and Attanas (2016). For all nests that received a thermistor or camera, at least 3 eggs in the nest were floated to determine egg age at the time of instrumentation. Thermistor data collected during 2004–2015 were presented in Morgan and Attanas (2016). Thermistor data collected after 2015 was archived and is available for analysis to determine nest attendance patterns and nest survival. No thermistors were installed in 2019.

IDENTIFICATION OF UNKNOWN EIDER NESTS

We assigned species to unidentified nests (i.e., nests where females were not observed or not identified) based on classification of feather samples. We mounted on acid-free paper a sample of 10 contour feathers from each unknown eider nest and a sample of 10 feathers from some known eider nests. Seven experienced waterfowl biologists then classified the feathers from each sample in blind tests. To reduce bias, the status of each feather sample (known or unidentified species) was unknown to the biologist at the time of classification. The biologist classified feathers as striped, brown-speckled, gray-speckled, or no markings. If ≥70% of feathers from each nest were classified as striped and/or brown-speckled, we identified the nest as a "probable Spectacled Eider". If ≤50% of feathers were classified as striped and/or brown-speckled, we identified the nest as a "probable King Eider". If the percentage of striped plus brown-speckled feathers was between 51% and 69%, we could not assign species and the nest was listed as "unidentified eider". We combined the results of all biologists' classifications and assigned a final species identification if there was independent agreement among ≥75% of biologists.

HABITAT USE AND OCCUPANCY

Using GPS nest coordinates, we assigned each Spectacled and King eider nest that we found to a mapped wildlife habitat class that was originally designated by Roth et al. (2008; 2007), and that has been updated as needed using an integrated terrain-unit (ITU) approach as described in Roth et al. (2007). Based on nest coordinates and the location of surrounding habitat classes, we were able to calculate the distance of each nest to infrastructure (roads, pads, and processing facilities), and waterbodies. We also determined the proportion of nests found in each habitat type in relation to the amount of each habitat type that we searched. Waterbody is defined as any body of water that was mapped during the Kuparuk Ecological Land Survey or subsequently updated using the ITU approach and includes Sedge Marsh, which is often characterized by very shallow (<50 cm) standing water and is found along the margins of larger ponds and lakes.

We compiled a multi-year dataset for site occupancy and habitat use to address patterns of Spectacled Eider occupancy that could be used to focus our search efforts in subsequent years. Each search area was defined as an individual site. We filtered our multi-year dataset to sites that were visited in consecutive years since 2009 because we do not have a complete record of all sites searched prior to that year. If a site was revisited in at least one consecutive year, it was included in our data subset. Based on this subset of nest search data, we calculated the percentage of consecutive years in which nests were found at a given site as a measure of the likelihood that a site will remain an active nesting area from one year to the next.

RESULTS AND DISCUSSION

CONDITIONS IN THE STUDY AREA

Mean monthly temperatures indicate a warmer-than-average May in 2019 compared to the 27-year mean (1993–2019). Daily average temperatures during the eider arrival period (late May) were generally warmer than the 27-year mean (Figure 3). Total thawing degree days (the sum of average daily temperatures >0 °C, TDD) for late May were near average in Kuparuk (Figure 4). Snow depth reached 0 cm on 23 May, indicating that most tundra and ponds were clear of snow when eiders arrived (Figure 3). Since 1993, the average first day of zero snow depth in Kuparuk was 31 May. Warmer-than-average conditions in

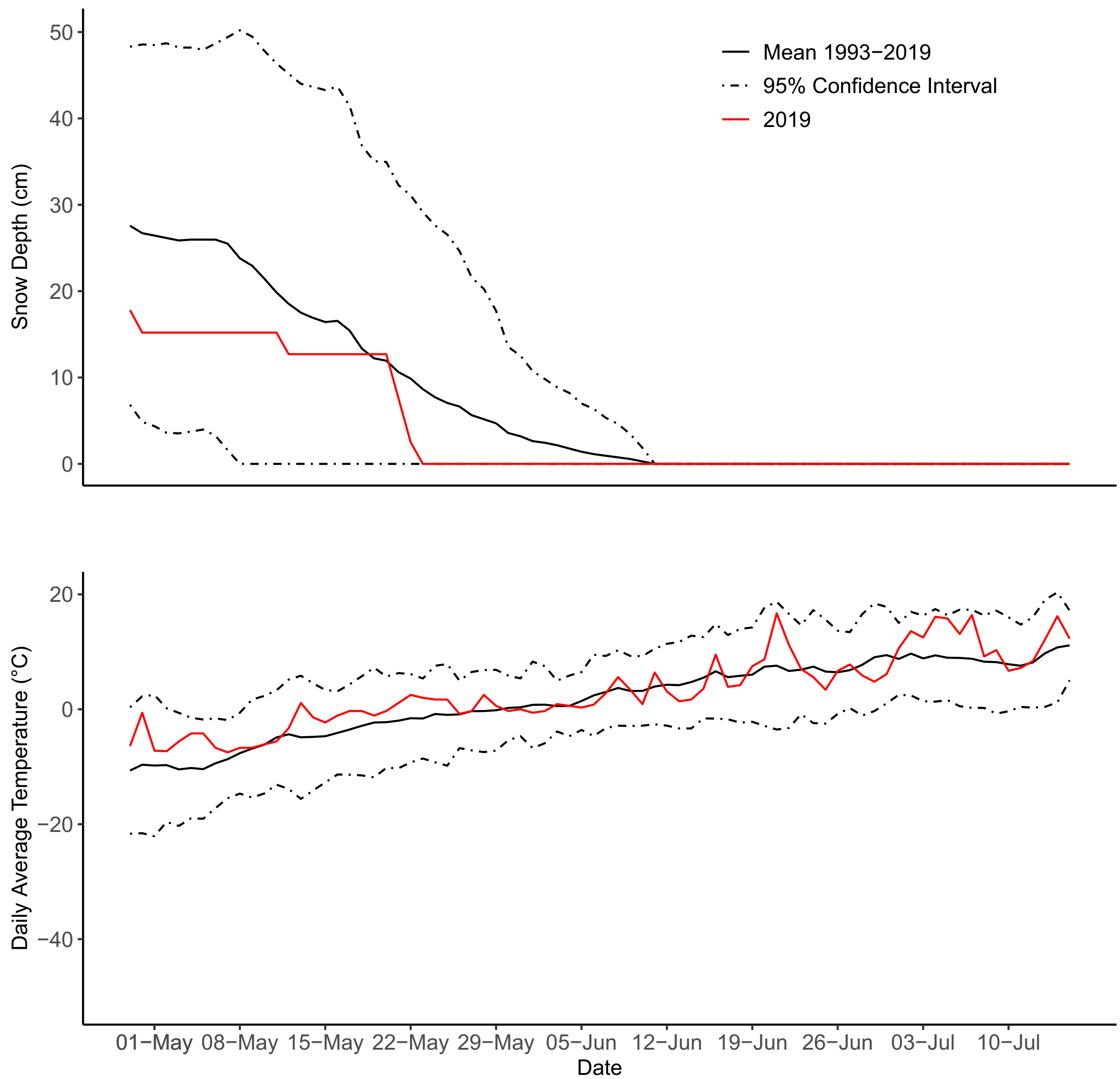

Figure 3. Snow depth (cm) and mean daily average temperatures (° C) and means for 1993–2019 at the Kuparuk airstrip (PAKU), Alaska, May–July 2019.

the Brooks Range and foothills led to breakup flooding in mid-May. Peak stage and discharge for the Colville River delta occurred on 24 May, earlier than the long-term average peak stage (30 May) and discharge date (31 May; Michael Baker International 2019). Peak stage and discharge data for the Kuparuk River was not available for 2019. Warmer than average temperature and earlier than average spring break-up conditions were reported for most waterfowl nesting areas in northern Alaska in 2019 (U.S. Fish and Wildlife Service 2019). Daily average temperatures during the nest initiation/early incubation period (early June) were slightly lower than the 27-year mean. During the hatching and brood-rearing period (mid- to late July), daily average temperatures were generally above the long-term mean but fluctuated widely (Figure 3; http://www.ncdc.noaa.gov/oa/climate/ghcn-daily/). The mean July temperature in 2019 was 11.7°C,

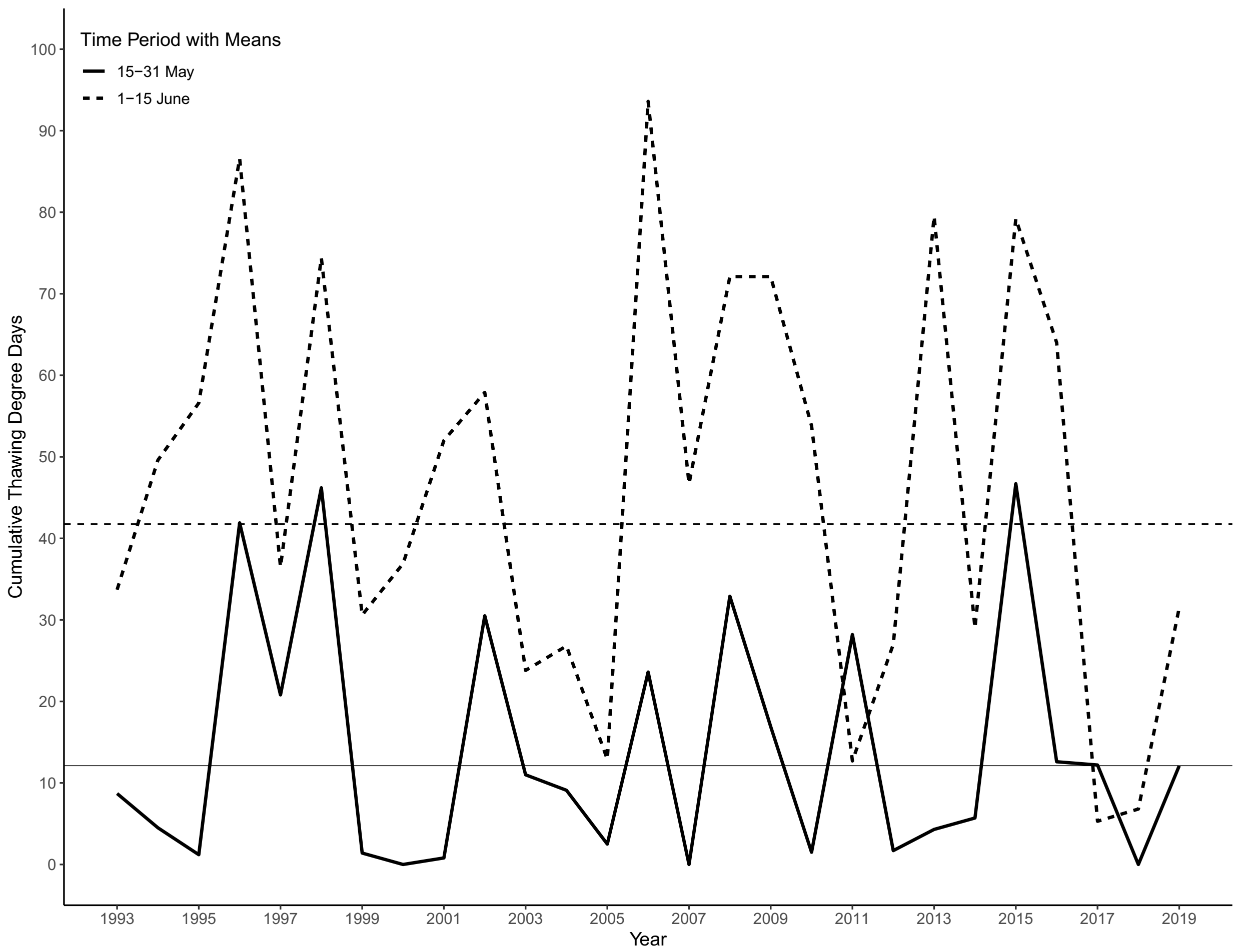

Figure 4. Cumulative number of thawing degree-days and means (horizontal lines) recorded for 15–31 May and 1–15 June recorded at the Kuparuk airstrip (PAKU), Alaska, 1993–2019.

the highest since surveys began in 1993 and nearly 3 °C higher than the 27-year mean of 8.9 °C.

Appropriate timing for pre-nesting eider surveys includes thawed shallow water bodies and thawed margins of deep water bodies. The timing of pre-nesting aerial surveys in 2019 was appropriate based on the condition of water bodies. Timing of ground nest searches was also appropriate, based on the lack of snow and presence of pre-nesting eiders.

PRE-NESTING AERIAL SURVEY

DISTRIBUTION AND ABUNDANCE

We conducted an aerial survey (Figure 1) for breeding pairs of eiders in the Kuparuk area during 9–11, and 14 June, 2019. In 2019 we did not survey the southern-most areas surveyed in 2009–2015, that have low eider densities (Figures 5 and 6; Morgan and Attanas 2016). In 2019 no Common or Steller's eiders were observed. Spectacled and King eiders were distributed uniformly across the study area in 2019, with the exception of the eastern portion of the study area. No Spectacled Eiders were observed in the western and southwestern portion of the study area near the eastern banks of the Colville River, while high numbers of King Eiders were observed near the confluence of the Miluveach and Colville rivers (Figures 5 and 6).

We recorded 21 groups of Spectacled Eiders (in groups of 1–2 individuals), totaling 32 birds, of which 3 groups were flying (Table 2). The indicated total for Spectacled Eiders was 34 with a

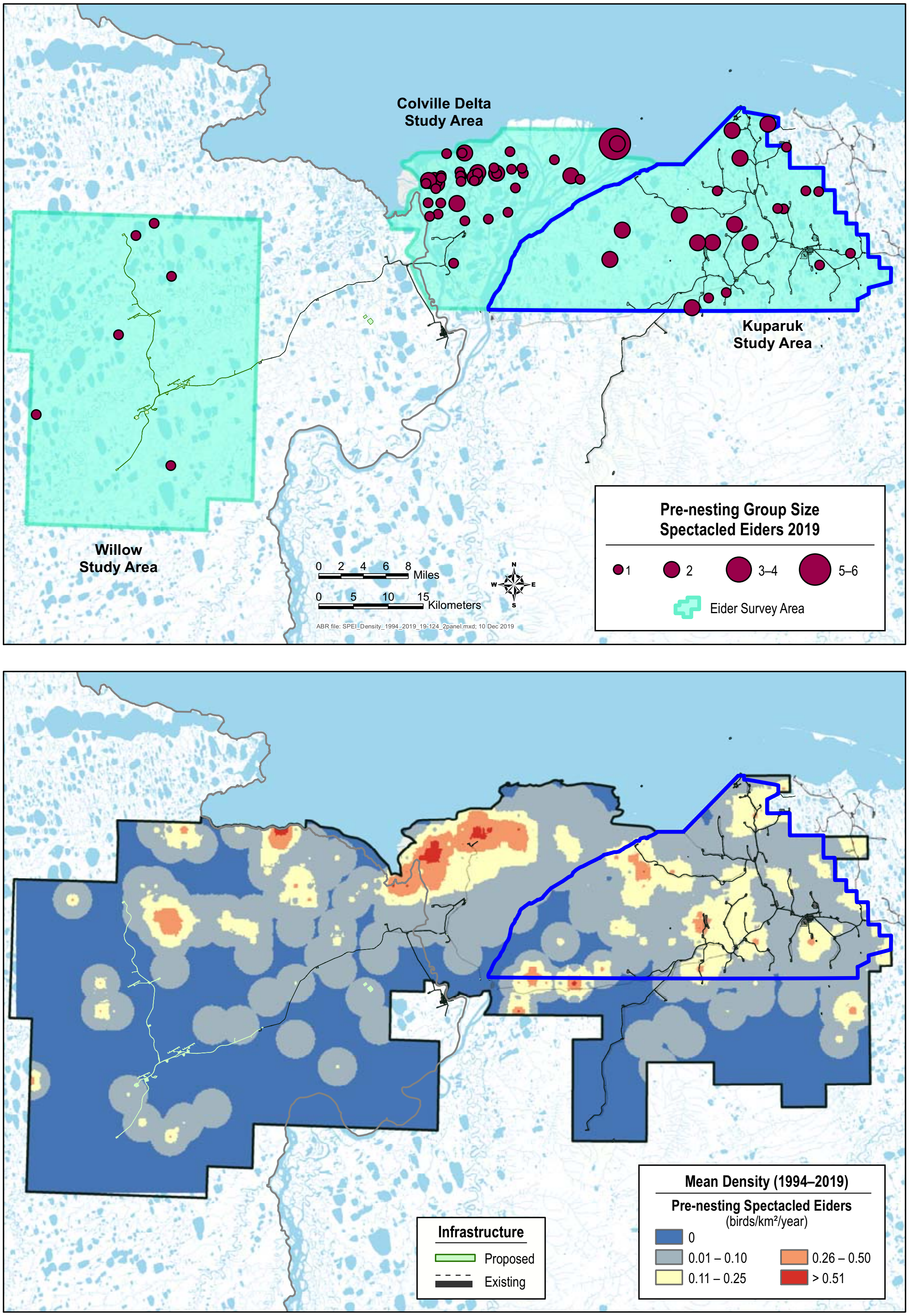

Figure 5. Group size (2019) and mean densities (1994–2019) of Spectacled Eiders observed during pre-nesting aerial surveys, Kuparuk Oilfield, Alaska.

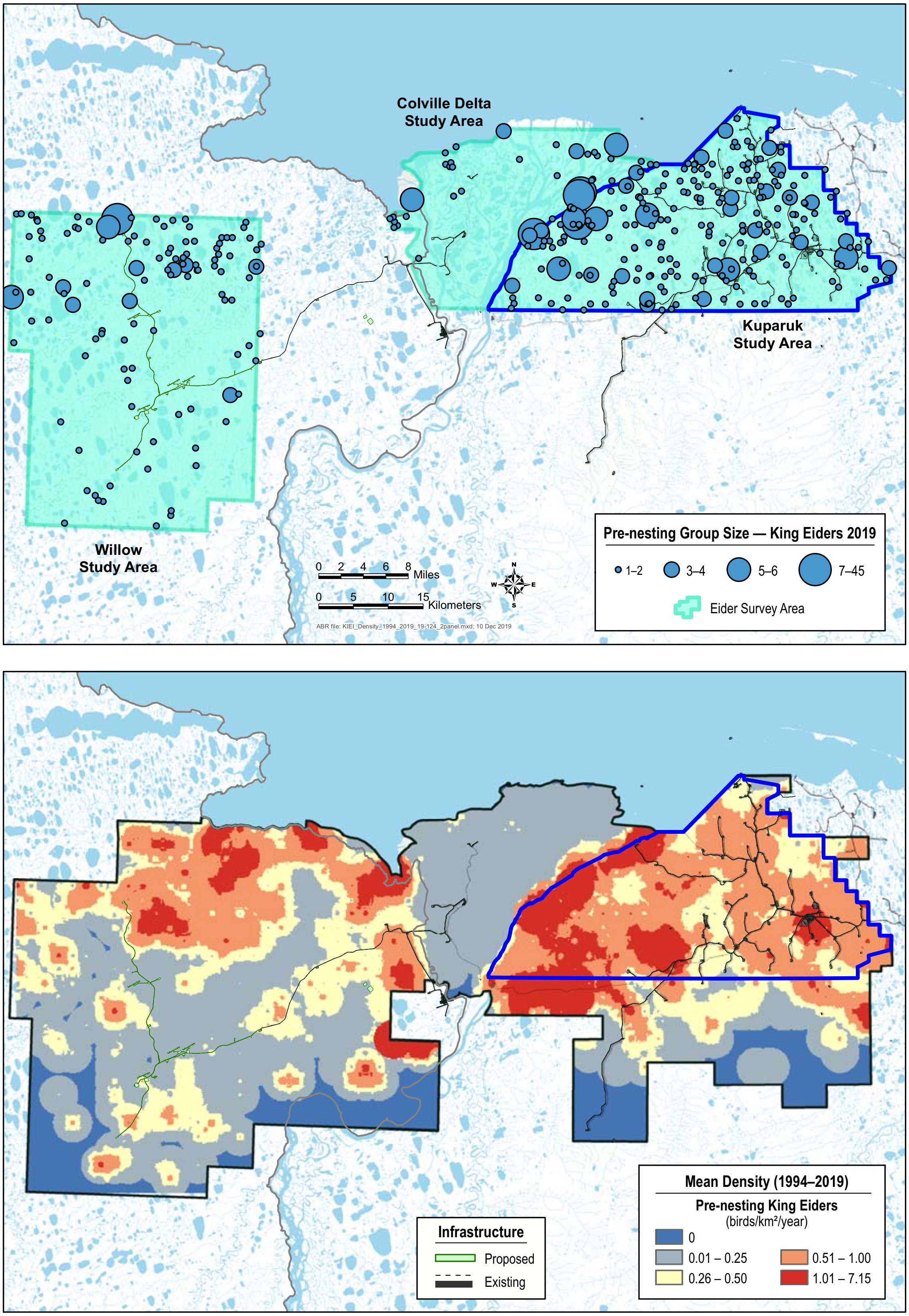

Figure 6. Group size (2019) and mean densities (1994–2019) of King Eiders observed during pre-nesting aerial surveys, Kuparuk Oilfield, Alaska.

Table 2. Annual number and density (birds/km²) of eiders during pre-nesting aerial surveys in the Kuparuk Oilfield in 1993, 1995–2015, and 2019.

Year	Area Surveyed (km²)	Spectacled Eider				King Eider			
		Total[a]		Density[b]		Total[a]		Density[b]	
		Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
1993									
First survey	525.1	125	91	0.24	0.17	na	na	na	na
Second survey	525.1	41	34	0.08	0.06	na	na	na	0.18
1995	550.5	34	39	0.06	0.07	195	205	0.35	0.37
1996	550.5	40	32	0.07	0.06	207	254	0.38	0.46
1997	550.5	51	40	0.09	0.07	264	325	0.48	0.59
1998	550.5	58	50	0.1	0.09	130	151	0.24	0.27
1999	525.4	76	50	0.14	0.09	123	126	0.23	0.24
2000	525.4	60	40	0.11	0.08	169	188	0.32	0.36
2001	525.4	61	58	0.12	0.11	251	283	0.48	0.54
2002	525.4	27	32	0.04	0.06	468	538	0.89	1.02
2003	525.4	31	44	0.05	0.08	215	304	0.41	0.58
2004	525.4	27	38	0.05	0.07	264	371	0.50	0.71
2005	525.4	18	20	0.03	0.04	165	219	0.31	0.42
2006	525.4	24	24	0.05	0.05	362	419	0.69	0.80
2007	640.4	48	27	0.07	0.08	315	353	0.49	0.55
2008	640.4	21	20	0.02	0.03	453	571	0.71	0.89
2009	640.4	28	28	0.04	0.04	298	344	0.47	0.54
2010	640.4	58	56	0.09	0.09	301	348	0.47	0.54
2011	640.4	17	16	0.02	0.02	313	385	0.49	0.60
2012	640.4	55	40	0.09	0.06	291	315	0.45	0.49
2013	640.4	51	46	0.08	0.07	272	292	0.42	0.46
2014	640.4	37	24	0.06	0.04	283	318	0.44	0.50

Table 2. Continued.

Year	Area Surveyed (km²)	Spectacled Eider				King Eider			
		Total[a]		Density[b]		Total[a]		Density[b]	
		Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
2015	640.4	35	26	0.05	0.04	255	284	0.40	0.44
2019	504.8	32	34	0.06	0.07	410	334	0.81	0.66
Mean		–	–	0.068	0.064	–	–	0.47	0.55
SE		–	–	0.006	0.005	–	–	0.036	0.040

[a] Observed total includes flying and non-flying eiders. Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a). Mean and SE calculated for n = 23 years.

[b] Numbers not corrected for sightability. Density (birds/km²) based on 50% coverage. Mean and SE calculated for n = 23 years (Spectacled Eider) and n = 22 years (King Eider).

density of 0.07 indicated eiders/km² in 2019, similar to the long-term average density for the Kuparuk area (0.064 ± 0.005 eiders/km²). This extrapolates to 64 observed and 68 indicated total Spectacled Eiders in the entire 2019 Kuparuk study area. As in previous years, the density of Spectacled Eiders in the Kuparuk study area was higher than the density in the NE NPR-A and lower than in the Colville River Delta study area in 2019 (Figure 5).

The number of Spectacled Eiders in the Kuparuk trend analysis area may be declining by 2% per year during 1995–2019 (Figure 7; ln(adults) = –0.021 (year) + 44.69, R^2 = 0.14, P = 0.09); however, this is not statistically significant. There were no statistically significant changes in the number of Spectacled Eiders in the NE NPR-A during 1999–2014 (ln(adults) = 0.025 (year) + 47.39, R^2 = 0.02, P = 0.60; Shook et al. 2020); or the Colville Delta study area from 1993–1998 and 2000–2019 (ln(adults) = 0.017 (year) – 30.67, R^2 = 0.07, P = 0.19; Shook et al. in prep.). The USFWS reported a decline in the number of Spectacled Eiders across the entire Arctic Coastal Plain of 2% per year estimated from the North Slope waterfowl surveys, although this decline is not statistically significant (Wilson et al. 2018). None of the trends differ significantly from equilibrium, suggesting that although there is substantial interannual variation, the population of Spectacled Eiders on the ACP is stable to slightly decreasing.

We recorded 213 groups of King Eiders (1–20 individuals per group) totaling 410 birds, of which 84 groups were in flight (Table 2). The indicated total for King Eiders was 334 with a density of 0.66 indicated eiders/km² in 2019, higher than the long-term average density (0.55 ± 0.040 eiders/km²). The relatively high density in 2019 compared to the last 10 years may in part be due to the change in study area that excluded the low-density, southern transects. Extrapolating to the entire 2019 Kuparuk study area yields 820 observed and 668 indicated total King Eiders. Consistent with most years, the density of King Eiders was higher in the Kuparuk study area than in the adjacent Colville River Delta and NE NPR-A study areas (Figure 6).

The number of King Eiders in the Kuparuk trend analysis area may be increasing by 2% per year during 1995–2019 (ln(adults) = 0.016 (year) – 27.25, R^2 = 0.08, P = 0.20), however the result is not significant. Although the density in 2019 is the highest since 2008, it is within the range of densities that ABR has recorded since 1995 (Figure 8). There was a significant increase of 3% per year in the number of King Eiders in the Colville Delta study area during 1993–2019 (ln(adults) = 0.034 (year) – 64.33, R^2 = 0.20, P = 0.02; Shook et al. in prep.). In the NE NPR-A, the number of King Eiders increased by 9% annually during 1999–2014 (ln(adults) = 0.09 (year) – 176.87, R^2 = 0.65, P < 0.001). These results are consistent with the USFWS ACP surveys indicating that King Eiders have been increasing at a significant rate of 2% annually since 1986 (Wilson et al. 2018).

HABITAT USE

The Kuparuk pre-nesting eider study area was 1,008 km², of which 819 km² (82%) have been mapped for wildlife habitats (408 km² of the surveyed area was mapped; Roth and Loomis 2008; Roth et al. 2007). Pre-nesting Spectacled Eiders were recorded in 7 of 25 available habitats in 2019 (Table 3). Three habitats were preferred (i.e., use was significantly greater than availability, $P \leq 0.05$) including 1 primarily coastal, salt-affected habitat (Brackish Water), and 2 aquatic habitats (Shallow Open Water with Islands or Polygonized Margins, and Shallow Open Water without Islands). The Shallow Open Water habitats were the most used habitats with 31.3% of the Spectacled Eider groups located there, followed by Brackish Water (6.3% use). One habitat was avoided (i.e., use was significantly less than availability): Moist Tussock Tundra, which also was the most abundant habitat (27.1% of the area). All other habitats were used in proportion to their availability or had low sample sizes precluding a determination of preference or avoidance.

King Eiders used 14 of 25 available habitats during pre-nesting surveys in 2019 (Table 3). King Eiders preferred 2 habitats, both of which were also preferred by Spectacled Eiders in Kuparuk: Shallow Open Water without Islands, and Shallow Open Water with Islands or Polygonized Margins.

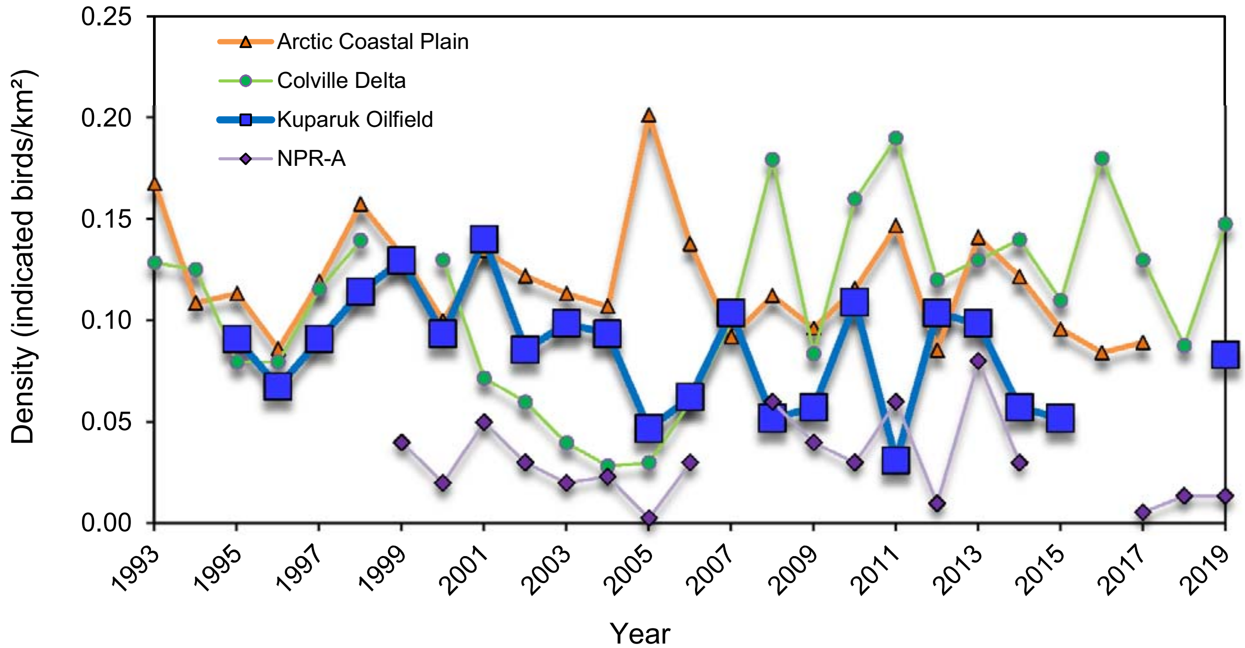

Figure 7. Annual densities of indicated total, pre-nesting Spectacled Eiders observed during aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2019.

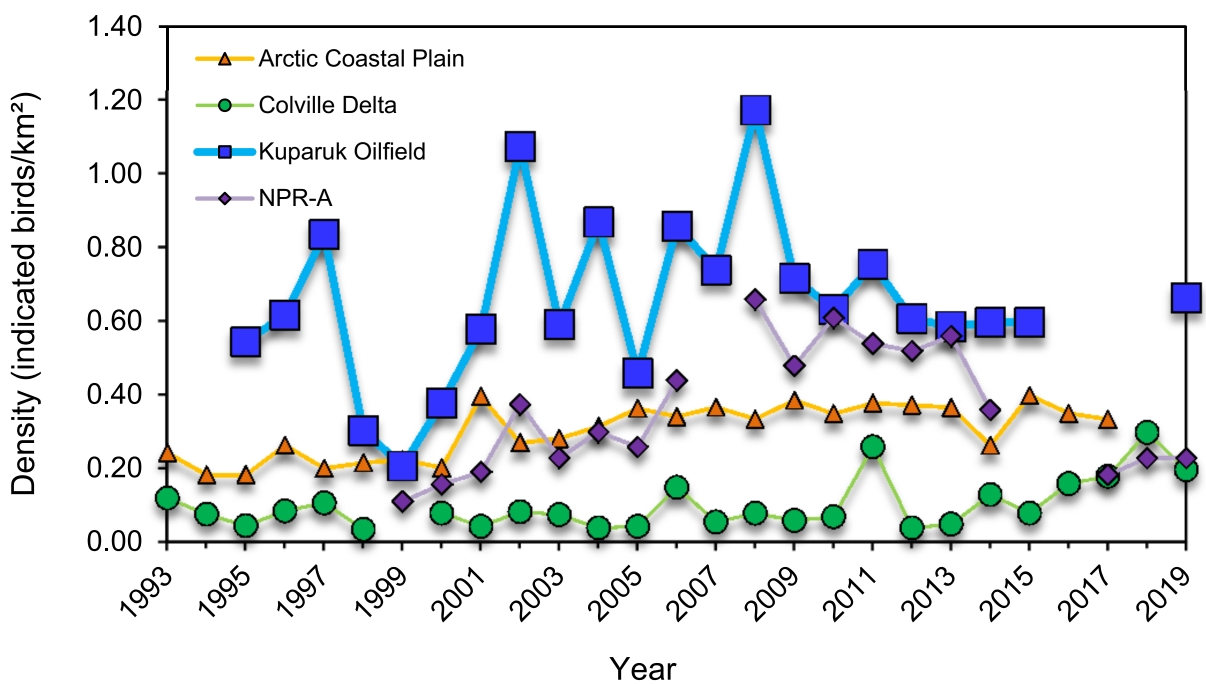

Figure 8. Annual densities of indicated total, pre-nesting King Eiders observed during aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2019.

Table 3. Habitat selection by pre-nesting Spectacled and King eider groups in the Kuparuk Oilfield 2019.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
SPECTACLED EIDER						
Open Nearshore Water	0	0	0.0	0.7	ns	low
Brackish Water	2	1	6.3	0.0	prefer	low
Tapped Lake with Low-water Connection	0	0	0.0	0.1	ns	low
Tapped Lake with High-water Connection	0	0	0.0	0.0	ns	low
Salt Marsh	0	0	0.0	0.3	ns	low
Tidal Flat Barrens	0	0	0.0	0.1	ns	low
Salt-killed Tundra	0	0	0.0	0.1	ns	low
Deep Open Water without Islands	2	1	6.3	5.2	ns	low
Deep Open Water with Islands or Polygonized	2	1	6.3	4.8	ns	low
Shallow Open Water without Islands	7	5	31.3	4.0	prefer	low
Shallow Open Water with Islands or Polygonized	6	5	31.3	3.2	prefer	low
River or Stream	0	0	0.0	0.5	ns	low
Sedge Marsh	0	0	0.0	1.9	ns	low
Deep Polygon Complex	0	0	0.0	0.0	ns	low
Grass Marsh	0	0	0.0	0.3	ns	low
Young Basin Wetland Complex	0	0	0.0	1.7	ns	low
Old Basin Wetland Complex	4	2	12.5	11.5	ns	low
Riverine Complex	0	0	0.0	0.4	ns	low
Nonpatterned Wet Meadow	0	0	0.0	7.7	ns	low
Patterned Wet Meadow	1	1	6.3	9.6	ns	low
Moist Sedge-Shrub Meadow	0	0	0.0	15.5	ns	low
Moist Tussock Tundra	0	0	0.0	27.1	avoid	low
Tall, Low, or Dwarf Shrub	0	0	0.0	2.4	ns	low
Barrens	0	0	0.0	0.5	ns	low
Human Modified	0	0	0.0	2.3	ns	low
Total	24	16	100	100		
KING EIDER						
Open Nearshore Water	0	0	0.0	0.7	ns	low
Brackish Water	2	1	0.9	0.0	ns	low
Tapped Lake with Low-water Connection	0	0	0.0	0.1	ns	low
Tapped Lake with High-water Connection	0	0	0.0	0.0	ns	low
Salt Marsh	0	0	0.0	0.3	ns	low
Tidal Flat Barrens	0	0	0.0	0.1	ns	low
Salt-killed Tundra	0	0	0.0	0.1	ns	low
Deep Open Water without Islands	9	5	4.7	5.2	ns	
Deep Open Water with Islands or Polygonized	6	2	1.9	4.8	ns	
Shallow Open Water without Islands	80	43	40.2	4.0	prefer	low
Shallow Open Water with Islands or Polygonized	63	29	27.1	3.2	prefer	low
River or Stream	3	2	1.9	0.5	ns	low
Sedge Marsh	7	5	4.7	1.9	ns	low

Table 3. Continued.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
Deep Polygon Complex	0	0	0.0	0.0	ns	low
Grass Marsh	0	0	0.0	0.3	ns	low
Young Basin Wetland Complex	0	0	0.0	1.7	ns	low
Old Basin Wetland Complex	7	6	5.6	11.5	ns	
Riverine Complex	2	1	0.9	0.4	ns	low
Nonpatterned Wet Meadow	2	2	1.9	7.7	avoid	
Patterned Wet Meadow	3	2	1.9	9.6	avoid	
Moist Sedge-Shrub Meadow	8	4	3.7	15.5	avoid	
Moist Tussock Tundra	3	2	1.9	27.1	avoid	
Tall, Low, or Dwarf Shrub	0	0	0.0	2.4	ns	low
Barrens	0	0	0.0	0.5	ns	low
Human Modified	5	3	2.8	2.3	ns	low
Total	200	107	100	100		

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

Shallow Open Water without Islands was the most used with 40.2% of King Eider groups located there, followed by Shallow Open Water with Island or Polygonzied Margins (27.1% use). Pre-nesting King Eiders avoided 4 habitats, including the 2 most abundant habitats in the Kuparuk study area: Moist Sedge-Shrub Meadow (15.5% available) and Moist Tussock Tundra (27.1% available). Nonpatterned Wet Meadow and Patterned Wet Meadow were also avoided by pre-nesting King Eiders in 2019. All other habitats were used in proportion to their availability or had low sample sizes precluding a determination of preference or avoidance.

GROUND NEST SEARCH

During 21–26 June 2019, 6 biologists conducted ground nest searches of 14 sites in the Kuparuk Oilfield (Figure 2) and found 1 Spectacled Eider nest—the lowest number of Spectacled Eider nests found since nest searching began in Kuparuk in 1993. The only Spectacled Eider nest found in 2019 was located in the CPF-3 area near DS-3O (Appendix A) and was likely depredated by a red fox hours before we searched the area; a red fox was resting on the tundra east of the nest near Oliktok Road when we arrived. Additionally, we found 8 King Eider nests in 2019; nests were located in the CPF-1 area near DS-1E and DS-1Y; in the CPF-2 area near DS-2X, and the CPF-2 processing plant; and in the CPF-3 area near the CPF-3 processing plant (Appendix A).

NEST FATE AND IDENTIFICATION OF UNKNOWN EIDER NESTS

During 18–19 July, we were able to re-visit and determine nest fate for 8 King Eider nests (Appendix A); the only Spectacled Eider nest found in 2019 failed during June nest searches and did not require a fate visit. Of the 8 King Eider nests found in the Kuparuk Oilfield in 2019, 6 hatched at least 1 young and 1 failed. We could not determine fate for the remaining King Eider nest because the nest island was inaccessible during fate checks. Successful King Eider nests were located at the DS-1Y, CPF-2, and CPF-3 study sites. Apparent nest success for Spectacled Eiders in 2019 was 0%, much lower than the long-term mean of 37.5% (Table 4). Since Kuparuk nest searches began in 1993, there have been 5 years in

Table 4. Numbers and apparent nesting success (percent of nests) of Spectacled and King eider nests found in the Kuparuk Oilfield, Alaska, 1993–2019, and annual nest search effort.

	Spectacled Eider			King Eider			Nest Search Effort (No. Areas Searched)[b]
		Successful Nests			Successful Nests		
Year	Total Nests[a]	Number	Percent	Total Nests[a]	Number	Percent	
1993	17	6	35.3	16	12	75.0	33
1994	14	5	35.7	20	6	31.6[c]	24
1995	14	4	28.6	8	1	12.5	17
1996	16	7	43.8	17	7	43.8[d]	17
1997	11	3	27.3	14	1	7.1	13
1998	12	5	41.7	20	5	25.0	10
1999	5	3	60.0	13	2	15.4	11
2000	11	7	63.6	19	8	42.1	13
2001	8	1	12.5	17	3	20.0[e]	10
2002	18	9	50.0	26	11	42.3	11
2003	17	8	47.1	16	4	25.0	13
2004	5	0	0.0	17	4	23.5	10
2005	13	12	92.3	14	7	50.0	9
2006	8	5	62.5	21	7	33.3	12
2007	8	2	25.0	21	2	9.5	9
2008	6	0	0.0	33	14	45.2[f]	10
2009	9	5	55.6	17	3	18.8[g]	10
2010	4	2	50.0	4	1	25.0	11
2011	8	4	57.1	14	7	53.8[h]	12
2012	12	4	33.3	17	2	11.8	17
2013	8	4	50.0	14	4	28.6	14
2014	8	5	62.5	11	2	20.0	10
2015	8	0	0.0	7	4	57.1	12
2016	7	0	0.0	12	0	0.0	13
2017	8	2	28.6	18	4	44.4	14
2018	2	1	50.0	10	4	40.0	14
2019	1	0	0.0	8	6	85.7	14
Mean	9.6	3.9	37.5	15.7	4.9	32.8	—

[a] Includes nests for known and probable (based on feather identification) species, but does not include unidentified eider nests. Refer to Appendix A for detailed information on all eider nests found in 2019, including their fates.
[b] Number of distinct areas in the Kuparuk Oilfield searched for Spectacled Eider nests. No areas were searched specifically for King Eiders. UAF researchers searched 3 areas in 2004 and 1 area in 2005 without ABR assistance; Spectacled Eider nests found during these searches were included in totals (5 in 2002, 3 in 2003, and 1 in 2005).
[c] Three King Eider nests had unknown fate; therefore, nesting success was calculated for 19 nests.
[d] One nest was still active when last checked; therefore, nesting success was calculated for 16 nests.
[e] Two nests had unknown fates; therefore, nesting success was calculated for 15 nests.
[f] Two nests had unknown fates; therefore, nesting success was calculated for 31 nests.
[g] One nest had unknown fate; therefore, nesting success was calculated for 16 nests.
[h] One nest had unknown fate; therefore, nesting success was calculated for 13 nests.

which we have documented complete Spectacled Eider nest failure in our study area; 3 of the 5 years of complete failure have occurred in the past 5 years. Apparent nest success for King Eiders in 2019 was 85.7%, much higher than the long term mean of 32.8% and the highest success rate we have documented since surveys began in 1993 (Table 4).

All nests found in June were visually identified to species in the field; thus, it was not necessary to use feather samples for nest identification in 2019.

NEST MONITORING

No time-lapse cameras or nest thermistors were deployed in 2019 during nest searches due to the lack of active Spectacled Eider nests. In 2019, we analyzed archived photos from 1 time-lapse camera that was deployed in 2018 at Spectacled Eider nest 201803243302, located south of the CPF-2 flare pits (see Attanas and Burgess 2019 for a qualitative description of the nest). This nest was successful and fledged at least 2 chicks on 15 July 2018, according to time-lapse photos. Average incubation constancy for this nest was 98.7 ± 0.8%, and the hen took 0.8 recesses/d which averaged 25.7 ± 3.1 min each (Appendix B). This incubation constancy is within the range of values for other eiders monitored with cameras as part of this study and the CD-3 eider monitoring studies on the Colville delta (Johnson et al. 2006, 2007; Johnson et al. 2008).

During 2008–2018, average incubation constancy for camera-monitored Spectacled Eiders in Kuparuk was high (98.1 ± 0.2%, range 94.8–99.6, *n* = 23 nests). Monitored Spectacled Eiders took an average of 1.3 recesses/d, and the mean recess length was 38.4 min. Average incubation constancy for failed nests (98.2 ± 0.2%, range 97.0–99.1, *n* = 8 nests) was similar to that of successful nests (98.1 ± 0.2%, range 94.8–99.6, *n* = 15 nests), as was mean recess frequency (1.7 recesses/d for failed nests and 1.1 recesses/d for successful nests). These results suggest that poor nest attendance is not the primary reason for low nesting success for Spectacled Eiders in Kuparuk. Incubation parameters for Spectacled and King eiders monitored with egg thermistors during 2004–2015 is presented in Morgan and Attanas 2016.

HABITAT USE

As in past years, the lone Spectacled Eider nest found in 2019 was located in an aquatic habitat, close to a permanent waterbody. The distance of this nest to the nearest aquatic habitat was 2.0 m; however, this nest was located 120.3 m from the nearest mapped permanent waterbody, farther than the 27-year mean of 9.7 ± 1.4 m (range 0–160.9, *n* = 258 nests; Table 5). Only the deepest portions of the thermokarst pond where the nest was located were mapped as a waterbody by Roth et al. (2007, 2008) even though the entire area is permanently flooded. Thus, the calculated distance to the nearest mapped waterbody was much greater than the distance to nearest water for this nest.

In Kuparuk, King Eiders appear to nest slightly closer to waterbodies than do Spectacled Eiders (Table 6). In 2019, the mean distance of King Eider nests to the nearest waterbody was 3.0 ± 3.0 m (range 0–23.8 m; *n* = 8 nests), closer than the 27-year mean of 7.1 ± 19.9 m (range 0–233.9 m; *n* = 424 nests).

Most eider nests are found relatively far from oilfield infrastructure. The one Spectacled Eider nest we found in 2019 was an outlier, located in a pond just 7.3 m from the Oliktok road (Table 7; Figure 2). Over the years, there have been numerous nesting attempts by a single Spectacled Eider hen in this thermokarst pond just north of the road to DS-3O; these nests account for the lowest observed distances to infrastructure. The 27-year mean distance of Spectacled Eider nests to infrastructure is 416.2 ± 12.6 m (range 7.3–1,240.4 m; *n* = 258 nests). King Eider nests found in 2019 had a mean distance to infrastructure of 536.0 ± 124.9 m (range 138–1,014.3 m; *n* = 8 nests), farther than the 27-year mean of 453.5 ± 11.0 m (Table 8; range 9.3–1,347.8 m; *n* = 424 nests).

Identification of habitats used by Spectacled Eiders is a critical component of understanding nesting ecology and how landscape changes may affect Spectacled Eider distribution. Since 2009, our search areas have been composed primarily of 3 habitat types, in decreasing order by area: Shallow Open Water with Islands or Polygonized Margins, Sedge Marsh, and Nonpatterned Wet Meadow (Table 9). Similarly, the highest percentages of Spectacled and King eider nest

Table 5. Distances (m) of Spectacled Eider nests to the nearest aquatic habitat in the Kuparuk Oilfield, Alaska, 1993–2019.

	Distance to aquatic habitat			
Year	Mean	SE	Range	n[a]
1993	3.5	1.3	0–16.6	17
1994	1.3	0.6	0–6	14
1995	6.0	3.0	0–38.3	14
1996	3.2	1.8	0–27.9	16
1997	6.7	3.3	0–36.8	11
1998	2.4	1.2	0–13.1	12
1999	12.0	8.3	0–43.9	5
2000	4.7	2.4	0–26.4	11
2001	0.9	0.6	0–4	8
2002	1.5	0.7	0–8.3	18
2003	16.5	5.7	0–81.4	17
2004	12.3	7.6	0–36.4	5
2005	6.8	4.0	0–43.9	13
2006	5.1	4.7	0–37.8	8
2007	8.7	5.4	0–39.8	8
2008	1.6	1.6	0–9.4	6
2009	1.2	0.8	0–6.4	9
2010	33.9	21.1	0–87.5	4
2011	31.9	21.3	0–160.9	8
2012	15.5	10.4	0–125.1	12
2013	34.0	17.7	0–133.4	8
2014	8.2	5.4	0–37.4	8
2015	18.5	11.1	0–87.5	8
2016	34.5	13.7	0–83.6	7
2017	4.1	2.4	0–19.9	8
2018	7.6	7.6	0–15.2	2
2019	2.0	—	—	1
27-year mean	9.7	1.4	0–160.9	258

[a] Includes known and probable Spectacled Eider nests; probable nests based on identification of contour feathers from nests.

occurrence, in decreasing order, have been in Sedge Marsh, Nonpatterned Wet Meadow, and Shallow Open Water with Islands or Polygonized Margins. During 2009–2019, nearly 50% of Spectacled Eider annual nest occurrence has typically been in Sedge Marsh or Nonpatterned Wet Meadow. In 2019, the one Spectacled Eider nest found was in Human Modified habitat (Table 10), the tenth year since 2002 in which a Spectacled Eider has nested in this thermokarst pond north of the intersection with DS-3O. Since 2009, just over 2% of Spectacled Eider nests have been located in Human Modified habitat; most of these were located in this pond. King Eiders nest in many of the same habitats as Spectacled Eiders with over 65% of King Eider annual nest occurrence also occurring in Sedge Marsh or Nonpatterned Wet Meadow during 2009–2019 (Table 9). In 2019, half of the King Eider nests we found were in Sedge Marsh, while the remaining 40% of nests were found in Shallow Open Water with Islands or Polygonized Margins, Nonpatterned Wet Meadow, and Shallow Open Water without Islands (Table 10).

Table 6. Distances (m) of King Eider nests to the nearest aquatic habitat in the Kuparuk Oilfield, Alaska, 1993–2019.

Year	Distance to aquatic habitat			
	Mean	SE	Range	*n*[a]
1993	13.4	9.6	0–154.6	16
1994	4.4	1.8	0–27.3	20
1995	5.4	1.5	0–11.3	8
1996	2.8	1.6	0–20.9	17
1997	14.7	6.2	0–70.5	14
1998	23.6	12.2	0–233.9	20
1999	2.6	1.7	0–17.1	13
2000	6.3	2.6	0–35.7	19
2001	11.4	7.8	0–105.8	17
2002	9.6	3.5	0–79.4	26
2003	10.6	5.3	0–69.8	16
2004	6.4	3.0	0–37.6	17
2005	8.1	4.3	0–55	14
2006	3.4	2.1	0–39.7	21
2007	1.9	1.0	0–20.1	21
2008	3.6	1.7	0–43.8	33
2009	3.9	1.6	0–22.7	17
2010	4.4	3.6	0–15.2	4
2011	6.3	3.0	0–32.7	14
2012	2.0	1.2	0–18.4	17
2013	9.4	4.7	0–52	14
2014	0.2	0.2	0–2	11
2015	31.4	14.6	0–82	7
2016	0.8	0.6	0–6.9	12
2017	4.2	1.9	0–30.6	18
2018	6.6	4.5	0–40.5	10
2019	3.0	3.0	0–23.9	8
27-year mean	7.1	1.0	0–233.9	424

[a] Includes known and probable King Eider nests; probable nests based on identification of contour feathers from nests.

OCCUPANCY

Since 2009, 16 different sites have been searched in consecutive years, yielding 110 consecutive site-year searches. Of the 57 site-year combinations that had at least 1 Spectacled Eider nest in year 1, 28 (49%) had a Spectacled Eider nest in the following year. The maximum number of consecutive years a site has remained empty before being used again is 4 years. The high re-occupancy rate suggests that nest presence in one year is a good predictor for nest occurrence in subsequent years; however, the re-occupancy rate has declined from 60% in 2017 due to the low number of Spectacled Eider nests found during the past 2 years. In 2019, there were few sightings of Spectacled Eiders during the pre-nesting aerial survey, which suggests that overall nesting effort in the Kuparuk oilfield was low. No pre-nesting surveys were conducted during 2016–2018, so we do not have data on eider densities for comparison during those years. As vegetation, water level, and snow melt conditions at sites can change between years, continued searching of previously-used areas can help us identify small-scale habitat characteristics that influence Spectacled Eider nest site selection.

Table 7. Distances (m) of Spectacled Eider nests to the nearest oilfield infrastructure[a] in the Kuparuk Oilfield, Alaska, 1993–2019.

Year	Mean	SE	Range	*n*[b]
1993	492.9	44.9	115.3–748.4	17
1994	498.1	56.3	162.7–837.4	14
1995	430.3	41.3	211.9–822.9	14
1996	426.4	44.4	116.2–873.3	16
1997	488.5	58.4	214.6–871.5	11
1998	460.0	54.6	206.6–671.7	12
1999	375.2	58.0	196.6–540.7	5
2000	348.3	51.6	135.9–690.2	11
2001	493.2	109.4	268.6–1,240.4	8
2002	409.2	46.0	52.2–733.9	18
2003	456.2	51.0	177.0–896.2	17
2004	543.2	111.9	215.3–883.2	5
2005	388.6	43.6	67.8–665.2	13
2006	409.6	33.4	264.4–531.1	8
2007	406.7	37.6	232.9–546.3	8
2008	364.8	59.9	141.6–510.5	6
2009	354.6	49.6	107.9–551.1	9
2010	329.6	125.0	29.1–594.4	4
2011	346.1	73.6	28.7–703.7	8
2012	392.7	79.1	8.2–861.1	12
2013	442.4	110.4	24.0–1,100.9	8
2014	291.9	68.9	36.8–547.3	8
2015	292.9	53.4	27.0–439.3	8
2016	398.2	75.8	101.7–624.8	7
2017	393.5	105.9	68.1–1,050.4	8
2018	435.7	200.7	234.9–636.4	2
2019	7.3	—	—	1
27-year mean	416.2	12.6	7.3–1,240.4	258

[a] Oilfield infrastructure includes roads, pads, and processing facilities.
[b] Includes known and probable Spectacled Eider nests; probable nests based on identification of contour feathers from nests.

CONCLUSIONS

In 2019, we continued a multi-year effort to study pre-nesting eiders using aerial surveys, to document the location and causes of failure of Spectacled Eider nests in the Kuparuk Oilfield, and to collect incidental information on King Eider nests. These data provide insight into habitat use and changes in distribution or abundance of Spectacled and King eiders on the North Slope during pre-nesting and nesting. The aerial surveys provide broad-scale distribution, abundance, and habitat use data, while targeted and consistent searches of potential nesting areas quantify interannual variation in breeding effort and reproductive success. The long-term data show that the overall density of pre-nesting Spectacled Eiders may be declining slightly in Kuparuk while the number of King Eiders is increasing, which is consistent with data from other studies on the Arctic Coastal Plain. Site re-use by nesting Spectacled Eiders in the Kuparuk Oilfield has been high since this study began, facilitating the long-term annual collection of nesting habitat associations and breeding success. Both Spectacled and King eiders frequently nest in the same habitat

Table 8. Distances (m) of King Eider nests to the nearest oilfield infrastructure[a] in the Kuparuk Oilfield, Alaska, 1993–2019.

Year	Mean	SE	Range	*n*[b]
1993	345.0	46.3	28.0–677.0	16
1994	484.8	48.1	153.8–778.5	20
1995	481.5	55.3	197–692.8	8
1996	473.2	55.8	189.7–931.7	17
1997	381.1	69.6	25.7–809.2	14
1998	510.1	65.9	9.3–1,347.8	20
1999	305.6	44.0	132.7–619	13
2000	558.8	51.8	269.9–1,028.0	19
2001	475.1	61.6	9.9–952.8	17
2002	475.1	49.4	22.1–993.1	26
2003	518.2	70.6	15.3–1,034.4	16
2004	369.3	39.8	104.2–637.8	17
2005	407.0	45.2	219.6–872.2	14
2006	463.2	30.2	229.3–674.5	21
2007	385.5	37.8	85.4–705.8	21
2008	427.1	31.3	47.6–749.7	33
2009	446.5	39.9	199.3–705	17
2010	389.0	27.2	342.3–463.3	4
2011	370.2	36.0	136.8–612.2	14
2012	441.5	50.5	95.8–887.3	17
2013	504.3	64.2	244.6–1,093.4	14
2014	467.7	68.9	218.2–918.9	11
2015	620.4	99.9	380.3–1,136.8	7
2016	559.5	81.9	56.3–991.1	12
2017	475.2	66.9	96.2–1,028.5	18
2018	451.4	95.3	91.3–1,021.6	10
2019	536.0	124.9	138–1,014.3	8
27-year mean	453.5	11.0	9.3–1,347.8	424

[a] Oilfield infrastructure includes roads, pads, and processing facilities.
[b] Includes known and probable King Eider nests; probable nests based on identification of contour feathers from nests.

types, but annual or seasonal conditions within nesting habitat likely influence species-specific nest site selection and breeding success. In 2019, both species nested primarily in aquatic habitats but while King Eiders had the highest apparent nest success rate recorded to date, the only Spectacled Eider nest recorded failed. Annual monitoring provides a consistent record of interannual variability and context for any changes due to environmental factors or anthropogenic activity.

Table 9. Average area (km²) searched per year, average percentage of total area searched, and percentage of Spectacled and King eider nests located in each habitat type searched in the Kuparuk Oilfield, 2009–2019. Standard errors are shown in parentheses.

		Percentage of Total		
Habitat	Area (km^2)	Area Searched	Spectacled Eider Nests	King Eider Nests
Shallow Open Water with Islands or Polygonized Margins	1.17 (0.11)	26.91 (0.97)	6.64 (2.59)	12.09 (3.27)
Sedge Marsh	1.06 (0.09)	24.82 (0.8)	28.73 (6.27)	48.09 (5.46)
Nonpatterned Wet Meadow	0.78 (0.05)	18.64 (0.45)	16.27 (4.58)	17.27 (4.31)
Shallow Open Water without Islands	0.35 (0.03)	8.09 (0.56)	0	1.73 (1.25)
Old Basin Wetland Complex	0.26 (0.03)	6.27 (0.73)	4.82 (2.82)	10.45 (4.42)
Patterned Wet Meadow	0.23 (0.03)	5.36 (0.47)	9.18 (4.8)	4.64 (2.06)
Young Basin Wetland Complex	0.13 (0.01)	3.09 (0.28)	12 (4.32)	3.64 (1.96)
Moist Sedge-Shrub Meadow	0.09 (0.01)	2.09 (0.25)	18 (8.51)	0.73 (0.73)
Human Modified	0.09 (0.01)	2.18 (0.4)	0.73 (0.73)	1.27 (0.86)
Deep Open Water without Islands	0.06 (0)	1.55 (0.16)	2.18 (1.47)	0
Moist Tussock Tundra	0.05 (0.02)	1.36 (0.31)	2.45 (1.65)	0

Table 10. Total area (km²) of each habitat types searched and number of Spectacled and King eider nests found in each habitat type in the Kuparuk Oilfield, 2019.

		Number of Nests	
Habitat	Search Area (km^2)	Spectacled Eider	King Eider
Shallow Open Water with Islands or Polygonized Margins	1.88	0	2
Sedge Marsh	1.56	0	4
Nonpatterned Wet Meadow	1.04	0	1
Shallow Open Water without Islands	0.41	0	1
Old Basin Wetland Complex	0.32	0	0
Patterned Wet Meadow	0.21	0	0
Young Basin Wetland Complex	0.14	0	0
Human Modified	0.09	1	0
Moist Sedge-Shrub Meadow	0.07	0	0
Deep Open Water without Islands	0.07	0	0
Moist Tussock Tundra	0.03	0	0
Grass Marsh	0.01	0	0
Total	5.83	1	8

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Appendix A. Nest-site characteristics, nest fate, and clutch size of eider nests found during ground nest searches in the Kuparuk Oilfield, 21–26 June 2019.

Species	General Location	Nest Fate[a]	Clutch Size[b]	Number of Membranes	Micro-habitat	Wildlife Habitat Type[c]	Waterbody Type	Distance to Nearest (m): Aquatic Habitat	Distance to Nearest (m): Oilfield Infrastructure[d]
Spectacled Eider	DS-3O	F	—	0	Island	Human Modified	Shallow Open Water without Islands	120.3	7.3
King Eider	CPF2 (New)	S	5	4	Peninsula	Shallow Open Water with Islands or Polygonized Margins	Shallow Open Water with Islands or Polygonized Margins	0	154.7
King Eider	DS-1E	F	4	0	Hummock	Nonpatterned Wet Meadow	Shallow Open Water with Islands or Polygonized Margins	23.9	1014.3
King Eider	DS-1Y	S	5	3	Peninsula	Sedge Marsh	Shallow Open Water with Islands or Polygonized Margins	0	839.2
King Eider	DS-1Y	S	—	5	Hummock	Sedge Marsh	Shallow Open Water with Islands or Polygonized Margins	0	578.8
King Eider	DS-1Y	S	5	3	Peninsula	Sedge Marsh	Shallow Open Water with Islands or Polygonized Margins	0	926.3
King Eider	CPF3 (2017)	S	3	1	Shoreline	Sedge Marsh	Shallow Open Water with Islands or Polygonized Margins	0	307.4
King Eider	CPF2 (New)	S	8	7	Island	Shallow Open Water with Islands or Polygonized Margins	Shallow Open Water with Islands or Polygonized Margins	0	138
King Eider	DS-2X	U	—	—	Island	Shallow Open Water without Islands	Shallow Open Water without Islands	0	329.3

[a] S = Hatched at least one young; F = Failed to hatch any young; U = Unknown fate.
[b] Clutch size is "–" for nests where the incubating female was not flushed and for nests that were found after they had failed.
[c] Wildlife Habitat Type refers to aggregated habitat types from Roth et al. 2007.
[d] Oilfield infrastructure includes roads, pads, and processing facilities.

Appendix B. Nest history and incubation activity at Spectacled Eider nests monitored by time-lapse digital cameras, Kuparuk Oilfield, Alaska, 2008–2018. No cameras were deployed in 2019 due to lack of nests. Standard errors are in parentheses.

Year	Nest No.	Location	Instrument Type	Fate[a]	Nest Initiation Date[b]	Predator	Min. Clutch Size[c]	Date of Instrument Setup	Date of Hatch or Failure	No. Days Monitored[d]	Average Incubation Constancy[d] (%)	Recess Frequency[d] (no/d)	Mean Recess Length[d] (min/ recess)
2008	20085502	DS-1E	Reconyx PM-75	F	—	Arctic Fox	3	25 June	28 June	2.1	97.6(1.7)	1.4	25.3(4.3)
2008	20085203	DS-2C	Reconyx PM-75	F	—	Arctic Fox	3	25 June	8 July	12	98.3(0.5)	1	23.4(1.8)
2008	20084401[e]	DS-2T (South)	Reconyx PM-75	F	—		3	26 June	—	—	—	—	—
2009	20095502	DS-1E	Reconyx PM-75	S	11 June		4	22 June	5 July	12	99.6(0.2)	0.4	15.2(1.7)
2009	20095503	DS-1E	Reconyx PM-75	S	12 June	Glaucous Gull[f]	4	22 June	6 July	13	99.1(0.4)	0.6	23.1(6.4)
2009	20094301	DS-2V	Reconyx PM-75	S	13 June		6	23 June	7 July	13	98.1(0.5)	1	29.5(2.7)
2010	20103204401	DS-2T (North)	Reconyx PM-75	S	10 June		—	27 June	4 July	3.8	98.1(0.5)	1.6	19.5(6.3)
2010	20103204403[g]	DS-2T (South)	Reconyx PM-75	F	—	Parasitic Jaeger	—	27 June	8 July	11	—	—	—
2010	20103200301	DS-3O	Reconyx PM-75	S	19 June		3	22 June	13 July	6.5	99.5(0.3)	0.8	27.8(6.0)
2011	20113205203	DS-2C	Reconyx PM-75	F	—	Glaucous Gull	—	24 June	10 July	15.1	97.0(0.5)	4.8	26.5(18.6)
2011	20113204401	DS-2T (South)	Reconyx PM-75	S	20 June		4	24 June	11 July	16	98.3(0.5)	0.9	27.7(4.2)
2012	20123204301	CPF2 (New)	Reconyx PM-75	S	18 June		4	24 June	12 July	17	99.1(0.2)	0.6	22.3(1.5)
2012	20123204302	DS-2F	Reconyx PM-75	S	16 June		3	24 June	10 July	15	97.5(0.5)	1.5	25.9(2.8)
2012	20123200701	DS-3O	Reconyx PM-75	S	17 June		4	23 June	11 July	17	98.1(0.4)	1	29.4(3.5)

Appendix B. Continued.

Year	Nest No.	Location	Instrument Type	Fate[a]	Nest Initiation Date[b]	Predator	Min. Clutch Size[c]	Date of Instrument Setup	Date of Hatch or Failure	No. Days Monitored[d]	Average Incubation Constancy[d] (%)	Recess Frequency[d] (no/d)	Mean Recess Length[d] (min/ recess)
2013	20133204301	DS-2F	Reconyx PM-75	S	11 June	Common Raven[f]	4	22 June	7 July	14	98.2(0.5)	1.3	20.8(3.0)
2013	20133205401	DS-2G (North)	Reconyx PM-75	S	16 June		3	25 June	9 July	13	96.4(0.8)	1.8	30.5(3.6)
2013	20133200701	DS-3O	Reconyx PM-75	F	16 June	Red Fox	4	21 June	9 July	17.2	98.6(0.4)	0.8	26.7(2.2)
2014	20143204712	DS-1E	Reconyx PM-75	S	7 June		4	29 June	6 July	6	98.3(0.6)	1.2	20.3(4.3)
2014	20143203031	DS-2T (North)	Reconyx PM-75	S	9 June	Glaucous Gull[f]	4	28 June	4 July	5	94.8(1.3)	1.6	41.1(2.4)
2014	20143200713	DS-3O	Reconyx PM-75	F	21 June	Red Fox	4	25 June	3 July	7.8	98.1(0.9)	0.8	41.3(2.7)
2015	201532044001	DS-2C	Reconyx PM-75	F	23 June	Glaucous Gull	3	27 June	2 July	4.3	97.9(1.8)	2.1	335.2(329.4
2015	201532032068	DS-2V	Reconyx PM-75	F	—	Red Fox	6	27 June	30 June	2.4	99.1(0.5)	1.3	10.7(4.9)
2015	201532007104	DS-3O	Reconyx PM-75	F	15 June	Red Fox	4	26 June	30 June	4.3	98.6(0.7)	1.4	13.8(7.5)
2018	201803243302	DS-2F	Reconyx PC-800	S	18 June		3	25 June	15 July	15.1	98.7(0.4)	0.8	25.7(3.1)

[a] S = successfully hatched, F = failed to hatch.
[b] Incubation start dates for successful nests estimated by subtracting 24 d from hatch date; for failed nests, nest age estimated using egg floatation data. Nests with no initiation date had no float data or did not hatch.
[c] The minimum number of eggs in a nest is equal to the number of eggs at the time of instrumentation or the number of membranes found in the nest post-hatch if the bird was not flushed during instrumentation. If the number of membranes was greater than the number of eggs for any nest, the number of membranes is used.
[d] Summarized from the day after instrument deployment to day before hatch or the time of nest failure; excludes period of time when photo or video images could not be interpreted because of poor weather, poor light conditions, or instrument malfunction.
[e] No incubation parameter data could be calculated for this nest. Eider hen was not present during instrumentation and never returned to nest 20084401. Nest appeared to have been parasitized by a Canada Goose and later failed.
[f] Nest was partially predated but still hatched ≥1 egg.
[g] Incubation parameters could not be calculated due to missing data.