SPECTACLED EIDER MONITORING AT THE CD-3 DEVELOPMENT, 2007

ANNUAL REPORT

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EXECUTIVE SUMMARY

We investigated the effects of construction activity and aircraft overflights on nesting Spectacled Eiders in 2007 as part of a multi-year study at CD-3, a new satellite well pad in the Alpine Satellite Development Program on the Colville Delta. CD-3 is located on the outer Colville Delta in nesting habitat used by Spectacled Eiders. The Spectacled Eider is a threatened species, listed under the Endangered Species Act, and concerns about aircraft and construction disturbance of breeding Spectacled Eiders and a lack of information on the effects of disturbance on the species, led ConocoPhillips, Alaska, Inc., to initiate this investigation. Gravel was deposited for CD-3 during winter 2005 and construction continued through 2006. Drilling for wells occurred only during winter, and the drill rig was moved to Alpine (CD-2 or CD-4) over ice roads before ice roads were closed in spring (usually mid-May). CD-3 consists of a 0.9-km-long airstrip and apron connected by a 0.6-km-long road to the well pad. The total gravel footprint for CD-3 is 9.1 ha (0.09 km² or ~22.4 acres). Access to CD-3 is limited to ice roads during winter and aircraft during the remainder of the year.

The goal of this 3-year study was to investigate how productivity, nesting behavior, and habitat use of Spectacled Eiders were influenced by construction and aircraft activity at CD-3. We began this 3-year study in 2005. In 2005–2007, we collected data on the pre-nesting and nesting distribution of eiders, habitat selection, incubation behavior, nest survival, and human activity in the study area. Baseline data on pre-nesting (initiated in 1993) and nesting (initiated in 2001) distributions facilitated before–after construction comparisons.

Construction activity in 2007 was monitored by 3 time-lapse cameras. Low levels of construction and human activity occurred on the gravel footprint throughout the eider breeding season. Crews were present at the CD-3 development 2–3 times/wk and generally worked a 12-h shift from 0600–1800. Crews primarily worked at the well pad. Vehicle traffic was associated with transporting crews from the airstrip to the well pad and 1–2 pieces of heavy equipment used to resurface and compact the gravel at the well pad. Few vehicles were recorded traveling on the airstrip. Transportation of crews in the area was primarily by twin engine CASAs and Twin Otters, but helicopters were occasionally used for this purpose. Flight paths of helicopters were recorded by GPS units onboard each aircraft and flight paths of airplanes were assumed from the alignment of the airstrip. Helicopter flights within 200 m of all eider nests were summarized by flight length, altitude, and duration. Cumulative helicopter flight time within 200 m of all known eider nests from 28 May to hatch or failure totaled 0.8 h. Minimum helicopter flight altitudes within 200 m of nests ranged from 0 m to 113 m during the same period. Summer operations at CD-3 were supported by a total of 26 helicopter flights (takeoffs and landings) and 58 airplane flights from 28 May–17 July (approximately pre-nesting through the end of incubation for eider nests).

Aerial surveys were conducted over the Colville Delta for pre-nesting Spectacled Eiders with consistent methods during 1993–1998, and 2000–2007. The number of Spectacled Eiders recorded on the aerial survey in 2007 increased for the second consecutive year over numbers recorded during the past several years. To investigate displacement of eiders from the CD-3 facilities, we compared the distance of pre-nesting groups to development project features on the Colville Delta among 3 construction periods (pre-Alpine [before 1998], post-Alpine [1998–2004], and post CD-3 [2005–2007]). The mean distances of Spectacled Eider groups from these features differed little between the pre-Alpine, post-Alpine, and post-CD-3 periods. During 2005–2007, when construction of CD-3 and CD-4 began and transitioned into operation, pre-nesting eiders were found closer on average to Alpine, CD-3, and CD-4 than they were in prior years. Tests of differences in mean distance of Spectacled Eider groups among construction periods showed no indication that pre-nesting Spectacled Eiders were displaced by the Alpine, CD-3, or CD-4 pads.

We found 14 Spectacled Eider nests in the nest-search area in 2007, a number similar to the 7-year mean. Three nests were inactive, resulting in 11 active nests in 2007. In all years with comparable nest searches (2001–2007) except

2001, successful nests were nearer to the location of CD-3 than were failed nests. In 2007, the 6 successful nests averaged 429 m closer to CD-3 than the 8 failed nests. Comparison of distances of successful and failed nests to CD-3 among years and among construction periods identified no significant differences. These analyses suggest that the placement of the gravel footprint and activity at CD-3 in 2005–2007 did not result in changes in overall nest distribution nor were failed nests closer to CD-3, where they would have been exposed to higher levels of human activities.

We monitored incubation behavior with time-lapse cameras placed near 10 of 11 active Spectacled eider nests that were found in 2007, and 9 of those nests also were monitored with temperature-sensing eggs. Activity budgets estimated separately with temperature-sensing eggs and time-lapse cameras produced similar results, indicating that temperature-sensing eggs were an accurate method for recording incubation activity.

Apparent nesting success for Spectacled Eiders in 2007 was 43%, which was above the long-term pre-construction average of 37%. Of 10 active nests monitored, 5 hatched and 5 failed. Arctic foxes were implicated at all 5 failed nests where they flushed incubating females. Poor nest attendance by hens did not contribute to the failure of monitored nests. Three nests failed prior to discovery and their causes of failure were unknown.

In 2007, helicopter flight paths were recorded within 200 m of 9 active Spectacled Eider nests in the study area and the other 2 active nests had no helicopter flights within 200 m. There was no clear relationship between apparent nest success and helicopter overflights. The nest closest to the gravel footprint (53 m) hatched and was exposed to relatively high levels of helicopter overflights. Three nests failed prior to discovery, so exposure to helicopter flights within 200 m was unknown, but 2 of 5 nests with no exposure failed. The median cumulative flight time of helicopters within 200 m of all failed nests (12 sec) was significantly less than the flight time within 200 m of hatched nests (215 sec), indicating that the amount of helicopter traffic at that scale did not determine nest success. The sample size of nests with helicopter landings (3 nests) and fixed-wing flights (5 nests) within 200 m was too small to reach any conclusions about the effects of those events on nesting success.

To identify shifts in habitat use related to development activity, we compared baseline habitat selection on the Colville Delta (prior to construction of Alpine) by pre-nesting Spectacled Eiders during the pre-Alpine period (1993–1997) with habitat selection during the post-Alpine period (1998–2004) and post-CD-3 period (2005–2007). During the pre-Alpine period, 4 habitats were identified as preferred by pre-nesting Spectacled Eider groups and during the post-Alpine period, 2 of those habitats were replaced by 2 different preferred habitats. We compared the use of the preferred habitats identified during the baseline years with use of those same habitats in the later 2 construction periods. Although the amount of use of baseline preferred habitats declined from pre-Alpine to post-Alpine to post-CD3, the differences were not significant.

We also evaluated shifts in use of preferred nesting habitat between 2 construction periods. Habitat selection by nesting eiders prior to construction of CD-3 was evaluated in the same nest-search area between 2001 and 2004. Two habitats were preferred and these 2 habitats contained 71% of the nests. After construction of the CD-3 pad and airstrip, use of those habitats occurred at similar levels, with 67% of the nests. The gravel footprint of CD-3 covered about 9.1 ha (22.4 acres) of tundra of which 6.0 ha (14.8 acres) were in preferred habitats comprising <0.1 % of the total area of those nesting habitats available on the Colville Delta.

In summary, preliminary analyses showed no evidence of displacement and little evidence of changes in habitat use among pre-nesting and nesting Spectacled Eiders in the 3 years since construction of CD-3 began. Productivity (nesting success and clutch size) was similar to previous years, and helicopter overflights and proximity to the construction site had no clear effects on overall nesting success. Future analyses will include detailed evaluations of the influence of environmental and human disturbance factors on nesting success and incubation behavior.

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ACKNOWLEDGMENTS

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INTRODUCTION

During 2005, ABR, Inc., was contracted to initiate a multi-year study into the effects of construction of the CD-3 well pad and airstrip on Spectacled Eiders nesting on the Colville River delta. CD-3 is 1 of 5 well pads proposed by ConocoPhillips Alaska, Inc. (CPAI), in the Alpine Satellite Development Project (ASDP) (BLM 2004). The CD-3 satellite pad was designed to operate without an all-season road; instead, it is accessed by vehicles on an ice road in winter and by aircraft in other seasons. The CD-3 pad and airstrip are located in a nesting ground for Spectacled Eiders (see Johnson et al. 2004b); consequently, disturbance of Spectacled Eiders by construction activities and aircraft overflights was a major concern of the U.S. Fish and Wildlife Service (USFWS) in its Biological Opinion for the ASDP (USFWS 2004). The Spectacled Eider was listed as threatened in 1993 (58 FR 27474-27480) under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Section 7 of the ESA requires a consultation for construction projects within a threatened species' range. In the Biological Opinion culminating the Section 7 process, the USFWS recognized the absence of studies on the effects of disturbance from construction and aircraft on breeding Spectacled Eiders. CPAI voluntarily sponsored this study to investigate some of the impact concerns raised in that Biological Opinion and to improve our understanding of development impacts on this species so that future development could be designed and permitted in a manner that would conserve the species.

The Spectacled Eider has been a focal species for wildlife studies on the Colville River delta since surveys first were sponsored there by CPAI's predecessors (ARCO Alaska, Inc., and later, Phillips Alaska, Inc.) in 1992 (Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 1999b, 2000a, 2000b, 2001, 2002, 2003a, 2003b, 2004a, 2005, 2006a, 2007a, 2008; Burgess et al. 2000, 2002, 2003). Aerial surveys for pre-nesting eiders have been conducted in all years from 1992 to the present except for 1999, when British Petroleum and ARCO Alaska were merging. Ground-based nest surveys were conducted sporadically near the current CD-3 pad location in 1992–1994, 1997, and 2000, with thorough coverage of the current study area beginning in 2001, when the final location of the CD-3 pad and airstrip was first delineated. These surveys were conducted annually through 2007.

The goal of the current investigation is to evaluate how the placement of the CD-3 well pad and airstrip and the activities associated with their construction and operation affect nesting Spectacled Eiders. In 2007, we collected data on the distribution of pre-nesting and nesting eiders, habitat selection, incubation behavior, and nest survival. Baseline data on pre-nesting and nesting distributions facilitate before–after construction comparisons that otherwise would not be possible. In this annual report, we summarize data collected in 2007. Some preliminary analyses are presented; however, final analyses will be conducted after laboratory analysis of nest feathers collected in 2007. Readers are cautioned, therefore, that results presented here are preliminary and may change somewhat with further analysis.

STUDY AREA

The place names used throughout this report are those depicted on U.S. Geological Survey (USGS) 1:63,360-scale topographic maps, because they are the most widely available published maps of the region. The corresponding local Iñupiaq names for drainages also are provided in parentheses at the first usage in text and on the study area map (Figure 1). Iñupiaq names are presented out of respect for local residents, to facilitate clearer communication with Iñupiaq speakers, and because they pre-date the English names used on USGS maps. Nuiqsut elders have supplied names for some channels and streams to CPAI in recent years. Marjorie Kasak Ahnupkanna and Archie Ahkiviana were consulted to confirm the names of channels on the Colville River delta (E. Wilson, Alaska Native Language Center, pers. comm.).

The Colville River delta (or Colville Delta) contains the Alpine Facilities (occupying 37 ha, including the CD-1 and CD-2 pads, a 1.8-km airstrip, and a 3-km road between the pads), which was the first producing oilfield on the Colville Delta, and 2 new sites under construction in 2005 and 2006, CD-3 and CD-4 (Figure 1). This study

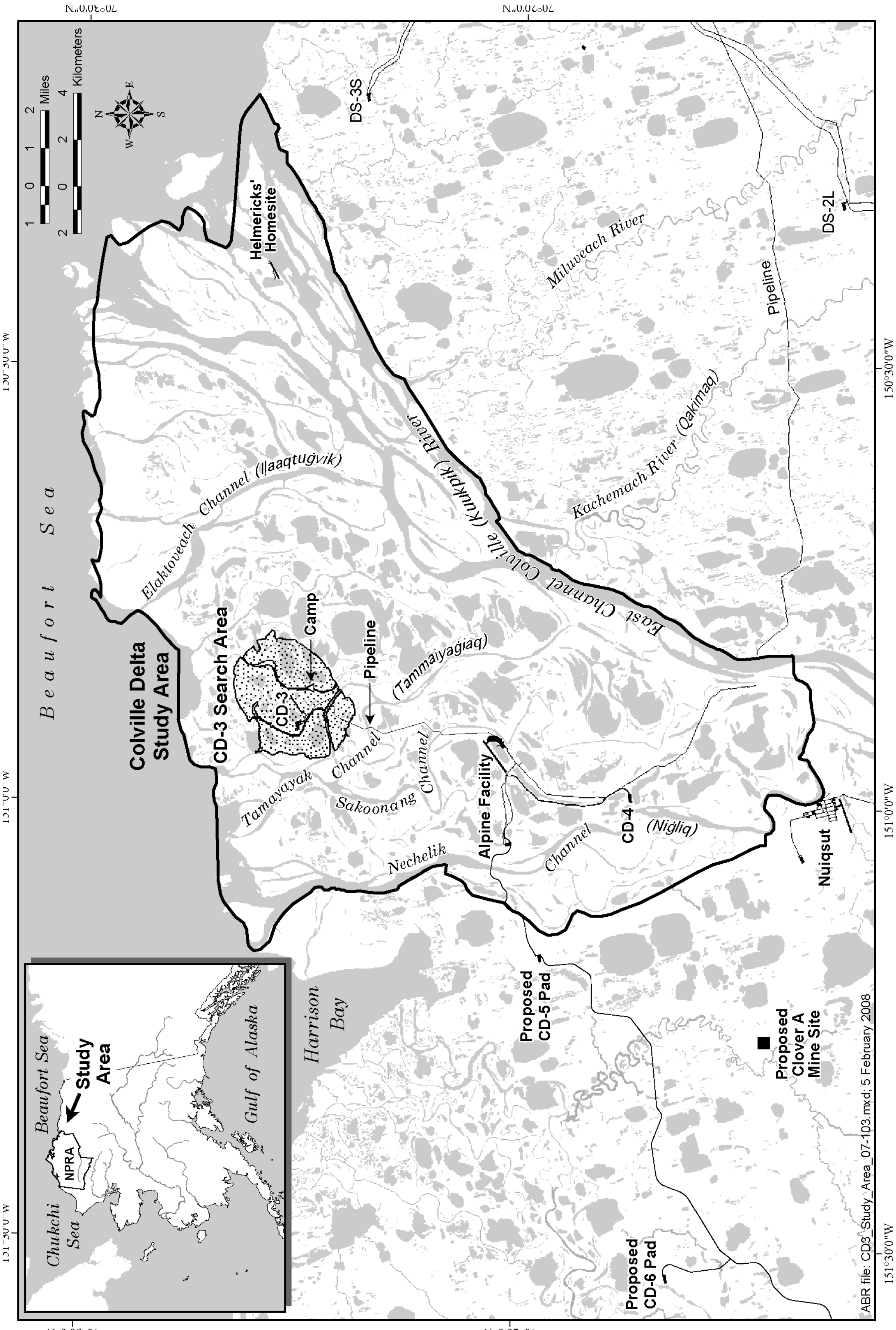

Figure 1. Study area and CD-3 nest-search area, Colville Delta, Alaska, 2007.

focuses on CD-3 and its vicinity because that facility was placed in a nesting area for Spectacled Eiders. CD-3 is a roadless development that is accessed via an all-season landing strip and a winter ice road (whereas CD-4 is connected by an all-season road to the processing facility at CD-1). CD-3 has a 0.9-km airstrip and apron connected by a 0.6-km road to the well pad. The total gravel footprint for CD-3 is 9.1 ha (0.09 km² or ~22.4 acres). CD-3 began producing oil in August 2006. The CD-3 nest-search area encompasses a roughly 1.9-km radius around the gravel airstrip, and is located between the Elaktoveach (Iḷaaqtuġvik) and Niġliq channels (Figure 1). The CD-3 nest-search area is subdivided by 3 channels of the Colville River: the Tamayayak (Tammayaiġiaq), the West Ulamniġiaq, and the East Ulamniġiaq.

As used in this report, the Colville Delta study area (552 km²) spans the entire delta from the east bank of the East Channel of the Colville River to the west bank of the westernmost distributary of the Nechelik (Niġliq) Channel and inland to the juncture of these channels (Figure 1). The Colville Delta is one of the most prominent and important landscape features on the Arctic Coastal Plain of Alaska, because of its large size and its use by concentrations of birds, mammals, and fish. Two permanent human settlements occupy the Colville Delta area—the Iñupiat village of Nuiqsut and the Helmericks' family home site (Colville Village).

METHODS

EIDER SURVEYS

Regional abundance and distribution of eiders were evaluated with data collected by Johnson et al. (2008) on aerial surveys flown during the pre-nesting period, while male eiders (the more visible of the 2 sexes in breeding plumage) were present on the breeding grounds. The pre-nesting survey, conducted 13–14 June 2007, consisted of strip transects that covered the Colville Delta and the Kuparuk Oilfield (detailed methods and results are reported separately in Anderson et al. 2008 for the Kuparuk Oilfield and Johnson et al. 2008 for the Colville Delta). The surveys have been conducted with the same methods since 1993. In 1992, aerial surveys sampled portions of the Colville Delta that were not comparable to the current survey area, so that year has been excluded from summaries of abundance and habitat use. In this report, we use the pre-nesting locations to evaluate temporal changes in distribution and habitat selection in relation to the construction of Alpine and the CD-3 and CD-4 pads.

The CD-3 nest-search area encompassed 17.6 km² in 2007 (Figure 1) and had boundaries that were similar to those in 2001–2006 (Johnson et al. 2002, 2003b, 2004a, 2005, 2006b, 2007b). The search area boundaries were selected to encompass the area of potential disturbance by aircraft landings and takeoffs (≥1.9 km from the proposed airstrip location), based on noise contours originally estimated for the Alpine Development airstrip (see Johnson et al. 2003a).

In 2007, 6 to 8 nest searchers set up a tent camp on the east side of the East Ulamnigiaq channel ~810 m from the CD-3 airstrip. Nest searchers walked or boated (5-m river boat with 10-hp 4-stroke motor) each day to the areas that were searched. Boating was confined to 2 major channels (Tamayayak and East Ulamnigiaq) and required ≤1 h of motor time each day. Water levels during nest searching were well below bank height, so it was unlikely that noise or visual disturbance from boating affected nesting eiders. A helicopter was used as transport to and from camp to the western portion of the search area on 3 days when water levels were too low and waves too high for boating (29 June–1 July). Prior to 2005, daily access to the nest-search area was via helicopter from Alpine or the Helmericks' homesite in the northeastern delta. Otherwise, nest-search methods were similar among years. The details of pre-2007 field activities are summarized in previous reports (Johnson et al. 2000a, 2002, 2003b, 2004a, 2005, 2006b, 2007b).

Intensive nest searches were conducted in the CD-3 nest-search area 17 June–1 July 2007. Searchers worked together walking a regular search pattern with ~10-m spacing between adjacent observers. Each team member thoroughly searched for nests of eiders on all dry ground (not flooded) between themselves and adjacent observers. The following data were recorded for each nest found: species, distance to nearest water, distance to nearest waterbody, waterbody class, habitat type, and, if the bird flushed, the number of eggs in the nest. In the field, all nest locations were plotted on color photomosaics (~1:14,000–1:18,000 scale) and recorded as waypoints on handheld global positioning systems (GPS). Observers attempted not to flush birds during nest discovery, but all hens were flushed for the installation of temperature-sensing eggs (see below). Once a bird was flushed, the observer counted the eggs, floated the eggs (to estimate age), collected a small sample of contour feathers from the nest, and covered the eggs with down and vegetation before leaving the site. We floated up to 4 eggs from each clutch in a small container of water and recorded the position in the water column (bottom, middle, at the surface, and breaking the surface [we recorded percent of egg volume above the surface to nearest 5%]), and angle (to nearest degree from horizontal). We estimated the age of the eggs with a float schedule used by USFWS (T. Bowman, unpubl. data). The age of the oldest egg was used to backdate to the start of incubation. For nests that hatched, the start of incubation was calculated assuming a 24-day incubation period (Peterson et al. 2000).

When necessary (for example, when nests were unattended by an adult bird at discovery), down and contour feather samples were used to identify nests to species. We classified nests to species based on color patterns of contour feathers (Anderson and Cooper 1994). Contour feathers have been collected since 1994 and have been archived for future analyses.

Nests were revisited to check their fates during weekly camera maintenance (see below) and during 16–18 July 2007. Each nest site recorded in June was revisited and examined for evidence of nest fate. Eider nests were classified as successful if thickened egg membranes were found that had detached from the eggshells (Mickelson 1975). If no membranes were found, the nest was classified as failed. All nests were examined for evidence of predation, such as crushed eggshells and blood, yolk, or albumin on the egg shells. During the nest checks, shorelines, lakes, and islands were searched opportunistically for the eider broods. Brood locations were plotted on color photomosaics, and the numbers of adults and young were recorded.

Required borough, state, and federal permits were obtained for authorized survey activities and camping. The North Slope Borough authorized land use for a camp site (Permit N07-343). A Scientific or Educational Permit (Permit No. 07-069) was acquired from the State of Alaska under AS 16.05.930, and a Federal Fish and Wildlife Permit—Threatened and Endangered Species (Permit No. TE012155-0) was acquired from the USFWS under Section 10 of the ESA.

TIME-LAPSE CAMERAS

We used 12 Silent Image® Professional (model PM35, 640x480 pixel; Reconyx, Lacrosse, WI) digital time-lapse cameras customized with 8× lenses to record incubation behavior of nesting Spectacled Eiders and predators, and 2 of the same model cameras with standard lenses to record human activity at CD-3. All cameras were equipped with 1- or 2-GB compact flash memory cards. We set cameras on the first eider nests (Figure 2) found active with >1 egg. Installation occurred within 1 day of nest discovery. The cameras were mounted on tripods that were tied down to stakes to stabilize them against the wind (Figure 2). Cameras were installed 25–50 m from nests, which allowed us to avoid disturbing incubating hens when the memory cards and batteries were changed. Cameras monitoring human activities were placed >200 m from the areas they were viewing to get a more complete view of the pads. All cameras were programmed to take ~2 images/min (32-sec intervals). The memory card and batteries (8 rechargeable AA NiMH) in each camera were exchanged approximately every 7 days.

We reviewed digital images on personal computers with Irfanview software (version 4.1.0). Eider activity was classified into 3 major classes of activity: incubation, recess, and break, following definitions of Cooper (1978). Incubation included sitting postures of normal incubation, assumed incubation (bird could not be seen, but did not leave the nest), alert incubation (head up in a rigid, attentive posture), concealed incubation (head and body down and flattened in vegetation), preening on the nest, and gathering nest material while on the nest. Break activities included brief standing activities at the nest: settling, sitting or standing beside the nest, changing positions, standing over the nest, rolling eggs, standing while preening, gathering nest material off the nest, and cleaning

Figure 2. Spectacled Eider nest and time-lapse camera in the CD-3 nest-search area, Colville Delta, Alaska, 2007.

the nest. Recess activities were absences from the nest and those activities immediately preceding and following the recess: egg covering or uncovering, standing beside the nest, walking, flying, swimming, and gone from view. Predators in camera views were identified to species and classified by distance from the nest and activity: running, flying, sitting, standing, eating eggs at nest, and carrying eggs away from nest. We also recorded the activity and distance from the nest of other waterfowl and caribou.

Nests were monitored from the day of camera set-up through nest failure or when the hen and brood were observed leaving the nest. Day of hatch was defined as occurring 24-h before the hen and brood departed. The day of nest failure was assigned based on event. Foxes were assumed to take every egg within a short period of their discovery of the nest and nests visited by foxes were assumed failed, even if the hen returned to incubate for some period of time. Avian predators may cause partial predation so their presence at a nest did not indicate failure unless a hen quit incubating, at which point the nest was considered failed.

The number of days or minutes of monitoring were calculated after excluding the day of camera set-up, hatch, fledging, or failure, as well as periods of poor visibility, camera maintenance, and researcher disturbance. Periods of poor visibility (e.g., heavy fog, moisture on the lens, or too little or too much light for correct photographic exposure) were excluded from calculations when we could not judge whether a hen was incubating or off the nest. Researcher disturbance occurred if an incubating bird was flushed by research activities. In such cases, we subtracted 30 min from time of flush and added 30 min to the time when the hen resumed normal incubation and recorded the entire period "disturbed". Incubation constancy was calculated as the percentage of time the bird was observed incubating out of the number of minutes monitored. Mean daily number of recesses was calculated as the sum of the number of recesses divided by number of days monitored.

TEMPERATURE-SENSING EGGS

Artificial, temperature-sensing eggs were constructed from domestic duck eggs that were stained with tea to approximate the size and color of Spectacled Eider eggs. Domestic duck eggs were opened to remove their contents and once dry, a thermistor (TMC6-HB with 1.8-m long cord, ±0.5º C accuracy, ±0.4º C resolution; Onset Computer Corporation, Bourne, MA) was glued into each egg with epoxy cement and several more layers of epoxy cement were spread on the inside of the eggshell to reinforce it. The artificial egg was glued with silicon caulk to a 19-cm spike, which served to anchor the egg in the nest.

Spectacled Eider nests that were active when discovered were instrumented with temperature-sensing eggs. To install the artificial egg and instrumentation, we flushed the hen, removed the eggs, and covered them with an insulator. We made a hole for the anchoring spike of the artificial egg by driving a 1.2-cm diameter rod into the frozen tundra under the nest and then inserted the anchoring spike. The thermistor cord from the egg was hidden in a shallow trench (2–3 cm deep) leading 12–24 cm outside the nest to where the data logger was buried 3–5 cm under the vegetation mat. The thermistor cord was wrapped around a separate stake to prevent loss of the cord and data logger to predators. A HOBO® H8 data logger (Onset Computer Corporation, Bourne, MA) was set to record temperature in degrees Celsius at 5-min intervals and sealed in a plastic bag to protect it from soil moisture. After the artificial egg and data logger were installed, the eider eggs were returned to the nest and covered with down and then with dry vegetation to camouflage the nest from predators. We recorded the time when the hen was flushed from the nest, when the data logger began recording, when the researchers left the nest, and when the hen returned to the nest, if that was observed. After nests had hatched or failed, the data loggers and artificial eggs were retrieved and the temperature data were downloaded to a laptop computer using BoxCar Pro version 4.3.1.1 (Onset Computer Corporation, Bourne, MA). Data were exported to Microsoft® Excel for summary and analysis.

Preliminary classifications of incubation activity were made using temperature data from the artificial eggs, applying rules of interpretation developed for Greater White-fronted Geese in a previous multi-year study (Johnson et al. 2003). Rules were based on the minimum egg temperature during incubation (28.3º C) and on the temperature change between 2 successive 5-min recording intervals (e.g., a >1º C decrease in temperature between 2 intervals indicated that the bird was off the nest and ≥1º C increase in temperature indicated that the bird was on the nest). A series of rules defined off-nest activity—recesses—and 2 on-nest activities—incubation breaks and incubation. A recess was judged to occur when the egg temperature was <28.3º C and temperature was not increasing >1º C from the previous interval. Recesses also were identified when egg temperature was ≥28.3º C but dropping >1º C from the previous interval, if the following interval was also a recess. An incubation break was identified by temperature drop of >1º C from the previous interval but nest temperature was ≥28.3º C and the following interval was not a recess. Breaks were not identified during the interval prior to a recess (although they did occur occasionally), because we could not distinguish them from sequential recess intervals based on temperature (e.g., egg temperatures for the initial recess interval usually started above 28.3º C and dropped >1º C as the egg cooled). Therefore, we classified intervals with these temperature conditions as breaks when they were single-interval events, and as recesses when they occurred immediately before other recess intervals. All other conditions indicated incubation.

The number of days and minutes monitored were determined in a similar manner to time-lapse cameras except periods of viewing time lost to camera-specific problems did not apply to temperature data. Incubation constancy and mean number of recesses per day were calculated similarly. All nests monitored with temperature-sensing eggs were also monitored with cameras, so the day of nest failure was determined using camera data.

CONDITIONS IN THE STUDY AREA

Weather data was summarized from stations in the Kuparuk Oilfield and Colville Village (NOAA: http://lwf.ncdc.noaa.gov). We summarized thawing degree-days for late May and for early June by summing the number of degrees Celsius that the mean daily temperature exceeded freezing each day.

Data on human activity were collected directly and indirectly. Helicopter flights by Bell 206 Long Rangers were recorded with Garmin 296 GPS receivers and downloaded at the end of each day. We imported the track logs from MapSource 4.2 (Garmin International, Inc., Olathe, KS) into Arc 8 (ESRI, Redlands, CA) and identified which flight lines were within 200 m of individual Spectacled Eider nests. The buffer size was somewhat arbitrary and was chosen as a starting point for effect analyses; however, 200 m is the area around Spectacled Eider nests in which USFWS (in Section 7 consultations under the Endangered Species Act) attempts to minimize disturbance from construction and development activities (USFWS 2004). Each flight line record contained data on altitude, speed, date and time, and heading, and within each 200-m buffer, the length of flight line and length of time. The flight lines were truncated at 200 m from each nest and reassembled to estimate the flight-line length within 200 m of each nest. Using the speed of the helicopter on each flight segment, we then calculated the length of time the helicopter was within 200 m of each nest. We summarized daily helicopter flights within 200 m of each nest in seconds of total flight time. If helicopters landed on the tundra or airstrip apron and kept their turbines running, we treated them the same as overflights by recording total flight time within 200 m of nests. The end of each helicopter event was considered to be when the turbines stopped running. Exposure of eiders to helicopter overflights throughout the incubation period for each nest was calculated from the estimated start of incubation until each nest hatched or failed. Separately, we also summarized exposure of each nest from 28 May (the approximate date of early arrival of eiders on the delta) until the nest hatched or failed, to estimate total exposure from pre-nesting through nesting periods. Nests that failed prior to discovery were assumed to have started incubation on 10 June (1 day before the earliest known start date during 2005–2007 [*n* = 35 eiders]) and failed on the day they were discovered. We acknowledge that using the above dates for nests that failed prior to discovery probably overestimates the helicopter exposure for these nests, and is therefore conservative (more likely to indicate an effect of helicopter overflights on nesting success), but to exclude these nests from analyses of effects would have the opposite and unacceptable influence on the analyses.

We used 2 time-lapse digital cameras (described above) to monitor human activity on the CD-3 airstrip, apron, and access road from the airstrip to the well pad. Camera 012 was installed on the apron to monitor the northeastern half of the airstrip while camera 011 was installed on the tundra 370 m from the airstrip to monitor the apron where aircraft parked during crew changes and southwestern half of the airstrip. This camera also was oriented so that the access road, about 630 m from the camera, was within view. Cameras 011 and 012 collected data from 28 May–19 July. We also used one of the cameras equipped with an 8× zoom lens to record activity at the well pad due to the proximity of a Spectacled Eider nest to the pad. This camera was approximately 375 m from the well pad and collected data from 27 June–9 July. Buildings on the pad prevented a view of the entire pad, so monitoring was restricted to activities on the south side of the pad closest to the nesting eider.

For airstrip, road, and well pad activity, we recorded the direction of travel and duration (total time active) of all vehicles, people, and aircraft in each image. For airstrip travel, we used paired arrival and departure times as indicated by direction of travel among photos to estimate the total duration of most vehicle activity. Vehicles traveling northeast on the airstrip were assumed active until they appeared moving southwest. Pickup trucks were sometimes missed by time-lapse cameras so no assumptions were made regarding total duration on airstrip. Vehicle duration on the road was based only on vehicles seen in photos.

Data from cameras 011 and 012 were combined to quantify activity on the airstrip and apron whereas data from camera 011 were used to quantify activity on the access road. Data were summarized by aircraft type, small trucks (pickup trucks, all-terrain vehicles [ATV]), large trucks (trucks >1 ton capacity), machinery, and pedestrians (either passengers associated with crew changes or people working on site). At each location we calculated event duration (amount of time that ≥1 aircraft, vehicle type, or person was active) and cumulative aircraft-, vehicle-, or person-minutes (cumulative sum of minutes each aircraft, vehicle, or person was active; e.g., 2 vehicles operated concurrently would have twice the duration of one vehicle). Parked vehicles were excluded from these summaries. Parked aircraft were included in summaries as it was difficult to ascertain whether or not engines were running. For the road, we calculated frequency (number of times vehicles traveled between the well pad and airstrip) of vehicle types. Nest searchers associated with this study were included in summaries as pedestrian traffic when on the airstrip or road.

ANALYSES

We evaluated the response of Spectacled Eiders to construction and operation of CD-3 by comparing various attributes of Spectacled Eider distribution and habitat use among 3 periods of time, which we refer to as construction periods: pre-Alpine (1993–1997, the baseline period before any construction of oilfield facilities), post-Alpine (1998–2004 [however, no surveys were conducted in 1999], from the beginning of construction of Alpine in 1998 until gravel placement for CD-3 and CD-4), and post-CD-3 (2005–2007, after gravel placement and the beginning of construction for CD-3 and CD-4). For simplicity, the 3 construction periods described will be referred to as the pre-Alpine, post-Alpine, and post-CD-3 construction periods.

PRE-NESTING AND NEST DISTRIBUTION

Spectacled Eider pre-nesting and nesting locations were digitized as described above and the distances to various landscape and oilfield features were measured in GIS. We measured the distance of pre-nesting groups to the coast, to the Alpine airstrip, to Alpine (entire gravel footprint), to the CD-3 footprint, to the CD-4 footprint, and to the nearest gravel pad (smallest among distances to Alpine, CD-3, and CD-4). We compared the distances of pre-nesting eiders from each of these features among the construction periods with 1-way ANOVAs. We used a 2-way ANOVA to test for the effects of year, construction period, and fate on Spectacled Eider nest distribution relative to CD-3. We examined the pre-nesting and nesting data for normality and homogeneity of variances, and as a result, used a rank transformation on nest distances. Distance analyses were performed with SPSS 14.0 for Windows (Chicago, IL).

NESTING SUCCESS

We used time-lapse cameras to monitor, until hatch or failure, all Spectacled Eider nests that were active when discovered. All but 1 of those nests was also monitored with temperature-sensing eggs. Nests were monitored from 22 June to 19 July. Nest ages for failed nests were determined by floating eggs and backdating, and for hatched nests we backdated from hatch date assuming a 24-d incubation period. We calculated apparent nesting success by dividing the number of hatched nests by the total number of nests found.

HABITAT USE AND SELECTION ANALYSES

Spectacled Eider nest locations from the ground searches and pre-nesting group locations from aerial surveys were plotted on the maps of wildlife habitats using coordinates recorded either from GPS readings taken in the field, or by transferring field-plotted locations from photomosaics to GIS and deriving coordinates. The coordinates were used in GIS to assign each eider location to a wildlife habitat. For each construction period, we calculated separately for the pre-nesting and nesting records 1) the number of nests or groups of eiders (singles, pairs, or larger associations not in flight during pre-nesting), 2) the percent of total observations in each habitat (habitat use), and 3) the percent availability of each habitat in the search or survey area. Data from 1993 to 2007 were used for analyses of pre-nesting eider habitat and data from 2001 to 2007 were used for analyses of nesting habitat.

For each season, a statistical analysis of habitat selection was used to evaluate whether habitats were used in proportion to their availability. When multiple years of survey data were available, all comparable data were used in the analysis of habitat selection. For the selection analysis, annual surveys were considered comparable only when the survey areas were nearly identical in habitat composition and extent.

Monte Carlo simulations (1,000 iterations) were used to calculate a frequency distribution of random habitat use, and this distribution was used to compute 95% confidence intervals around the expected value of habitat use (Haefner 1996, Manly 1997). Random habitat use was based on the percent availability of each habitat, and the sample sizes in each simulation equaled the number of observed nests or groups of Spectacled Eiders. We defined habitat preference (i.e., use > availability) as observed habitat use greater than the 95% confidence interval of simulated random use, which represents an alpha level of 0.05 (2-tailed test). Conversely, we defined habitat avoidance (i.e., use < availability) as observed habitat use below the 95% confidence interval of simulated random use. The simulations and calculations of confidence intervals were conducted with Microsoft® Excel.

We examined the relative use of pre-nesting habitats by comparing use of preferred and non-preferred habitats among the 3 construction periods with a chi-square test of independence. We pooled use of all habitats that were significantly preferred and pooled use of all other habitats during 1993–1997, which was considered the reference construction period prior to construction of Alpine. Use of preferred habitat during nesting was evaluated over the 2 construction periods for which we collected data, post-Alpine and post-CD-3. We pooled the use of preferred habitats and pooled use of all other habitats from the post-Alpine period (prior to construction of CD-3), which was the reference construction period for the nesting habitat comparison. We used chi-square goodness-of-fit tests to compare habitat use in the post-CD-3 construction period with expected values of habitat use from the post-Alpine construction period. Chi-square tests were performed with SPSS 14.0 for Windows (Chicago, IL).We assumed for these tests that the amount of preferred and non-preferred habitat available was unchanged between pre-construction and post-construction periods, but actually the gravel footprints reduced the amount of habitat available. For example, CD-3 (0.09 km^2 [22.4 acres] total gravel cover) covered 0.06 km^2, or slightly less than 1% of the available preferred habitat in the nest-search area after construction. Although we did not correct the expected values for the loss of habitat, the resulting analysis was conservative with regards to showing a change in use (i.e., more likely to show there was a reduction in use of preferred habitat, because some of that habitat was no longer available).

RESULTS

CONDITIONS IN THE STUDY AREA

ENVIRONMENTAL

Birds returning to the Colville Delta encountered slightly cooler than average spring conditions in May 2007. Mean monthly temperatures in the nearby Kuparuk Oilfield in 2007 were almost 3° C cooler for May than the long-term (19-year) mean for that month, whereas the mean temperature in June (4.2° C) was similar to the long-term mean (www.ncdc.noaa.gov/oa/ncdc.html). Temperatures for Colville Village (an island on the outer Colville Delta) in 2007 were >2° C cooler in May and 1° C cooler in June compared to the 11-year mean. The 46 cumulative thawing degree-days recorded in the Kuparuk Oilfield during the period of waterfowl arrival and peak initiation of nests (15 May–15 June) was equal to the 19-year mean (range = 19–128 thawing degree-days; Figure 3). Zero thawing degree-days were recorded in May 2007 (in the 19-year record, only May 2000 also had 0 thawing degree-days), but temperatures warmed in early June and the cumulative thawing degree-days in the first 15 days of June 2007 was near the long-term mean for that period. Zero thawing degree-days also were recorded at Colville Village in May, but the total accrued by 15 June (30 thawing degree-days) remained 5 degree-days less than the 11-year mean at that site.

Snow cover in the outer Colville Delta was about 75% at the end of May, but by 7 June only 5–10% snow cover remained. Breakup (peak stage) on the Colville River in 2007 was on 4 June, 3 days later than average, but within the historic 10-day period for peak water surface elevation. This breakup was considered a 3-year flood event (Jeff Baker, Michael Baker, Jr. Inc., pers. comm.). Deep lakes on the Colville Delta retained 95% ice cover on 7 June, ~80% ice cover through 19 June, and 25–35% ice cover on 25 June, but ice was essentially gone from the lakes by the end of June after several days of high winds. Midges had a

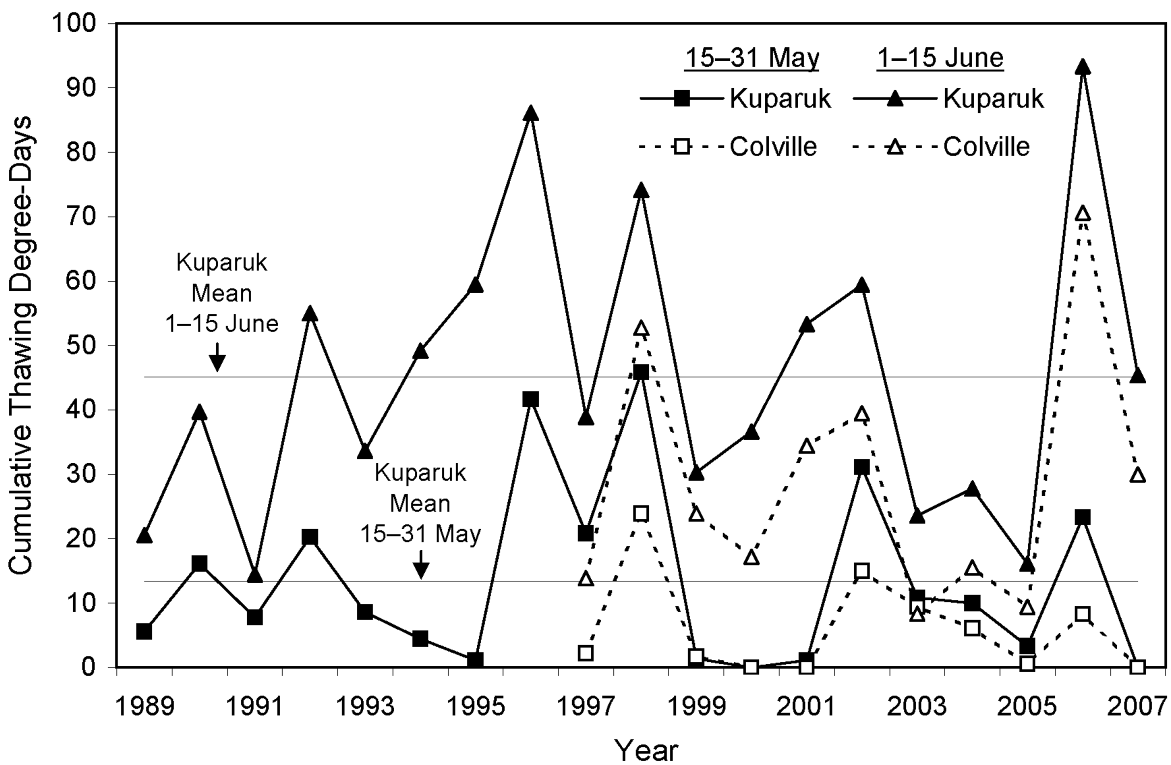

Figure 3. Cumulative thawing degree-days 15–31 May and 1–15 June, Kuparuk Oilfield and Colville Village, Alaska, 1988–2007.

prolonged hatch from 20–25 June. A few mosquitos were first noted on the Colville Delta on 18 June, but large numbers did not emerge before early July. Small groups of caribou, presumably seeking refuge from higher concentrations of mosquitos to the south of the Colville Delta, were seen on 20, 21, 24, and 25 June. The first Lapland Longspur chicks were found on 18 June and the first shorebird chicks (Semipalmated Sandpipers) were seen on 28 June. Greater White-fronted Goose nests did not hatch before 2 July. The timing of nesting by Spectacled Eiders in 2007 was later than the timing in 2006, but similar to the timing in 2005. The median hatch date for Spectacled Eider nests in 2007 was 10 July compared with median hatch dates of 14 July in 2005 and 8 July in 2006. Phenology is somewhat delayed in the outer Colville Delta by comparison with other more inland locations on the Arctic Coastal Plain, and temperatures typically remain cool, with large ice-choked deep lakes, until early to mid-July in most years. Conditions are rarely warm enough for mosquitos to emerge before the end of June. From these many indicators, we estimate that the breeding season conditions were near average in terms of timing for the Colville Delta in 2007.

HUMAN DISTURBANCE

Cameras monitoring the airstrip and road generally operated 24 h/d, providing 1,440 min/d of monitoring from 28 May to 19 July. Camera maintenance and poor visibility due to fog or sun glare prevented data collection for up to 470 min during some days. Cameras documented pickup trucks, an ATV, a loader, roller, grader, and a water truck (≥1 ton capacity). Aircraft included two Bell 206 Long Rangers, as well as two fixed-wing aircraft, a CASA C212 Aviocar and de Havilland Twin Otter. Because the images were a sample of time and had limited views of the access road, airstrip, apron, and CD-3 well pad, the activity levels reported here represent a minimal estimate of the levels of activity that took place on the gravel footprint.

Crews were present at the CD-3 development 2–3 days/wk and rarely worked on consecutive days. People were transported from Alpine to CD-3 around 06:00 with work generally ending around 18:00 when crews were taken back to Alpine. Both helicopters and fixed-wing aircraft transported crews throughout the monitoring period, but fixed-wing aircraft were flown more often than helicopters. The Otter and CASA landed (and took off) a combined total of 58 times, or 1.1 times/d (n = 52.3 days), whereas the helicopter landed 26 times, or 0.5 times/d (Table 1). In total, fixed-wing aircraft and helicopters spent 417 min on the CD-3 airstrip (Table 1). Cameras never recorded >1 aircraft at a time on the airstrip.

Vehicle traffic was highest on the airstrip and apron (Table 2), where cameras documented 19.2 min/d (range = 0–252 min/d, n = 52.3 days) of vehicle events. Over 95% of 1,003 vehicle event minutes were recorded on the apron as opposed to the airstrip. Machinery, associated with gravel maintenance and the transport of cargo, had the highest number of event minutes, averaging 16.5 min/d. Small trucks were the most commonly used vehicle type, but only averaged 2.5 min/d because they were typically used for short durations to transport crews between the airstrip and well pad (Table 2). Small trucks were seen on the airstrip on 8 occasions. Machinery was present on the airstrip during only one day. Cameras rarely recorded >1 vehicle on the airstrip at a time, so cumulative vehicle minutes were similar to total vehicle event durations.

Cameras documented an average of 4.2 vehicles/d (range = 0–46 vehicles/d, n = 51.3 days) traveling on the access road between the airstrip and CD-3 (Table 3). After landing at CD-3, crews typically used small trucks and traveled directly to the well pad. Small trucks were the most frequently recorded vehicle type, accounting for 2.9 vehicles/d and average vehicle event duration of 2.9 min/d (Table 3). Machinery was recorded 1.1 times/d. Most often, machinery traveled the road non-stop, but occasionally worked on road maintenance which contributed to average vehicle duration of 2.3 min/d (Table 3). Cameras rarely recorded >1 vehicle on the road at a time, so cumulative vehicle minutes were similar to total vehicle event durations.

Pedestrians on the airstrip and apron consisted of pedestrian workers (people working on runway maintenance or unloading freight planes) and aircraft passengers (present during crew change) (Table 4). Pedestrian workers accounted for the majority of event duration and cumulative minutes, averaging 5.5 min/d and 12.6 min/d, respectively

Table 1. Frequency of aircraft landings and takeoffs and number of minutes active on the CD-3 airstrip and apron, as recorded by 2 time-lapse cameras, Colville Delta, Alaska, 2007.

	Helicopter		Fixed-Wing							
	Bell 206		Otter		CASA		All Aircraft Total			
Date	Freq[a]	Aircraft Min[b]	Freq[a]	Aircraft Min[b]	Freq[a]	Aircraft Min[b]	Freq[a]	Aircraft Min[b]	Duration (Min)[c]	Minutes Monitored
28 May	6	26	0	0	0	0	6	26	26	606
29 May	0	0	0	0	0	0	0	0	0	1,440
30 May	0	0	0	0	0	0	0	0	0	1,440
31 May	0	0	0	0	0	0	0	0	0	1,440
01 June	0	0	2	5	2	8	4	13	13	1,440
02 June	0	0	0	0	0	0	0	0	0	1,440
03 June	0	0	0	0	4	12	4	12	12	1,440
04 June	0	0	0	0	0	0	0	0	0	1,440
05 June	0	0	0	0	0	0	0	0	0	1,440
06 June	0	0	0	0	0	0	0	0	0	1,440
07 June	4	45	4	16	0	0	8	61	61	1,440
08 June	2	27	0	0	2	7	4	34	34	1,440
09 June	0	0	0	0	0	0	0	0	0	1,440
10 June	0	0	2	5	2	13	4	18	18	1,440
11 June	0	0	0	0	0	0	0	0	0	1,440
12 June	0	0	0	0	0	0	0	0	0	1,440
13 June	0	0	0	0	0	0	0	0	0	1,440
14 June	0	0	2	9	2	7	4	16	16	1,440
15 June	0	0	0	0	0	0	0	0	0	1,440
16 June	0	0	0	0	0	0	0	0	0	1,440
17 June	0	0	2	6	2	42	4	48	48	1,440
18 June	0	0	0	0	0	0	0	0	0	1,440
19 June	0	0	0	0	0	0	0	0	0	1,440
20 June	0	0	0	0	0	0	0	0	0	1,440
21 June	4	18	0	0	0	0	4	18	18	1,440
22 June	0	0	2	5	2	6	4	11	11	1,440
23 June	0	0	0	0	0	0	0	0	0	1,440
24 June	0	0	4	13	6	55	10	68	68	1,440
25 June	0	0	0	0	0	0	0	0	0	1,440
26 June	0	0	0	0	0	0	0	0	0	1,440
27 June	0	0	0	0	0	0	0	0	0	1,440
28 June	4	6	0	0	0	0	4	6	6	1,331
29 June	0	0	0	0	0	0	0	0	0	1,440
30 June	0	0	0	0	0	0	0	0	0	1,440
01 July	0	0	0	0	0	0	0	0	0	1,440
02 July	4	12	0	0	0	0	4	12	12	1,440
03 July	0	0	0	0	0	0	0	0	0	1,440
04 July	0	0	0	0	0	0	0	0	0	1,440
05 July	0	0	2	7	2	10	4	17	17	1,440

Table 1. Continued.

Date	Helicopter: Bell 206 Freq[a]	Helicopter: Bell 206 Aircraft Min[b]	Fixed-Wing: Otter Freq[a]	Fixed-Wing: Otter Aircraft Min[b]	Fixed-Wing: CASA Freq[a]	Fixed-Wing: CASA Aircraft Min[b]	All Aircraft Total Freq[a]	All Aircraft Total Aircraft Min[b]	All Aircraft Total Duration (Min)[c]	Minutes Monitored
06 July	0	0	0	0	0	0	0	0	0	1,440
07 July	0	0	0	0	0	0	0	0	0	1,440
08 July	0	0	2	7	2	9	4	16	16	1,440
09 July	0	0	0	0	0	0	0	0	0	1,436
10 July	0	0	0	0	0	0	0	0	0	1,440
11 July	0	0	0	0	0	0	0	0	0	1,440
12 July	0	0	2	7	2	9	4	16	16	1,440
13 July	0	0	0	0	0	0	0	0	0	1,354
14 July	0	0	0	0	0	0	0	0	0	1,440
15 July	2	4	2	7	0	0	4	11	11	1,440
16 July	0	0	0	0	0	0	0	0	0	1,440
17 July	0	0	0	0	0	0	0	0	0	1,440
18 July	0	0	0	0	0	0	0	0	0	1,440
19 July	0	0	2	5	2	9	4	14	14	1,440
Total	26	138	28	92	30	187	84	417	417	75,247
Mean[d]	0.5	2.6	0.5	1.8	0.6	3.6	1.6	8.0	8.0	1,419.8

[a] Frequency = number of takeoffs + landings
[b] Aircraft Min = sum of each minute each aircraft was on apron and airstrip
[c] Duration = number of minutes ≥1 aircraft was active on airstrip and apron
[d] Daily means for aircraft are calculated with number of days = total minutes monitored / 1440 min, whereas mean minutes monitored = total minutes monitored / number of days camera was in place

(n = 52.3 days). Researchers associated with this study were responsible for a total of 130 event minutes (45%) and 243 people minutes (59%). Aircraft passengers were transported from the well pad to the airstrip apron in a small truck and either waited in the vehicle for aircraft or stood on the apron. During crew changes, aircraft parked at the edge of the apron near the southwestern end of the airstrip. Arriving and departing passengers were accounted for as they entered or exited aircraft which, on average, took just over 5 min (n = 18 crew changes). The small group size of crews (range = 2–7 people) and the short duration of crew changes limited the event duration and cumulative people minutes to 1.8 min/d and 6.2 min/d, respectively (n = 51.3 days). Pedestrians were rarely recorded by cameras on the access road (Table 4).

On 27 June, a camera was set up to monitor human activity at the well pad in the vicinity of Spectacled Eider nest 503. The number of buildings and relatively expansive area of the well pad prevented a complete view of the gravel surface, so the camera view was restricted to a small area on the south side of the pad closest to the eider nest. The camera was removed on 9 July after the hen and brood departed the nest. The camera documented 9.5 event-min/d and 10.1 cumulative vehicle-min/d (n = 11.2 days; Table 5). Machinery was the most commonly recorded vehicle type. Gravel maintenance occurred on the south side of the pad during 2 days which contributed to 6.0 min/d of vehicle events (n = 11.2 days; Table 5). People were recorded in groups of 1–4, accounting for 3.4 event-min/d and 6.1 person-min/d (Table 5).

Table 2. Duration of activity of vehicles[a] on the CD-3 airstrip and apron, as recorded by 2 time-lapse cameras, Colville Delta, Alaska, 2007.

	Small Truck		Large Truck		Machinery		Unknown Vehicle Type		All Vehicles Combined		
Date	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Total Min Monitored[d]
28 May	21	21	0	0	0	0	0	0	21	21	606
29 May	0	0	0	0	0	0	0	0	0	0	1,440
30 May	0	0	0	0	0	0	0	0	0	0	1,440
31 May	0	0	0	0	0	0	0	0	0	0	1,440
01 June	6	6	0	0	0	0	0	0	6	6	1,440
02 June	0	0	0	0	0	0	0	0	0	0	1,440
03 June	11	11	0	0	0	0	0	0	11	11	1,440
04 June	0	0	0	0	0	0	0	0	0	0	1,440
05 June	0	0	0	0	0	0	0	0	0	0	1,440
06 June	0	0	0	0	0	0	0	0	0	0	1,440
07 June	7	7	0	0	0	0	0	0	7	7	1,440
08 June	3	3	0	0	0	0	0	0	3	3	1,440
09 June	0	0	0	0	0	0	0	0	0	0	1,440
10 June	2	2	1	1	10	10	0	0	13	13	1,440
11 June	0	0	0	0	0	0	0	0	0	0	1,440
12 June	0	0	0	0	0	0	0	0	0	0	1,440
13 June	0	0	0	0	0	0	0	0	0	0	1,440
14 June	8	8	0	0	245	245	0	0	252	253	1,440
15 June	0	0	0	0	0	0	0	0	0	0	1,440
16 June	0	0	0	0	0	0	0	0	0	0	1,440
17 June	16	16	0	0	0	0	0	0	16	16	1,440
18 June	0	0	0	0	0	0	0	0	0	0	1,440
19 June	0	0	0	0	0	0	0	0	0	0	1,440
20 June	0	0	0	0	0	0	0	0	0	0	1,440
21 June	3	3	0	0	0	0	0	0	3	3	1,440
22 June	10	10	0	0	42	42	0	0	52	52	1,440
23 June	0	0	0	0	0	0	0	0	0	0	1,440
24 June	7	7	0	0	33	33	0	0	40	40	1,440
25 June	0	0	0	0	0	0	0	0	0	0	1,440
26 June	0	0	0	0	0	0	0	0	0	0	1,440
27 June	0	0	0	0	0	0	0	0	0	0	1,440
28 June	1	1	0	0	1	1	0	0	2	2	1,331
29 June	0	0	0	0	0	0	0	0	0	0	1,440
30 June	0	0	0	0	0	0	0	0	0	0	1,440
01 July	0	0	0	0	0	0	0	0	0	0	1,440
02 July	4	4	0	0	122	175	0	0	124	179	1,440
03 July	0	0	0	0	0	0	0	0	0	0	1,440
04 July	0	0	0	0	0	0	0	0	0	0	1,440

Table 2. Continued.

Date	Small Truck		Large Truck		Machinery		Unknown Vehicle Type		All Vehicles Combined		
	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Total Min Monitored[d]
05 July	16	16	0	0	197	218	2	2	212	236	1,440
06 July	0	0	0	0	0	0	0	0	0	0	1,440
07 July	0	0	0	0	0	0	0	0	0	0	1,440
08 July	10	10	9	9	212	212	3	3	231	234	1,440
09 July	0	0	0	0	0	0	0	0	0	0	1,436
10 July	0	0	0	0	0	0	0	0	0	0	1,440
11 July	0	0	0	0	0	0	0	0	0	0	1,440
12 July	1	1	1	1	2	2	0	0	3	4	1,440
13 July	0	0	0	0	0	0	0	0	0	0	1,354
14 July	0	0	0	0	0	0	0	0	0	0	1,440
15 July	4	4	0	0	0	0	0	0	4	4	1,440
16 July	0	0	0	0	0	0	0	0	0	0	1,440
17 July	0	0	0	0	0	0	0	0	0	0	1,440
18 July	0	0	0	0	0	0	0	0	0	0	1,440
19 July	3	3	0	0	0	0	0	0	3	3	1,440
Total	133	132	11	11	864	938	5	5	1,003	1,087	75,287
Mean[e]	2.5	2.5	0.2	0.2	16.5	17.9	0.1	0.1	19.2	20.8	1,420.5

[a] Small truck = 4-wheeler and pickup; large trucks >1 ton capacity; machinery = roller, loader, and grader
[b] Duration = number of minutes ≥1 vehicle was active on airstrip or apron
[c] Veh min = cumulative sum of minutes each was active on the airstrip or apron, thereby accounting for multiple vehicles operating at one time
[d] Min monitored = number of minutes camera was in place – number of minutes fog, snow, or glare prevented interpretation of photos
[e] Daily means for vehicles are calculated with number of days = total minutes monitored / 1440 min, whereas daily mean minutes monitored = total minutes monitored / number of days camera was in place

In addition to the flights to and from CD-3 reported above, helicopter flights supported other activities. Flights in May and early June transported hydrologists conducting lake sampling and monitoring river levels during break up (see Table 6 and Appendix 1 for helicopter flights within 200 m of nests on these dates). On 15 June, 6 flights were made to our campsite to sling gear and ferry personnel (Appendix 2). One of these flights occurred within 200 m of nest 105, accounting for all 31 sec of helicopter exposure on that day (Table 6). Flights also occurred on 18 June (2 flights), 20 June (1 flights), and 21 June (2 flights) to move personnel or gear to and from our camp, exposing nest 105 to 2, 4, and 6 sec, respectively, of helicopter over-flights. Due to low water levels in the Tamayayak Channel, we used the helicopter to ferry our crew from camp to the west side of the study area on 29 June (2 flights), and 30 June (4 flights), which accounted for all flights within 200 m of known nests on those days (150–353 sec., Table 6, Appendices 2 and 3). A helicopter also took our gear and personnel from camp to Alpine on 1 July which contributed to the total of 125 sec of flights within 200 m of nests on that day. On 25 and 26 June, a loon survey was conducted around lakes in the area. All flights within 200 m of nests on 25 June were attributed to this survey while no flights occurred within 200 m of any nests on 26 June. Similar surveys were conducted weekly through 13 August (Appendices 1–4).

Table 3. Frequency, duration, and type of vehicles[a] on the CD-3 access road, Colville Delta, Alaska, 2007.

	Small Truck			Large Truck			Machinery			Unknown Vehicle Type			All Vehicles			
Date	Freq.	Duration (min)[b]	Veh. Min[c]	Freq.	Duration (min)[b]	Veh. Min[c]	Freq.	Duration (min)[b]	Veh. Min[c]	Freq.	Duration (min)[b]	Veh. Min[c]	Freq.	Duration (min)[b]	Veh. Min[c]	Total Min Monitored[d]
28 May	8	12	12	0	0	0	0	0	0	0	0	0	8	12	12	572
29 May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
30 May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
31 May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
01 June	6	4	4	0	0	0	0	0	0	0	0	0	6	4	4	1,440
02 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
03 June	4	4	4	0	0	0	0	0	0	0	0	0	4	4	4	1,440
04 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
05 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
06 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
07 June	6	5	5	0	0	0	0	0	0	0	0	0	6	5	5	1,434
08 June	4	4	4	0	0	0	0	0	0	0	0	0	4	4	4	1,440
09 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
10 June	2	3	3	0	0	0	0	0	0	0	0	0	2	3	3	1,440
11 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
12 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
13 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
14 June	25	23	24	0	0	0	10	17	17	0	0	0	35	40	41	1,440
15 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
16 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
17 June	13	11	11	0	0	0	0	0	0	0	0	0	13	11	11	1,440
18 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,251
19 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
20 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
21 June	4	4	4	0	0	0	0	0	0	0	0	0	4	4	4	1,440
22 June	4	4	4	0	0	0	8	12	12	0	0	0	12	16	16	1,440
23 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
24 June	10	11	11	0	0	0	6	8	8	0	0	0	16	19	19	1,440

Table 3. Continued.

Date	Small Truck			Large Truck			Machinery			Unknown Vehicle Type			All Vehicles			Total Min Monitored[d]
	Freq.	Duration (min)[b]	Veh. Min[c]	Freq.	Duration (min)[b]	Veh. Min[c]	Freq.	Duration (min)[b]	Veh. Min[c]	Freq.	Duration (min)[b]	Veh. Min[c]	Freq.	Duration (min)[b]	Veh. Min[c]	
25 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
26 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,429
27 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,423
28 June	2	2	2	0	0	0	3	4	4	0	0	0	5	6	6	970
29 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
30 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
01 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
02 July	8	6	6	0	0	0	7	11	12	0	0	0	15	18	18	1,433
03 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
04 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
05 July	26	31	31	0	0	0	15	37	37	5	8	8	46	73	76	1,440
06 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
07 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
08 July	12	10	11	2	2	2	7	29	29	0	0	0	21	21	42	1,061
09 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,430
10 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
11 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
12 July	3	3	3	3	2	2	2	2	2	0	0	0	9	8	7	1,440
13 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,200
14 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
15 July	4	5	5	0	0	0	0	0	0	0	0	0	4	4	5	1,269
16 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,423
17 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
18 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
19 July	6	5	6	0	0	0	0	0	0	0	0	0	6	6	6	1,440
Total	147	147	150	5	4	4	58	120	121	5	8	8	215	272	283	73,935
Mean[e]	2.9	2.9	2.9	0.1	0.1	0.1	1.1	2.3	2.4	0.1	0.2	0.2	4.2	5.3	5.5	1395.0

[a] Small Truck = 4-wheeler and pickup; large trucks >1 ton capacity; machinery = roller, loader, and grader
[b] Duration = number of min ≥1 vehicle was active on access road
[c] Veh. Min = cumulative sum of minutes each vehicle was active on access road, thereby accounting for multiple vehicles operating at one time
[d] Min Monitored = number of minutes camera was in place – number of minutes fog, snow, or glare prevented interpretation of photos
[e] Daily means for vehicles are calculated with number of days = total minutes monitored / 1440 min, whereas daily mean minutes monitored = total minutes monitored / number of days camera was in place

Table 4. Group size and duration of pedestrians observed on the airstrip and apron, and CD-3 access road, Colville Delta, Alaska, 2007.

	Airstrip and Apron										Access Road			
	Pedestrian Workers			Aircraft Passengers			Total Airstrip Pedestrians				Pedestrian Workers			
Date	Max Group Size[a]	Duration (Min)[b]	Person Min[c]	Max Group Size[a]	Duration (Min)[b]	Person Min[c]	Max Group Size[a]	Duration (Min)[b]	Person Min[c]	Min Monitored[d]	Max Group Size[a]	Duration (Min)[b]	Person Min[c]	Min Monitored[d]
28 May	2	3	5	2	3	5	2	6	10	606	0	0	0	572
29 May	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
30 May	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
31 May	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
01 June	0	0	0	4	3	11	4	3	11	1,440	0	0	0	1,440
02 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
03 June	0	0	0	3	4	11	3	4	11	1,440	0	0	0	1,440
04 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
05 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
06 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
07 June	3	22	65	6	7	19	6	29	84	1,440	0	0	0	1,434
08 June	1	1	1	5	6	13	5	7	14	1,440	0	0	0	1,440
09 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
10 June	0	0	0	3	3	4	3	3	4	1,440	0	0	0	1,440
11 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
12 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
13 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
14 June	1	6	6	4	4	10	4	10	16	1,440	0	0	0	1,440
15 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
16 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
17 June	2	27	30	5	5	12	5	31	42	1,440	0	0	0	1,440
18 June	2	31	62	0	0	0	2	31	62	1,440	0	0	0	1,251
19 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
20 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
21 June	0	0	0	2	1	2	2	1	2	1,440	0	0	0	1,440
22 June	1	7	13	3	2	5	3	9	18	1,440	0	0	0	1,440
23 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
24 June	2	52	140	7	21	114	7	73	254	1,440	6	14	52	1,440
25 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
26 June	2	5	18	0	0	0	2	5	18	1,440	0	0	0	1,429
27 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,423

Table 4. Continued.

	Airstrip and Apron										Access Road			
	Pedestrian Workers			Aircraft Passengers			Total Airstrip Pedestrians				Pedestrian Workers			
Date	Max Group Size[a]	Duration (Min)[b]	Person Min[c]	Max Group Size[a]	Duration (Min)[b]	Person Min[c]	Max Group Size[a]	Duration (Min)[b]	Person Min[c]	Min Monitored[d]	Max Group Size[a]	Duration (Min)[b]	Person Min[c]	Min Monitored[d]
28 June	6	27	135	3	3	6	6	30	141	1,331	6	6	35	970
29 June	6	15	62	0	0	0	6	15	62	1,440	4	3	10	1,440
30 June	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
01 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
02 July	2	5	11	3	4	10	3	10	21	1,440	2	2	4	1,433
03 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
04 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
05 July	3	28	36	7	7	26	7	36	62	1,440	0	0	0	1,440
06 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
07 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
08 July	3	53	65	6	7	28	6	60	93	1,440	0	0	0	1,061
09 July	2	3	4	0	0	0	2	3	4	1,436	2	4	7	1,430
10 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
11 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
12 July	0	0	0	7	6	24	7	6	24	1,440	0	0	0	1,440
13 July	0	0	0	0	0	0	0	0	0	1,354	0	0	0	1,200
14 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
15 July	2	3	6	5	4	14	5	7	20	1,440	0	0	0	1,269
16 July	1	1	1	0	0	0	1	1	1	1,440	0	0	0	1,423
17 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
18 July	0	0	0	0	0	0	0	0	0	1,440	0	0	0	1,440
19 July	0	0	0	5	4	12	5	4	12	1,440	0	0	0	1,440
Max/total	6	289	660	7	94	326	7	384	986	75,287	6	29	108	73,935
Mean[e]	0.1	5.5	12.6	0.1	1.8	6.2	0.1	7.3	18.9	1,420.5	0.1	0.6	2.1	1,395.0

[a] Max group size = maximum number of people seen at a time in a single photo
[b] Duration = number of min ≥1 person was active on airstrip, apron, or road
[c] Person Min = cumulative sum of minutes each person was active airstrip, apron, or road, thereby accounting for multiple people present at one time
[d] Min Monitored = number of minutes camera was in place – number of minutes fog, snow, or glare prevented interpretation of photos
[e] Daily means for people are calculated with number of days = total minutes monitored / 1440 min, whereas daily mean minutes monitored = total minutes monitored / number of days camera was in place

Table 5. Duration of activity of vehicles[a] and people on the south side of the CD-3 pad near Spectacled Eider nest 503, Colville Delta, Alaska, 2007.

	Small Truck		Large Truck		Machinery		Unknown Vehicle Type		All Vehicles Combined		Pedestrian Workers			
Date	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Duration (min)[b]	Veh. Min[c]	Max Group Size	Duration (Min)	Person Min	Total Min Monitored[d]
27 June	1	1	0	0	0	0	0	0	1	1	1	5	5	729
28 June	1	1	0	0	3	3	1	1	4	5	1	1	1	1,303
29 June	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
30 June	0	0	0	0	0	0	0	0	0	0	0	0	0	1,327
01 July	0	0	0	0	0	0	0	0	0	0	0	0	0	1,428
02 July	1	1	3	3	4	4	0	0	8	8	0	0	0	1,324
03 July	0	0	0	0	0	0	0	0	0	0	0	0	0	1,277
04 July	0	0	0	0	0	0	0	0	0	0	0	0	0	1,316
05 July	13	13	0	0	34	35	1	1	46	49	3	6	9	1,195
06 July	0	0	0	0	0	0	0	0	0	0	0	0	0	1,276
07 July	0	0	0	0	0	0	0	0	0	0	0	0	0	1,303
08 July	13	14	9	9	26	26	1	1	48	50	4	26	54	1,319
09 July	0	0	0	0	0	0	0	0	0	0	0	0	0	947
Total	29	30	12	12	67	68	3	3	107	113	4	38	69	16,184
Mean[e]	2.6	2.7	1.1	1.1	6.0	6.1	0.3	0.3	9.5	10.1	0.8	3.4	6.1	1,244.9

[a] Small truck = 4-wheeler and pickup; large trucks >1 ton capacity; machinery = roller, loader, grader
[b] Duration = number of minutes ≥1 vehicle was active on pad
[c] Veh min = cumulative sum of minutes each was active on pad, thereby accounting for multiple vehicles operating at one time
[d] Min monitored = number of minutes camera was in place—number of minutes fog, snow, or glare prevented interpretation of photos
[e] Daily means for events are calculated with number of days = total minutes monitored / 1440 min, whereas daily mean minutes monitored = total minutes monitored / number of days camera was in place

Table 6. Daily cumulative flight time (sec) and minimum flight altitude (m) of helicopters within 200 m of Spectacled Eider nests and an unidentified eider nest as recorded by GPS receivers in 2 helicopters during the pre-nesting and incubation periods (24 May–18 July) in the CD-3 project area, Colville Delta, 2007.

	Nest Number															
	Spectacled Eider														Unid. eider	Daily Total
Date[b]	5	7	8	101	104	105	109	113	302	303	503	504	611	712	103	
28 May	0	0	0	0	0	0	6	0	0	0	344	0	0	0	0	350
29 May	0	0	0	0	0	0	0	0	0	0	0	0	4	6	0	10
31 May	0	11	0	0	0	0	4	0	0	0	0	10	10	3	11	49
01 June	0	0	0	0	0	0	0	0	0	0	0	0	10	6	0	16
03 June	0	0	0	0	0	0	0	0	0	0	0	0	12	8	0	20
06 June	0	0	0	0	0	0	0	0	0	0	23	0	5	0	0	28
07 June	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
09 June	0	10	14	0	1	10	0	0	0	0	0	17	0	0	9	61
10 June	0	0	0	0	0	0	460	0	0	0	0	0	0	0	0	460
15 June	0	0	0	0	0	31	0	0	0	0	0	0	0	0	0	31
18 June	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	9
19 June	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	11
20 June	0	0	0	0	0	4	29	0	0	0	0	0	0	0	0	33
21 June	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0	29
25 June	0	0	0	0	43	20	16	43	0	0	0	0	22	19	0	163
27 June	0	31	50	49	0	0	0	0	0	0	739	58	0	0	44	971
28 June	0	0	0	18	0	37	0	0	0	0	0	0	0	0	0	55
29 June	0	7	207	0	0	19	13	0	0	0	0	21	50	56	0	373
30 June	0	0	0	0	11	21	0	0	0	32	3	9	28	33	13	150
01 July	0	0	0	0	0	68	25	0	0	0	11	0	13	8	0	125
02 July	0	6	8	0	0	24	5	0	12	0	20	0	0	0	0	75
03 July	0	0	0	0	15	0	0	35	0	0	0	0	0	0	0	50
09 July	0	14	21	0	10	0	40	0	9	20	67	39	28	34	42	324
10 July	0	0	0	0	18	0	10	9	0	0	0	0	0	0	0	37

Table 6. Continued.

	Nest Number															
	Spectacled Eider														Unid. eider	
Date[b]	5	7	8	101	104	105	109	113	302	303	503	504	611	712	103	Daily Total
14 July	0	0	0	0	7	15	6	0	0	0	0	0	0	0	0	28
16 July	0	2	12	0	13	6	8	0	0	0	8	7	0	0	55	111
17 July	9	23	8	5	0	19	8	0	0	0	0	14	13	7	22	128
18 July	10	18	13	8	8	0	18	0	21	29	0	0	0	0	0	125
Total Inc. Sec [c]	0	0	286	0	79	273	518	87	12	32	773	88	72	157	0	2,377
Min. Altitude (m) During Inc. [c]	–	–	2	–	45	16	0	46	99	28	0	16	5	2	–	
Total Sec [d]	0	21	300	0	80	287	528	87	12	32	1,140	115	113	180	20	2,915
Min. Altitude (m) During Pre-nesting – Iinc. [d]	–	113	2	–	45	16	0	46	99	28	0	16	5	2	113	
Nest Fate[e]	P	F	H	P	H	H	F	H	P	P	H	P	F	H	F	

[a] Outlined data includes the first day of incubation to the day of nest hatch or failure (as determined from video or temperature-sensing eggs); shaded periods indicate assumed incubation periods for nests of unknown age (failed before discovery), starting at earliest known initiation date in 2005–2007 and ending with nest discovery

[b] Date range includes approximate date of early arrival on the delta to the hatch or failure date of each nest; unlisted dates indicate no helicopter flights occurred within 200 m of any nest

[c] Total flight time and minimum altitude during incubation (outlined dates)

[d] Total flight time and minimum altitude were calculated from 28 May through the date the nest became inactive

[e] Fate includes hatch (H), predation (P, predation on attended nest observed on time-lapse images), disturbance/predation (D/P, failure caused by predation in conjunction with known or possible disturbance [nest unattended at time of failure] observed on time-lapse images), and failed (F, failure and cause unobserved)

Cumulative helicopter flight time within 200 m of all known Spectacled Eider nests (n = 14) and 1 unidentified eider was 0.8 h (2,915 sec) from 28 May to hatch or failure and 0.7 h (2,377 sec) during the incubation period (Table 6). The number of flights within 200-m buffers in 2007 compared with 2005 and 2006 was lower due to the locations of nests and a decrease in the number of helicopter flights between Alpine and CD-3 in 2007. No nests were within 200 m of the airstrip apron where helicopters landed in 2007 (although landings at other sites did occur, see below), and none were directly in the flight path between Alpine and CD-3. In 2007, crews working at CD-3 were transported more often in fixed-wing aircraft than in helicopters (Table 1) and crew size was small, so when helicopters were used for transport, the number of flights was typically limited to 2–4 round trips.

Spectacled Eider nest 105, which hatched successfully, was exposed to helicopters on more days during incubation than any other nest, yet its total exposure in flight time was average for successful nests (Tables 6 and 7). Nest 105 had more days of flights because it was on the flight path between our camp and Alpine and between our camp and the west side of the study area, (Appendices 2 and 3). Nest 503, 53 m from the CD-3 well pad, also was successful and had the highest amount of helicopter overflights of any nest, with 773 sec of flight time within 200 m during incubation (Table 6, Appendices 2 and 3). Over 95% (739 sec) of the exposure to helicopters during incubation at this nest occurred on 27 June when a helicopter landed several times at the pad to sling spill-containment materials from the well pad to areas along the river channel. Only 4 nests had no helicopter flights within 200 m during incubation and all of them failed. Four nests failed prior to nest discovery and could not be aged; thus their daily helicopter exposures also were unknown. We assumed these nests were incubated from 10 June until the date of discovery (potentially overestimating the time incubated and exposed), so that these nests could be included in summaries for failed nests (Tables 6 and 7). The mean time helicopters were within 200 m of these nests with unknown ages was 147.5 sec (n = 4), compared with a mean of 26.4 sec for nests with estimated incubation periods. Therefore, we are confident that inclusion of unaged nests with assumed incubation periods increases the chances of detecting an effect of helicopter flights on nesting success and is a conservative approach.

The mean flight times within 200 m of nests were skewed by high values for nests 109 and 503 (Table 7), so we used ranked values in a nonparametric test to compare the amount of helicopter flight time near hatched and failed nests. The amount of time helicopters flew within 200 m of hatched nests (median = 215 sec) was significantly more than flight time within 200 m of failed nests (median = 12 sec; Mann-Whitney U test, $Z = 7.0$, $P = 0.02$), suggesting that the amount of helicopter activity within 200 m of nests had no negative effect on overall nesting success in the nest-search area. Similar evaluations were conducted with minimum altitude of helicopter flights, frequency of helicopter landings, and frequency of fixed-wing flights, all at the scale of 200 m from nests (Table 7). Only 1 comparison suggested a possible causal relationship for failed nests. More fixed-wing flights occurred within 200 m of failed nests than within 200 m of successful nests (Table 7), but the difference was not significant (Mann-Whitney U test, $Z = -0.9$, $P = 0.36$) as only 5 nests (1 hatched and 4 failed) had any flights in those zones. The evaluation of helicopter landings was limited even more because only 3 nests (2 hatched and 1 failed) had landings within 200 m. The maximum number of fixed-wing flights and helicopter landings within 200 m of any nest was 17 fixed wing flights and 4 helicopter landing/takeoffs (i.e., 2 landings and 2 takeoffs). Therefore, because of the small number of nests exposed and relatively few flights and landings, we cannot reach any conclusions about the effects of fixed-wing flights or helicopter landings at the scale of the current analysis (within 200 m). We will be pooling nests from previous years and evaluating effects on nesting success at several scales in a more comprehensive analysis in a future report.

DISTRIBUTION AND ABUNDANCE

PRE-NESTING

The 2007 aerial survey for pre-nesting eiders in the Colville Delta study area was conducted 13 and 14 June and observers counted 41 Spectacled

Table 7. Summary of helicopter and twin-engine aircraft flights within 200 m of Spectacled Eider nests in the CD-3 project area, Colville Delta, Alaska, 2007.

	Successful Nests (n = 6)					Failed Nests (n = 9)[a]				
	Mean	Median	SE	Min.	Max.	Mean	Median	SE	Min.	Max.
Helicopters										
Cumulative Flight Time (sec) during Incubation[b]	275.8	215	105.8	79	773	80.2	12	55.8	0	518
Cumulative Flight Time (sec) during Pre-nesting–Nesting[c]	345.7	233.5	163.4	80	1,140	93.4	21	56.3	0	528
Min. Flight Altitude (m) during Incubation[b]	18.5	9	8.9	0	46	29.6[d]	16	18.0	0	99
Freq. of Helicopter Landings/Takeoffs during Incubation[b]	1.0	0	0.7	0	4	0.2	0	0.2	0	2
Twin-engine Aircraft										
Flight Freq. during Incubation[b]	2.7	0	2.7	0	16	5.3	0	2.2	0	17
Flight Freq. during Pre-nesting–Nesting[c]	4.7	0	4.7	0	28	10.9	0	4.6	0	24

[a] Includes 8 identified Spectacled Eider nests and 1 unidentified eider nest
[b] Total for incubation period based on estimated start of incubation until hatch or failure for individual nests (see Table 6)
[c] Total for pre-nesting (28 May) through hatch or failure
[d] n = 5 nests because 3 failed nests had no helicopter traffic within 200 m

Eiders that were on the ground and 11 that were in flight (Johnson et al. 2008). The number of birds counted on the Colville Delta in 2007 was an increase over counts made in the previous 7 years and was higher than the long-term mean. The CD North sub-area, which has the highest concentration of Spectacled Eiders on the delta, followed a similar trend (see Johnson et al. 2008).

To evaluate changes in the distribution of pre-nesting eiders, we compared the distance of pre-nesting groups to the coast and to each of 5 development-project features on the Colville Delta among 3 construction periods (Figure 4, Table 8). The mean distances of Spectacled Eider groups from these features differed very little between the pre- and post-Alpine construction periods (1993–1997 and 1998–2004). During the post CD-3 period (2005–2007), however, pre-nesting eiders were somewhat closer to Alpine, the Alpine airstrip, CD-3, and CD-4 than they were in prior years (Table 8). Of 6 distance comparisons, 3 resulted in significant differences ($P \leq 0.05$) among the 3 construction periods. Pairwise comparisons (Tukey's HSD) were conducted for each of the 3 facilities (Alpine, Alpine airstrip, and CD-4) with significant overall differences among construction periods. Eider groups were closer to each of these 3 facilities in the post-CD-3 period than in the pre-Alpine or the post-Alpine periods($P \leq 0.04$). The 3 tests that demonstrated significant differences are not spatially independent, however, because Alpine, the Alpine airstrip, and CD-4 are all in the same general location on the delta (Figure 1). Therefore, one would expect similar results in comparisons of eider distributions to these 3 facilities. Nonetheless, because Spectacled Eiders were closer to, not farther from, all facilities with human activity (pipelines were not included in these spatial tests) during the post-CD-3 period, we conclude that construction and operation activities at these sites in 2005–2007 did not result in avoidance of the areas around oilfield facilities.

NESTING

In 2007, we found 14 Spectacled Eider nests in the nest-search area around CD-3 (Figure 5), the lowest number of nests found since 2003, but similar to the 7-year mean of 13.8 nests. Eleven Spectacled Eider nests were active when

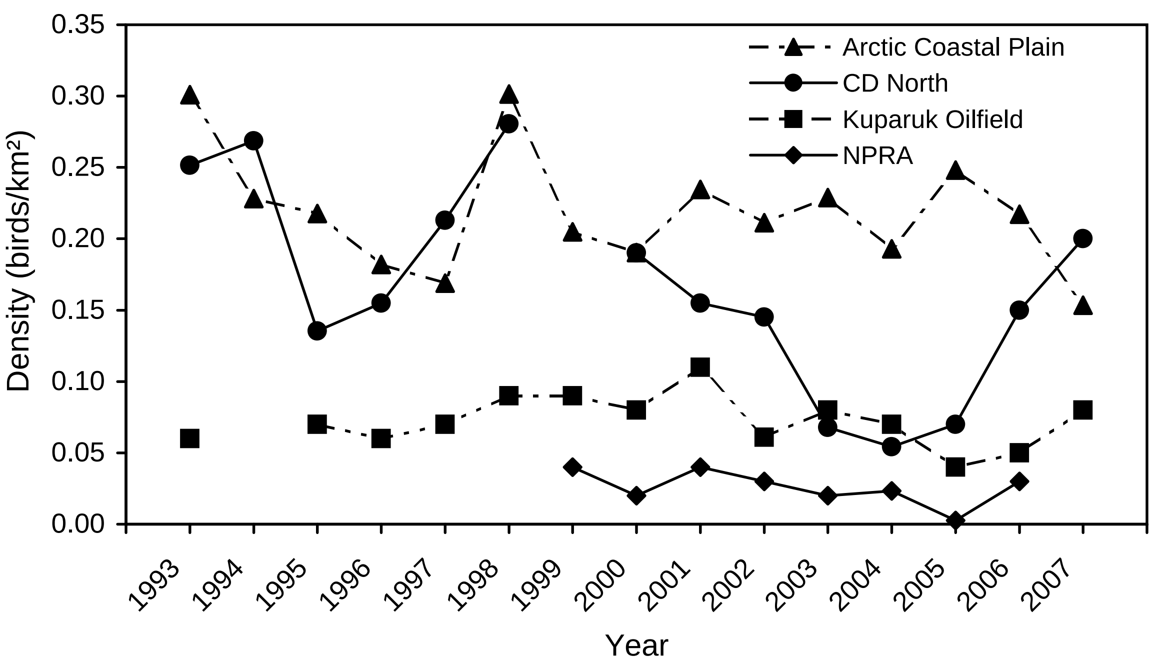

Figure 4. Densities of pre-nesting Spectacled Eiders from aerial surveys of the Colville Delta, NPRA, Kuparuk Oilfield, and Arctic Coastal Plain, Alaska, 1993–2007. (Kuparuk data from Anderson et al. 2008 and Arctic Coastal Plain data from Larned et al. 2008.)

Table 8. Results of 1-way ANOVAs comparing the distances (km) of pre-nesting Spectacled Eider groups from the coastline and various oil facilities among 3 construction periods: pre-Alpine construction (1993–1997), post-Alpine construction (1998, 2000–2004), and post-CD-3 construction (2005–2007).

Test Variable Construction Period	*n*	Mean	SE	$F_{2,228}$	*P*-value
Distance to Coast				0.465	0.629
Pre-Alpine	95	4.29	0.27		
Post-Alpine	92	4.42	0.26		
Post-CD-3	44	4.74	0.36		
Distance to Alpine Airstrip				4.820	0.009
Pre-Alpine	95	10.23	0.41		
Post-Alpine	92	10.58	0.40		
Post-CD-3	44	8.43	0.51		
Distance to Alpine				4.837	0.009
Pre-Alpine	95	10.14	0.42		
Post-Alpine	92	10.41	0.42		
Post-CD-3	44	8.22	0.54		
Distance to CD-3				0.955	0.386
Pre-Alpine	95	5.38	0.38		
Post-Alpine	92	5.64	0.42		
Post-CD-3	44	4.71	0.39		
Distance to CD-4				4.361	0.014
Pre-Alpine	95	11.49	0.45		
Post-Alpine	92	11.82	0.45		
Post-CD-3	44	9.58	0.57		
Distance to Nearest Gravel Pad				2.263	0.106
Pre-Alpine	95	4.97	0.37		
Post-Alpine	92	5.40	0.42		
Post-CD-3	44	4.00	0.36		

discovered and 3 had failed before discovery (i.e., inactive at discovery). Total nest density was 0.8 nests/km². In addition, we found 1 unidentified eider nest and 1 King Eider nest. We attempted to identify all eider nests without hens at the time of discovery using contour feather characteristics (Anderson and Cooper 1994). During 2001–2005, we found an average of 12.6 nests (0.7 nests/km²) in the same search area, with the previous maximum number of 20 nests found in 2006. In 2000, 14 Spectacled Eider nests were found in this vicinity, but the search area was smaller (12.2 km²) and did not extend as far south as in subsequent years (see Johnson et al. 2000a), so those nests were not included in comparisons of distribution or habitat use among years.

We evaluated changes in distribution and the effects of proximity to CD-3 on nesting success by comparing the distances of successful and failed nests from CD-3 in each year and construction period (Table 9). In all but 2001, successful nests were closer to the location of CD-3 than were failed nests. In 2007, successful nests averaged 799 m from CD-3 (SE = 263, *n* = 6), and failed nests averaged 1,228 m from CD-3 (SE = 253, *n* = 8). The closest nest to the gravel footprint in 2007 was 53 m from the well pad, and this nest hatched (Figure 5). The second closest nest was 75 m from

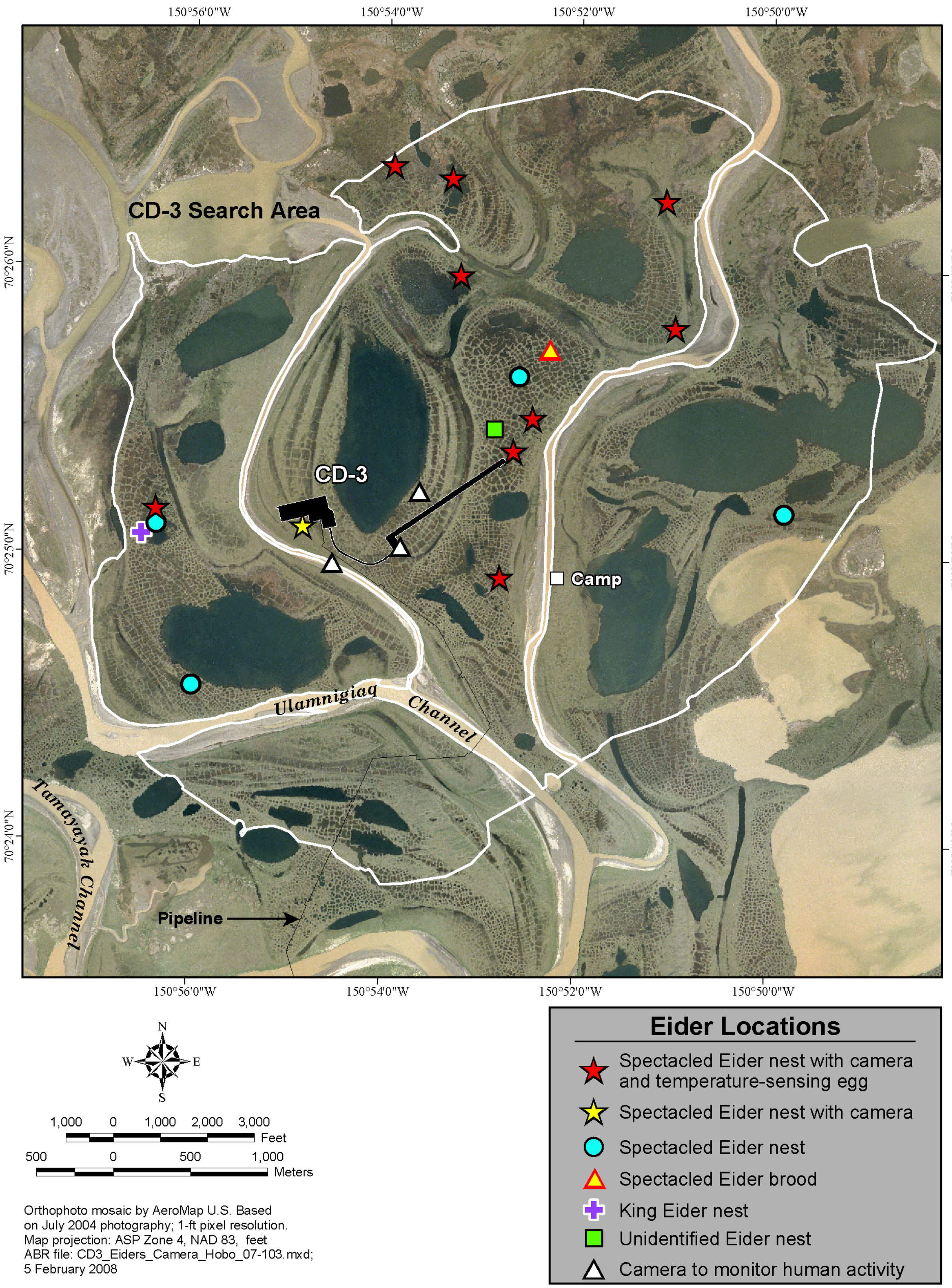

Figure 5. Locations of Spectacled, King, and unidentified eider nests, broods, temperature-sensing eggs, and time-lapse cameras in the CD-3 nest-search area, Colville Delta, Alaska, 2007.

Table 9. Distance (m) of successful and failed Spectacled Eider nests from CD-3 by year and construction period, Colville Delta, Alaska, 2001–2007.

	Successful Nests			Failed Nests		
Year/Construction Period	Mean	SE	*n*	Mean	SE	*n*
2001	1,864.8	–	1	1,133.2	455.8	6
2002	419.7	378.6	2	1,736.9	536.2	5
2003	878.3	249.6	3	1,474.6	242.5	9
2004	925.0	247.1	10	935.3	292.5	9
Post-Alpine (2001–2004 combined)	911.8	177.4	16	1,281.8	175.3	29
2005	839.7	121.7	6	937.4	225.3	12
2006	1,001.8	247.8	8	1,329.2	258.7	12
2007	798.8	262.8	6	1,227.6	253.1	8
Post-CD-3 (2005–2007 combined)	892.3	126.9	20	1,156.9	142.3	32

the end of the airstrip, and it failed. The farthest nest from the airstrip was 2,020 m away, and it also failed. We compared the distances of successful and failed nests to CD-3 among years with a 2-way ANOVA on rank-transformed data, which identified no significant main effects (among years or between fates) or interaction term ($F = 0.90$; df = 13, 83; $P = 0.56$, $R^2 = 0.12$). We repeated the test after pooling the years into construction (2001–2004) and post-construction periods (2005–2007). Results were similar to the multi-year analysis, with no significant effects ($F = 1.09$; df = 3, 93; $P = 0.36$, $R^2 = 0.03$). These analyses suggest that the placement of the gravel footprint and construction activity at CD-3 in 2005–2006 and operations in 2007 did not result in any changes in overall nest distribution, nor did they result in any detectable impacts on apparent nesting success with respect to distance from the footprint. However, a more in-depth analysis of nest survival (see below) with disturbance and environmental factors will be necessary to understand the relative strength of variables and will not be possible until the sample size of nests has increased.

NESTING SUCCESS

Apparent nesting success (nests hatched/nests of known fate) was 40–43% (6 of 15 or 6 of 14 nests hatched) for Spectacled Eiders in 2007, just above the long-term average. The lower value included 1 unidentified failed nest which may have belonged to a Spectacled Eider, whereas the higher value excludes that nest from the estimate. Apparent nesting success in 2005 and 2006 was 33% and 40%, respectively. Apparent nesting success for all Spectacled Eider nests with known fate found on the Colville Delta before construction of CD-3 (1993 to 2004) was 37% (27 of 73 nests). Average clutch size in 2007 was 3.8 eggs/nest ($n = 11$ active nests), which was slightly below the pre-CD-3 average for the Colville Delta (4.0 eggs/nest, $n = 40$ active nests). Future analyses will use models of nest survival (Program MARK, White and Burnham 1999) to evaluate effects of environmental and disturbance covariates on daily survival rates of nests.

INCUBATION MONITORING

THERMISTORED EGGS

Temperature-sensing eggs, along with time-lapse cameras, and egg floatation data provided detailed nest histories and activity budgets for incubating hens (Table 10). We inserted temperature-sensing eggs into 9 of 11 active Spectacled Eider nests that we found in 2007 (Figure 5). The eider at nest 503 would not move off her nest, so we did not install a temperature-sensing egg, and nest 113 was first found in July during hatch. In total, researchers were present at each nest for 30–59 min (mean = 40 min, $n = 8$). Incubation resumed 15–114 min

Table 10. Nest history and preliminary incubation activity of Spectacled Eider nests monitored by temperature-sensing eggs and time-lapse digital cameras in the CD-3 project area, Colville Delta, Alaska, 2007.

				Date Range		Days Monitored[a]		Preliminary Incubation Constancy (%)[a]		Preliminary Mean Daily No. Recesses[a]		Preliminary Mean Recess Length (min)[a]	
Nest Number	Distance to CD-3 (m)	Fate	Predator	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera
005	1,970	F	Arctic Fox	23–25 June	23–25 June	1.0	1.0	96.9[b]	97.6[b]	1[b]	1[b]	45.0[b]	46.9[b]
008	316	S	–	25 June–11 July	25 June–11 July	14.0	12.9	99.1	99.0	0.6	0.8	22.5	21.0
101	1,392	F	Arctic Fox	24–25 June[c]	24–25 June	–	0.3	–	100[b]	–	0[b]	–	0[b]
104	1,213	S	–	26 June–10 July	26 June–10 July	12.0	12.0	98.9	99.0	0.6	0.6	27.9	25.5
105	599	S	–	27 June–8 July[c]	27 June–8 July	–	8.8	–	94.5	–	3.1	–	26.4
302	2,020	F	Arctic Fox, Parasitic Jaeger	22 June–3 July	23 June–3 July	10.0	9.0	99.2	99.0	0.3	0.6	23.3	19.5
303	1,840	F	Arctic Fox, Parasitic Jaeger	22 June–1 July	23 June–1 July	8.0	6.1	99.3	99.2	0.5	0.7	20.0	19.7
503	53	S	–	–	24 June–9 July	–	13.0	–	98.5	–	0.7	–	31.1
504	75	F	Arctic Fox	24–30 June	24–30 June	5.0	5.0	99.9	99.8	0.2	0.2	10.0	12.3
712	778	S	–	29 June–19 July	29 June–19 July	18.0	18.0	98.7	98.4	0.9	1.2	20.3	19.1

[a] Excludes day of instrumentation, hatch, fledging or failure, periods of time where photo images could not be interpreted due poor weather conditions, and flushes attributed to research activities

[b] Data are not averaged since total time monitored was ≤1 full day

[c] Temperature-sensing egg malfunctioned and data were not interpretable

(mean = 49 min, *n* = 9) after departure of researchers from nest site. All nests with temperature-sensing eggs were incubated by their hens after the installation and remained active for at least 38 hours after installation. Temperature data from Spectacled Eider nests 101 and 105 were not interpretable due to equipment malfunctions.

TIME-LAPSE CAMERAS

We monitored 10 of 11 active Spectacled Eider nests found in 2007 with time-lapse cameras (Figure 5, Table 10). Nest 113 was not monitored because it was first found in July during hatch. Cameras were placed 25–50 m from nests (mean = 31 m) and camera installation averaged 23 min (*n* = 10 nests, range 14–37 min) of the mean of 40 min required to complete all research activities at each nest. We exchanged memory cards and batteries in each camera 1 time/wk and exchanges averaged 12 min (*n* = 12 exchanges) at each camera. On one occasion, a hen was flushed during camera maintenance. The hen from nest 712 was observed on camera images returning from a normal recess and incubating for 8 min before a researcher approached the camera. The eider began to conceal when the person was 150 m away and flushed as the researcher approached the camera which was 30 m from the nest. A Canada Goose and Red-throated Loon nesting within 3 m of the eider flushed seconds before the eider and may have startled the hen into leaving the nest. No predators were observed near the nest during the eider's absence. The eider returned to the nest within 5 min of the researcher departing.

Of 10 nests monitored with time-lapse photography, 5 hatched and 5 failed (Table 10). All 5 failed nests were depredated by arctic foxes. A pair of Parasitic Jaegers may have eaten ≥1 egg after a fox already flushed the hens at nests 302 and 303 (see below). According to egg floatation data, all nests were at least 1 week old at the time of nest failure. Predators also were recorded near nests without causing predation. Arctic foxes were recorded near 6 of 10 nests without interaction with the hens (however, 3 of these nests eventually failed due to fox predation). Parasitic Jaegers were recorded near 4 nests and Glaucous Gulls were recorded near 3 (*n* = 10 nests). Hens were incubating normally in all cases when predators were recorded near nests.

Caribou were a source of disturbance on 5 July when one or more large groups moved past Spectacled Eider nests 008 and 104. The hen at nest 008 was incubating normally when a caribou appeared about 50 m from the nest. Two min later, a small bull was recorded grazing <0.5 m from the eider, which was concealing. In the next photo, taken 32 sec later, neither the hen nor the caribou were in camera view. The eider returned to the nest 9 min later, although caribou continued to run past. The hen immediately resumed incubation in a concealed posture, but was flushed again 5 min later. The hen was absent for 10 min before returning to incubate. In both cases, the eider was not observed covering the nest prior to flushing. The caribou could not be accurately counted due to the time-lapse nature of the camera, but 25 min elapsed before the entire group passed the nest. The nest hatched, but suffered partial predation although no predators were recorded on camera. A depredated egg was found 1 m from the nest with dried yolk and a speck of blood around a hole in the egg. A group of caribou also ran past the eider at nest 104 in an event that lasted 12 min. A caribou was recorded for 2 consecutive frames about 0.25 m from the nest (Figure 6). The hen did not flush, but incubated in concealment posture during the entire time that caribou were present.

Researchers also accidentally flushed the hen from nest 008 2 days after the nest was found. A group of 6 researchers watched a fox running 30–50 m from nest 008. A female eider was seen standing nearby and was thought to be from that nest. A researcher quickly moved toward the nest to chase the fox out of the area and/or cover the nest, however, the hen was incubating in a concealed posture and flushed when the person was 10–15 m from the nest. The female returned to incubate after 18 min. No predators were recorded near the nest during her absence.

Two Spectacled Eiders nested <100 m from the gravel footprint at CD-3. Spectacled Eider nest 503, which hatched successfully, was 53 m from the south side of the CD-3 well pad (Figure 5). This eider was exposed to several types of human disturbances due to its proximity to the well pad. Pad activity was monitored during the 13 d prior to the hen and ducklings' departure from the nest and work crews were recorded at the well pad on 5 of those days. Except for one occasion involving trash collection (known as stick picking), human activity

Figure 6. Digital time-lapse images of the incubating female at Spectacled Eider nest 104 in concealment posture while caribou run <0.5 m from the nest (the hen is by the cow's front right foot) and a Parasitic Jaeger hovering over the nest (no predation occurred), Colville Delta, 2007.

was confined to the gravel pad of CD-3. On 5 July, a clean-up worker (known as "stickpickers") was recorded collecting trash within 10–100 m of the nest for approximately 25 min. The hen continued incubating during the event, but exhibited both alert and concealment postures. Workers were recorded more often in vehicles than on foot (Table 5). Gravel maintenance, during which crews operated a roller and grader, was the most commonly recorded human activity on the south side of the pad nearest the eider nest. No people were recorded approaching the nest.

Spectacled Eider nest 504 was 75 m from the northeast end of the airstrip (Figure 5). The nest was in the flight path of fixed-wing aircraft arriving and departing the CD-3 development. The nest was monitored for 6 d prior to arctic fox predation. Only one nest recess was observed and it occurred after a helicopter took off from the airstrip apron. The helicopter was flying from the southwest end of the airstrip towards the northeast and was approximately 750 m from the eider nest when the eider stood, covered the nest, and flew out of camera view. The helicopter turned toward Alpine and left the area and the eider resumed incubation 12 min later. We judged this recess to be a normal recess, because the hen took time to cover her eggs, a behavior that is normally not observed when hens are flushed or disturbed. The recess was not likely influenced by the presence of the helicopter, because earlier in the day the helicopter flew closer, within 210 m of the nest, without eliciting a noticeable reaction from the eider. The hen was not observed leaving the nest again until failure 2 d later when it was flushed by an arctic fox.

For all 5 arctic fox predation events, hens were observed on time-lapse images incubating normally and concealing prior to being flushed from nests by fox. Predation occurred 2–4 times within 10 min, suggesting that foxes were carrying eggs away from nests. Foxes generally spent about 1 min/predation event at nests before leaving camera view. At 2 nests (302 and 303), pairs of Parasitic Jaegers may have taken ≥1 egg after females had been flushed by foxes. In both cases, the hens returned to the nest, driving the jaegers away, only to be flushed again by a fox several minutes later. Four females continued to incubate for an average of 15.7 h (range = 1.8–51.3 h) after foxes were last recorded at nests. At nest 101, a fox flushed the hen twice over the course of 4 min, each time staying at the nest for <1 min. The eider resumed incubating 14 min after the fox was last recorded on camera and continued to incubate for >2 d (51.3 h), although she took at least 8 recesses during this period. Prior to leaving the nest for the last time, the hen appeared to stand and cover it. No egg remains were found and only the temperature-sensing egg was left in the nest upon nest inspection.

HABITAT SELECTION

Baseline conditions of habitat selection by pre-nesting Spectacled Eiders prior to construction of Alpine were evaluated from aerial surveys during 1993–1997 and compared to habitat selection during the post-Alpine period and during the post-CD-3 period. During the pre-Alpine construction period, 4 habitats were identified as preferred by pre-nesting Spectacled Eider groups: Brackish Water, Salt Marsh, Deep Polygon Complex, and Grass Marsh (Table 11). During the post-Alpine period (1998–2004), 2 of those habitats (Salt Marsh and Grass Marsh) were replaced by 2 different preferred habitats (Deep Open Water with Islands or Polygonized Margins and Shallow Open Water with Islands or Polygonized Margins). The switch in habitats between preferred and non-preferred categories was the result of small changes of 1–3 % in use of each habitat (Table 11).

In 2007, 23 groups of pre-nesting Spectacled Eiders were seen on the ground (flying birds cannot be used in habitat analyses) and we combined those with the 6 groups seen in 2005 and 15 groups in 2006 in a habitat selection analysis (Table 11). Twenty-five groups (57% of 44 groups) were found in 3 habitats preferred in the post-CD-3 period: Brackish Water, Deep Polygon Complex, and Patterned Wet Meadow. Patterned Wet Meadow was not preferred during the pre-Alpine or post-Alpine construction periods (Table 11). Because the selection analysis can be affected by small changes in use and changes in sample size, as well as stochastic variation in the distribution of eider observations, we tested for changes in the use of preferred versus non-preferred habitats across the 3 construction periods. We combined the

Table 11. Habitat selection of pre-nesting Spectacled Eiders on the Colville Delta during 3 construction periods: pre-Alpine construction (1993–1997), post-Alpine construction (1998, 2000–2004), and post-CD-3 construction (2005–2007).

	Pre-Alpine					Post-Alpine					Post-CD-3				
Habitat	No. of Groups	Use (%)	Availability (%)	Monte Carlo Results[a]	Sample Size[b]	No. of Groups	Use (%)	Availability (%)	Monte Carlo Results[a]	Sample Size[b]	No. of Groups	Use (%)	Availability (%)	Monte Carlo. Results[a]	Sample Size[b]
Open Nearshore Water	0	0	2	ns	low	0	0	2	ns	low	0	0	2	ns	low
Brackish Water	12	13	1	prefer	low	11	12	1	prefer	low	3	7	1	prefer	low
Tapped Lake with Low-water Connection	5	5	4	ns	low	7	8	5	ns	low	0	0	4	ns	low
Tapped Lake with High-water Connection	5	5	4	ns	low	1	1	4	ns	low	0	0	4	ns	low
Salt Marsh	8	8	3	prefer	low	6	7	3	ns	low	4	9	3	ns	low
Tidal Flat Barrens	0	0	7	avoid		1	1	6	avoid		0	0	7	ns	low
Salt-killed Tundra	10	11	5	ns	low	9	10	5	ns	low	6	14	5	ns	low
Deep Open Water without Islands	2	2	4	ns	low	8	9	4	ns	low	2	5	4	ns	low
Deep Open Water with Islands or Polygonized Margins	3	3	2	ns	low	5	5	2	prefer	low	1	2	2	ns	low
Shallow Open Water without Islands	1	1	<1	ns	low	2	2	<1	ns	low	0	0	<1	ns	low
Shallow Open Water with Islands or Polygonized Margins	1	1	<1	ns	low	2	2	<1	prefer	low	1	2	<1	ns	low
River or Stream	3	3	15	avoid		5	5	14	avoid		1	2	15	avoid	
Sedge Marsh	0	0	<0.1	ns	low	0	0	<0.1	ns	low	0	0	<0.1	ns	low
Deep Polygon Complex	24	25	3	prefer	low	20	22	3	prefer	low	7	16	3	prefer	low
Grass Marsh	2	2	<1	prefer	low	0	0	<1	ns	low	1	2	<1	ns	low
Young Basin Wetland Complex	0	0	<0.1	ns	low	0	0	<0.1	ns	low	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low	0	0	<0.1	ns	low	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	9	9	8	ns		8	9	8	ns		2	5	8	ns	low
Patterned Wet Meadow	9	9	19	avoid		7	8	20	avoid		15	34	19	prefer	
Moist Sedge-Shrub Meadow	0	0	2	ns	low	0	0	2	ns	low	0	0	2	ns	low
Moist Tussock Tundra	0	0	<1	ns	low	0	0	<1	ns	low	1	2	<1	ns	low
Tall, Low, or Dwarf Shrub	0	0	5	avoid	low	0	0	5	avoid	low	0	0	5	ns	low
Barrens	1	1	15	avoid		0	0	15	avoid		0	0	15	avoid	
Human Modified	0	0	<0.1	ns	low	0	0	<0.1	ns	low	0	0	<0.1	ns	low
Total	95	100	100			92	100	100			44	100	100		

[a] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability; % use = (groups / total groups) × 100

[b] Low = expected number of nests <5, blank = expected number of nests ≥5

habitats preferred in the pre-Alpine construction period (considered the baseline or reference period in terms of development) as the reference set of habitats and compared their use among the 3 construction periods.

The combined use of habitats preferred during the pre-Alpine period declined from the pre-Alpine period (48% of all groups), to the post-Alpine period (40% of all groups), and to the post-CD-3 period (34%), but the test of independence among the periods was not significant ($\chi^2 = 2.83$, df = 2, $P = 0.24$). Although the individual pre-nesting habitats that were identified as preferred differed among the 3 construction periods, Brackish Water and Deep Polygon Complex were among those preferred in all periods. The combined use of the 4 habitats preferred during the baseline period prior to development was not significantly affected by the construction of Alpine or CD-3, however, the declining trend in use of preferred habitats among the construction periods may suggest an effect. We note that this analysis is sensitive to sample sizes and that the post-CD3 period had about half the number of eider groups that were recorded in the 2 earlier periods (Table 11). We suspect that the results of this analysis will vary until the sample size for pre-nesting eider groups during the post-CD-3 period reaches parity with the other periods.

We also compared habitat selection by nesting Spectacled Eiders to identify possible shifts in habitat use between the pre-construction period (2001–2004) and the construction period (2005–2007). We evaluated habitat selection prior to construction of CD-3 using 45 nests found in the same nest-search area between 2001 and 2004 (Table 12). Two habitats were preferred—Deep Polygon Complex and Patterned Wet Meadow—and these 2 habitats contained 71% of the nests. During construction of the CD-3 pad and airstrip in 2005–2007, a similar percentage of nests (67%, 35 of 52 nests) occurred in the same 2 preferred habitats (Figure 7). A goodness-of-fit test was used to compare the proportion of nests in each of the 2 preferred nesting habitats and all non-preferred habitats combined between construction and pre-construction periods, using the habitats preferred in 2001–2004 to compute the expected values of habitats preferred after construction; the test found no change in use of preferred habitats by nesting birds between those years ($\chi^2 = 0.43$, df = 2, $P = 0.81$).

The gravel footprint for CD-3 covered approximately 9.1 ha (22.4 acres) of tundra. The gravel footprint included 6 ha (14.8 acres) of Deep Polygon Complex and Patterned Wet Meadow, the 2 preferred nesting habitats from the baseline period. The gravel footprint covered <1% of the preferred nesting habitat in the 17.6-km^2 CD-3 nest search area and <0.1% of the preferred habitat on the Colville Delta.

SUMMARY

The number of pre-nesting Spectacled Eiders counted during aerial surveys of the Colville Delta increased for the second time in several years to a level higher than the long-term mean. The number of nests in the CD-3 nest-search area was the lowest since 2004, but equal to the 7-year mean. The lack of correspondence between pre-nesting and nesting abundance may be an artifact of the aerial survey technique used during pre-nesting or may be due to the difference in the size and habitat quality of the 2 areas being compared.

Pre-nesting groups of Spectacled Eiders did not display an obvious avoidance (increased distance to gravel) to construction of oilfield facilities on the Colville Delta. Use of pre-nesting habitats preferred during the baseline period did not change significantly after either Alpine or CD-3 were built. The small sample size of years (3) after CD-3 construction weakens our conclusion about habitat use during pre-nesting because annual variation is high. With additional years of data, we anticipate that clearer patterns of habitat use will emerge. Nest locations of Spectacled Eiders in the CD-3 area did not indicate displacement from the vicinity of the gravel footprint of CD-3 and the level of use of preferred habitats was similar to that observed during pre-construction years. Proximity of nests to the footprint did not appear to affect apparent nesting success, but a more in-depth analysis of nest survival with disturbance and environmental factors is necessary to understand the relative strength of the many variables that could be affecting nesting success.

Apparent nesting success typically is low for Spectacled Eiders, averaging 37% (n = 73

Table 12. Habitat selection of nesting Spectacled Eiders in the CD-3 project area, Colville Delta, Alaska, 2001–2007.

	2001–2004					2005–2007				
Habitat	Total Nests	Use (%)	Availability (%)	Monte Carlo Results[a]	Sample Size[b]	Total Nests	Use (%)	Availability (%)	Monte Carlo Results[a]	Sample Size[b]
Brackish Water	1	2.2	2.9	ns	low	1	1.9	2.8	ns	low
Tapped Lake with High-water Connection	1	2.2	4.9	ns	low	0	0	5.0	ns	low
Salt Marsh	1	2.2	4.2	ns	low	1	1.9	4.2	ns	low
Salt-killed Tundra	3	6.7	11.8	ns		5	9.6	10.7	ns	
Deep Open Water without Islands	1	2.2	4.3	ns	low	0	0	4.2	ns	low
Deep Open Water with Islands or Polygonized Margins	4	8.9	10.1	ns	low	4	7.7	10.2	ns	
Shallow Open Water without Islands	0	0	0.3	ns	low	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	0	0	0.8	ns	low	2	3.8	0.9	ns	low
Deep Polygon Complex	13	28.9	12.1	prefer		15	28.8	12.2	prefer	
Grass Marsh	0	0	0.2	ns	low	0	0	0.2	ns	low
Nonpatterned Wet Meadow	2	4.4	14.7	ns		4	7.7	14.6	ns	
Patterned Wet Meadow	19	42.2	25.9	prefer		20	38.5	26.1	ns	
Moist Sedge–Shrub Meadow	0	0	2.4	ns	low	0	0	2.5	ns	low
Tall, Low, or Dwarf Shrub	0	0	1.4	ns	low	0	0	1.5	ns	low
Barrens	0	0	4.1	ns	low	0	0	3.9	ns	low
Human Modified	–	–	0	–	–	0	0	0.5	ns	low
Total	45	100	100			52	100	100		

[a] Significance calculated from 1,000 simulations at = 0.05; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability
[b] Low = expected number of nests <5, blank = expected number of nests ≥5

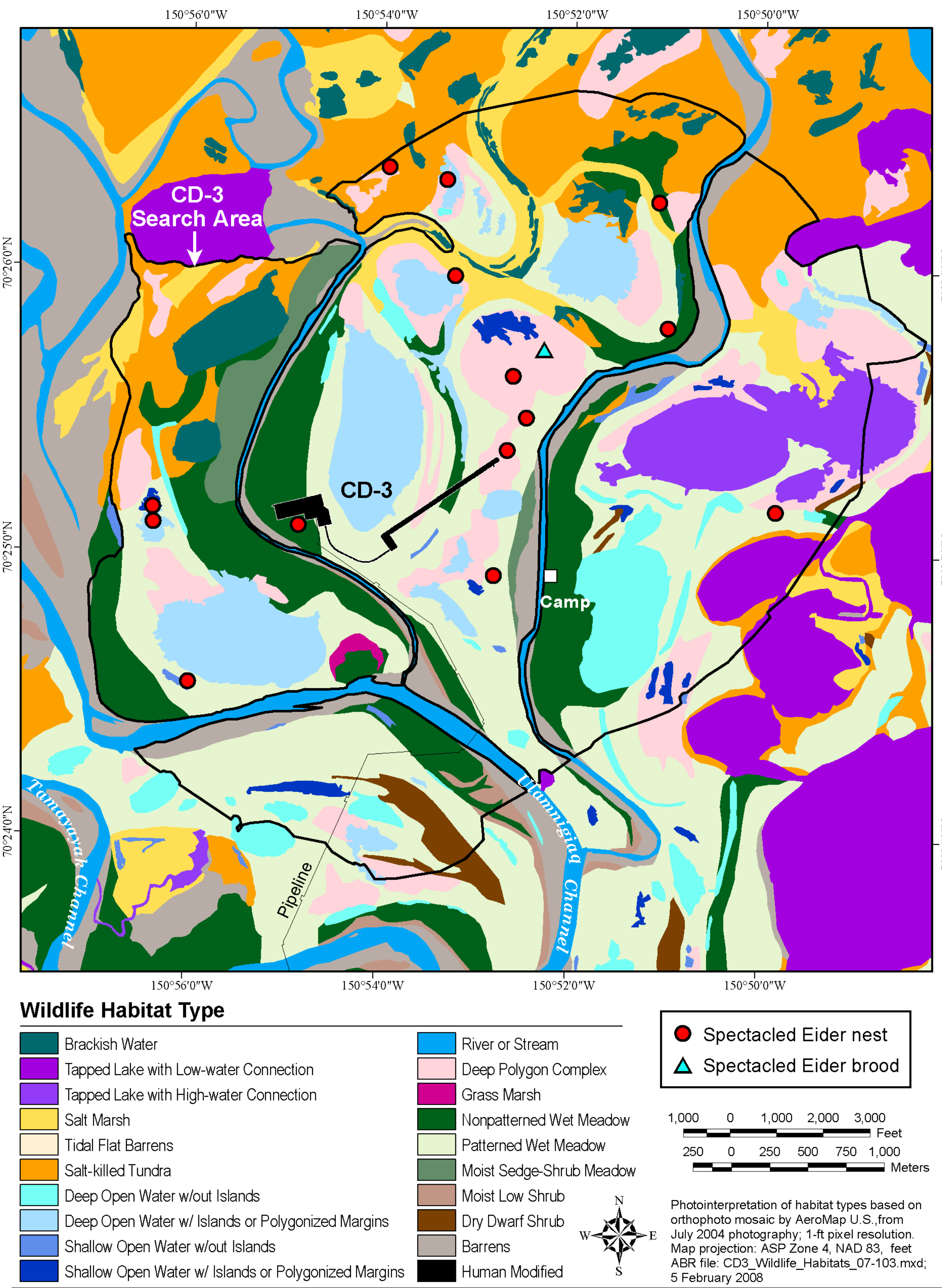

Figure 7. Habitat map and Spectacled Eider nest and brood locations in the CD-3 nest-search area, Colville Delta, Alaska, 2007.

identified Spectacled Eider nests) in the CD-3 nest-search area between 1993 and 2004. In 2007, the apparent success rate was 43% for identified Spectacled Eider nests. The cause of failure was unknown at 3 nests which had failed prior to discovery. Predators ultimately were involved in the remaining 5 nest failures, all of which were observed on camera images and involved attacks on incubated nests. Nest failures clearly were caused by arctic foxes, and in all cases they drove off incubating Spectacled Eiders. At 2 of these nests Parasitic Jaegers took advantage of eiders flushed by foxes and may have taken ≥1 egg, although in both cases, hens returned to defend their nests against the jaegers. Further analyses are planned to evaluate the effects of helicopter and other sources of disturbance on the incubation activities of monitored Spectacled Eiders; these analyses should shed light on whether nesting Spectacled Eiders are responding behaviorally to identified disturbances (other birds, people, predators, helicopters, or vehicles) and whether those responses increase the probability of nest failure.

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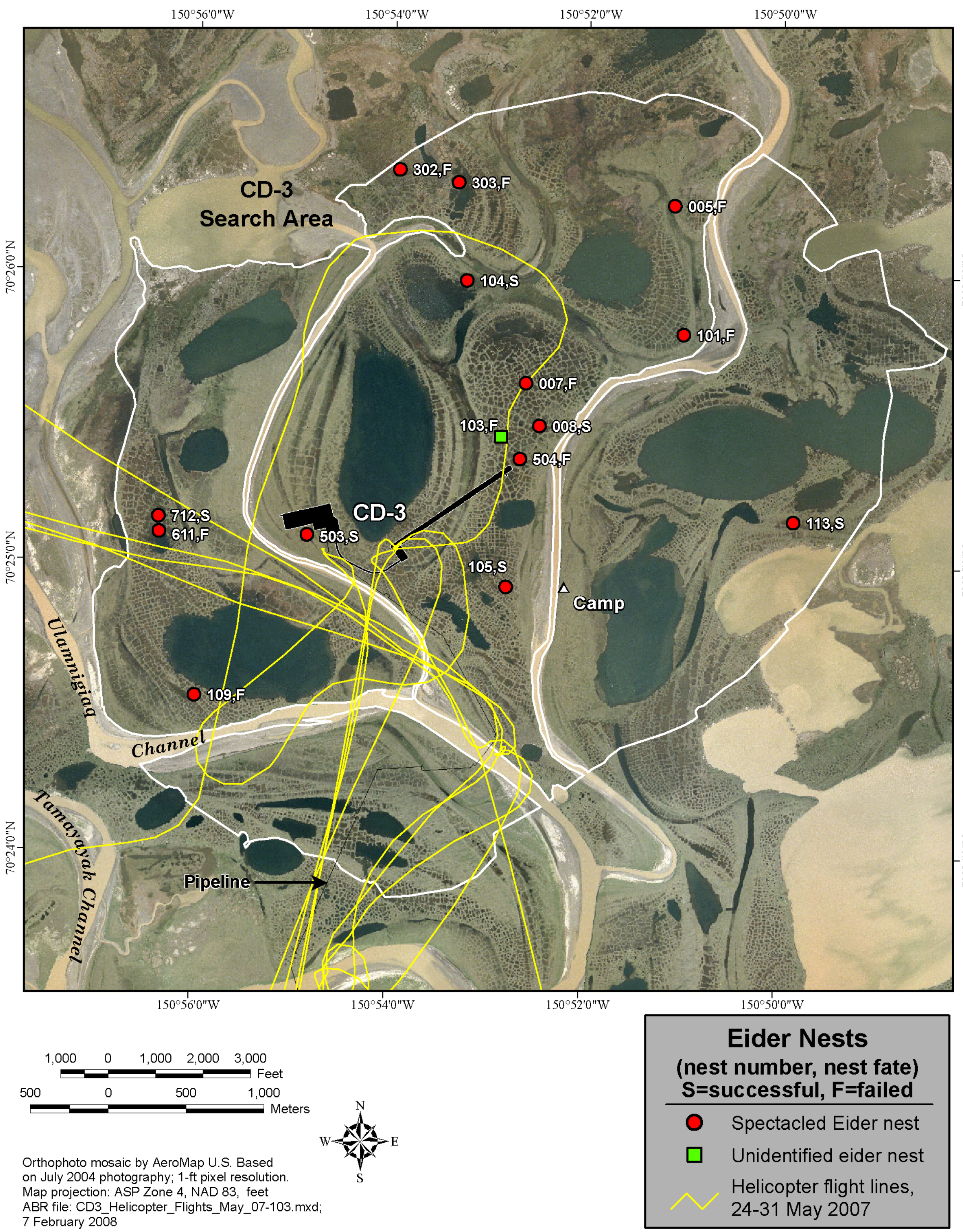
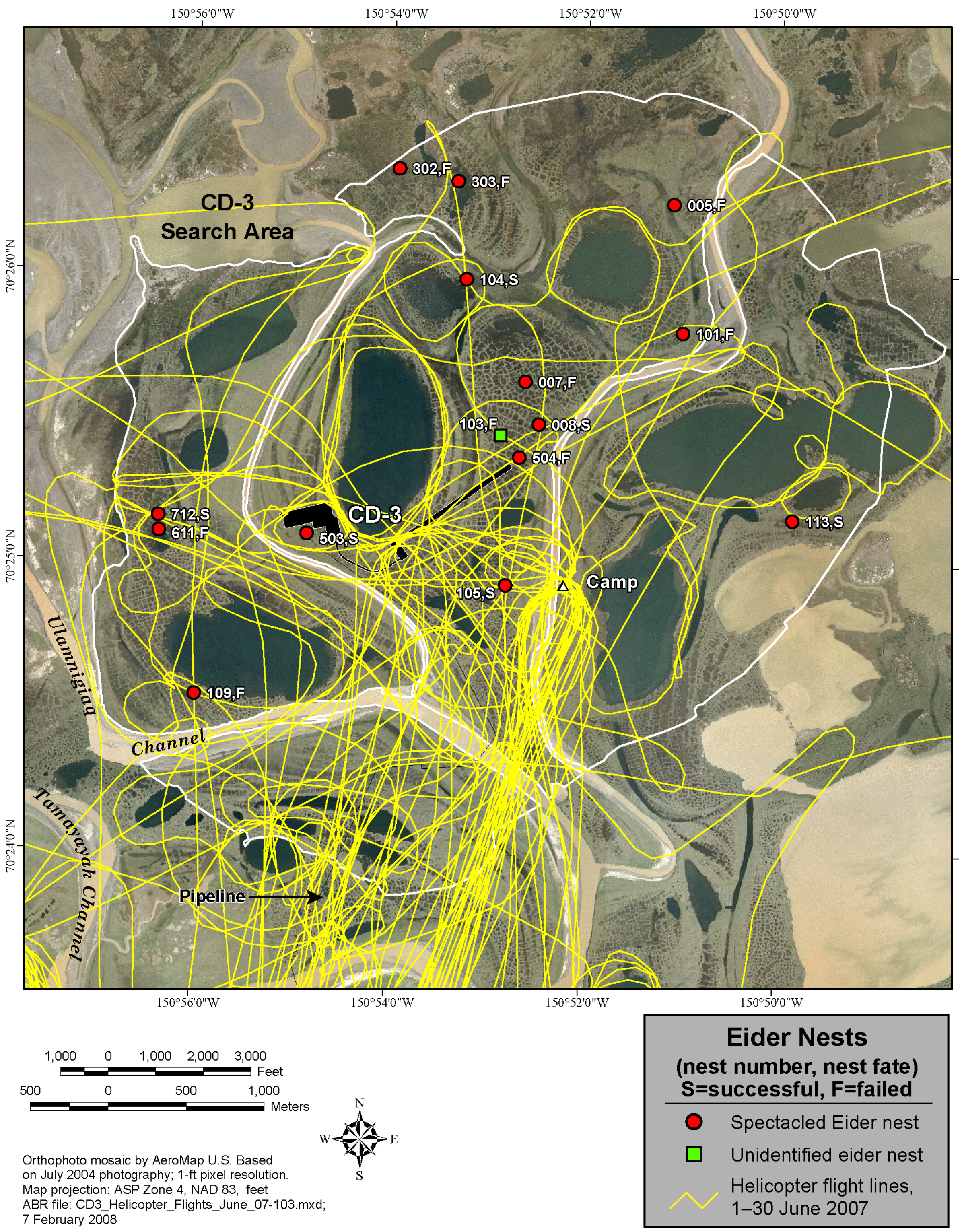
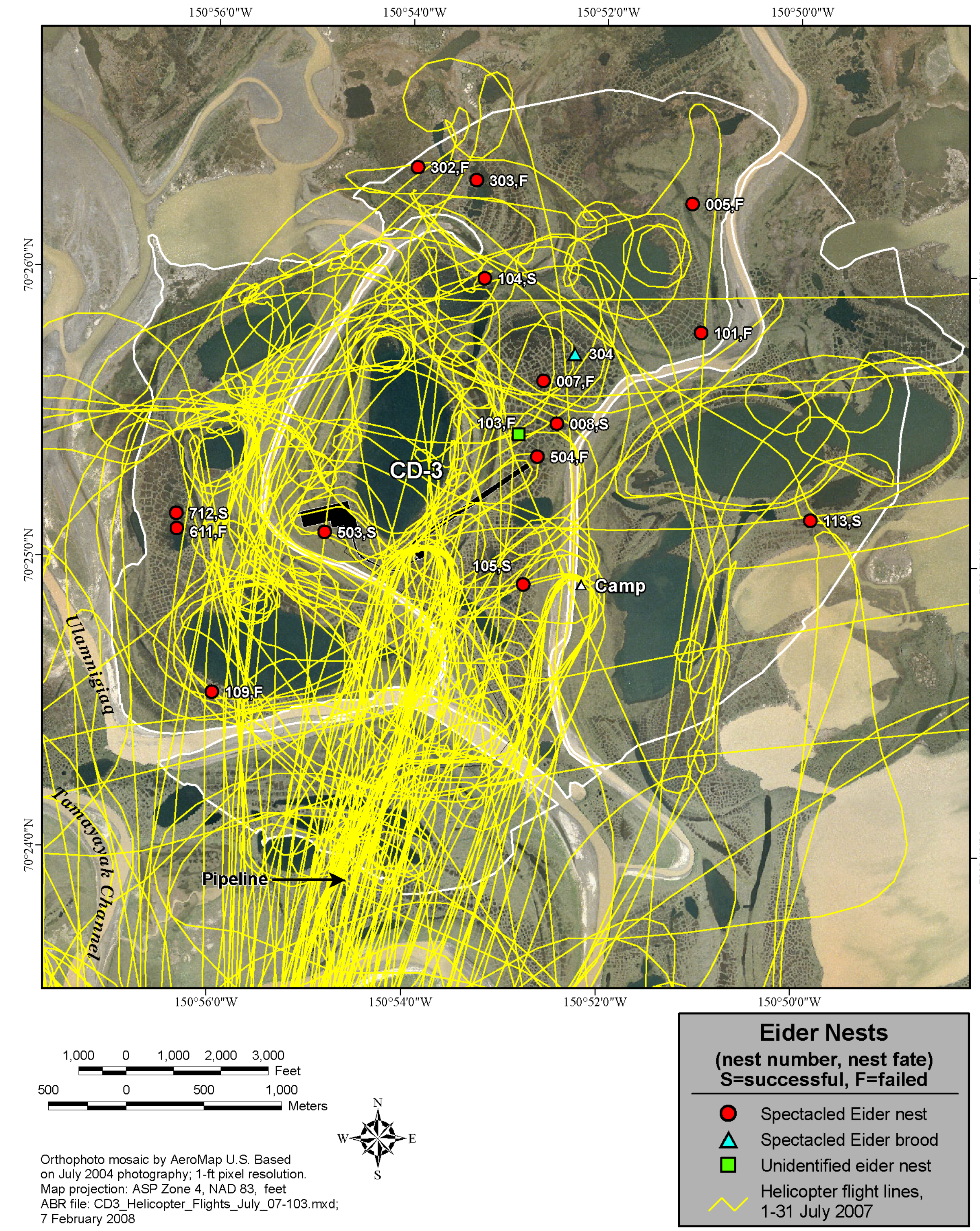


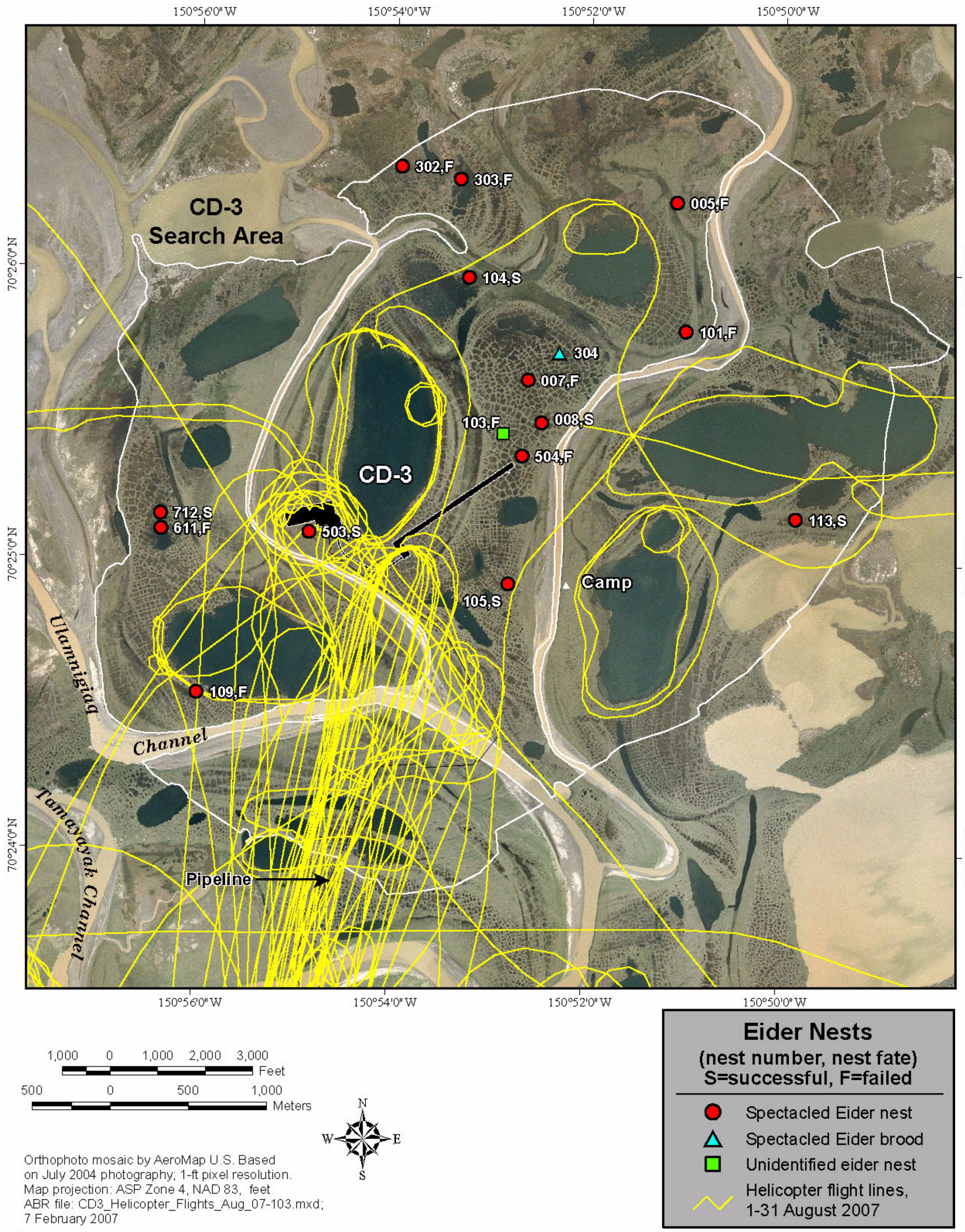
Appendix 1. Helicopter flight lines and Spectacled Eider nests in the CD-3 nest-search area, Colville Delta, Alaska, May 2007.



Appendix 2. Helicopter flight lines and Spectacled Eider nests in the CD-3 nest-search area, Colville Delta, Alaska, June 2007.



Appendix 3. Helicopter flight lines and Spectacled Eider nests and brood in the CD-3 nest-search area, Colville Delta, Alaska, July 2007.



Appendix 4. Helicopter flight lines and Spectacled Eider nests and brood in the CD-3 nest-search area, Colville Delta, Alaska, August 2007.