SPECTACLED EIDER MONITORING AT THE CD-3 DEVELOPMENT, 2006

FINAL ANNUAL REPORT

Prepared for

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

and

Anadarko Petroleum Corporation
3201 C Street, Suite 603
Anchorage, AK 99503

Prepared by

Charles B. Johnson
Julie P. Parrett
Pamela E. Seiser

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

August 2007

Printed on recycled paper.

EXECUTIVE SUMMARY

We investigated the effects of construction activity and aircraft overflights on nesting Spectacled Eiders in 2006 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. 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 km^2 or ~22.4 acres). Access to CD-3 is limited to ice roads during winter and aircraft during the remainder of the year. 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.

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 and 2006, 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 will facilitate before–after construction comparisons. In 2006, preliminary analyses were conducted with the second year of construction-period data.

Construction activity was monitored by 3 time-lapse cameras. High levels of construction and human activity occurred on the gravel footprint throughout the eider breeding season. Crews of ~60 people in 2 12-h shifts primarily worked on the well pad and 1–2 pieces of heavy equipment were used to resurface and compact the gravel airstrip. All transportation of crews in the area was by helicopters through 19 June; on 20 June to mid-July transport was almost exclusively by twin engine CASAs and Twin Otters. Flight paths of helicopters were recorded by GPS units onboard each aircraft and flight paths of airplanes were assumed from potential approach and takeoff paths. 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 during nesting totaled 16.7 h. Minimum helicopter flight altitudes ranged from 0 m to 144 m during the same period. Summer construction was supported by an average of 21 roundtrip helicopter flights and 5.8 roundtrip airplane flights till the end of incubation (17 July).

Aerial surveys were conducted over the Colville Delta for pre-nesting Spectacled Eiders with consistent methods during 1993–1998, and 2000–2006. The 2006 aerial survey for pre-nesting eiders in the Colville Delta study area resulted in an increase over the number of Spectacled Eiders recorded during the past several years. To investigate displacement, 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 [2005–2006]). The mean distances of Spectacled Eider groups from these features differed little between the pre-Alpine, post-Alpine, and post-CD-3 periods. During 2005–2006, after the gravel pads for CD-3 and CD-4 were placed and construction was in progress, 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 20 Spectacled Eider nests in the nest-search area in 2006, the highest number of nests found since searches began in 2001. Two nests were inactive and one was of unknown status, resulting in 18 active nests in 2006. In all but 2001, successful nests were closer to the location of CD-3 than were failed nests. In 2006, the 8 successful nests averaged 300 m closer to CD-3 than the 13 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 construction activity at CD-3 in 2005–2006 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 disturbance.

We monitored incubation behavior by inserting temperature-sensing eggs into 18 active Spectacled Eider nests that we found in 2006, and 11 of those nests also were monitored with time-lapse cameras. Activity budgets estimated separately with temperature-sensing eggs and time-lapse cameras produced similar budgets, indicating that temperature-sensing eggs were an accurate method for recording incubation activity.

Apparent nesting success for Spectacled Eiders in 2006 was 40%, just above the long-term average. Of 18 active nests monitored, 8 hatched and 10 failed. Four nests failed after arctic fox predation, 1 nest failed from predation by Parasitic Jaegers, and 5 nests failed from unknown causes. The 1 nest that failed from avian predation exhibited low incubation constancy over the last several days before predation and may have been influenced by disturbances from construction related activities.

In 2006, helicopter flight paths were recorded within 200 m of 13 active Spectacled Eider nests in the study area and the other 5 active nests had no helicopter flights within 200 m. There was no clear relationship between apparent nest success and helicopter overflights. Two nests were near the gravel footprint and exposed to similarly high levels of helicopter overflights; the nest nearest the airstrip (116 m) hatched, whereas the nest nearest the road (9 m) failed. Four of 5 nests with no helicopter flights within 200 m failed. The median cumulative flight time of helicopters within 200 m of all failed (15.5, sec n = 10) and hatched (76.0 sec, n = 8) nests was not significantly different (P = 0.17).

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 (2005–2006). 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. In the post-CD-3 period, when sample size was smaller, only 1 of those habitats was preferred. The gravel footprint of CD-3 covered about 9.1 ha of which 1.04 ha were in habitat (Deep Polygon Complex) that was determined to be preferred during the pre-Alpine period. The gravel footprint covered <0.1 % of the total area of preferred habitats on the Colville Delta. 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 and detected no change in the overall use of preferred versus non-preferred habitats between the pre-Alpine and post-Alpine periods, but during the post-CD-3 period, preferred habitats were used less than expected.

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 nearly identical levels, with 72% of the nests in the same 2 preferred habitats.

In summary, preliminary analyses showed no evidence of displacement and mixed evidence of changes in habitat use among pre-nesting and nesting Spectacled Eiders in the first 2 years of construction of CD-3. 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.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGMENTS

In addition to the authors of this report, many others collaborated on the 2005 CD-3 eider monitoring study. The ABR biologists and technicians who contributed to this project include: Lauren Attanas, Becky Baird, Peter Elstner, Spencer Rearden, and John Rose. Pilots Dick Hawkins and John Mertke of Maritime Helicopters safely transported crews and gear to and from the field. On the ground, Mary Mae Ashoff and Brent Veltcamp faithfully kept our camp supplied and supported. In our Fairbanks office, Allison Zusi–Cobb, Will Lentz, and Matt Macander provided expert support in data analysis and GIS, and Pam Odom hammered this report into publication form. Field gear was assiduously prepared by our tireless expeditors, Tony LaCortiglia and Davya Flaharty. We thank Alaska Clean Seas for loaning us a river boat and motor that never let us down. We thank all of the other ConocoPhillips Alaska, Inc. (CPAI), staff and contractors in the Alpine oilfield for assistance in making 2006 another successful field season.

This study was conceived and designed during discussions among Caryn Rea (Senior Staff Biologist and Environmental Studies Coordinator for CPAI), Ted Swem (USFWS), and ABR. Caryn Rea was instrumental in getting the study implemented and funded by CPA, Inc., and Anadarko Petroleum Corporation. We appreciate the reviews and comments made by Caryn Rea and ABR’s Bob Burgess.

INTRODUCTION

During 2005, ABR, Inc., initiated 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 Program (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. Because the CD-3 pad and airstrip are located in nesting habitat for Spectacled Eiders (see Johnson et al. 2004b), disturbance of Spectacled Eiders by construction activities and aircraft overflights was a major concern of the US 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 (Colville 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; 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 determined. These surveys will continue 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 success and use of nesting habitats by Spectacled Eiders. In 2006, we collected data on the pre-nesting distribution of eiders, the distribution of nests, 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 2006. Some preliminary analyses are presented; however, final analyses will be conducted after the final field season is completed in 2007. Readers are cautioned, therefore, that results presented here are preliminary and may change with additional years of data.

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 (the CD-1 and CD-2 pads, an airstrip, and a road between the pads), 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 focuses on the CD-3 and its vicinity because CD-3 was placed

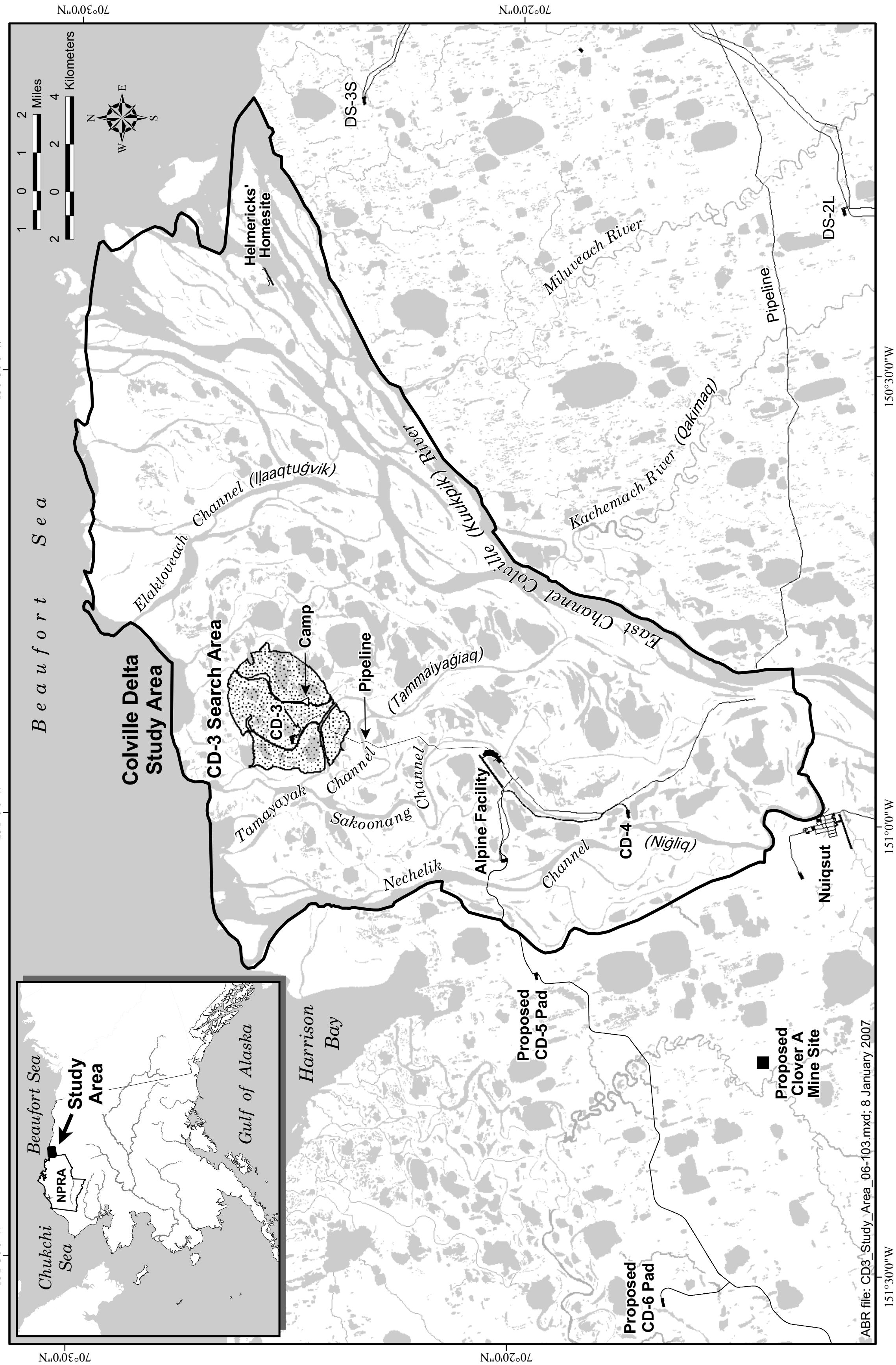


Figure 1. Study area and CD-3 nest-search area, Colville Delta, Alaska, 2006.

in a high density area of Spectacled Eider nests. CD-3 began producing oil in August 2006. 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 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). The study focused on the area near the CD-3 gravel footprint where impacts to nesting eiders were most likely to occur. 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 channelsof 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 occur in the Colville Delta area—the IÒupiat 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 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 10–14 June 2006, consisted of strip transects that covered the Colville Delta, the Kuparuk Oilfield, and part of the Northeast Planning Area of the NPRA, and detailed methods and results are summarized in separate reports (Anderson et al. 2007, Johnson et al. 2007). The surveys were conducted with the same methods since 1993. Because aerial surveys in 1992 were conducted on 6 plots that sampled portions of the Colville Delta, 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 2006 (Figure 1) and had boundaries that were similar in 2001–2005 (Johnson et al. 2002, 2003b, 2004a, 2005, 2006b). 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 2006, 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 ≤1h 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. Prior to 2005, 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-2006 field activities are summarized in previous reports (Johnson et al. 2000a, 2002, 2003b, 2004a, 2005, 2006b). Intensive nest searches were conducted in the CD-3 nest-search area 18 June–2 July 2006. Searchers worked together walking a regular search pattern with ~10-m spacing between adjacent observers. Each team member thoroughly searched all dry ground (not flooded) between themselves and adjacent observers for nests of eiders. 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 searches, but see below for the installation of temperature-sensing eggs. When 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). 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.

Nest checks (to determine fate) were conducted between 17 and 19 July in 2006. One late-hatching nest was revisited on 24 July. 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 egg remnants or blood, yolk, and 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 state and federal permits were obtained for authorized survey activities. A Scientific or Educational Permit (Permit No. 06-039) 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 Telephoto (model PM35T25; Reconyx, Lacrosse, WI) digital time-lapse cameras equipped with 8X lenses and 1- or 2-GB memory cards to record incubation behavior of nesting Spectacled Eiders, predators, and human activity at CD-3. We set cameras on the first 10 eider nests (Figure 2) found active with >1 egg. Installation occurred within 1 day of nest discovery. One additional nest was monitored with a camera 4 days following nest discovery, after another nest failed and a previously deployed camera became available. Therefore, a total of 10 cameras were used to monitor 11 nests. The remaining 2 cameras were used to monitor human activity and a third camera was employed after another nest failure made that camera available (see Conditions in the Study Area). The cameras were mounted on tripods that were tied down to stakes to stabilize them against the wind (Figure 2). Cameras were installed 25–45m 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 3.97). 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 beside the nest, changing positions, standing over the nest, standing beside the nest, rolling eggs, standing while preening, gathering nest material off the nest, and cleaning 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

Figure 2. Spectacled Eider nest and time-lapse camera in the CD-3 nest-search area, Colville Delta, Alaska, 2006.

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.

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, ±0.5° C accuracy, ±0.4° 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.

All Spectacled Eider nests that were active when discovered (18 nests) 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 (28.3° C) and on the temperature change between 2 successive 5-min recording intervals (e.g., a >1° C decrease in temperature between 2 intervals indicated that the bird was off the nest and ≥1° 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 <28.3° C and temperature was not increasing >1° C from the previous interval. Recesses also were identified when egg temperature was ≥28.3° C but dropping >1° C from the previous interval, if the following interval was also a recess. An incubation break was identified by temperature drop of >1° C from the previous interval but nest temperature was ≥28.3° 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 28.3° C and dropped >1° 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.

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 the mean daily temperature exceeded freezing each day.

Data on human activity were collected directly and indirectly. Helicopter flights by Bell 206 Jet and 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, heading, and within each 200-m buffer, the length of flight line and length of time. A Bell 212 helicopter that flew daily crew changes to CD-3 during June had only one flight line recorded. We gathered data on the frequency and timing of its flights with the cameras described below, then used that frequency as a multiplier to estimate the length of time and length of flight lines. We summarized daily totals of time and length of helicopter flights through each buffer. These totals estimated the amount of daily helicopter disturbance to individual nesting eiders.

We used 3 time-lapse digital cameras (described above) to monitor human activity: 2 cameras exclusively monitored human activity and 1 camera was switched from an eider nest following nest failure to monitor activity on the access road from the airstrip to the CD-3 well pad. We were unable to obtain an unobstructed view of the well pad due to the number of buildings, so human activity on the pad was not quantified. Camera 275 was installed on the apron to monitor the northeastern half of the airstrip while camera 002 was installed on the tundra 290 m from the airstrip to monitor the southwestern end where aircraft parked during crew changes. Camera 002 also had a partial view of the apron with the road to the CD-3 well pad in the background. Cameras 275 and 002 collected data from 31 May–17 July. On 5 July, camera 007 became available due to a failure of a monitored eider nest and was set up on the tundra 560 m from the road to provide more complete traffic data. Personnel at CD-3 security recorded date, time, and direction of aircraft landing and taking off from the airstrip and type and direction of vehicles traveling on the airstrip.

For airstrip and road 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 due to their faster travel speed (21 kph), so in these cases, no assumptions were made regarding total duration on airstrip. We added vehicle durations from CD-3 security logs when activity was missed by cameras or occurred outside of camera view. Vehicle duration on the road was based only on vehicles seen in photos.

Data from cameras 002 and 275 were combined to quantify activity on the airstrip and apron while data from cameras 002 and 007 were used to quantify activity on the access road. Data were summarized by aircraft type, small truck (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 minutes (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; thus, 2 vehicle operated concurrently would have twice the duration of one vehicle). Parked vehicles were excluded from these summaries. For the road, we calculated frequency (number of times vehicles traveled between the well pad and airstrip) of vehicle types.

ANALYSES

We evaluated the response of Spectacled Eiders to construction 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 (the baseline, 1993–1997, before any construction of oilfield facilities), post-Alpine (1998–2004, after construction of Alpine began in 1998 and before gravel placement for CD-3 and CD-4), and post-CD-3 and CD-4, after gravel placement and the beginning of construction for CD-3 and CD-4 (2005–2006). Surveys from 1992 were not included in the analyses because they were conducted on 6 plots rather than the entire Colville Delta, and thus did not have a comparable abundance or distribution of eider locations as in subsequent years. For simplicity, the 3 construction periods described will be called the pre-Alpine, post-Alpine, and post-CD-3 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 pads (entire gravel footprint), to CD-3 and CD-4 pads, and to the nearest gravel pad (smallest among distances to Alpine, CD-3, and CD-4). We compared the distances of eiders from each of these features among the 3 construction periods with one-way ANOVAs, Kruskal-Wallis tests, and *t*-tests in SPSS 14.0 for Windows (Chicago, IL).

NEST SURVIVAL

We used temperature-sensing eggs to monitor nest attendance of all Spectacled Eider nests that were active when discovered. Eighteen nests were monitored until hatch or failure. Eleven of these nests also were monitored with time-lapse cameras. Nests were monitored from 21 June to 18 July. Nest ages for failed nest were determined by floating eggs and backdating, and for hatched nests we backdated from hatch date assuming a 24-d incubation period. We used the Known Fate data type in program MARK 4.2 (White and Burnham 1999) to estimate daily nest survival rates. A more sophisticated analysis of nest survival using environmental and disturbance covariates will be presented in a manuscript after the sample size of nests increases.

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. By this method, a wildlife habitat was assigned to each observation. 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 2006 were used for analyses of pre-nesting eider habitat and data from 2001 to 2006 were used for nesting habitat.

For each season, a statistical evaluation 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 statistical evaluation of habitat selection. For statistical evaluations, 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 used chi square tests to compare the relative use of pooled preferred and non-preferred habitats among the 3 construction periods (e.g., before construction of Alpine [1993–1997], after construction of Alpine [1998–2004], and after construction of CD-3 [2005–2006]) for pre-nesting habitat and among 2 construction periods (pre-CD 3 [2001–2004] and post-CD-3 [2005–2006]) for nesting habitat. Non-preferred habitats included both avoided habitats and those with non-significant selection. We used the proportions of observations in preferred versus non-preferred habitats in the relevant pre-construction period as the expected values. We assumed for this test that the amount of preferred and non-preferred habitat available was unchanged between pre-construction and post-construction periods, but actually the gravel footprint for CD-3 (0.09 km² [22.4 acres] total gravel cover) covered 0.06 km² 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 Colville Delta encountered warmer than average spring conditions in 2006. Mean monthly temperatures in 2006 in the nearby Kuparuk Oilfield were almost 2° warmer than the 19-year mean during May and 3° warmer than the 19-year mean during June (www.ncdc.noaa.gov/oa/ncdc.html). The number of thawing-degree days during the waterfowl arrival and peak nest initiation period (15 May–15 June) was the third highest recorded in 19 years at Kuparuk and the highest in 10 years at Colville Village on the outer Colville Delta (Figure 3). Breakup on the Colville River in 2006 was characterized by high water-surface elevations throughout the delta. While the date of peak discharge (30 May 2006) was considered average, the peak surface elevation and peak discharge were the second and fourth highest recorded, respectively (Michael Alexander, pers. comm.). Snow cover in the NPRA and Kuparuk Oilfield was still about 50% in early June, but was mostly gone by 10 June (ABR, unpubl. data). The outer Colville Delta was about 80% snow-covered at the end of May, but was essentially snow-free by 12 June. Deep lakes (≥2 m deep) on the Colville Delta retained 80% ice cover through 12 June, but only the northernmost deep lakes still retained a small amount of thin ice (<30%) by 26 June, the least amount of ice cover observed on deep lakes during late June since we

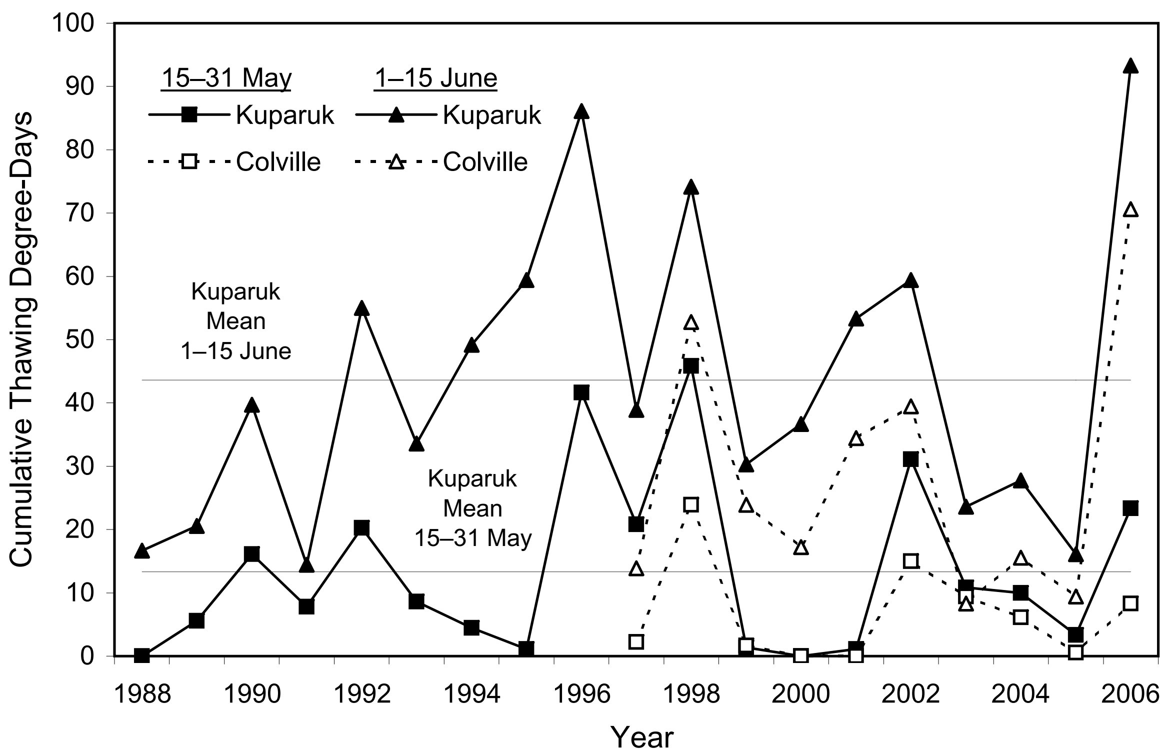


Figure 3. Cumulative number of thawing degree-days recorded for 15–31 May and 1–15 June, Kuparuk Oilfield and Colville Village, Alaska, 1988–2006.

began monitoring conditions in 1993. Other indicators of a warm spring were the early bloom of tundra flowers, early emergence of mosquitos, and early hatch of nests in the CD-3 area. *Parrya nudicaulus*, *Caltha palustris*, *Primula borealis*, and *Petasites frigidus* had bloomed and *Salix glauca* had leafed out by 20 June. Mosquitos were first noted on 20 June and were moderately abundant on 22 June. The emergence of mosquitos coincided with our first observation of a group of 6 caribou, presumably seeking refuge from more abundant mosquitos to the south of the Colville Delta. On 25 June, we found the first hatching nests of Greater White-fronted Geese and the first Lapland Longspur chicks; this date is 5–10 days early for hatching geese, but average to late for Lapland Longspur hatch. On 27 June, we found the first shorebird fledgling, a Pectoral Sandpiper. Whereas these dates may not be early for the same events in other locations on the Arctic Coastal Plain, the outer Colville Delta remains cool with ice-choked deep lakes until early to mid-July in most years and 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 advanced 4 to 7 days over a normal year on the Colville Delta, and presume a similar condition existed in the adjacent NPRA study area.

HUMAN DISTURBANCE

Cameras generally operated 24-h/d, providing 1,440 min/d of monitoring from 31 May to 17 July. Camera maintenance and poor visibility prevented data collection for up to 303 min during some days. Cameras documented a number of pickup trucks, an ATV, a loader, roller, grader, Bobcat (small loader), boom lift, several pickups = 1 ton capacity, a bus, and water truck. Aircraft included three helicopters, a Bell 212 and Bell 206 Jet and 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, and apron, the activity levels reported here represent a minimal estimate of the levels of activity that took place on the gravel footprint.

Crews were primarily transported between Alpine and CD-3 from 11 May–12 June on the Bell 212 helicopter. From 1–19 June, the 212 landed (and took off) an average of 21.0 times/d (n = 19 days), spending 76.3 min/d on the airstrip. In contrast, the CASA and Twin Otter landed an average of 2.4 times/d (n = 19 days), while the Bell 206 Jet and Long Rangers were recorded only during 3 days (Table 1). No helicopters landed at CD-3 between 20 June and 17 July, the end of the nesting period for monitored nests. From 20 June to 17 July, the CASA and Twin Otter transported crews, averaging 5.8 flights/d (n = 27 days), spending 65.4 min/d on the airstrip (Table 1). In addition to passengers, the CASA often transported only freight. After 17 July, airplanes supported crew shifts except occasionally when Bell 206 helicopters substituted.

Cameras documented an average of 46.2 vehicles/d (n = 46.1 days) traveling on the access road, resulting in 9–163 min of cumulative vehicle activity/d (Table 2). Due to the time-lapse delay in photos and limited camera view, most vehicles were recorded for < 1 min and others were likely missed, underestimating frequency and vehicle event duration. Vehicle estimates improved with the addition of camera 002 on 5 July. Cameras rarely recorded >1 vehicle on the road at a time, so cumulative vehicle minutes were similar to total vehicle event durations (Table 2). Small trucks accounted for the majority of traffic between the airstrip and well pad.

Vehicle traffic was higher on the airstrip and apron (Table 3), where cameras documented 86–682 min/d of vehicle events and 88–1,203 min/d of cumulative vehicle minutes (n = 47.1 days). Machinery, used during runway maintenance and freight deliveries, accounted for 79% of the total vehicle event duration minutes during the monitoring period. CD-3 Security personnel drove the length of the airstrip during security rounds and accounted for a large portion of the small truck travel.

Pedestrians on the airstrip and apron were common and consisted of pedestrian workers (people working on runway maintenance or unloading freight planes) and aircraft passengers (present during crew changes) (Table 4). Aircraft passengers were transported to the airstrip apron in a bus and either waited in the vehicle for aircraft or stood on the apron at the edge of camera view. We could not consistently account for people standing by the bus and so, excluded them from calculations

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, 2006.

	Helicopter				Fixed-Wing							
	Bell 212		Bell 206[a]		Otter		CASA		All Aircraft Total			
Date	Freq[b]	Aircraft Min[c]	Freq[b]	Aircraft Min[c]	Freq[b]	Aircraft Min[c]	Freq[b]	Aircraft Min[c]	Freq[b]	Aircraft Min[c]	Duration (min)[d]	Minutes Monitored
31 May	6	14	2	4	0	0	0	0	8	18	19	605
01 June	44	83	0	0	0	0	4	61	48	144	141	1,440
02 June	38	93	0	0	0	0	4	63	42	156	156	1,440
03 June	32	78	0	0	0	0	6	93	38	171	147	1,440
04 June	32	74	0	0	6	26	0	0	38	100	99	1,440
05 June	0	0	0	0	14	57	8	38	22	95	95	1,440
06 June	2	4	2	6	8	29	14	88	26	127	128	1,440
07 June	42	82	0	0	0	0	0	0	42	82	82	1,440
08 June	50	94	0	0	0	0	0	0	50	94	94	1,440
09 June	42	71	0	0	0	0	4	68	46	139	137	1,440
10 June	48	84	0	0	0	0	4	39	52	123	123	1,440
11 June	52	97	0	0	0	0	0	0	52	97	97	1,440
12 June	48	90	2	1	0	4	2	64	52	159	142	1,440
13 June	60	103	0	0	0	0	4	66	64	169	165	1,440
14 June	60	114	0	0	0	0	0	0	60	114	114	1,440
15 June	52	76	0	0	0	0	0	0	52	76	76	1,440
16 June	46	76	0	0	0	0	0	0	46	76	76	1,440
17 June	62	79	0	0	0	0	4	75	66	154	154	1,440
18 June	52	83	0	0	0	0	4	73	56	156	155	1,440
19 June	36	68	24	46	0	0	4	23	64	137	119	1,440
20 June	0	0	0	0	4	19	6	46	10	65	65	1,440
21 June	0	0	0	0	12	43	0	0	12	43	43	1,440
22 June	0	0	0	0	10	44	2	6	12	50	50	1,440
23 June	0	0	0	0	12	49	0	0	12	49	49	1,440
24 June	0	0	0	0	6	26	8	90	14	116	115	1,440
25 June	0	0	0	0	6	25	6	20	12	45	44	1,440
26 June	0	0	0	0	6	22	6	27	12	49	49	1,440
27 June	0	0	0	0	6	24	6	21	12	45	45	1,440
28 June	0	0	0	0	10	36	2	6	12	42	42	1,440
29 June	0	0	0	0	6	25	6	32	12	57	57	1,440
30 June	0	0	0	0	6	25	6	35	12	60	60	1,440
01 July	0	0	0	0	10	43	6	189	16	232	218	1,440
02 July	0	0	0	0	4	18	6	78	10	96	98	1,440
03 July	0	0	0	0	4	17	6	27	10	44	44	1,440
04 July	0	0	0	0	6	18	8	75	14	93	92	1,440
05 July	0	0	0	0	6	18	4	22	10	40	40	1,440
06 July	0	0	0	0	6	18	4	18	10	36	36	1,440
07 July	0	0	0	0	6	17	4	17	10	34	34	1,440
08 July	0	0	0	0	6	15	10	96	16	111	111	1,440
09 July	0	0	0	0	6	16	8	53	14	69	69	1,440

Table 1. Continued.

	Helicopter				Fixed-Wing							
	Bell 212		Bell 206[a]		Otter		CASA		All Aircraft Total			
Date	Freq[b]	Aircraft Min[c]	Freq[b]	Aircraft Min[c]	Freq[b]	Aircraft Min[c]	Freq[b]	Aircraft Min[c]	Freq[b]	Aircraft Min[c]	Duration (min)[d]	Minutes Monitored
10 July	0	0	0	0	6	17	6	24	12	41	41	1,440
11 July	0	0	0	0	6	22	6	24	12	46	46	1,440
12 July	0	0	0	0	12	38	0	0	12	38	38	1,440
13 July	0	0	0	0	2	5	0	0	2	5	5	1,440
14 July	0	0	0	0	4	13	0	0	4	13	13	1,440
15 July	0	0	0	0	8	46	10	135	18	181	157	1,440
16 July	0	0	0	0	0	0	12	65	12	65	65	1,440
17 July	0	0	0	0	0	0	6	25	6	25	25	932
Total	804	1,463	30	57	204	775	206	1,882	1,244	4,177	4,070	67,777
Mean[e]	17.1	31.1	0.6	1.2	4.3	16.5	4.4	40.0	26.4	88.7	86.5	1,412.0

[a] Includes both Long Ranger and Jet Ranger helicopters
[b] Frequency = number of takeoffs + landings
[c] Aircraft Min = sum of each minute each aircraft was on apron and airstrip
[d] Duration = number of minutes ≥1 aircraft was active on airstrip and apron
[e] 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

of passenger duration and cumulative minutes. 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 walked to and from aircraft and ranged in group size from 8–22 people. Crew changes, due to large group sizes, accounted for the most cumulative people minutes with an average of 193.2 min/d (n = 47.1 days), but events were short in duration, taking 2-139 min/d (mean = 47.6 min/d, n = 47.1 days). In contrast, pedestrian workers on the airstrip operated in small groups of 1–6, contributing fewer cumulative people minutes (mean = 105.5 min/d), but were present for longer periods of time and accounted for the most event duration minutes, averaging 80.9 min/d (n = 47.1 days). Pedestrians were rarely recorded by cameras on the access road (Table 4).

In addition to the flights to and from CD-3 reported above, helicopter flights supported activities other than construction. Flights in May and early June transported hydrologists conducting lake sampling and monitoring river levels during break up (see Table 5 for helicopter flights within 200 m of nests on these dates). On 16–17 June, 7 flights were made to our campsite (Appendix 2) to sling gear and ferry personnel (no flights occurred within 200-m nest buffers). Flights also occurred on 19 June (2 flights), 22 June (2), 26 June (1), and 28 June (1) to move personnel or gear to and from our camp (no flights were within 200-m nest buffers). On 26 and 27 June, a loon survey was conducted around lakes in the area, accounting for the long flight lines on those dates (229 sec and 154 sec, respectively, within 200-m nest buffers), and similar surveys were conducted weekly through 17 August. On 3–4 July, 9 flights took our gear and personnel from camp to Alpine (no flights were within 200-nest buffers).

Cumulative helicopter flight time within 200 m of all known eider nests was 79.2 h (284,977 sec) from 28 May to hatch or failure and 23.1 h (82,985sec) during the incubation period (Table 5). The high levels of flights within 200-m buffers was due to the location of 2 nests within 200 m of the airstrip apron where helicopters landed. When helicopters landed for crew changes, they kept their turbines running. We considered landings the

Table 2. Frequency, duration, and type of vehicles[a] on the CD-3 access road, as recorded by 2 time-lapse cameras, Colville Delta, Alaska, 2006.

	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]
31 May	8	4	4	5	4	4	2	2	2	0	0	0	15	10	10	533
01 June	18	10	10	20	13	13	12	11	11	0	0	0	50	33	34	1,440
02 June	17	9	9	21	14	14	14	9	9	0	0	0	52	30	32	1,440
03 June	10	5	5	21	12	12	3	2	2	0	0	0	34	18	19	1,137
04 June	19	11	11	13	7	7	6	4	4	0	0	0	38	21	22	1,303
05 June	20	12	12	11	10	10	7	4	4	0	0	0	38	25	26	1,440
06 June	20	11	11	8	7	7	4	2	2	0	0	0	32	20	20	1,440
07 June	18	10	10	16	8	9	13	12	12	2	1	1	49	31	32	1,439
08 June	25	14	14	14	11	11	15	13	13	0	0	0	54	37	38	1,440
09 June	10	5	5	17	12	12	7	5	5	0	0	0	34	21	22	1,402
10 June	14	7	7	23	14	14	3	2	2	0	0	0	40	23	23	1,440
11 June	17	10	10	20	13	13	11	7	7	6	3	3	54	33	33	1,251
12 June	17	9	9	18	10	10	11	6	6	1	1	1	47	25	26	1,427
13 June	11	6	6	27	14	14	14	8	8	1	1	1	53	28	29	1,440
14 June	19	10	10	28	15	15	4	2	2	1	1	1	52	27	28	1,440
15 June	10	5	5	11	6	6	9	5	5	0	0	0	30	16	16	1,440
16 June	9	5	5	13	7	7	2	2	2	1	1	1	25	14	15	1,301
17 June	8	5	5	20	11	11	11	9	9	0	0	0	39	23	25	1,440
18 June	12	6	6	13	7	7	6	3	3	1	1	1	32	16	17	1,439
19 June	13	7	7	24	13	13	11	6	6	0	0	0	48	26	26	1,440
20 June	16	9	9	4	2	2	3	2	2	0	0	0	23	12	13	1,302
21 June	12	7	7	7	4	4	3	2	2	1	1	1	23	13	14	1,242
22 June	13	7	7	10	5	5	13	7	7	0	0	0	36	19	19	1,440
23 June	21	12	12	8	5	5	6	4	4	0	0	0	35	19	21	1,440
24 June	14	7	7	8	4	4	8	4	4	1	1	1	31	16	16	1,440

Table 2. Continued.

	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]
25 June	17	9	9	10	5	5	1	1	1	1	1	1	29	14	16	1,440
26 June	10	5	5	4	2	2	6	3	3	0	0	0	20	10	10	1,440
27 June	5	3	3	11	6	6	17	13	13	0	0	0	33	21	22	1,440
28 June	6	3	3	8	4	4	4	3	3	2	1	1	20	10	11	1,440
29 June	20	11	11	8	4	4	1	1	1	0	0	0	29	15	16	1,430
30 June	10	5	5	1	1	1	12	6	6	1	1	1	24	13	13	1,440
01 July	9	5	5	10	5	5	1	1	1	0	0	0	20	10	11	1,440
02 July	10	5	5	7	4	4	5	3	3	0	0	0	22	11	12	1,440
03 July	6	3	3	8	4	4	3	2	2	0	0	0	17	9	9	1,440
04 July	27	14	14	8	4	4	15	11	11	0	0	0	50	29	29	1,436
05 July[e]	10	7	7	9	7	7	20	26	26	0	0	0	39	38	40	1,440
06 July	26	33	33	18	18	19	11	11	11	2	4	4	57	66	67	1,440
07 July	36	40	40	17	15	17	15	34	34	2	1	1	70	89	92	1,440
08 July	47	51	52	26	25	26	21	29	29	1	1	1	95	99	108	1,440
09 July	43	54	54	15	15	15	30	56	56	1	1	1	89	122	126	1,440
10 July	40	49	49	13	13	13	5	7	7	0	0	0	58	69	69	1,440
11 July	52	67	68	23	27	28	36	36	38	1	1	1	112	122	135	1,440
12 July	44	59	60	15	14	14	15	33	33	0	0	0	74	100	107	1,440
13 July	35	40	42	2	2	2	9	14	14	0	0	0	46	54	58	1,440
14 July	23	23	23	8	8	8	3	3	3	0	0	0	34	33	34	1,311
15 July	52	57	57	29	28	29	51	73	76	2	1	1	134	156	163	1,440
16 July	32	39	39	19	20	20	10	15	15	0	0	0	61	70	74	1,440
17 July	21	20	20	11	14	14	2	3	3	0	0	0	34	36	37	932
Total	952	805	810	660	473	480	491	517	522	28	23	23	2,131	1,752	1,835	66,405
Mean[f]	20.6	17.5	17.6	14.3	10.3	10.4	10.6	11.2	11.3	0.6	0.5	0.5	46.2	38.0	39.8	1,412.9

[a] Small Truck = 4-wheeler and pickup; large trucks >1 ton capacity; machinery = roller, loader, grader, boom lift, Bobcat
[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] On 5 July, an additional camera was installed to monitor the access road
[f] 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 3. Duration of activity of vehicles[a] on the CD-3 airstrip and apron, as recorded by 2 time-lapse cameras, Colville Delta, Alaska, 2006.

Date	Small Truck Duration (min)[b]	Small Truck Veh. Min[c]	Large Truck Duration (min)[b]	Large Truck Veh. Min[c]	Machinery Duration (min)[b]	Machinery Veh. Min[c]	Unknown Vehicle Type Duration (min)[b]	Unknown Vehicle Type Veh. Min[c]	All Vehicles Combined Duration (min)[b]	All Vehicles Combined Veh. Min[c]	Total Min Monitored[d]
31 May	22	22	3	3	88	88	2	2	105	115	605
01 June	45	45	8	8	231	231	7	7	285	291	1,440
02 June	32	32	17	17	235	255	6	6	277	310	1,440
03 June	40	40	17	17	199	200	1	1	251	258	1,440
04 June	79	79	15	15	297	345	1	1	365	440	1,440
05 June	83	84	318	318	629	800	1	1	682	1,203	1,440
06 June	42	42	12	12	546	546	2	2	573	602	1,440
07 June	38	38	9	9	222	222	3	3	252	272	1,440
08 June	51	51	19	19	203	203	5	5	268	278	1,440
09 June	47	49	22	22	250	273	4	4	316	348	1,440
10 June	61	61	14	14	279	279	2	2	336	356	1,440
11 June	170	172	17	17	220	220	10	10	349	419	1,440
12 June	74	81	10	10	275	277	4	4	329	372	1,440
13 June	35	35	19	19	155	156	1	1	200	211	1,440
14 June	52	53	20	20	323	323	1	1	378	397	1,440
15 June	27	28	13	13	271	271	2	2	308	314	1,440
16 June	21	21	18	18	221	253	4	4	255	296	1,440
17 June	40	41	18	18	526	561	2	2	565	622	1,440
18 June	58	58	20	20	258	342	2	2	335	422	1,440
19 June	49	49	16	17	423	547	3	3	468	616	1,440
20 June	55	55	15	15	440	502	3	3	502	575	1,440
21 June	33	33	9	9	110	178	2	2	151	222	1,440
22 June	52	52	14	14	123	123	1	1	187	190	1,440
23 June	50	50	14	14	149	226	2	2	207	292	1,440
24 June	38	40	12	12	91	91	1	1	138	144	1,440
25 June	33	34	12	12	151	201	1	1	194	248	1,440
26 June	51	53	29	29	71	71	3	3	153	156	1,440
27 June	42	42	7	7	79	79	2	2	125	130	1,440
28 June	25	25	11	11	327	379	3	3	361	418	1,440
29 June	75	76	10	10	156	156	0	0	239	242	1,440
30 June	42	42	8	8	272	272	1	1	306	323	1,440
01 July	42	45	20	20	28	28	0	0	89	93	1,440
02 July	46	46	13	14	59	59	0	0	116	119	1,440
03 July	29	29	13	13	49	49	1	1	91	92	1,440
04 July	46	47	14	14	622	706	0	0	675	767	1,440

Table 3. 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	39	39	7	7	399	633	0	0	429	680	1,440
06 July	68	68	7	7	334	335	1	1	378	411	1,440
07 July	47	47	9	9	172	172	0	0	219	228	1,440
08 July	78	79	8	8	154	155	1	1	236	243	1,440
09 July	150	150	8	9	243	243	0	0	376	402	1,440
10 July	122	127	4	4	143	143	1	1	255	275	1,440
11 July	95	98	8	8	134	135	1	1	210	242	1,440
12 July	104	107	4	4	139	139	1	1	221	251	1,440
13 July	101	105	3	3	78	80	0	0	171	188	1,440
14 July	77	78	2	2	62	62	0	0	138	142	1,440
15 July	95	96	11	12	91	91	1	1	195	200	1,440
16 July	95	95	6	6	156	156	1	1	246	258	1,440
17 July	82	82	3	3	1	1	2	2	86	88	932
Total	2,878	2,921	886	890	10,684	11,857	92	92	13,591	15,761	67,777
Mean[e]	61.1	62.1	18.8	18.9	227.0	251.9	2.0	2.0	288.8	334.9	1,412.0

[a] Small Truck = 4-wheeler and pickup; large trucks >1 ton capacity; machinery = roller, loader, grader, boom lift, Bobcat
[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

same as flying (as long as the turbines were running) and recorded it in total flight time within 200 m of nests. We recorded tundra landings in nest buffers by Bell 206 helicopters in the same manner. The nest with the highest exposure to helicopters (nest 303 with 41,189 sec of flight time within 200 m during incubation) was on the flight path between CD-3 and Alpine and that nest was depredated by a Parasitic Jaeger on the final day of incubation (Table 5, Appendices 1–4). Another nest with slightly less exposure to helicopter overflights was also on that flight path (nest 601 with 41,101 sec of flight time within 200 m) and that nest hatched. Five nests had no helicopter flights within 200 m during incubation and 4 of these nests failed and 1 hatched. The mean flight times were skewed by the exceptionally high values for nests 303 and 601, so we used ranked values in a nonparametric test to compare the amount of helicopter flight time within 200 m of hatched and failed nests. The amount of time helicopters flew within 200 m of hatched (median = 76.0 sec of flight time within 200 m) and failed nests (median = 15.5 sec of flight time within 200 m) did not differ significantly (Mann-Whitney U test, $Z = -1.4$, $P = 0.17$), suggesting that the amount of helicopter activity (as measured by cumulative flight time) had no consistent effect on overall nesting success in the nest-search area.

DISTRIBUTION AND ABUNDANCE

PRE-NESTING

The 2006 aerial survey for pre-nesting eiders in the Colville Delta study area was conducted 11 and 13 June (Johnson et al. 2007). We counted 25 Spectacled Eiders that were on the ground and 6 that were in flight. The number of birds counted on the Colville Delta in 2006 was an increase over counts made in the previous 3 years and was only

Table 4. Group size and duration of pedestrians observed on the airstrip, including the apron, and CD-3 access road, Colville River Delta, Alaska, 2006.

	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]
31 May	1	14	14	13	12	56	13	26	70	605	0	0	0	533
01 June	4	72	119	15	53	217	15	125	336	1,440	0	0	0	1,440
02 June	4	73	115	17	39	167	17	111	282	1,440	0	0	0	1,440
03 June	4	58	100	13	50	187	13	106	287	1,440	0	0	0	1,137
04 June	2	60	68	18	55	254	18	116	322	1,440	0	0	0	1,303
05 June	2	23	26	21	38	203	21	61	229	1,440	0	0	0	1,440
06 June	3	63	98	16	42	190	16	105	288	1,440	0	0	0	1,440
07 June	3	37	54	15	55	199	15	92	253	1,440	1	1	1	1,439
08 June	2	66	95	18	61	252	18	127	347	1,440	0	0	0	1,440
09 June	4	125	189	16	43	184	16	167	373	1,440	1	1	1	1,402
10 June	3	89	110	16	51	218	16	140	328	1,440	0	0	0	1,440
11 June	4	45	77	12	32	111	12	77	188	1,440	0	0	0	1,251
12 June	3	36	52	16	91	340	16	127	392	1,440	1	1	1	1,427
13 June	4	205	261	15	103	329	15	307	590	1,440	0	0	0	1,440
14 June	2	177	210	16	102	405	16	277	615	1,440	0	0	0	1,440
15 June	3	98	119	17	65	245	17	163	364	1,440	0	0	0	1,440
16 June	2	13	15	16	63	237	16	77	252	1,440	0	0	0	1,301
17 June	6	86	151	16	80	281	16	166	432	1,440	0	0	0	1,440
18 June	5	105	153	16	94	337	16	199	490	1,440	0	0	0	1,439
19 June	2	183	205	16	139	383	16	321	588	1,440	0	0	0	1,440
20 June	5	174	226	20	89	254	20	262	480	1,440	0	0	0	1,302
21 June	2	50	51	16	61	181	16	111	232	1,440	0	0	0	1,242
22 June	3	90	95	13	39	120	13	129	215	1,440	0	0	0	1,440
23 June	3	18	22	19	23	125	19	41	147	1,440	0	0	0	1,440
24 June	4	100	129	19	32	159	19	132	288	1,440	0	0	0	1,440
25 June	3	116	129	18	18	86	18	133	215	1,440	0	0	0	1,440
26 June	2	54	58	16	22	122	16	76	180	1,440	0	0	0	1,440
27 June	4	111	122	19	34	182	19	145	304	1,440	0	0	0	1,440
28 June	3	69	77	15	25	135	15	94	212	1,440	0	0	0	1,440
29 June	4	49	78	16	38	166	16	87	244	1,440	0	0	0	1,430

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]	Total Min Monitored[d]
30 June	4	142	166	12	50	214	12	191	380	1,440	0	0	0	1,440
01 July	4	55	89	18	32	159	18	87	248	1,440	0	0	0	1,440
02 July	4	62	92	12	20	93	12	82	185	1,440	0	0	0	1,440
03 July	2	14	17	15	23	130	15	37	147	1,440	0	0	0	1,440
04 July	5	153	197	16	57	208	16	210	405	1,440	2	1	2	1,436
05 July[e]	2	109	114	19	78	282	19	188	396	1,440	0	0	0	1,425
06 July	3	85	123	22	28	143	22	113	266	1,440	1	2	2	1,440
07 July	5	45	48	20	48	180	20	92	228	1,440	0	0	0	1,440
08 July	3	87	100	22	36	174	22	123	274	1,440	0	0	0	1,440
09 July	5	95	106	20	24	134	20	119	240	1,440	2	1	2	1,440
10 July	3	47	58	19	21	132	19	68	190	1,440	0	0	0	1,440
11 July	3	80	93	19	19	119	19	97	212	1,440	1	1	1	1,440
12 July	3	115	139	21	19	150	21	132	289	1,440	0	0	0	1,440
13 July	2	18	18	8	2	12	8	20	30	1,440	0	0	0	1,440
14 July	2	5	6	17	5	45	17	11	51	1,440	0	0	0	1,311
15 July	6	187	333	22	55	271	22	242	604	1,440	1	1	1	1,440
16 July	2	40	40	20	67	262	20	107	302	1,440	1	11	11	1,440
17 July	2	9	10	21	6	59	21	15	69	932	0	0	0	932
Total	6	3,807	4,967	22	2,239	9,092	22	6,034	14,059	67,777	2	20	22	66,390
Mean[f]	3.3	80.9	105.5	17.3	47.6	193.2	17.3	128.2	298.7	1,412.0	0.2	0.4	0.5	1,383.1

[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] On 5 July, an additional camera was installed to monitor the access road
[f] 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. Daily cumulative flight time (sec) and minimum flight altitude (m) of helicopters within 200 m of Spectacled Eider nests as recorded by GPS receivers in 4 helicopters during the pre-nesting and incubation periods in the CD-3 project area, Colville Delta, 2006.

	Nest Number[a]																		Daily
Date[b]	006	011	014	221	226	303	316	408	409	415	416	544	545	546	601	613	615	618	Total
28 May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 May	0	0	0	0	0	10	0	0	0	0	0	0	0	0	5	8	0	0	23
30 May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	9
31 May	0	22	0	0	0	1,008	0	0	0	0	0	0	0	0	1,440	0	0	0	2,470
01 June	0	0	0	0	0	5,852	0	0	0	0	0	0	0	0	5,718	0	0	0	11,570
02 June	0	0	0	0	0	6,311	0	0	0	0	0	15	0	0	6,195	0	0	0	12,521
03 June	0	0	0	0	0	5,298	0	0	0	0	0	0	0	0	5,200	0	10	0	10,508
04 June	0	9	0	0	0	5,049	0	0	0	0	0	0	0	0	4,952	0	0	0	10,010
05 June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 June	0	0	0	0	0	314	0	0	0	0	0	8	0	0	986	0	0	0	1,308
07 June	0	0	0	0	0	5,749	0	0	0	0	0	0	0	0	5,621	0	0	0	11,370
08 June	0	0	0	0	0	6,610	0	0	0	0	0	0	0	0	6,457	0	0	0	13,067
09 June	0	0	0	0	0	5,077	0	0	0	0	0	0	0	0	4,949	0	0	0	10,026
10 June	0	0	0	0	0	5,963	0	0	0	0	0	0	0	0	5,816	0	0	0	11,779
11 June	0	10	0	0	0	6,818	0	0	0	0	0	0	0	0	6,657	0	0	0	13,485
12 June	0	0	0	0	0	11,019	0	0	0	0	0	0	0	0	10,872	0	0	0	21,891
13 June	0	0	0	0	0	12,753	0	0	0	0	0	0	0	0	12,571	0	0	0	25,324
14 June	0	0	0	0	0	13,953	0	0	0	0	0	0	0	0	13,771	0	0	0	27,724
15 June	0	0	0	0	0	9,537	0	0	0	0	0	0	0	0	9,378	0	0	0	18,915
16 June	0	0	0	0	0	9,480	0	0	0	0	0	0	0	0	9,339	0	0	0	18,819
17 June	0	0	0	0	0	10,152	0	0	0	0	0	0	0	0	9,964	0	0	0	20,116
18 June	0	0	6	0	0	10,317	4	7	5	0	0	0	0	0	10,158	0	0	0	20,497
19 June	0	134	0	0	0	11,195	0	0	0	0	0	0	0	0	11,623	0	0	0	22,952
21 June	0	0	0	0	0	0	0	0	7	0	0	0	0	0	10	0	0	0	17
26 June	0	0	26	54	0	7	19	15	14	0	0	0	49	0	0	4	33	0	221
27 June	0	0	31	35	0	6	13	9	9	0	0	0	28	0	0	15	9	0	154

Table 5. Continued.

Date[b]	Nest Number[a] 006	011	014	221	226	303	316	408	409	415	416	544	545	546	601	613	615	618	Daily Total
04 July	0	15	47	30	0	3	1	17	17	0	0	0	25	0	7	0	0	0	163
06 July	0	16	0	0	0	29	0	0	0	0	0	17	0	0	0	0	0	0	62
08 July	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
10 July	0	0	0	15	0	0	0	0	5	0	0	0	6	0	0	0	0	0	26
11 July	9	13	24	14	0	0	12	0	0	0	0	0	0	0	14	11	19	0	116
17 July	0	0	0	0	0	0	8	0	7	113	10	0	16	5	0	8	9	0	175
Total Inc. sec[c]	9	165	110	122	0	41,189	37	31	52	0	0	0	108	0	41,101	19	42	0	82,985
Total sec[d]	9	206	110	122	0	142,510	37	31	52	0	0	15	108	0	141,689	36	52	0	284,977
Min. Altitude (m)[d]	144	18	20	32	–	0	53	84	36	–	–	21	34	–	0	48	18	–	
Nest Fate[e]	H	H	H	H	H	D/P	P	P	P	F	F	F	P	F	H	H	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)
[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 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)

slightly below 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. 2007).

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 (Table 6, Figure 4). 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 (2005–2006), however, pre-nesting eiders appeared to be located closer to Alpine, Alpine airstrip, CD-3, and CD-4 than they were in

Table 6. Results of one-way ANOVAs comparing the distances (km) of pre-nesting Spectacled Eider groups from the coastline, Alpine, Alpine Airstrip, CD-3, CD-4, and nearest gravel pad among 3 construction periods: pre-Alpine construction (1993–1997), post-Alpine construction (1998, 2000–2004), and post-CD-3 construction (2005–2006).

Test Variable Construction Period	*n*	Mean	SE	*F*	*P*-value
Distance to Coast				0.071	0.932
Pre-Alpine	95	4.29	0.27		
Post-Alpine	92	4.42	0.26		
Post-CD-3	21	4.28	0.51		
Distance to Alpine Airstrip				3.105	0.047
Pre-Alpine	95	10.23	0.41		
Post-Alpine	92	10.58	0.40		
Post-CD-3	21	8.23	0.73		
Distance to Alpine				3.063	0.049
Pre-Alpine	95	10.14	0.42		
Post-Alpine	92	10.41	0.42		
Post-CD-3	21	8.02	0.75		
Distance to CD-3				0.816	0.444
Pre-Alpine	95	5.38	0.38		
Post-Alpine	92	5.64	0.42		
Post-CD-3	21	4.48	0.46		
Distance to CD-4				3.040	0.050
Pre-Alpine	95	11.49	0.45		
Post-Alpine	92	11.82	0.45		
Post-CD-3	21	9.27	0.78		
Distance to Nearest Gravel Pad				1.561	0.212
Pre-Alpine	95	4.97	0.37		
Post-Alpine	92	5.40	0.42		
Post-CD-3	21	3.86	0.43		

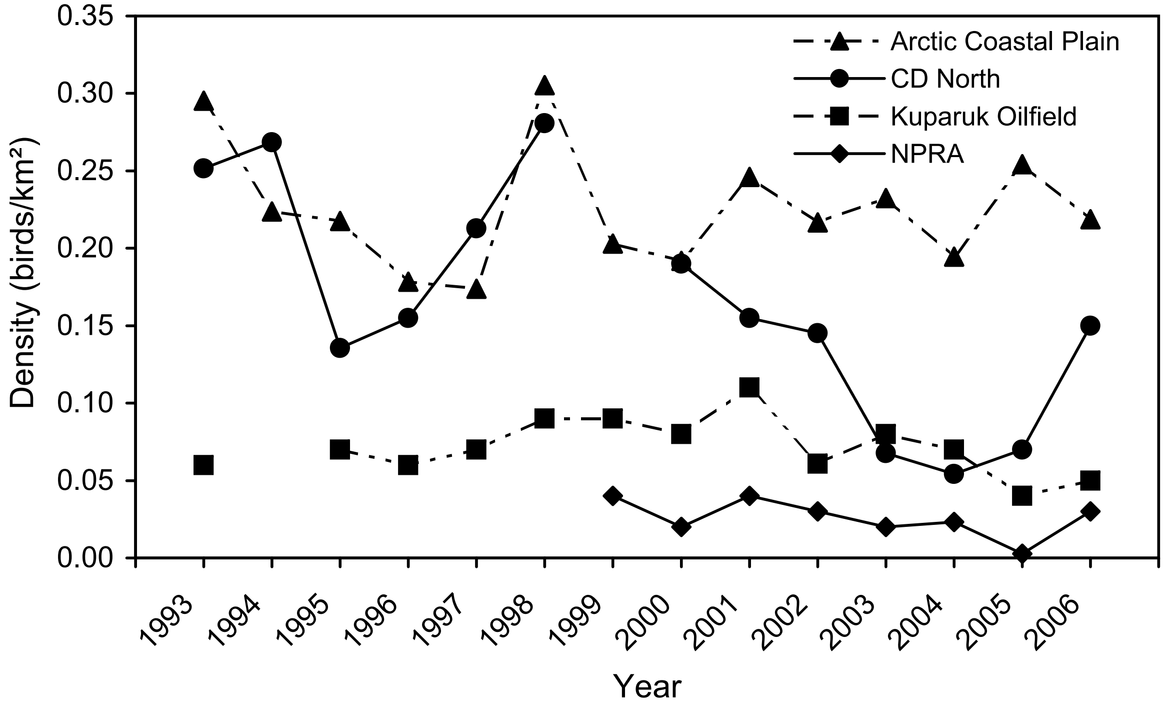


Figure 4. Densities of pre-nesting Spectacled Eiders from aerial surveys of the Colville Delta, NPRA, Kuparuk Oilfield, and Arctic Coastal Plain, Alaska, 1993–2006. Kuparuk data from Anderson et al. 2007 and Arctic Coastal Plain data from Larned et al. 2006.

prior years (Table 6). Of 6 distance comparisons, 3 resulted in significant differences ($P \leq 0.05$) among the 3 construction periods. Spectacled Eiders were nearest the Alpine airstrip, Alpine, and CD-4 in the post-CD-3 period (note that CD-3 and CD-4 were built the same year). Although not significant ($P = 0.44$), pre-nesting Spectacled Eiders also were closer to CD-3 in the post-CD-3 period. 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 facilities in the post-CD-3 period than in the post-Alpine period ($P \leq 0.04$), but comparisons between pre-Alpine and post-CD-3 periods for the same 3 facilities were marginally non-significant ($0.08 \leq P \leq 0.09$). Because Spectacled Eiders were closer to, not farther from, facilities during the post-CD-3 period than during earlier construction periods, we conclude that construction and operation activities at these sites in 2005–2006 did not result in avoidance of the general vicinities of oilfield facilities.

NESTING

In 2006, we found 20 Spectacled Eider nests in the nest-search area around CD-3 (Figure 5), the highest number of nests found in 7 years of nest searches. Eighteen Spectacled Eider nests were active when discovered and 2 had failed before discovery (i.e., inactive at discovery). Total nest density was 1.1 nest/km². In addition, we found 3 unidentified eider nests and 2 King Eider nests. 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 19 nests found in 2004. 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.

To evaluate changes in distribution and the effects of proximity to CD-3 on nesting success,

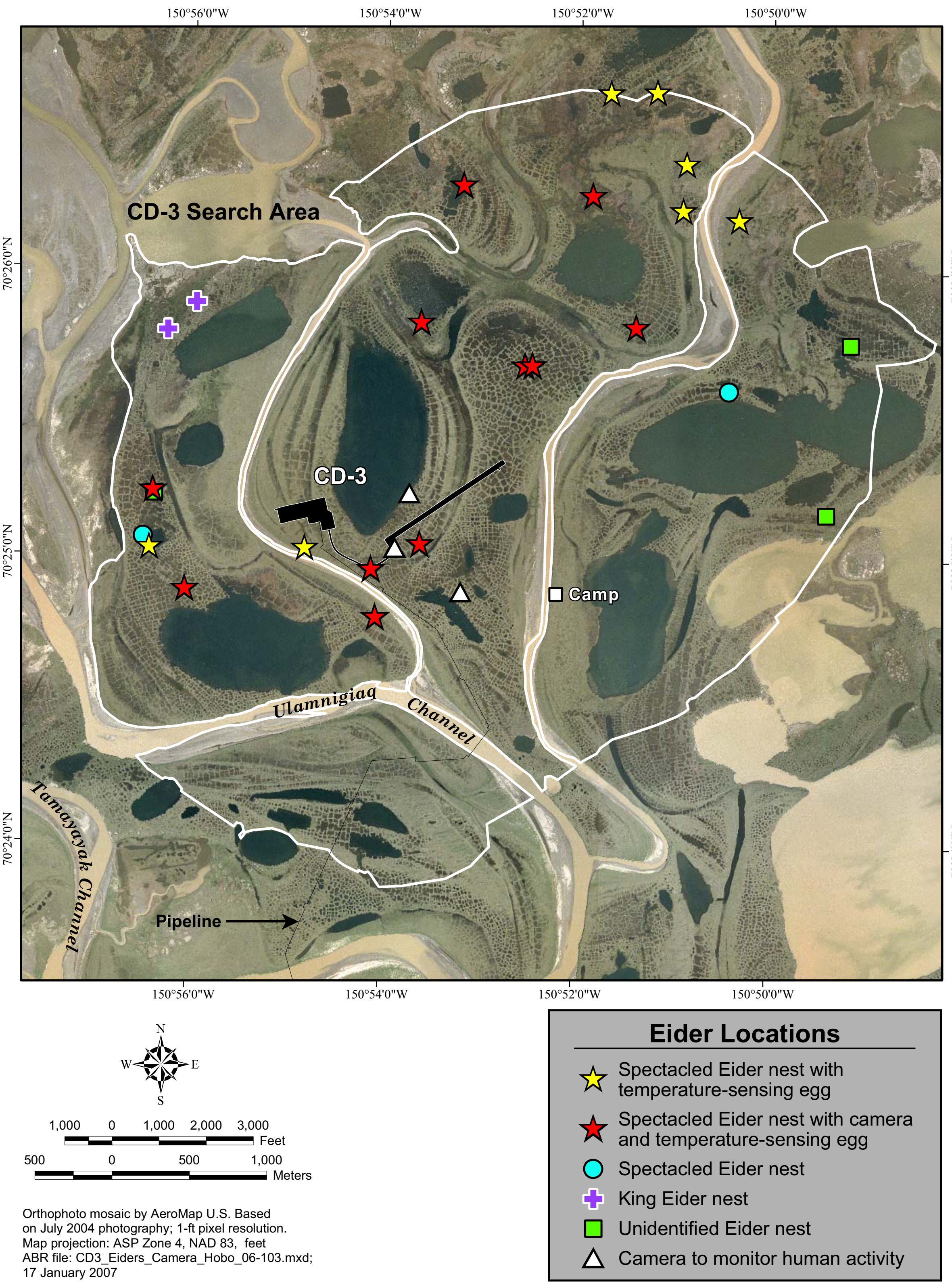


Figure 5. Locations of Spectacled, King, and unidentified eider nests, broods, temperature-sensing eggs, and time-lapse cameras in the CD-3 nest-search area, Colville Delta, Alaska, 2006.

we compared the distances of successful and failed nests from CD-3 in each year and construction period (Table 7). In all but 2001, successful nests were closer to the location of CD-3 than were failed nests. In 2006, successful nests averaged 1,002 m from CD-3 (SE = 248, n = 8), and failed nests averaged 1,329 m from CD-3 (SE = 259, n =12). The closest nest to the gravel footprint in 2006 was only 9 m from the airstrip, and this nest failed during hatch. The farthest nest from the airstrip was 2,580 m away, and it also failed. We also 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 = 0.933; df = 11, 82; P = 0.514, R^2 = 0.13). We repeated the test after pooling the years prior to construction (2001–2004), comparing the pre-construction and 2005–2006 distances to CD-3 of successful and failed nests. Results were similar to the multi-year analysis, with no significant effects (F = 0.798; df = 3, 82; P = 0.498, R^2 = 0.029). These analyses suggest that the placement of the gravel footprint and construction activity at CD-3 in 2005–2006 did not result in any changes in overall nest distribution, nor did they result in any detectable impacts on 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.

NEST SURVIVAL

Apparent nesting success (nests hatched/nests of known fate) was 40% (8 of 20 nests hatched [1 nest of unknown status was excluded]) for Spectacled Eiders in 2006, just above the long-term average. 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 2006 was 3.8 eggs/nest (n = 18 active nests), which was slightly below the pre-CD-3 average for the Colville Delta (4.0 eggs/nest, n = 40 active nests).

We calculated daily nest survival (Mayfield 1961, 1975) for nests that were monitored with temperature-sensing eggs or with time-lapse cameras in 2006 (Figure 5, Table 8) using program MARK. Nesting success calculated from daily nest survival is less biased than apparent nesting success (see review by Jehle et al. 2004), because it accounts for the different lengths of time individual nests were monitored. The mean daily survival rate in 2006 for 18 nests was 0.97 (SE = 0.009). The overall nesting success based on daily survival rate and a 24-d incubation period was 50% in 2006. In 2005, the daily survival rate was 0.95 (SE = 0.016) and the overall survival rate was 27%. Future

Table 7. Distance (m) of successful and failed Spectacled Eider nests from CD-3 by year and construction period, Colville Delta, Alaska, 2001–2006.

	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
Post CD-3 (2005–2006 combined)	932.3	147.8	14	1,133.3	172.7	24

Table 8. 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, 2006.

Nest Number	Distance to CD3 (m)	Fate	Predator	Dates Monitored		Whole Days Monitored[a]		Preliminary Incubation Constancy (%)[a]		Preliminary Mean Daily No. Recesses[a]		Preliminary Mean Recess Length (min)[a]	
				Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera
6	2,176	S	–	21 June–18 July	–	25	–	98.9	–	0.5	–	31.8	–
11	320	S	–	24 June–8 July	24 June–8 July	12	12[b]	99.2	99.0[b]	0.6	0.8[b]	20.0	18.3[b]
14	746	S	–	25 June–10 July	25 June–10 July	13	13[c]	98.0	98.2[c]	1.1	1.0[c]	22.8	23.8[c]
221	1,216	S	–	30 June–9 July	30 June–9 July	7	7[d]	99.5	99.3[d]	0.4	0.4[d]	20.8	22.9[d]
226	1,797	S	–	30 June–9 July	30 June–9 July	7	7[e]	98.5	98.1[e]	0.6	0.9[e]	37.5	32.7[e]
303	9	F	Parasitic Jaeger	23 June–10 July	23 June–10 July	16	16[f]	97.3	97.5[f]	1.4	1.3[f]	28.0	27.0[f]
316	1,033	F	Arctic Fox	29 June–5 July	29 June–5 July	5	5	96.9	97.0	1.0	1.0	44.0	43.0
408	626	F	Arctic Fox	28–30 June	28–30 June	1	0	96.2[g]	98.8[h]	2.0[g]	1.0[h]	27.5[g]	17.6[h]
409	641	F	Arctic Fox	28 June–4 July	28 June–4 July	5	5	96.9	97.2	1.2	1.2	36.7	33.7
415	2,474	F	Unknown	2–9 July	–	6	–	95.9	–	1.8		31.8	
416	2,581	F	Unknown	2–9 July	–	6	–	91.9	–	3.2		36.8	
544	152	F	Unknown	1–3 July	–	1	–	100[g]	–	0[g]		0[g]	
545	1,807	F	Arctic Fox	1–10 July	5–10 July	8	4	98.0	97.4	0.6	0.8	47.0	50.1
546	1,990	F	Unknown	2–3 July	–	0	–	100[h]	–	0[h]		0[h]	
601	116	S	–	23 June–11 July	29 June–11 July	16	10	96.7	97.6	1.3	1.0	35.7	29.8
613	798	S	–	27 June–9 July	27 June–9 July	10	10[i]	98.2	97.2[i]	0.8	1.2[i]	31.9	33.0[i]
615	844	S	–	27 June–7 July	–	8	–	99.7	–	0.3		15.0	
618	2,253	F	Unknown	2–3 July	–	0	–	100[h]	–	0[h]		0[h]	

[a] Excludes day of instrumentation, hatch, fledging, or failure
[b] Includes 6 days when 9–84 min of data were lost due to sun glare
[c] Includes 6 days when 8–125 min of data were lost due to sun glare
[d] Includes 7 days when 3–67 min of data were lost due to sun glare
[e] Includes 3 days when 82–125 min of data were lost due to sun glare
[f] Includes 12 days when 12–372 min of data were lost due to sun glare
[g] Data are not averaged since total time monitored was only 1 full day
[h] Data are from less than 1 day of monitoring
[i] Includes 1 day when 21 min of data were lost due to sun glare

analyses will include environmental and disturbance covariates in models of nest survival to evaluate effects on daily survival rates.

INCUBATION MONITORING

THERMISTORED EGGS

Temperature-sensing eggs, along with time-lapse cameras, and egg floatation data provided detailed histories used for survival analysis (above) and activity budgets for incubating hens (Table 8). We inserted temperature-sensing eggs into all 18 active Spectacled Eider nests that we found in 2006 (Figure 5). We installed temperature-sensing eggs and recorded egg flotation data in succession which took 16–40 min (mean = 23 min, n = 18). Incubation resumed 8–174 min (mean = 56 min, n = 17) following installation and floatation of eggs (i.e., after departure of researchers from nest site). The hen at nest 006 was not incubating upon nest discovery and was excluded in the above summary statistics. She and a male eider flushed from near the nest which contained one cold egg covered loosely with vegetation. The hen laid ≥2 more eggs and began incubating normally 58 hrs and 16 min following hobo installation. Eiders lay eggs at approximately daily intervals until the clutch is complete and, although they attend the nest, they do not begin regular incubation until the clutch is complete. We suspect eiders are more sensitive to disturbance during laying and the first days of incubation because they have less time invested in the nest, which could result in longer incubation breaks after disturbances in early incubation. All nests with temperature-sensing eggs were incubated by their hens after the installation and remained active for at least 4 hours after installation.

TIME-LAPSE CAMERAS

We monitored 11 of the 18 active Spectacled Eider nests with time-lapse cameras in 2006 (Figure 5, Table 8). Cameras were placed 25–45 m from nests (mean = 30 m). At 4 nests, camera installation, egg floatation, and hobo placement occurred simultaneously and averaged 29 min (range 22–40 min). Camera installation averaged 19 min (range 13–28 min) at 7 nests where camera installation occurred prior to hobo installation and egg floatation. We exchanged memory cards and batteries in each camera 1 time/week and exchanges averaged 12 min (*n* = 28 exchanges) at each camera. No hens were flushed during weekly camera maintenance. However, the hen at nest 303 was on a normal recess (observed on camera images covering the nest before leaving) during 1 camera visit (see discussion below).

Of 11 nests monitored with time-lapse photography, 6 hatched and 5 failed (Table 8). One failed following predation by a Parasitic Jaeger and 4 nests failed after arctic fox predation. According to egg floatation data, all 5 nests were at least 2 weeks old at the time of nest failure. One or more Glaucous Gulls were recorded near a nest while the hen incubated, but no predation occurred.

The cause of failure at Spectacled Eider nest 303, which was 9 m from the CD-3 access road, was attributed to predation by a Parasitic Jaeger, but poor nest attendance likely contributed. This nest was monitored by camera and temperature-sensing egg for 16 days. The nest was discovered 23 June and estimated to be 6–8 days old. On 8 and 9 July, approximately 21–23 days into the 24-day incubation period, the hen began taking more frequent and longer recesses averaging 2.5 recesses/d and 41.6 min/recess (*n* = 5 recesses) compared to 1.1 recess/d and 22.1 min/recess (*n* = 15 recesses) prior to 8 July. On 10 July, the day of nest failure, camera data showed the eider covering her eggs and leaving the nest at 1359 h for a normal recess. During camera maintenance at 1445 h, a researcher saw the eider still on recess feeding in a pond about 40 m from the nest. A Parasitic Jaeger was also seen pecking eggs at the nest and swallowing a dark object, presumably an unhatched eider duckling. Camera data indicated the jaeger spent <2 min at the nest. As the researcher approached the jaeger, the eider flew towards the predator, successfully driving it away from the nest. The hen resumed incubation at 1448 h. No nest cleaning by the eider was observed. The jaeger chased away a Glaucous Gull and hovered directly over the incubating eider which stretched its neck up toward the jaeger with an open bill, but continued incubating. The jaeger then perched on the CD-3 road overlooking the nest. At 1449 h, the jaeger flew back to the nest, took an egg or eggshell from next to the incubating eider and flew out of sight with it. The researcher finished camera maintenance and left the nest by 1457 h. The hen took one 80 min recess at 1614 h, eventually covering and leaving the nest permanently at 1852 h. No ducklings were observed on camera and no evidence of hatch was found upon nest inspection, although remains were heavily scavenged by avian predators. A small piece of crushed shell 10 cm long and < 50 small fragments were found near the nest.

The eider at nest 303 was also exposed to several types of potential human disturbance due to the proximity of the nest to the CD-3 access road. Nest 303 had the highest level of disturbance by helicopter flights within 200 m of the nest (Table 5). It also was near the flight path for airplanes landing and taking off from the airstrip. During the time this hen was monitored (23 June–10 July), an average of 41.0 vehicles per day (n = 18 days) traveled on the road between the well pad and airstrip. Vehicles were occasionally seen by researchers slowing and stopping near the nest for = 1 min, but these events were not recorded on camera due to the 32-sec image interval. Pedestrians were rarely recorded by camera on the road, but were witnessed twice near the nest on 4 July. At 1004 h, 3 people exited a pickup truck parked on the access road about 50 m from the incubating hen. The workers stayed about 50 m from the nest and walked to the adjacent pipeline. The hen concealed for 15 min during the event, but did not flush from the nest. Since the people and truck were not in view of cameras, the duration of this event was unknown. Workers were still near the pipeline when the researcher left at 1021 h. Also on 4 July, CD-3 security personnel witnessed a person at approximately 1210 h standing on the road near the nest taking photos. Our camera coverage of the road area at this time was incomplete, but showed a pickup parked on the road from 1209–1213 h. Images show the eider covered her nest quickly and left the area at 1209 h. Security approached to warn the photographer, but the man was walking south on the tundra under the pipeline. No predation was witnessed and the hen resumed incubating at 1240 h. Traffic rates on the road and possible disturbances near nest 303 were likely underestimated before a second camera was set up on 5 July to monitor more road area near the nest. It should be noted that construction and security workers at CD-3 were aware of nest 303 and many took protective interest in it. We observed no intentional harassment of the nesting eider, and other than the photographer, pedestrians were not seen approaching the nest site.

For all 4 fox predation events, hens were observed on time-lapse images incubating normally and concealing prior to being flushed from nests by a fox. At 3 nests (316, 409, 545) fox predation occurred over the course of 15–38 min (Figure 6). Foxes generally spent <1 min at nests before leaving camera view. Predation occurred 2–5 times within 10 min, suggesting that foxes were carrying eggs away from nests. In all cases, foxes spent >2 min at nests during the final encounter in which the fox may have been trying to remove the thermistored egg. In all cases, thermistor cords were severed with eggs removed and on two occasions, both the egg and spike used to anchor the egg into the nest were missing. At nest 408, fox predation occurred over the course of 16 hours. A fox flushed the hen twice over the course of 3 min, each time staying at the nest for <1. The eider resumed incubating 15 min after the fox was last recorded on camera. At a minimum, the thermistored egg was still present in the nest since it continued to collect nest temperature data. The hen was flushed again by a fox the following day. The fox stayed at the nest for 6–7 min, rolling in it before leaving. The eider returned and stood by the nest, but did not incubate again. Damage occurred to the thermistored egg at this time and was likely removed by the fox. All fox predated nests contained no egg remains upon nest site 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 separately with selection 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 9). During the post-Alpine

Figure 6. Digital time-lapse images of the Spectacled Eider at nest 316 incubating normally and fox predation at that nest (hen was flushed from nest), CD-3 nest-search area, Colville Delta, 2006.

Table 9. 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 (2005–2006).

	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	0	0	1	ns	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	3	14	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	4	19	5	prefer	low
Deep Open Water without Islands	2	2	4	ns	low	8	9	4	ns	low	2	10	4	ns	low
Deep Open Water with Islands or Polygonized Margins	3	3	2	ns	low	5	5	2	prefer	low	0	0	2	ns	low
Shallow Open Water without Islands	1	1	<1	ns	low	2	2	<1	ns	low	0	0	0	ns	low
Shallow Open Water with Islands or Polygonized Margins	1	1	<1	ns	low	2	2	<1	prefer	low	0	0	0	ns	low
River or Stream	3	3	15	avoid		5	5	14	avoid		1	5	15	ns	low
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	2	10	3	ns	low
Grass Marsh	2	2	<1	prefer	low	0	0	<1	ns	low	0	0	0	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	10	8	ns	low
Patterned Wet Meadow	9	9	19	avoid		7	8	20	avoid		6	29	19	ns	low
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	5	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	ns	low
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			21	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) x 100

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

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 9). Because the selection analysis can be affected by small changes in use, changes in sample size, as well as stochastic variation in the distribution of eider observations, we tested for changes in overall use of the preferred versus non-preferred habitats from the pre-Alpine construction period (considered the baseline or reference period in terms of development) to the post-Alpine construction period. Although the overall use of preferred habitats by pre-nesting eiders in the pre-Alpine period (48% of all groups) declined in the post-Alpine period (40% of all groups), we detected no change between construction periods (goodness-of-fit test, $\chi^2 = 2.48$, df = 3, $P = 0.48$). Therefore, although the individual pre-nesting habitats that were identified as preferred differed between the 2 construction periods, the construction of Alpine did not affect the pooled use of those habitats that were identified as preferred during the baseline period.

In 2006, 15 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 in a habitat selection analysis (Table 9). Four groups (19% of 21 groups) were found in the only habitat preferred in the post-CD-3 period, Salt-killed Tundra. Salt-killed Tundra was not preferred during the pre-Alpine or post-Alpine construction periods, but it did receive a high percentage of use (10–11%) by Spectacled Eiders in those years (Table 9). We pooled 2005 and 2006 pre-nesting locations together to test for shifts in habitat use from the pre-Alpine period. Use of preferred habitat in the post-CD-3 period was significantly less than expected (goodness-of-fit test, $\chi^2 = 11.00$, df = 3, $P = 0.01$). Sample size for the post-CD-3 period is small and our experience with these data from previous years suggests that 5 or 6 years of data are required for the data on habitat selection to stabilize. Therefore, although the analysis of 2 years of post-construction data suggest a shift has occurred in habitat use during pre-nesting, additional years of data are needed to conclude so with certainty.

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 (2005–2006). 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 10). 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 2005–2006, exactly the same percentage, 71% of the nests (27 of 38 nests), occurred in the same 2 preferred habitats (Figure 7). A goodness-of-fit test was used to compare the proportion of nesting in the 2 preferred habitats and all non-preferred nesting habitats between construction and pre-construction periods, using 2001–2004 nests to compute the expected values of habitat use; the test found no change in use of preferred habitats by nesting birds between those years ($\chi^2 = 0.16$, df = 5, P=0.999).

SUMMARY

The number of pre-nesting Spectacled Eiders counted during aerial surveys of the Colville Delta increased for the first time in several years, and the number of nests in the CD-3 nest-search area has been stable or increased. 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 (where dissimilar trends are occurring).

Pre-nesting groups of Spectacled Eiders did not display an obvious spatial response (increased distance) to construction of oilfield facilities on the Colville Delta. Use of the preferred habitats determined during the baseline period did not change after Alpine was built, but did change after CD-3 construction began. The small sample size of years (2) after CD-3 construction, weakens our conclusion of a shift in habitat use. Nest locations of Spectacled Eiders in the CD-3 area did not indicate displacement from the vicinity of the

Table 10. Habitat selection of nesting Spectacled Eiders in the CD-3 project area, Colville River Delta, Alaska, 2006.

	2001–2004					2005–2006				
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	2.6	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	2.6	4.2	ns	low
Salt-killed Tundra	3	6.7	11.8	ns		4	10.3	10.7	ns	low
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	2	5.1	10.2	ns	low
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	1	2.6	0.9	ns	low
Deep Polygon Complex	13	28.9	12.1	prefer		12	30.8	12.2	prefer	low
Grass Marsh	0	0	0.2	ns	low	0	0	0.2	ns	low
Nonpatterned Wet Meadow	2	4.4	14.7	ns		2	5.1	14.6	ns	
Patterned Wet Meadow	19	42.2	25.9	prefer		15	39.5	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			38	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

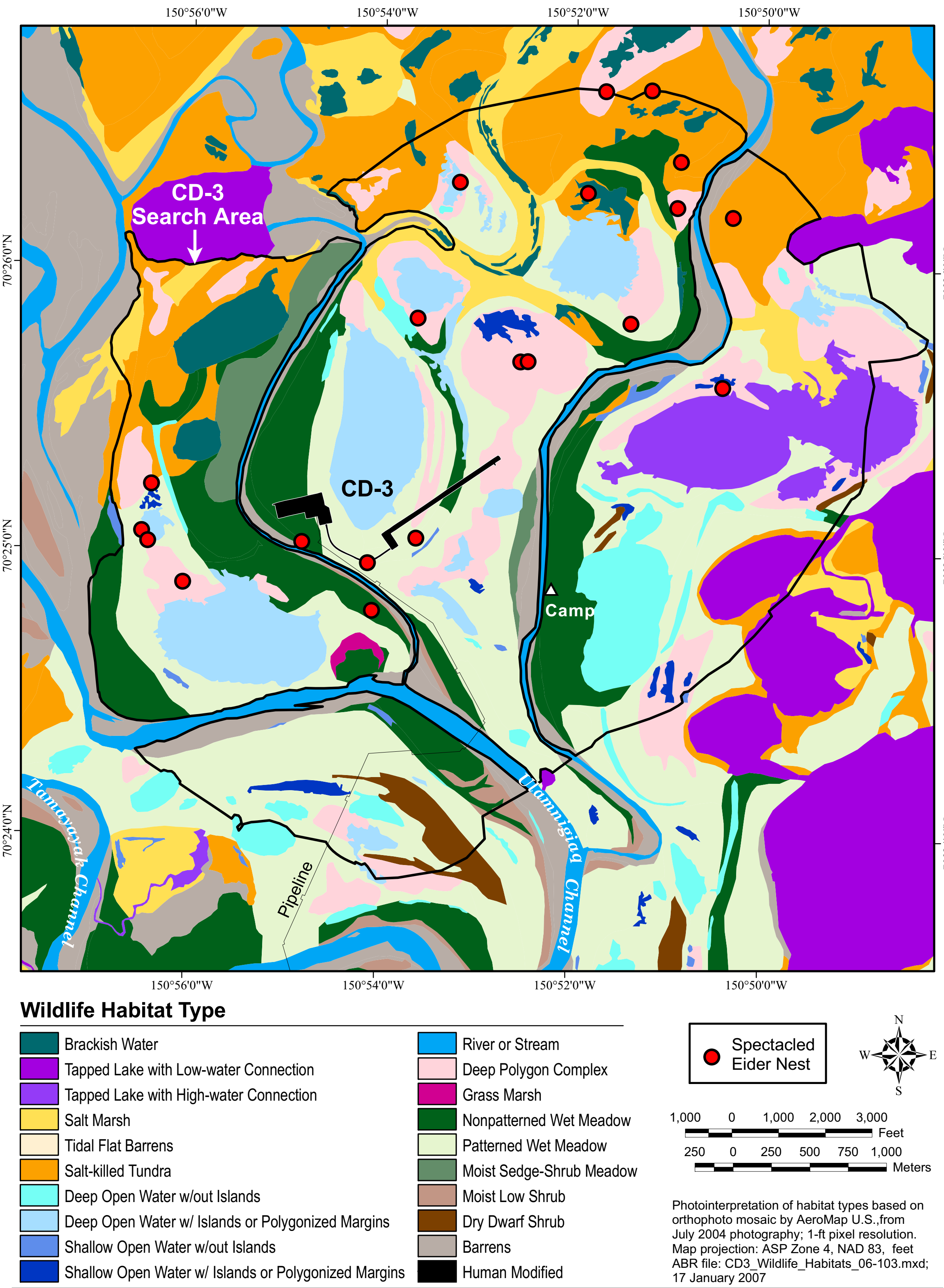


Figure 7. Habitat map and nest locations in the CD-3 nest-search area, Colville Delta, Alaska, 2006.

gravel footprint of CD-3 and the level of use of preferred habitats was exactly the same as that observed during pre-construction years. Proximity of nests to the footprint did not seem to affect overall nesting success, but a more in-depth analysis of nest survival with disturbance and environmental factors is necessary to understand the relative strength of variables and will not be possible until the sample size of nests has increased.

Nesting success typically is low for Spectacled Eiders, averaging 36% in the CD-3 nest-search area since 1993. In 2006, 8 of 18 nests hatched for a success rate of 40%. Predators ultimately were involved in all the nest failures, whether they attacked incubated nests or took eggs from unattended nests (while the hen was on normal recess or a recess caused by disturbance). Nest failures clearly were caused by arctic foxes in 4 cases where they drove off incubating Spectacled Eiders, and at another nest Parasitic Jaegers took advantage of a Spectacled Eider on nest recess. The cause of failure was unknown at 5 nests found active and another 2 nests which were abandoned or had failed prior to discovery. 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.

LITERATURE CITED

Anderson, B. A., and B. A. Cooper. 1994. Distribution and abundance of Spectacled Eiders in the Kuparuk and Milne Point oilfields, Alaska, 1993. Report for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 71 pp.

Anderson, B. A., R. J. Ritchie, A. A. Stickney, and J. E. Shook. 2007. Avian studies in the Kuparuk Oilfield, Alaska, 2006. Data summary report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

BLM. 2004. Alpine Satellite Development Plan final environmental impact statement. U.S. Department of the Interior, Bureau of Land Management, with assistance from Minerals Management Service, Anchorage, AK.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, P. E. Seiser, A. A. Stickney, and J. R. Rose. 2002. Wildlife studies in the CD South study area, 2001. Second annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 98 pp.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, P. E. Seiser, A. A. Stickney, and J. R. Rose. 2003. Wildlife studies in the CD South study area, 2002. Third annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 126 pp.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, A. A. Stickney, and J. R. Rose. 2000. Wildlife studies in the CD South study area, 2000. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 84 pp.

Cooper, J. A. 1978. The history and breeding biology of the Canada Geese of Marshy Point, Manitoba. Wildlife Monographs 61: 1–87.

Jehle, G., A. A. Yackel Adams, J. A. Savidge, and S. K. Skagen. 2004. Nest survival estimation: a review of alternatives to the Mayfield estimator. Condor 106: 472–484.

Johnson, C. B. 1995. Abundance and distribution of eiders on the Colville River Delta, Alaska, 1994. Report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 12 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2000a. Wildlife studies in the CD North study area, 2000. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 96 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. Neville, J. P. Parrett, A. K. Prichard, J. R. Rose, A. A. Stickney, and A. M Wildman. 2003a. Alpine avian monitoring program,

2001. Fourth annual and synthesis report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 194 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. P. Parrett, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2003b. Wildlife studies in the CD North study area, 2002. Third annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 104 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2002. Wildlife studies in the CD North study area, 2001. Second annual report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 114 pp.

Johnson, C. B., R. M. Burgess, A. M. Wildman, A. A. Stickney, P.E. Seiser, B. E. Lawhead, T. J Mabee, A. K. Prichard, and J. R. Rose. 2005. Wildlife studies for the Alpine Satellite Development Project, 2004. Second annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 129 pp.

Johnson, C. B., R. M. Burgess, A. M. Wildman, A. A. Stickney, P. E. Seiser, B. E. Lawhead, T. J Mabee, J. R. Rose, and J. E. Shook. 2004a. Wildlife studies for the Alpine Satellite Development Project, 2003. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 155 pp.

Johnson, C. B., M. T. Jorgenson, R. M. Burgess, B. E. Lawhead, J. R. Rose, and A. A. Stickney. 1996. Wildlife studies on the Colville River Delta, Alaska, 1995. Fourth annual report for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 154 pp.

Johnson, C. B., B. E. Lawhead, D. C. Payer, J. L. Petersen, J. R. Rose, A. A. Stickney, and A. M Wildman. 2001. Alpine avian monitoring program, 2000. Third annual report for PHILLIPS Alaska, Inc. and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 92 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, J. E. Roth, S. F. Schlentner, A. A. Stickney, and A. M. Wildman. 2000b. Alpine avian monitoring program, 1999. Second annual report for PHILLIPS Alaska, Inc. and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 86 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1998. Wildlife studies on the Colville River Delta, Alaska, 1997. Sixth annual report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 144 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1999a. Wildlife studies on the Colville River Delta, 1998. Seventh annual report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 102 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1997. Wildlife studies on the Colville River Delta, Alaska, 1996. Fifth annual report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 139 pp.

Johnson, C. B., W. Lentz, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1999b. Alpine avian monitoring program, 1998. First annual report for ARCO Alaska, Inc. and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 46 pp.

Johnson, C. B., J. P. Parrett, and P. E. Seiser. 2006b. Spectacled Eider monitoring at the CD-3 development, 2005. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, and J. E. Shook. 2006a. Avian studies for the Alpine Satellite Development Project, 2005. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, and J. E. Shook. 2007. Avian studies for the Alpine Satellite Development Project, 2006. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., A. Zusi-Cobb, A. M. Wildman, A. A. Stickney, and B. A. Anderson. 2004b. Biological assessment for Spectacled and Steller's eiders in the Alpine Satellite Development Project Area. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 119 pp.

Larned, W., R. Stehn, R. Platte. 2006. Eider breeding population survey, Arctic Coastal Plain, Alaska, 2006. Unpublished report, U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bulletin 73: 255–261.

Mayfield, H. 1975. Suggestions for calculating nesting success. Wilson Bulletin 87: 455–466.

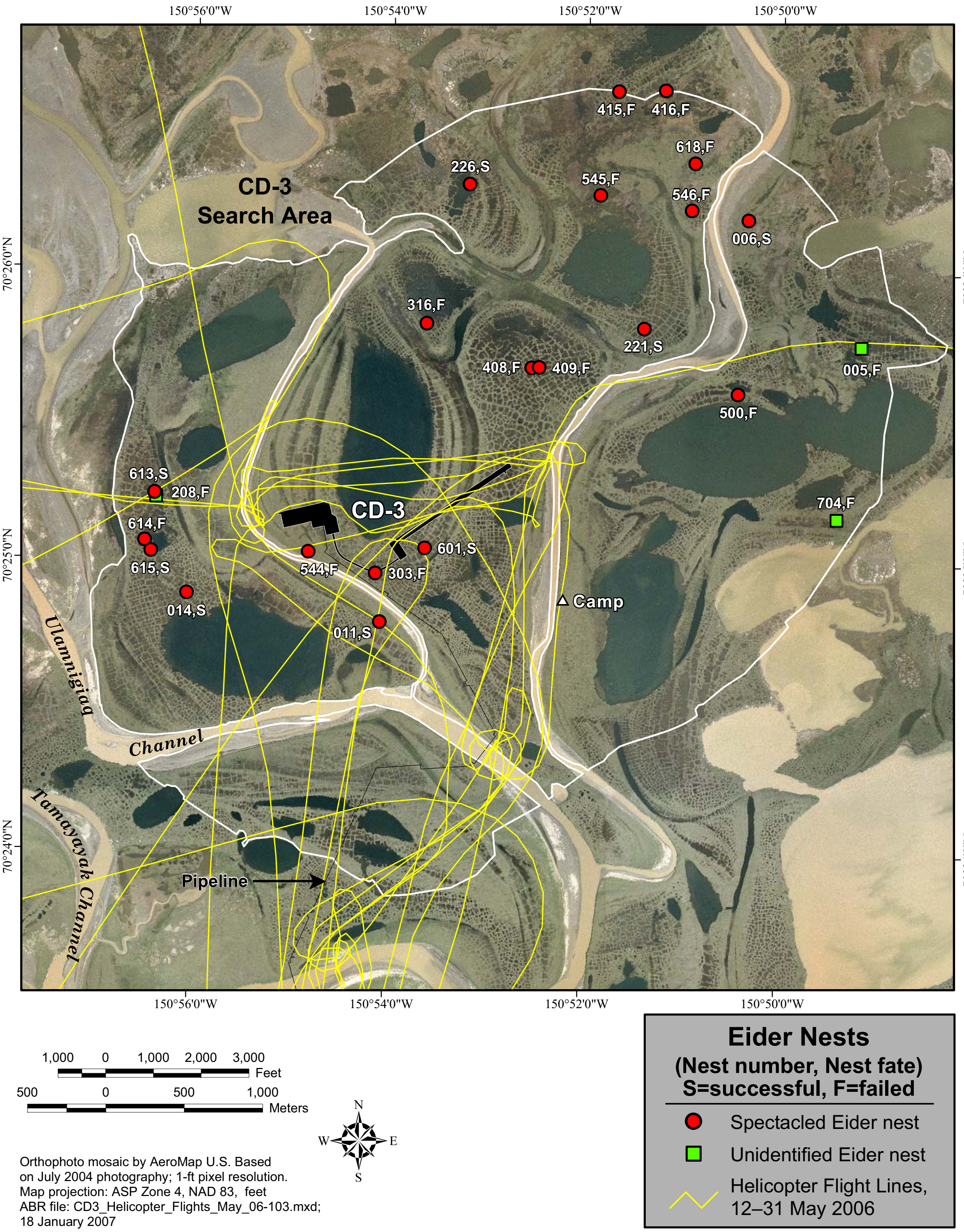
Mickelson, P. G. 1975. Breeding biology of Cackling Geese and associated species on the Yukon-Kuskokwim Delta, Alaska. Wildlife Monographs No. 45.

Smith, L. N., L. C. Byrne, C. B. Johnson, and A. A. Stickney. 1994. Wildlife studies on the Colville River Delta, Alaska, 1993. Report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 95 pp.

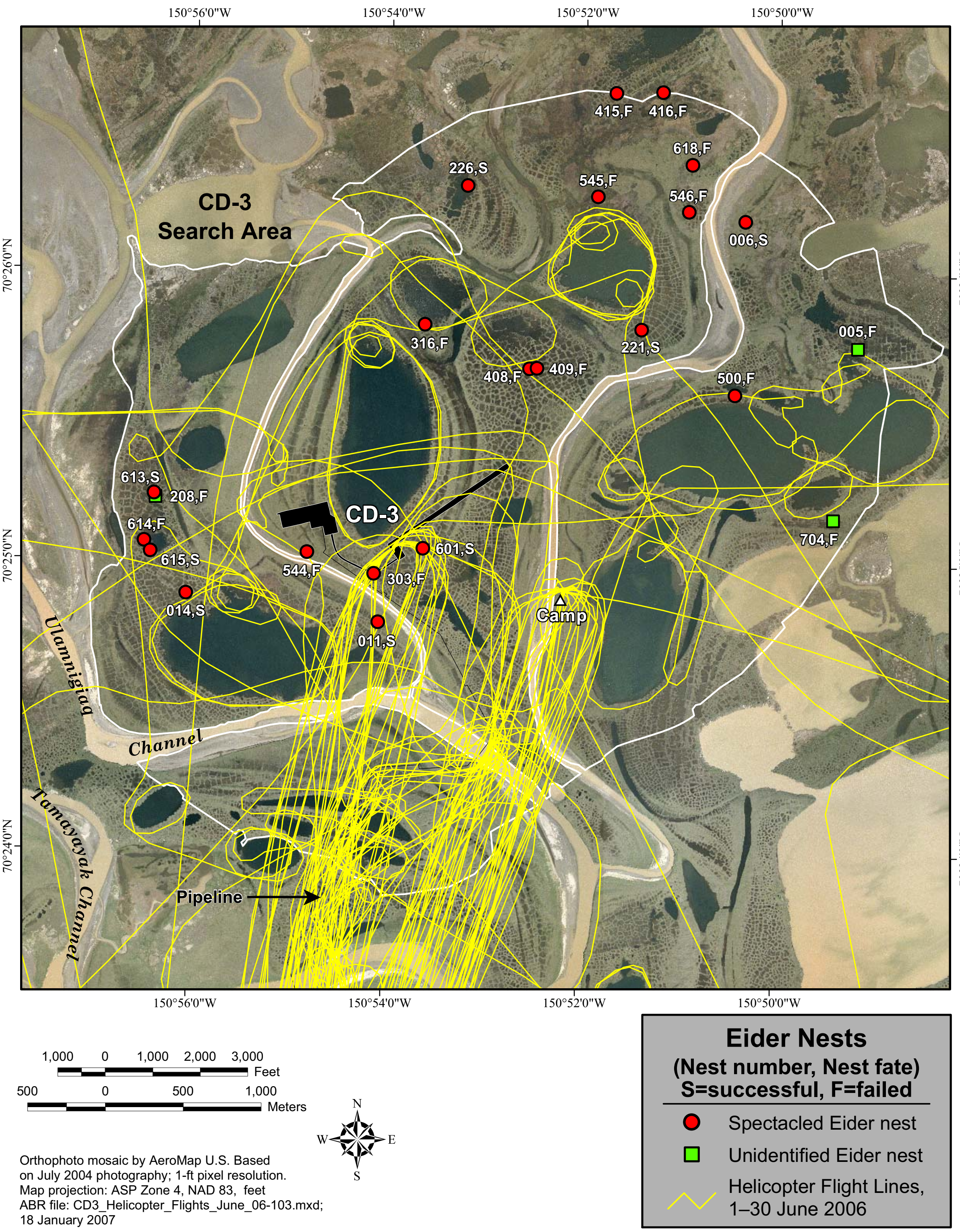
Smith, L. N., L. C. Byrne, and R. J. Ritchie. 1993. Wildlife studies on the Colville River Delta, Alaska, 1992. Report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 69 pp.

White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46: 120–139.

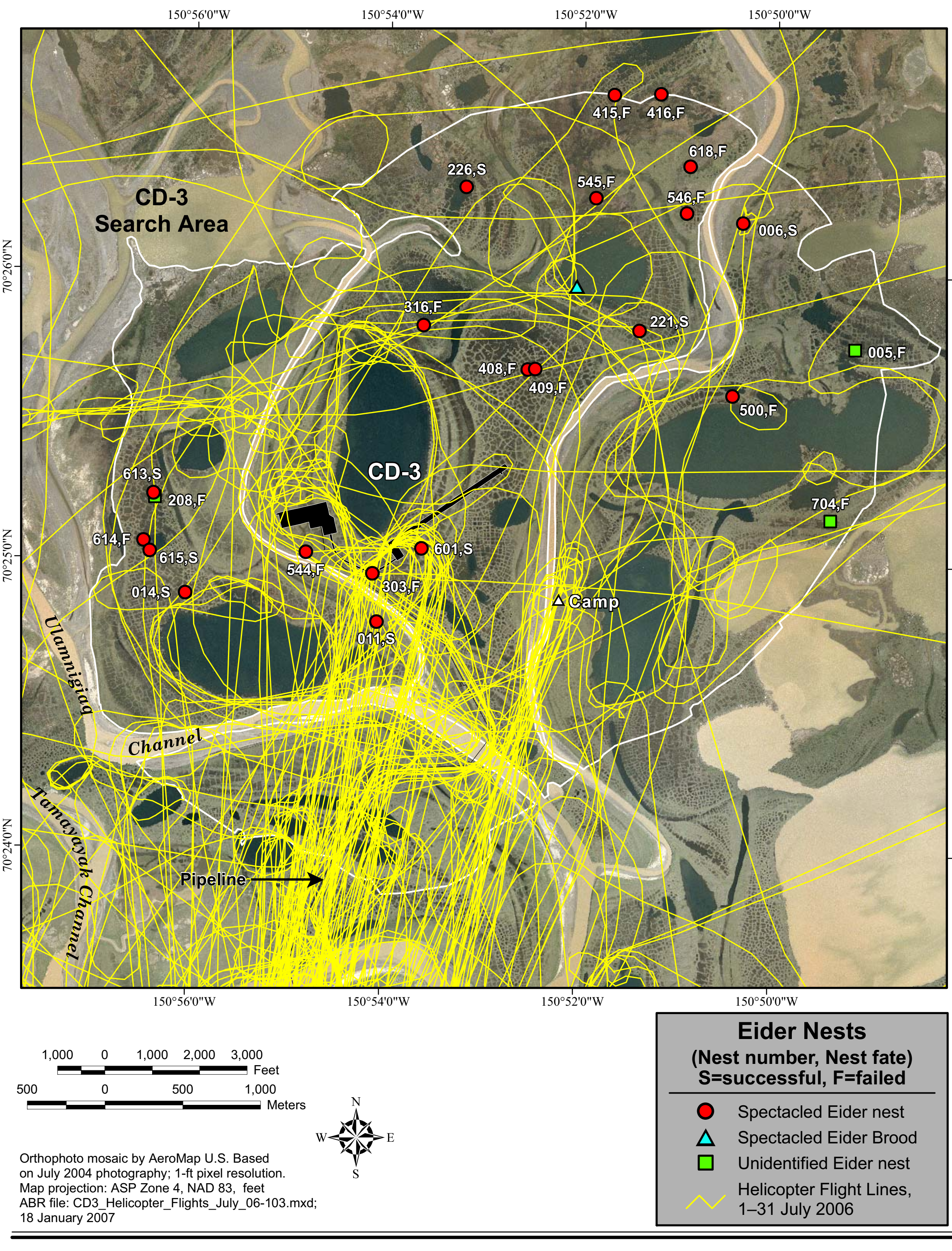
USFWS. 2004. Final Biological Opinion. U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office.



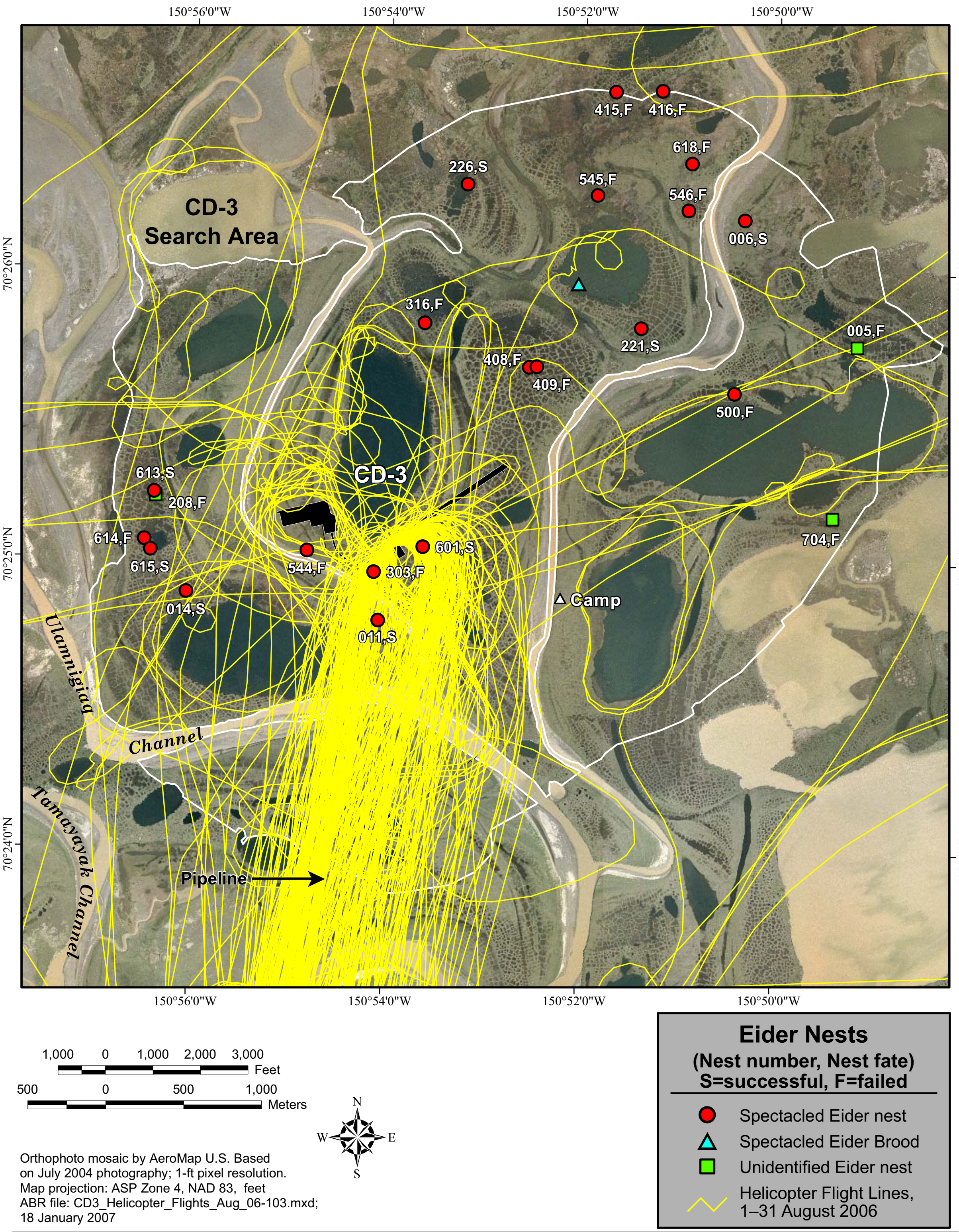
Appendix 1. Helicopter flight lines and Spectacled Eider nests in the CD-3 nest-search area, Colville Delta, Alaska, May 2006.



Appendix 2. Helicopter flight lines and Spectacled Eider nests in the CD-3 nest-search area, Colville Delta, Alaska, June 2006.



Appendix 3. Helicopter flight lines and Spectacled Eider nests and broods in the CD-3 nest-search area, Colville Delta, Alaska, July 2006.



Appendix 4. Helicopter flight lines and Spectacled Eider nests and broods in the CD-3 nest-search area, Colville Delta, Alaska, August 2006.