SPECTACLED EIDER MONITORING AT THE CD-3 DEVELOPMENT, 2005

FIRST ANNUAL REPORT

Prepared for

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March 2006

Printed on recycled paper.

EXECUTIVE SUMMARY

The effects of construction activity and aircraft overflights on nesting Spectacled Eiders were investigated in 2005 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. Access to CD-3 is limited to ice roads during winter and aircraft during the remainder of the year. Concerns about aircraft and construction disturbance of breeding Spectacled Eiders, a species listed as threatened under the Endangered Species Act, and a lack of information on the effects of disturbance on that species, led ConocoPhillips, Alaska, Inc. to initiate this investigation.

Gravel was deposited on the outer Colville Delta for CD-3 during winter 2005 and construction is scheduled to continue through 2006. 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).

The goal of this study was to investigate how habitat use, nesting behavior, and productivity of Spectacled Eiders were influenced by construction and aircraft activity at CD-3. In 2005, we collected data on the pre-nesting distribution of eiders, distribution of nests, habitat selection, incubation behavior, and nest survival. Baseline data on pre-nesting and nesting distributions facilitated before–after construction comparisons. Preliminary analyses were conducted with the first year of construction-period data.

In 2005, temperatures during spring arrival (15 May–15 June) were the lowest among the last 9 years. The breakup of the Colville River was protracted till 9 June and peak volume was lower than average. Snow cover melted on a normal schedule by mid-June but ice on large lakes remained longer than normal into mid-July.

Construction activity was monitored by 2 time-lapse cameras. Construction and human activity on the gravel footprint was sporadic and generally at low levels prior to 6 July. On 6 July, crews of 4–8 people working a 12-h shift began using a variety of trucks and heavy equipment to resurface and compact the gravel footprint. All transportation of crews in the area was by helicopters, which were monitored by GPSs onboard each aircraft. Flights within 200 m of all eider nests were summarized by flight length, altitude, and distance to the nest. Cumulative flight lengths within 200 m of all known eider nests during nesting totaled 89 km. Minimum flight altitudes ranged from 0 m to 65 m during the same period and minimum horizontal distance of overflights from nests ranged from 2 m to 68 m. Helicopter flights in the study area were sporadic until 6 July when the summer construction period began at CD-3. Summer construction was supported by 2–4 roundtrip helicopter flights daily (0.6–5.4 km of flight lengths daily within 200 m of all eider nests), in addition to continued sporadic surveys and miscellaneous helicopter-supported activities.

In 2005, there was no clear relationship between nest success and helicopter overflights. The nest with the highest exposure to helicopters (17 km of cumulative flight length within 200 m) hatched. Two nests with no helicopter flights within 200 m failed. The mean cumulative flight length within 200 m of all failed (2.9 km, $n = 12$) and hatched (4.8 km, $n = 6$) nests was not significantly different ($P \geq 0.4$).

Aerial surveys were conducted for pre-nesting Spectacled Eiders over the Colville Delta during 1993–1998, and 2000–2005. The 2005 aerial survey for pre-nesting eiders in the Colville Delta study area was conducted 8–13 June and resulted in the second lowest count of Spectacled Eiders recorded during pre-nesting surveys on the Colville Delta in 12 years. To investigate displacement, we compared the distance of pre-nesting groups to each of 5 development project features on the Colville Delta among 3 construction periods. The mean distances of Spectacled Eider groups from these features differed little between the pre- and post-Alpine construction periods (1993–1997 and 1998–2004). During 2005, pre-nesting eiders appeared to be located closer to Alpine, CD-4, and the nearest gravel pad than they were in prior years. The mean distance to CD-3 in 2005 (5.6 km) was nearly the same as the mean distances (5.4 and 5.6 km, respectively) during the pre-Alpine and post-Alpine construction periods. None of tests of differences among years were significant ($P \geq 0.20$), and none of the differences in mean distance

among construction periods were suggestive of displacement from Alpine, CD-3, or CD-4.

Despite the low counts of Spectacled Eiders during the pre-nesting survey in 2005, we found 18 Spectacled Eider nests in the nest-search area, the second highest number of nests since 2001. In 2005, 16 Spectacled Eider nests were active when discovered, 1 had failed before discovery, and the other had 1 cold egg and appeared to be abandoned (total nest density = 1.0 nest/km²). In all but 2001, successful nests were closer to the location of CD-3 than were failed nests. In 2005, successful nests averaged 840 m from CD-3 (n = 6), and failed nests averaged 937 m from CD-3 (n =12). Comparison of distances of successful and failed nests to CD-3 among years identified no significant differences among years or between fates (P = 0.6). Results were similar when pre-construction years were pooled and compared with 2005 (P = 0.7). These analyses suggest that the placement of the gravel footprint and construction activity at CD-3 in 2005 did not result in changes in nest distribution nor were failed nests closer to CD-3, where they would have been exposed to higher levels of disturbance.

Apparent nesting success for Spectacled Eiders in 2005 was 33% (6 of 18 nests hatched), just below the long-term average of 37%. Average clutch size in 2005 was 4.5 eggs/nest (n = 16 nests), which was similar to the long-term average for the Colville Delta (4.0 eggs/nest, n = 40 nests). Of 11 nests monitored with time-lapse photography and temperature-sensing eggs, 5 hatched and 6 failed. Three nests failed after arctic fox predation, and 3 nests failed following predation by Parasitic Jaegers and a Glaucous Gull. Six more nests failed from unknown causes. All 3 of the nests that failed from avian predation exhibited low incubation constancy and may have been influenced by disturbances from researchers and construction related activities.

To monitor incubation behavior, temperature-sensing eggs were inserted into all 16 active Spectacled Eider nests that we found in 2005, and 11 of those nests also were monitored with time-lapse cameras. Incubation activities determined by temperature records from artificial eggs had an error rate of 3% when compared with time-lapse video images of one nesting eider. Activity budgets estimated separately with temperature-sensing eggs and time-lapse cameras for 6 nests produced similar budgets. Mean incubation constancy differed by only 0.1% between the 2 methods and the mean number of recesses per day differed by only 0.1 recesses per day. In contrast, temperature-sensing eggs markedly underestimated break frequency (mean difference was 11.9 breaks/d) and overestimated break time (mean difference was 19.4 min/d). The biases in break values from temperature-sensing eggs did not result in similar biases in incubation and recess values, which are used as response variables in activity analyses.

Baseline conditions of habitat selection by pre-nesting Spectacled Eiders prior to construction of Alpine were evaluated from aerial surveys conducted during 1993–1997 and compared with habitat selection during the post-Alpine period (1998–2004; observations in 2005 were too few for a similar analysis). 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. During the post-Alpine period, 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. No change in the overall use of preferred versus non-preferred habitats was detected between construction periods (P = 0.48), although the overall use of preferred habitats by pre-nesting eiders in the pre-Alpine period (48% of all groups) declined somewhat (40% of all groups) after Alpine was built.

Habitat selection by eiders nesting prior to construction of CD-3 was evaluated using 45 nests found in the same nest-search area between 2001 and 2004. Two habitats were preferred—Deep Polygon Complex and Patterned Wet Meadow—and these 2 habitats contained 71% of the nests. After construction of the CD-3 pad and airstrip in 2005, use of preferred habitat occurred at a similar level (P = 0.94), with 78% of the nests (14 of 18 nests) in the same 2 preferred habitats.

In summary, preliminary analyses showed no evidence of displacement or changes in habitat use among pre-nesting and nesting Spectacled Eiders in the first year 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 nesting success. Future analyses will include detailed evaluations of the influence of environmental and human disturbance factors on nesting success and incubation behavior.

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ACKNOWLEDGMENTS

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, Kristen Bartecchi-Rozelle, Joe Bickley, Andrew Cyr, Matt Evans, Adrian Gall, and Tim Obritschkewitsch. Nuiqsut elder, Joeb Woods, provided boat transportation on the Colville River and invaluable knowledge of the delta and its wildlife. Pilots Mike Warlick, Gary Brogdon, and John Mertke of Maritime Helicopters safely transported crews and gear to and from the field. We also thank our airplane pilot Sandy Hamilton of Arctic Air Alaska, for many years of eider surveys. On the ground, Justin Harth and Brent Veltcamp faithfully kept our camp supplied and supported. In our Fairbanks office, Allison Zusi–Cobb, Will Lentz, Matt Macander, and Dorte Dissing provided expert support in data analysis and GIS, and Pam Odom hammered this report into publication form. In all phases of this study, we were assisted by our tireless expeditor, Doris Armijo. This study was funded by ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation and was administered by Caryn Rea, Senior Staff Biologist and Environmental Studies Coordinator, for whose support and guidance we are grateful. We appreciate the reviews and comments made by Caryn Rea and ABR's very own Bob Burgess. 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 staff and contractors in the Alpine oilfield for assistance in making 2005 another successful field season.

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 will be 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.

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, 2006; 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 beginning in 2001, when the final location of the CD-3 pad and airstrip was first determined.

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 2005, 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 will facilitate before–after construction comparisons that otherwise would not be possible. In this annual report, we summarize the data collected in 2005. 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 clear 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) includes the Alpine Facilities (the CD-1 and CD-2 pads, an airstrip, and a road between the pads; at present the only producing oilfield on the Colville Delta) and 2 new sites under construction in 2005 and 2006, CD-3 and CD-4 (Figure 1). An all-season road connects CD-4 to the processing facility at CD-1. CD-3 is a roadless development that will be accessed via an all-season landing strip and a winter ice road. CD-3 has a 0.9-km long

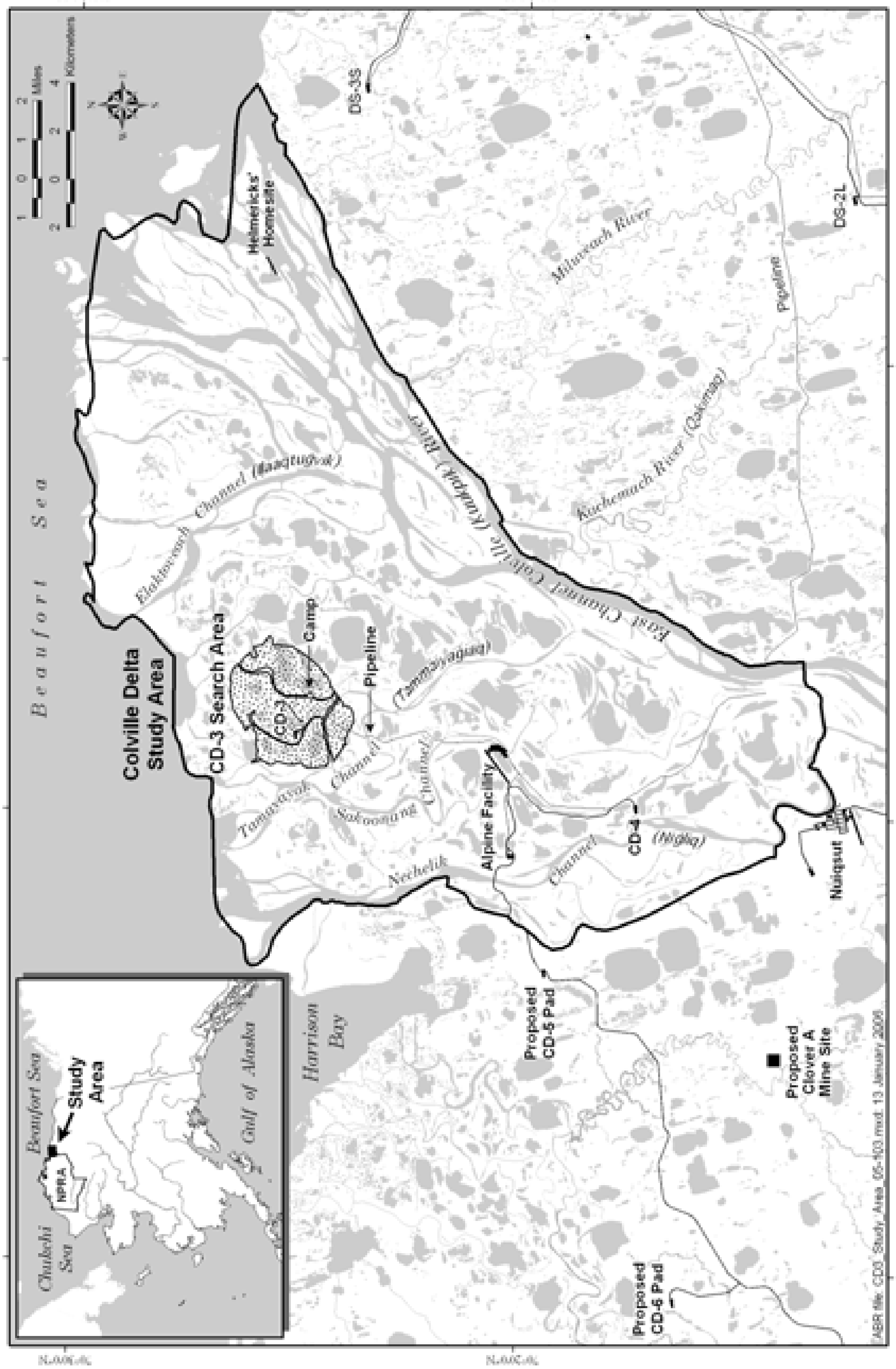


Figure 1. Study area and CD-3 nest-search area, Colville Delta, Alaska, 2005.

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 (Iχaaqtubvik) and Nibliq channels (Figure 1). The CD-3 nest-search area is subdivided by 3 channels of the Colville River: the Tamayayak (Tammayaibiaq), the West Ulamnibiaq, and the East Ulamnibiaq.

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 (Nibliq) 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, both because of its large size and because of the concentrations of birds, mammals, and fish that are found there. Two permanent human settlements occur on the Colville Delta—the Iñupiat village of Nuiqsut and the Helmericks' family home site (Colville Village).

METHODS

EIDER SURVEYS

Regional abundance and distribution of eiders were evaluated with data collected 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 in 2005 covered the Colville Delta and part of the Northeast Planning Area of the NPRA, and detailed methods and results are summarized in a separate report (Johnson et al. 2006). In this report, we use the pre-nesting locations to evaluate temporal changes in distribution and habitat selection.

Intensive nest searches were conducted in the CD-3 nest-search area 17–29 June 2005. Six to 8 nest searchers set up a tent camp and 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 and required ≤1 h of motor time each day. Water levels during nest searching were well below bank height, so it was unlikely that noise or visual disturbance from boating affected nesting eiders. Nest search methods were similar to those used in previous years (Johnson et al. 2000a, 2002, 2003b, 2004a, 2005). 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, collected a small sample of contour feathers, and covered the eggs with down and vegetation before leaving the site. 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).

The CD-3 nest-search area encompassed 17.6 km² in 2005 (Figure 1) and had boundaries that were similar in 2001–2004 (Johnson et al. 2003b, 2004a). 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) and a surrounding reference area for comparison, based on noise contours originally estimated for the Alpine Development airstrip (see Johnson et al. 2003a).

Nest checks (to determine fate) were conducted between 18 and 21 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. 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,

Figure 2. Spectacled Eider nest and time-lapse camera in the CD-3 project area, Colville Delta, Alaska, 2005.

yolk, and albumin on the egg shells. During the nest checks, all shorelines, lakes, and islands were searched 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. 05-108) 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 8 Silent Image® Professional Telephoto (model PM35T25; Reconyx, Lacrosse, WI) digital time-lapse cameras equipped with 8× lenses and 1- or 2-GB memory cards to record incubation behavior of nesting Spectacled Eiders, predators, and construction activity at the airstrip. We set cameras on the first 6 nests (Figure 2) that we found and installation occurred within 1 day of nest discovery. When a camera-monitored nest failed prior to 6 July, we moved the camera to an unmonitored active nest. Five additional nests were monitored with cameras within 1–2 weeks after nest discovery, as nests failed and previously deployed cameras became available. On 29 June, we installed a camera to record construction activity on the airstrip, apron, and access road, prior to the initiation of summer construction activity on 6 July. The cameras were mounted on tripods that were tied down to stakes to stabilize them against the wind (Figure 2). Cameras were installed 20–50 m from nests, which allowed us to avoid disturbing incubating hens when the memory cards and batteries were changed. The 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 down and flattened in vegetation), preening on the nest, and gathering nest material (while on the nest). Break activities included brief sitting or standing activities at the nest: settling, sitting beside the nest, defensive activity, 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 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 approximated the size of Spectacled Eider eggs. Domestic duck eggs were opened to remove their contents and once dry, a thermistor (TMC6-HB with 1.8-m long cord, ±0.5º C accuracy, ±0.4º C resolution; Onset Computer Corporation, Bourne, MA) was glued into each egg with epoxy cement and several more layers of epoxy cement were spread on the inside of the eggshell to reinforce it. The artificial egg was glued with silicon caulk to a 19-cm spike, which served to anchor the egg in the nest.

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

Preliminary classifications of incubation activity were made using temperature data from the artificial eggs, applying rules of interpretation developed for Greater White-fronted Geese in a previous multi-year study (Johnson et al. 2003). Rules were based on the minimum egg temperature during incubation (28.3° 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.

We compared the activities indicated by egg temperatures with activities from the time-lapse cameras. We summarized camera data into 5-min intervals, so that there was correspondence between time intervals for the 2 methods. Error rates were calculated from a cross-tabulation of behaviors determined by both methods. We will be reevaluating the classification rules above with more nest data to improve the error rate in the future.

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 was collected directly and indirectly. Helicopter flights were recorded with a Garmin 296 GPS receiver on each craft 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, length of flight line (within the 200-m buffer), and distance from each nest. We intend to evaluate different sized buffers in future analyses.

Human activity on the airstrip and pad was monitored with 2 time-lapse digital cameras, described above. One camera was installed 680 m from the airstrip with a partial view of the airstrip, apron, and access road. The other camera was focused on an eider (nest 204), but also included in the mid-point of the airstrip approximately 450 m from the camera. We recorded the frequency (passes through the view of one camera) and duration (total time active) at 2 locations (airstrip and airstrip apron combined, access road and well pad combined) of all vehicles, people, and aircraft in each image. We used paired arrival and departure times as indicated by direction of travel among photos to estimate the total duration of vehicle activity. Vehicles traveling northeast on the airstrip were assumed active until they appeared moving southwest while vehicles traveling on the access road to the well pad were assumed active until they appeared traveling back to the airstrip apron.

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 after gravel placement for CD-3 and CD-4 (2005). For simplicity, the 3 construction periods described will be called the pre-Alpine, post-Alpine, and post-CD-3 periods. Future reports will present analyses of the effects of construction and helicopter activity on activity budgets of incubating birds.

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 13.0 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. Sixteen nests were monitored until hatch or failure. Nests were monitored from 21 June to 18 July. Nest age was not determined, so initiation dates were unknown. 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 future reports when the sample size of nests is greater.

HABITAT USE AND SELECTION ANALYSES

Spectacled Eider locations from the ground and 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 georeferenced maps or photomosaics to GIS and subsequently deriving coordinates. By this method, a wildlife habitat was assigned to each observation. Habitat use (% of observations in each habitat type) was determined separately for each year and season (i.e., pre-nesting and nesting). For each year/season, we calculated 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.

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 this purpose, annual surveys were considered comparable only when the survey areas were nearly identical in habitat composition, because habitat availability was calculated by summing annual habitat availability over years.

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 a chi square test to compare the relative use of pooled preferred and non-preferred habitats among the 3 construction periods (e.g., before construction of Alpine, after construction of Alpine, and after construction of CD-3). Non-preferred habitats included both avoided habitats and those with non-significant selection. We used the proportion 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 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

Spring conditions in 2005 on the Colville Delta were cooler than average for returning birds. The mean temperature in May 2005 (–4.7° C) at the nearby Kuparuk Oilfield (where long-term records are available) was similar to the 18-year mean for May (–5.0° C) , but the mean temperature in June 2005 (3.1° C) was cooler than the long-term June mean (4.7° C). The number of thawing-degree days during the waterfowl arrival and peak nest initiation period (15 May–15 June) was the lowest recorded in the last 9 years at both Kuparuk and Colville Village on the outer Colville Delta (Figure 3). Breakup on the Colville River started early in May in 2005, but cooler

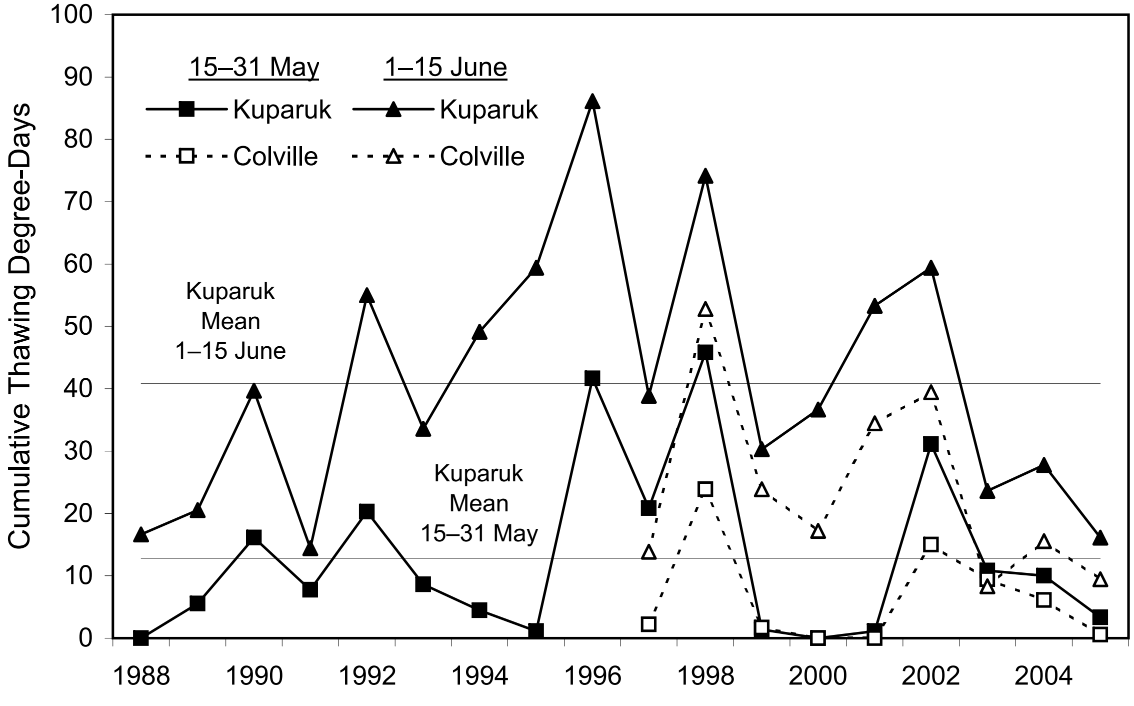


Figure 3. Cumulative number of thawing degree-days recorded for 15–31 May and 1–15 June, Kuparuk Oilfield and Colville Village, Alaska, 2005.

temperatures later on delayed peak flow until 9 June, resulting in a protracted breakup with a peak volume that was lower than average (Michael Baker, unpubl. data). Snow cover in the NPRA and Kuparuk Oilfield was estimated at 10–50% during aerial surveys in the first week of June (ABR unpubl. data) and by mid-June snow cover dwindled to less than 10% in these 2 areas. The outer Colville Delta retained measurable snow depths until 9 June 2005. Deep lakes on the Colville Delta retained 60–85% ice cover through 5 July and 30–50% ice cover through 12 July.

HUMAN DISTURBANCE

The gravel pad for CD-3 was laid down during the winter ice road season and construction activity essentially ceased when the ice road was closed (~7 May). Construction and human activity on the gravel footprint was sporadic and generally at low levels (included occasional site inspections, surveying, and vehicle maintenance) prior to 6 July. Starting on 6 July, crews of 4–8 people began using a variety of trucks and heavy equipment (1 loader, 2 graders, 1 D3 dozer, 2 roller/compactors, 1 pickup, 1 mechanic truck, and 1 water truck) to resurface and compact the gravel footprint. Construction activity was determined from images from 2 time-lapse cameras (Tables 1 and 2). One camera was used to assess activity on the access road and well pad (Table 1), and data from both cameras were used to assess activity on the airstrip and apron (Table 2). Cameras generally operated 24-h/d, providing 1,440 min/d of monitoring 29 June–18 July. Camera malfunctions, camera maintenance, and poor visibility prevented data collection during some periods, resulting in no data on activity on the access road and well pad 10–11 July, and less than 12 h (720 min) of monitoring on 12 July. Because the images were a sample of time and had limited views of the access road, well pad, airstrip, and apron, the activity levels reported here represent a minimal estimate of the levels of activity that took place on the gravel footprint.

Excluding 12 July (when activity was monitored less than 12 hours), the camera documented between 267–598 min of vehicle activity on the access road and well pad each day (Table 1). Because multiple vehicles typically were operating, the cumulative vehicle minutes often were twice that estimate, ranging from 267–1,499 min/d. Machinery made up the majority of the vehicle operating minutes each day, followed by large trucks.

Vehicle traffic was somewhat lower on the airstrip and apron (Table 2), where both cameras together documented 2–481 min/d of vehicle activity and 10–1,034 min/day of cumulative vehicle minutes. As with the access road and well pad, machinery made up the majority of vehicle operating minutes each day, but small trucks, helicopters, humans on foot, and unidentified vehicles were more frequently recorded on the airstrip and apron than they were on the access road and well pad. Helicopters were present on the airstrip and apron 0–26 min/d and people were present 0–74 min/d (Table 2).

All GPS-recorded helicopter flight paths during the pre-nesting and nesting periods that approached within 200 m of a known Spectacled Eider nest were identified by GIS analysis and summarized by day (Table 3, Appendices 1–4). Cumulative flight lengths within 200 m of all known eider nests between 28 May and 17 July (last day of incubation) totaled 89 km (helicopter records from 11 July were missing). Minimum flight altitudes within 200 m of all nests ranged from 0 m (landings) to 65 m during the same period (Table 3). Minimum horizontal distance of overflights to nests ranged from 2 m (directly over nest) to 68 m.

Helicopter flights occurred throughout the nest-search area but were sporadic until 6 July when the summer construction period began at CD-3. Summer construction was supported by 2–4 roundtrip helicopter flights daily, in addition to continued sporadic surveys and miscellaneous helicopter-supported activities. Flights in May and early June were primarily supporting hydrological studies of river levels during break up (0.4–5.6 km of daily flight lengths within 200-m buffers). Four flights (0.2–5.6 km of flight lengths within 200-m buffers) to CD-3 were made during June (1, 4, 5, and 22 June) to transport surveyors working on the gravel pad. On 9 June, a flight took Department of Natural Resource personnel on a tour of CD-3 (2.6 km flight length within 200-m buffers). On 15–16 June, 9 flights were made to our campsite (Appendix 2) to sling gear and ferry personnel (total 1.5 km flight length within 200-m nest buffers). Flights also occurred on 18, 20, 22, and

Table 1. Frequency, duration, and type of vehicles[a] on the CD-3 access road and well pad as recorded by a time-lapse camera, Colville Delta, Alaska, 2005. Images were recorded at 32-sec intervals by a digital camera 680 m from the airstrip.

	Small Truck			Large Truck			Machinery[b]			All Vehicles			
Date	Freq.	Duration (min)[c]	Veh. Min[d]	Freq.	Duration (min)[c]	Veh. Min[d]	Freq.	Duration (min)[c]	Veh. Min[d]	Freq.	Duration (min)[c]	Veh. Min[d]	Total Min Monitored
06 July	0	0	0	0	0	0	16	267	267	16	267	267	1,440
07 July	5	5	5	0	0	0	8	388	895	14	388	902	1,440
08 July	0	0	0	0	0	0	13	534	1,038	13	534	1,038	967
09 July	7	5	5	6	226	226	32	473	683	45	473	913	1,427
10 July[e]	–	–	–	–	–	–	–	–	–	–	–	–	0
11 July[e]	–	–	–	–	–	–	–	–	–	–	–	–	0
12 July	0	0	0	0	0	0	2	142	142	2	142	142	518
13 July	6	9	9	2	31	31	12	529	619	20	529	659	1,440
14 July	1	1	1	2	227	227	8	586	1,129	11	586	1,357	1,440
15 July	0	0	0	0	0	0	20	526	1,499	20	526	1,499	1,440
16 July	1	1	1	8	215	215	10	321	549	19	326	765	844
17 July	0	0	0	0	0	0	8	302	307	8	302	307	1,148
18 July	0	0	0	2	116	116	12	595	1,348	14	598	1,463	1,440
Total	20	20	20	20	815	815	141	4,663	8,476	182	4,671	9,312	13,545
Mean[f]	2.1	2.1	1.5	2.1	86.6	86.6	15.0	495.7	901.1	19.3	496.7	990.0	1,041.9

[a] Small truck = pickup; large truck = trucks > 1 ton capacity; machinery = roller, bulldozer, loader, and backhoe

[b] The backhoe sometimes stayed 2 or 3 days at the well pad before returning to the airstrip apron. In these cases, duration was calculated based on when the backhoe was seen on the access road in photos

[c] Duration = number of min ≥1 vehicle was active on access road and well pad. Durations of all vehicles but small trucks were estimated from paired departure and return times. Small trucks traveling on the airstrip sometimes were missed by the time-lapse cameras, so durations for small trucks were calculated based on the time they were seen on the access road in photos

[d] Veh. Min = cumulative sum of minutes each vehicle was active on access road and well pad, thereby accounting for multiple vehicles operating at one time

[e] No data collected due to camera malfunction

[f] Daily means for vehicles 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

Table 2. Duration of activity of helicopters, people, and vehicles[a] on the CD-3 airstrip and apron, as recorded by 2 time-lapse cameras, Colville Delta, Alaska, 2005. Images were recorded at 32-sec intervals by digital cameras 680 m and 450 m from the airstrip.

	Helicopter		People		Small Truck		Large Truck		Machinery		Unknown Vehicle Type		All Sources Combined		
Date	Duration (min)[b]	Aircraft Min[c]	Duration (min)[b]	People 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]	Duration (min)[b]	Source Min[c]	Minutes Monitored[d]
04 July	0	0	5	10	0	0	0	0	0	0	0	0	0	10	1,440
05 July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,440
06 July	8	8	74	92	1	1	0	0	259	327	2	2	259	429	1,440
07 July	7	7	40	44	40	21	13	13	345	431	43	9	395	525	1,440
08 July	13	13	7	7	6	6	68	70	409	473	14	14	435	583	1,440
09 July	10	10	33	35	43	43	110	126	470	811	10	10	481	1,034	1,440
10 July[e]	6	6	2	16	3	3	0	0	210	211	7	7	218	237	1,440
11 July[f]	–	–	0	0	7	7	113	113	164	169	2	2	242	291	1,440
12 July	26	26	29	47	12	12	37	37	10	10	1	1	59	133	898
13 July	6	6	26	38	21	21	22	22	9	9	1	1	50	97	1,440
14 July	20	20	33	42	7	9	7	7	14	14	5	5	33	98	1,440
15 July	4	4	33	36	0	0	4	7	23	27	2	1	28	75	1,440
16 July	9	9	7	9	1	1	8	11	7	7	1	1	15	38	844
17 July	5	5	2	3	0	0	0	0	1	1	2	2	2	10	1,148
18 July	8	8	62	66	0	0	3	3	231	236	25	18	254	331	1,440
Total	123	123	354	445	140	123	385	410	2,153	2,724	114	72	2,471	3,891	20,170
Mean[g]	9.5	9.5	25	31.8	10	8.8	27	29.3	154	194.5	8	5.1	176	277.8	1344.6

[a] Small truck = pickup; large truck = trucks > 1 ton capacity; machinery = roller, bulldozer, loader, grader, and backhoe

[b] Duration = number of minutes ≥ 1 vehicle, helicopter, or person was active on airstrip and apron, assumed from paired departure and return times. Small trucks traveling on the airstrip sometimes were missed by the time-lapse cameras, so durations active on the airstrip for small trucks were calculated based on only the time small trucks were seen in photos

[c] Aircraft, people, vehicle, and source (all combined) min = cumulative sum of minutes each was active on the airstrip and apron, thereby accounting for multiple vehicles operating at one time

[d] Minutes monitored per day were taken from 1 of the 2 cameras that monitored the longest on that day

[e] Duration and aircraft minutes were estimated from helicopter route files due to a malfunction of the camera monitoring the airstrip apron

[f] Helicopter minutes are unknown due to incomplete helicopter route files and a malfunction of the camera monitoring the airstrip apron

[g] Daily means for people, aircraft, and vehicles 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

Table 3. Daily cumulative total flight length (km), minimum flight altitude (m), and minimum horizontal distance (m) to nest of helicopters within 200 m of Spectacled Eider nests as recorded by GPS receivers in 3 helicopters during the pre-nesting and incubation periods in the CD-3 project area, Colville Delta, 2005. Boxes outline period from early arrival on the delta to hatch or failure.

	Nest Number[a]																		Daily Total
Date[b]	004	015	017	204	212	301	303	401	406	407	504	505	516	522	524	600	611	613	
28 May	0	0	0	0	0	0.39	0	0.45	0	0	0	0	0	0	0	0.20	0	0	1.04
29 May	0.44	0	0	0	0	0.59	0	0.54	0	0	0	0.44	0	0	0	0.34	0	0	2.36
30 May	0	0	0	0	0.82	0.80	0	0	0	0	0	0	0	0.66	0	0.31	0.66	0	3.25
31 May	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0.40	0	0	0.41
01 June	0.31	0	0	0.04	0.39	0	0	0.88	0	0	0	0	0	0	0	1.10	0.39	0	3.10
02 June	0	0	0	0.51	0	0	0.49	0.71	0	0	0.32	0.78	0	0	0	0	0	0	2.82
03 June	0	0.40	0	0	0	0	0	0.03	0	0	0	0	0	0	0	0.32	0.40	0	1.15
04 June	0.60	0	0	0.59	0	0.36	0	0	0	0	0.27	0.45	0.41	0.31	0.43	0.25	0	0	3.67
05 June	1.00	0	0	0	0	1.88	0	0.84	0	0	0	0	0	0	0.08	1.83	0	0	5.64
06 June	0	0	0	0	0	0.82	0	0.54	0	0	0	0	0	0	0	0	0	0	1.36
09 June	0.59	0.25	0	0	0	1.07	0	0.65	0	0	0	0	0	0	0	0	0	0	2.57
15 June	0	0	0	0	0	0	0	0.24	0	0	0	0	0	0	0	0	0	0	0.24
16 June	0	0	0	0.44	0	0.06	0	0.40	0	0	0.42	0	0	0	0	0	0	0	1.31
18 June	0.29	0	0	0	0	1.20	0	1.89	0	0	0	0	0	0	0	2.16	0	0	5.53
20 June	0	0	0	0	0	0	0	0.32	0	0	0	0	0	0	0	0	0	0	0.32
21 June	0.34	0	0	0.38	0	0.73	0.51	0	0	0	0	0.51	0	0.11	0	0.17	0	0	2.76
22 June	0	0	0	0	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0.18
26 June	0	0	0	0	0	0	0	0.66	0	0	0	0	0	0	0	0	0	0	0.66
27 June	0.94	0	0	1.00	0	0.32	0.69	0	1.21	0.82	0.43	0.87	0.67	0.37	0.82[c]	0.93	0	0	9.07
29 June	0	0	0[c]	0	0	0.21	0	3.05	0	0	0	0	0	0	0	0	0	0	3.26
30 June	0	0	0	0	0	0	0	0.45	0	0	0	0	0	0	0	0	0	0	0.45
03 July	0.45	0	0	0	0	0	0	0.41	0	0	0	0.45	0	0	0	0	0	0	1.31
04 July	0	0	0	0	0	1.27	0	0.40	0	0	0	0	0	0	0	0.59	0	0	2.26

Table 3. Continued.

	Nest Number[a]																		
Date[b]	004	015	017	204	212	301	303	401	406	407	504	505	516	522	524	600	611	613	Daily Total
05 July	0	0.39	0	0	0	0	0.40	0	0	0	0	0.40	0	0.20	0	0	0	0	1.40
06 July	0.37	0	0	0.32	0.52	2.21	0	0.96	0	0	0	0	0	0	0	0.58	0.43	0	5.39
07 July	0.43	0.40	0	0	0	1.21	0	0.27	0	0	0	0	0	0	0	0.92	0.37	0	3.59
08 July	0.35	0.14	0	0	0.45	0.54	0	0.42	0	0	0	0	0	0	0	0.73	0.52	0	3.16
09 July	1.30	0	0	0	0	0	0	0	0	0	0	0.71	0	0	0	1.37	0	0	3.39
10 July	0	0	0	0	0	0.81	0	0	0	0	0	0	0	0	0	0.87	0	0	1.67
12 July	0.39	0.40	0	0	0.60	1.43	0	1.33	0	0	0	0.19	0	0	0	0	0.76	0	5.11
13 July	0	0	0	0	0	0.28	0	0	0	0	0	0	0	0	0	0.37	0	0	0.65
14 July	0.70	0	0	0	0	1.62	0	0.39	0	0	0	0.38	0	0	0	0.63	0	0	3.72
15 July	0	0	0	0	0	0.77	0	0.82	0	0	0	0	0	0	0	0.26	0	0	1.86
16 July	0	0	0	0	0	1.09	0	0.52	0	0	0	0	0.80	0	0.80	0.30	0	0	3.51
17 July	0	0	0	0	0	0.75	0	0.28	0	0	0	0	0	0	0	0.33	0	0	1.36
Total (km)[d]	8.50	1.99	0	3.27	1.20	8.09	1.69	17.19	1.21	0.82	1.01	2.18	1.07	1.65	1.34	9.18	3.53	0	89.49
Min. Altitude (m)[d]	0	9	–	0	46	3	18	0	59	64	18	18	65	43	65	2	6	–	
Min. Horiz. Dist. to Nest (m)[d]	15	13	–	52	20	2	18	6	15	2	45	60	3	68	14	7	14	–	
Nest Fate[e,f]	D/P	H	F	H	F	P	P	H	H	F	D/P	P	F	H	F	D/P	H	F	

[a] Outlined data includes the period between 28 May and the day of nest hatch or failure

[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, except on 11 July which is missing data

[c] Nest was discovered inactive on this date

[d] Total flight distances, minimum altitude, and minimum horizontal distance to nest 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 timelapse images), disturbance/predation (D/P, failure caused by predation in conjunction with known or possible disturbance [nest unattended at time of failure] observed on timelapse images), and failed (F, failure and cause unobserved)

[f] Hatch or failure date determined from video or temperature-sensing eggs, except for nests 017 and 524 which failed before discovery

26 June to move personnel and gear to and from our camp (total 6.9 km flight length within 200-m nest buffers). On 27 June, a loon survey was conducted around lakes in the area, accounting for the long flight lines on that date (9.1 km of flight length within 200-m nest buffers), and similar surveys were conducted weekly through 1 August. On 29–30 June, 6 flights took our gear and personnel from camp to Alpine (total 3.8 km flight length within 200-nest buffers). Other miscellaneous helicopter flights were made occasionally by construction personnel to CD-3 to inspect the site until 6 July, when 2–4 daily roundtrip flights (0.6–5.4 km of flight lengths daily) transported 4–8 workers to perform gravel work that continued through the incubation and brood-rearing period for Spectacled Eiders.

The nest with the highest exposure to helicopters (nest 401 with 17 km of flight length within 200 m) was on the flight path between CD-3 and Alpine and that nest hatched (Table 3, Appendices 1–4). Two nests (nests 017 and 613) had no helicopters within 200 m during 28 May–17 July and both those nests failed. The mean flight length within 200 m of all failed (2.9 km, *n* = 12) and hatched (4.8 km, *n* = 6) nests was not significantly different (t-test, $P \geq 0.4$), suggesting that the amount of helicopter activity (as measured by cumulative flight lengths) had little effect on nesting success in the nest-search area.

DISTRIBUTION AND ABUNDANCE

PRE-NESTING

The 2005 aerial survey for pre-nesting eiders in the Colville Delta study area was conducted 8–13 June (Johnson et al. 2006). We counted 14 Spectacled Eiders that were on the ground and 2 that were in flight. Although this was the second lowest count of Spectacled Eiders recorded during pre-nesting surveys on the Colville Delta in 12 years, it was an increase over the number recorded in 2004 (6 on the ground, 6 in flight; Johnson et al. 2005). The CD North sub-area, which has the highest concentration of Spectacled Eiders on the delta, followed a similar trend (see Johnson et al. 2006).

Since 2003, the number of Spectacled Eiders in the CD North sub-area during pre-nesting surveys has been low, whereas the trend lines for the Kuparuk study area and for the Arctic Coastal Plain region (Figure 4) appear relatively stable since 1993 (Anderson et al. 2006, Larned et al.

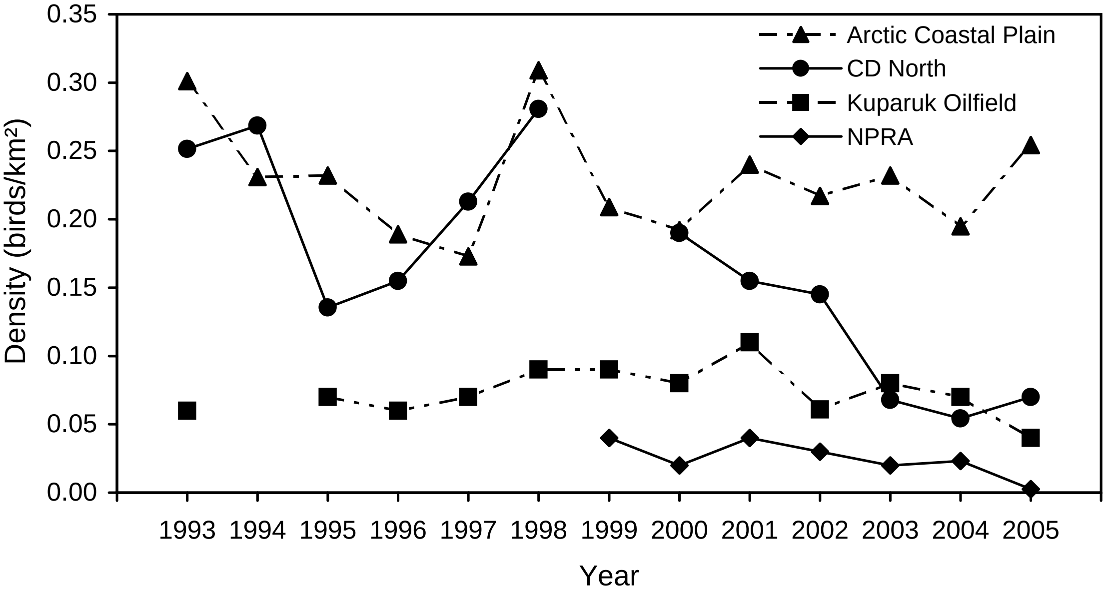


Figure 4. Densities of pre-nesting Spectacled Eiders from aerial surveys of the Colville Delta, NPRA, Kuparuk Oilfield, and Arctic Coastal Plain, Alaska, 1993–2005.

2005). Several explanations are possible: 1) a local decline in the breeding population might have occurred in the CD North sub-area, or 2) artifacts of the survey method (such as poor timing or variable survey personnel) may have affected the number of eider sightings in the CD North sub-area, or 3) the detectability of Spectacled Eiders may have declined in the CD North sub-area in recent years, or 4) use of the area by pre-nesting eiders may have declined. A local population decline appears unlikely, because the number of nests found in the CD-3 nest-search area has not declined (see below). The same aircraft, pilot, and surveyors were used in the Kuparuk, NPRA, and CD North areas, suggesting that observer bias is not a plausible explanation. However, survey timing does affect the number of male Spectacled Eiders present in the survey area (Johnson et al. 1999a) and the number of birds present during pre-nesting is highly variable on a daily basis (see Figure 3: Anderson et al. 2005). Although the relative detectability of Spectacled Eiders could be lower in the CD North sub-area than elsewhere (possibly due to a higher concentration of lakes and ice in the CD North sub-area), there is little reason to suspect that detectability would have changed since 2002. Similarly, aside from our observations of decreasing numbers, there is no corroborating evidence that the CD North sub-area is less attractive than previously to pre-breeding (versus breeding) eiders. Although survey timing seems to be the most likely of these explanations, we lack information to assign a cause and it is likely that more than a single factor contributed to the observed variation in numbers.

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 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), however, pre-nesting eiders appeared to be located farther from the coast and closer to Alpine, CD-4, and the nearest gravel pad than they were in prior years. The mean distance to CD-3 in 2005 (5.6 km) was nearly the same as the mean distances (5.4 and 5.6 km) during the earlier construction periods. None of the one-way ANOVAs were significant ($P \geq 0.20$), but the sample size for 2005 was too small to estimate distances from these features with much precision. Nonetheless, the differences in mean distances among construction periods were not suggestive of a disturbance effect (i.e., an increase in distance from facilities with increased construction or operation activity) from Alpine, CD-3, or CD-4.

NESTING

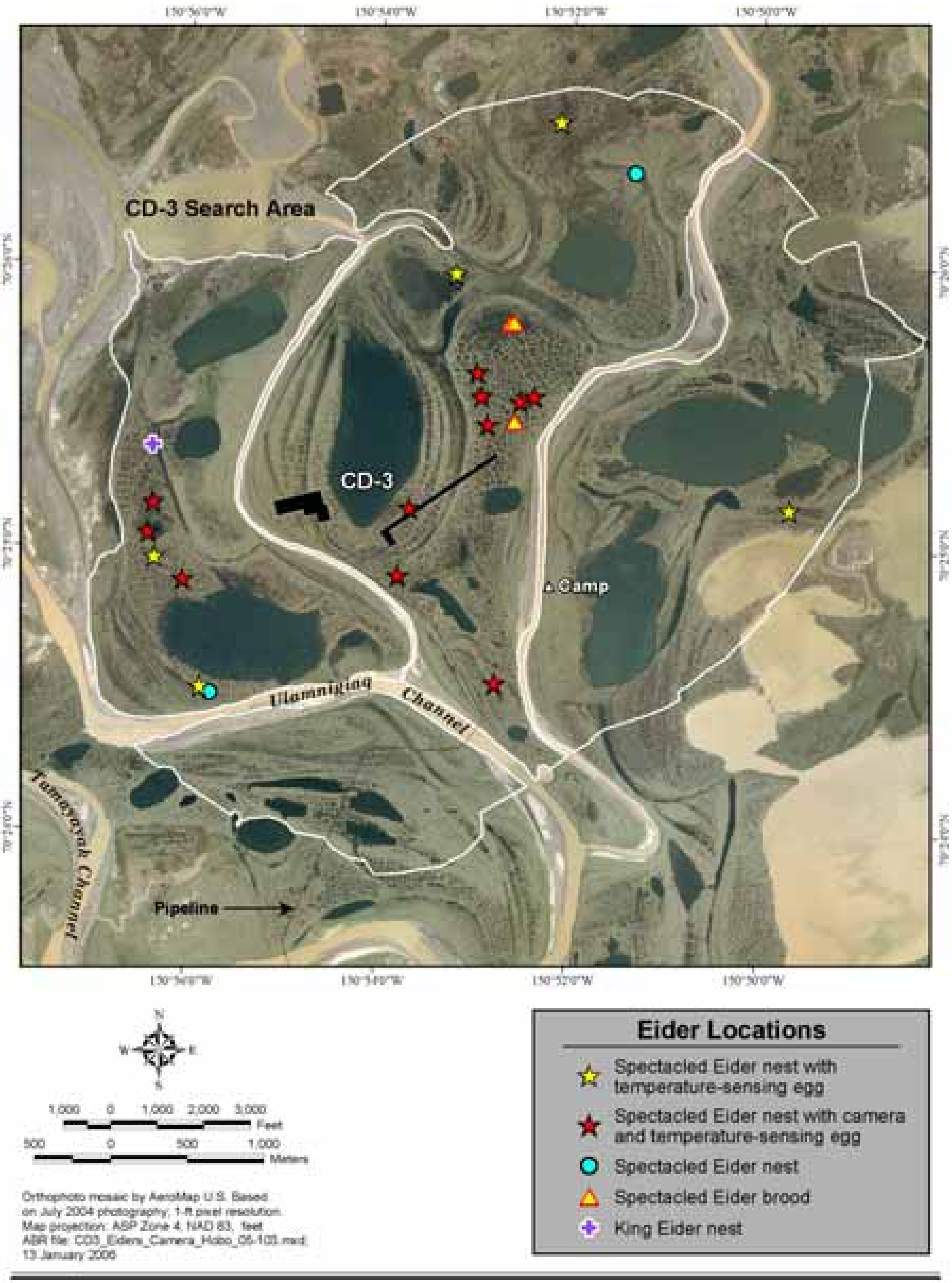
Despite the low counts of Spectacled Eiders during the pre-nesting survey in 2005, we found 18 Spectacled Eider nests in the nest-search area (Figure 5), the second highest number of nests since 2001. In 2005, 16 Spectacled Eider nests were active when discovered, 1 had failed before discovery, and the other had 1 cold egg and appeared to be abandoned (total nest density = 1.0 nest/km^2). The 2 inactive eider nests were identified to species from contour feather characteristics (Anderson and Cooper 1994). During 2001–2004, we found an average of 10.7 nests (0.6 nests/km^2) in the same search area, with the 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 km^2) 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, we compared the distances of successful and failed nests from CD-3 in each year and construction period (Table 5). In all but 2001, successful nests were closer to the location of CD-3 than were failed nests. In 2005, successful nests averaged 840 m from CD-3 (SE = 121, n = 6), and failed nests averaged 937 m from CD-3 (SE = 225.3, n =12). The closest nest to the gravel footprint in 2005 was only 17.5 m from the airstrip, and this nest failed after ≥14 d of incubation. The farthest nest from the airstrip was 2,208 m away, and it also failed. We also compared the distances of successful and failed nests to CD-3 among years with a two-way ANOVA on rank-transformed data, which identified no significant main effects (among years or between fates) or interaction term ($F = 0.822$; df = 9, 51; $P = 0.599$, $R^2 = 0.13$). We repeated the test

Table 4. Results of one-way ANOVAs comparing 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 and CD-4 gravel placement (2005).

Test Variable Construction Period	*n*	Mean	SE	*F*	*P*-value
Distance to Coast				0.388	0.679
Pre-Alpine	95	4.29	0.27		
Post-Alpine	92	4.42	0.26		
Post-CD-3 & 4 Gravel Placement	6	5.22	1.06		
Distance to Alpine Airstrip				1.582	0.208
Pre-Alpine	95	10.23	0.41		
Post-Alpine	92	10.58	0.40		
Post-CD-3 & 4 Gravel Placement	6	7.65	1.67		
Distance to Alpine				1.629	0.199
Pre-Alpine	95	10.14	0.42		
Post-Alpine	92	10.41	0.42		
Post-CD-3 & 4 Gravel Placement	6	7.32	1.76		
Distance to CD-3				0.108	0.898
Pre-Alpine	95	5.38	0.379		
Post-Alpine	92	5.64	0.425		
Post-CD-3 & 4 Gravel Placement	6	5.58	0.926		
Distance to CD-4				1.460	0.235
Pre-Alpine	95	11.49	0.452		
Post-Alpine	92	11.82	0.449		
Post-CD-3 & 4 Gravel Placement	6	8.71	1.822		
Distance to Nearest Gravel Pad				0.652	0.522
Pre-Alpine	95	4.97	0.373		
Post-Alpine	92	5.40	0.415		
Post-CD-3 & 4 Gravel Placement	6	3.89	0.930		

after pooling the years prior to construction (2001–2004), comparing the pre-construction and 2005 distances to CD-3 of successful and failed nests. Results were similar to the multi-year analysis, with no significant effects ($F = 0.496$; df = 3, 57; $P = 0.687$, $R^2 = 0.025$). These analyses suggest that the placement of the gravel footprint and construction activity at CD-3 in 2005 did not result in any changes in nest distribution, nor did they result in any detectable impacts on nesting success.



Orthophoto mosaic by AeroMap U.S. Based on July 2004 photography; 1-ft pixel resolution.
Map projection: ASP Zone 4, NAD 83, feet
ABR file: CD3_Eiders_Camera_Hobo_05-103.mxd
13 January 2006

Figure 5. Locations of Spectacled Eider and King Eider nests, temperature-sensing eggs, time-lapse cameras, and brood locations in the CD-3 project area, Colville Delta, Alaska, 2005.

Table 5. Distance (m) of successful and failed Spectacled Eider nests from CD-3 by year and construction period, Colville Delta, Alaska, 2005.

	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	952.7	430.0	3
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	1,161.0	165.4	27
2005	839.7	121.7	6	937.4	225.3	12

NEST SURVIVAL

Apparent nesting success (nests hatched/nests of known fate) was 33% (6 of 18 nests hatched) for Spectacled Eiders in 2005, just below the long-term average. Apparent nesting success for all Spectacled Eider nests with known fate found on the Colville Delta from 1993 to 2004 was 37% (27 of 73 nests). Average clutch size in 2005 was 4.5 eggs/nest (*n* = 16 nests), which was similar to the long-term average for the Colville Delta (4.0 eggs/nest, *n* = 40 nests).

We calculated daily nest survival (Mayfield 1961, 1975) for nests that were monitored with temperature-sensing eggs or with time-lapse cameras in 2005 (Figure 5, Table 6) using program MARK. The mean daily survival rate for 16 nests was 0.95 (SE = 0.016). 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 estimated nesting success based on daily survival rate for an assumed 24-d incubation period was 27% (95% CI = 9–49 %) in 2005. Future 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, provided detailed histories used for survival analysis (above) and activity budgets for incubating hens (Table 6). We inserted temperature-sensing eggs into all 16 active Spectacled Eider nests that we found in 2005 (Figure 5). Installation of temperature-sensing eggs took 9–26 min (mean = 15 min, *n* = 16). Incubation resumed 5–365 min (mean = 67 min, *n* = 16) following installation (i.e., after departure of researchers from nest site). The hen at nest 004 took an abnormally long time to return to her nest and resume incubation (365 min), and because she continued to incubate for 23 days of a 23–24 day incubation period, we assume she had not finished laying eggs or was near her first day of incubation. 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 13 hours after installation.

TIME-LAPSE CAMERAS

We monitored 11 Spectacled Eider nests with time-lapse cameras in 2005 (Figure 5, Table 6). Cameras were placed 20–50 m from nests (mean = 34 m). Camera installation took 19–41 minutes and averaged 32 min (*n* = 11 installations). We exchanged memory cards and batteries in each camera 1 time/week and exchanges averaged 17 min (*n* = 9 exchanges) at each camera. Only 1

Table 6. 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, 2005.

				Dates Monitored		Whole Days Monitored[a]		Preliminary Incubation Constancy (%)[a]		Preliminary Mean Daily No. Recesses[a]		Preliminary Mean Recess Length (min) [a]	
Nest Number	Distance to CD3 (m)	Fate	Predator	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera
004	193	F	Parasitic Jaeger	22 June–16 July	6–16 July	23	9	97.1	94.5	1.0	1.8	37.7	39.6
015	774	S	–	27 June–13 July	6–13 July	14	5[b]	99.9	99.8 [b]	0.1	0.4 [b]	15.0	7.5 [b]
204	369	S	–	13 June–12 July	13 June–12 July	17	17	99.8	99.7	0.2	0.4	13.8	11.7
212	845	F	avian	27–29 June	–	1	–	100[c]	–	0[c]	–	0	–
301	185	F	arctic fox	21–22 June	21–23 June	0	1	100[d]	99.2[c]	–	1.0[c]	0	11.0[c]
303	537	F	arctic fox	23–30 June	29–30 June	6	0	99.5	97.7[d]	0.5	–	13.3	23.2[d]
401	1,116	S	–	12 June–16 July	6–16 July	23	8	96.4	96.2	1.2	1.5	33.3	36.3
406	1,204	S	–	24 June–16 July	–	20	–	98.8	–	0.8	–	24.0	–
407	1,934	F	unknown	25 June–7 July	–	9	–	98.8	–	0.9	–	18.8	–
504	441	F	Parasitic Jaeger[f]	22–23 June	23 June	0	0	91.8[d]	0[d]	–	–	40.0[d]	–
505	380	F	arctic fox	23–24 June	23–24 June	0	0	100[d]	100[d]	–	–	0[d]	0[d]
516	1,225	F	unknown	26–27 June	–	0	–	93.2[d]	–	–	–	27.5[d]	–
522	744	S	–	27 June–11 July	6–11 July	12	3[e]	97.9	97.2[e]	0.9	1.3[e]	32.3	29.9[e]
600	17	F	Parasitic Jaeger, Glaucous Gull	22 June–6 July	22 June–6 July	13	13	96.2	96.1	1.2	1.2	47.7	46.4
611	831	S	–	no data	6–17 July	–	6	–	98.4	–	1.3	–	17.4
613	2,208	F	unknown	29 June–6 July	–	6	–	99.5	–	0.5	–	15.0	–

[a] Excludes day of instrumentation, hatch, fledging, or failure, and days of partial monitoring due to camera malfunction or fog

[b] Includes 3 days when 80–135 min of data were lost due to sun glare

[c] Data are not averaged since total time monitored was only 1 full day

[d] Data are from less than 1 day of monitoring

[e] Includes 2 days when 47–52 min of data were lost to sun glare

[f] Predation occurred after hen was disturbed by camera installation

incubating hen was flushed while installing cameras and that nest was subsequently lost to avian predators (see description of nest 504 below). No hens were flushed during weekly camera maintenance. However, one hen was on a normal recess (observed on camera images covering the nest before leaving), and that recess was probably prolonged (102 min versus mean = 39.6 min, *n* = 16 recesses) by the researcher's presence at the camera.

Of 11 nests monitored with time-lapse photography and temperature-sensing eggs, 5 hatched and 6 failed (Table 6). Three nests failed after arctic fox predation and 3 failed following avian predation. All 3 of the nests that failed due to avian predation also exhibited low incubation constancy prior to the observed predation events. In addition, all 3 of these nests were subjected to disturbances that may have contributed to egg losses and to subsequent failure by avian predation. In all cases, camera images provided only a partial documentation of events and, although the method provided valuable information, ultimate causes of failure sometimes remained unclear.

For 2 fox predation events, hens were observed on time-lapse images incubating normally prior to being flushed from the nest by a fox. At nests 301 and 303, several fox predation events occurred over the course of 2.5–10 hours. At both nests, a fox was seen carrying eggs away from the nest (Figure 6). Foxes also appeared to eat eggs at these nests, although no egg remains were found during later nest inspections. The hen at nest 303 returned after the final predation event and attempted to incubate, but left within an hour. The female from nest 301 did not return after the final fox encounter. The hen at nest 505 flushed 9 minutes before a fox appeared at the nest for ~1.5 minutes (4 consecutive images). It is uncertain whether the fox caused the bird to flush but was missed by the camera or if the bird flushed for an unrelated reason. The fox was not seen carrying eggs but did eat 1 egg in 1 image. We assumed that the fox flushed the hen off the nest and other eggs were taken in the 9 min before the fox was captured by the camera or in the intervals between subsequent images. The hen incubated for approximately an hour after the fox left and then covered the nest and departed for the last time. A Parasitic Jaeger was seen scavenging that nest after the hen departed, and a peck hole was found in the temperature-sensing egg.

Researcher disturbance combined with low attentiveness by the female Spectacled Eider allowed avian predation to cause the failure of nest 504. The temperature-sensing egg was installed at this nest after the female was flushed on 22 June. The female was attended by a male and may still have been laying eggs. The hen flushed from 20 m away when approached compared with the mean of 5.5 m (*n* = 15 birds) for the other incubating eiders. The bird was flushed off the nest again inadvertently the following day, when the camera was installed 30 m from the nest, and she was the only Spectacled Eider that flushed while setting up or servicing cameras. Camera images showed a Parasitic Jaeger eating eggs 65 minutes after researchers covered the nest with vegetation and left the area. The hen did not return to incubate after the camera installation or the predation event.

Poor nest attendance and disturbance from airstrip construction activities may have contributed to the failure of Spectacled Eider nest 600, which was 17 m from the airstrip footprint (Table 6). This nest was monitored by camera and temperature-sensing egg for 13 days and lost eggs to a Parasitic Jaeger and Glaucous Gull (Table 6). The hen at this nest had one of the lowest incubation constancies (96.1%) and longest mean recess durations (46 min/recess) of all eiders monitored for more than 1 day. Two and 3 days prior to the day of failure on 6 July, the hen spent 145 and 175 min off the nest, more than 6 times the average time off nest for successful hens (23.9 min/day, *n* = 6 nests). Helicopter flights occurred within 200 m of the nest 2 days before failure and the day of failure (Table 3), but not on every day with low incubation constancy. The day of failure, 6 July, coincided with the day summer construction activities commenced at CD-3. Helicopters flew 147–195 m from the nest at 7–83 m agl (some of these overflights were landings and takeoffs) from 0819 h to 0832 h that morning. Construction workers arrived at CD-3 near 0830 h and, according to camera data, at 0900 h started driving heavy equipment and walking on the airstrip apron (approximately 225 m from the nest). A researcher also was near the nest at this time, servicing the camera, and departed the area at 0915 h. Camera images during this period show the eider

Figure 6. Digital time-lapse images showing fox predation at Spectacled Eider nest 301 and a Parasitic Jaeger encounter (no predation occurred) at nest 204, Colville Delta, 2005.

incubating normally and concealing during camera maintenance. At 1000 h, the eider covered her eggs and left the nest, but did not flush. No construction activity or helicopter flights were observed on the apron or airstrip when the eider left, but a worker was driving a roller back and forth on the airstrip from 1100–1530 h, at times driving within approximately 20 m of the nest. Activity on the apron from 0900–1730 h mostly consisted of a loader moving pallets, at least one person directing the loads, and a roller driving back and forth. The hen did not incubate again after leaving the nest in the morning, but was seen swimming in the low-center polygon around the nest from 1245 to 1300 h. The first predation event was a Parasitic Jaeger that pecked ≥1 egg in the nest at 1400 h. The eider returned in <1 min and chased the jaeger from her nest. She remained at the nest for 2 min, during which time she removed a broken egg, then she left the nest and was not seen again on camera. The construction crew was picked up and taken back to Alpine at 1815 h. At 1845 h, a Glaucous Gull was recorded eating eggs at the nest. We conclude from this series of events that the hen did not leave its nest in response to a specific disturbance, because it covered its nest as during normal incubation recesses and no potential source of disturbance was nearby (within 200 m) at the time. However, the hen likely was deterred from returning to incubate because of the nearby construction activity. Poor nest attendance prior to nest failure may have been an indication that this eider hen was unable to continue incubating and was abandoning the nest when she took her last recess. We cannot attribute the failure of nest 600 solely to either disturbance or decreased incubation, and conclude that both factors contributed to the final predation event.

Partial predation by a pair of Parasitic Jaegers was observed at nest 004, but we were unable to determine whether that predation event, disturbance, or abandonment caused the nest to fail. Camera data indicated a recess began on 12 July, 13 min prior to a researcher arriving to service the camera. No helicopter flights were within 200 m of this nest until 56 min after the recess had begun. A jaeger was standing at the nest when the researcher arrived, but no eggs were damaged at that time. Nine minutes after departing the camera, the researcher saw a pair of jaegers at the nest and, after chasing them away, found that 1 of 3 original eggs was missing. After this prolonged recess (102 min), the eider returned to incubate and no further predation was observed during the rest of the monitoring period. The eider continued to incubate, but began taking more frequent and longer recesses on 14 July, 2 days prior to failure. On 14 July, a helicopter flew by the nest 4 times within 15 min ranging from 66 to 143 m from the nest and 76–106 m agl, but none of these flights corresponded with recesses at nest 004. On 16 July, after 23 days of monitoring into a 23–24 day incubation period, the eider covered her nest and did not return. No helicopter flights occurred within 200 m of the nest on the day of failure (Table 3). No eggs or shells were found near the nest during the nest fate visit indicating that a predator likely took the remaining eggs but the event was not captured on camera.

INCUBATION ACTIVITY

The classification of incubation activity by temperature-sensing eggs was evaluated for 1 nest that also was monitored with a time-lapse camera. Time constraints prevented evaluation of the classification with more nests. Cross tabulation of 3 activities (incubation, recesses, and breaks) at this nest estimated an overall 3% error rate in identification of activities from temperature-sensing eggs (97% correct; Table 7). The error rate was highest for breaks: 70% of 93 breaks were misclassified and 62% of breaks were misidentified as incubation. Incubation breaks involve brief nest maintenance activities (all were <5 min long and only 2 breaks were 3–4 min) and the temperature-sensing egg did not cool quickly enough to allow clear identification of the break from the change in temperature. The misclassification of breaks as incubation had no effect on estimates of incubation constancy or recess length because breaks were not considered off-nest activity and breaks were included in incubation time. Only a small number of breaks were misclassified as recesses (0.2%, 7 out of 2,853 records), potentially skewing the estimates of recess length and frequency and incubation constancy, but the bias was small.

We compared activity budgets estimated separately with temperature-sensing eggs and time-lapse cameras for 6 nests that were

Table 7. Comparison of 5-min intervals of incubation activities determined from temperature records of an artificial temperature-sensing egg with those simultaneously observed on time-lapse digital images (32-sec intervals summarized into 5-min intervals) of Spectacled Eider nest number 004, Colville Delta, Alaska, 2005.

Activity by Time-lapse Camera		Activity by Temperature-sensing Egg				% of Camera Intervals
		Break	Incubate	Recess	Total	
Break	No. of Intervals	28 [a]	58	7	93	
	% of Egg Intervals	30.1	62.4	7.5	100	3.3
Incubate	No. of Intervals	15	2,524 [a]	6	2,545	
	% of Egg Intervals	0.6	99.2	0.2	100	90.2
Recess	No. of Intervals	0	8	177 [a]	185	
	% of Egg Intervals	0	4.3	95.7	100	6.6
Total		43	2,590	190	2,823	
% of Egg Intervals		1.5	91.7	6.7	100	100

[a] Overall correct classifications = [(28 + 2,524 + 177) / 2,823] × 100 = 97 %

simultaneously monitored by both techniques for more than 1 d (Table 8). The 2 methods were similar for incubation constancy, number and length of recesses, and daily time off nest, but differed in the estimates of break frequency and break duration. Mean incubation constancy differed by only 0.1% by the two methods and the mean number of recesses per day differed by only 0.1 recesses per day. Mean recess length and time off nest both were slightly overestimated by temperature-sensing eggs (mean differences were 3.2 min/recess in recess length and 2.2 min/d in time off nest). In contrast, temperature-sensing eggs markedly underestimated break frequency (mean difference was 11.9 breaks/d) and overestimated break time (mean difference was 19.4 min/d). Similar errors in estimation of break frequency and break lengths by temperature-sensing eggs were recognized by Johnson et al. (2003) during nest monitoring of Greater White-fronted Geese.

We conclude that the temperature-sensing eggs, with our current classification rules, provide accurate estimates of incubation constancy, recess lengths, and recess frequency, which are the most important activities for evaluations of disturbance effects on incubation behavior. The frequency and length of incubation breaks estimated by temperature-sensing eggs were inaccurate as a result of the long intervals between temperature recordings (5 min) and the abbreviated nature of incubation breaks.

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 (observations in 2005, the post-CD-3 period, were too few for a similar analysis). 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 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 8). Because the selection

Table 8. Comparisons of Spectacled Eider incubation activity estimated from concurrently recording temperature-sensing eggs (5-min intervals) and digital time-lapse images (32-sec intervals), Colville Delta, Alaska, 2005.

		Mean Incubation Constancy (%)[a]		Mean No. Recesses/Day[a]		Mean Recess Length (min)[a]		Mean Time Off Nest/Day (min)[a]		Mean No. Breaks/Day [a]		Mean Min. of Break/Day[a]	
Nest Number	Days Monitored	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera	Temp.-sensing Egg	Camera
004	9	93.9	94.5	1.8	1.8	43.8	39.6	77.8	70.3	4.0	11.0	21.1	8.5
015	5	99.8	99.8[b]	0.2	0.4[b]	15.0	7.5[b]	3.0	3.0[b]	6.2	14.2[b]	33.0	8.3[b]
204	17	99.8	99.7	0.2	0.4	13.8	11.5	3.2	4.7	5.5	23.6	28.2	14.0
401	8	96.1	96.2	1.5	1.5	37.9	36.3	56.9	54.5	8.3	18.3	42.5	11.5
522	3	97.0	97.2[c]	1.3	1.3[c]	32.5	29.9[c]	43.3	39.8[c]	5.3	21.0[c]	26.7	12.3[c]
600	13	96.2	96.1	1.2	1.2	47.7	46.4	55.0	53.6	6.3	19.1	31.5	12.0
Mean		97.1	97.2	1.0	1.1	31.8	28.5	39.9	37.7	5.9	17.9	30.5	11.1

[a] Excludes day of instrumentation, hatch, fledging, or failure, and days of partial monitoring due to camera malfunction or fog

[b] Includes 3 days when 80–135 min of data were lost due to sun glare

[c] Includes 2 days when 47–52 min of data were lost to sun glare

Table 9. Habitat selection of pre-nesting Spectacled Eiders on the Colville Delta during 3 construction periods: pre-Alpine (1993–1997), post-Alpine (1998–2004), and post-CD-3 & 4 gravel placement (2005).

	Pre-Alpine (1993–1997)					Post-Alpine (1998—2004)					Post-CD-3 & 4 Gravel Placement (2005)				
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	0	0	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	0	0	5	ns	low
Deep Open Water without Islands	2	2	4	ns	low	8	9	4	ns	low	1	17	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	<1	ns	low
Shallow Open Water with Islands or Polygonized Margins	1	1	<1	ns	low	2	2	<1	prefer	low	0	0	<1	ns	low
River or Stream	3	3	15	avoid		5	5	14	avoid		0	0	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	1	17	3	ns	low
Grass Marsh	2	2	<1	prefer	low	0	0	<1	ns	low	0	0	<1	ns	low
Young Basin Wetland Complex	0	0	<0.1	ns	low	0	0	<0.1	ns	low	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low	0	0	<0.1	ns	low	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	9	9	8	ns		8	9	8	ns		1	17	8	ns	low
Patterned Wet Meadow	9	9	19	avoid		7	8	20	avoid		3	50	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	0	0	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			6	100	100		

[a] Significance calculated from 1,000 simulations at α= 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

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 use of those habitats that were identified as preferred during the baseline period.

In 2005, only 6 groups of Spectacled Eiders were seen on the ground (flying birds cannot be used in habitat analyses), which were too few to conduct the Monte Carlo selection analysis or a chi-square goodness-of-fit test to compare the use of preferred habitats between 2005 and previous construction periods. However, only one group (17% of groups) in 2005 was in a habitat previously identified as preferred, a large drop from the 40–48% that used preferred habitats during the pre- and post-Alpine construction periods (Table 9). We expect that sample sizes will increase sufficiently in future years to allow further evaluation of potential changes in habitat selection by pre-nesting Spectacled Eiders after construction of CD-3.

We also evaluated habitat selection by nesting eiders 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. After construction of the CD-3 pad and airstrip in 2005, 78% of the nests (14 of 18 nests) occurred in the same 2 preferred habitats (Figure 7). A goodness-of-fit test was used to compare the use of preferred and non-preferred nesting habitats between 2005 and pre-CD-3 construction years, using 2001–2004 nests to compute the expected values of habitat use, and found no change in use of preferred habitats by nesting birds between those years ($\chi^2 = 0.39$, df = 3, $P = 0.94$).

SUMMARY

The number of pre-nesting Spectacled Eiders counted during aerial surveys of the Colville Delta has declined for the last several years, although 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, may be due to the difference in the size of the 2 areas being compared (where dissimilar trends are occurring), or may be an indication that fewer eiders are using the Colville Delta during pre-nesting.

Pre-nesting groups of Spectacled Eiders have not displayed an obvious spatial response (increased distance or change in use of preferred habitat) to the oilfield facilities that have been built since 1998 on the Colville Delta. Similarly, nest locations of Spectacled Eiders in the CD-3 area did not indicate displacement from the area of the gravel footprint that was created during the previous winter and the level of use of preferred habitats was similar to that observed during pre-construction surveys. 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 factors will not be possible until the sample size of nests increases in subsequent years.

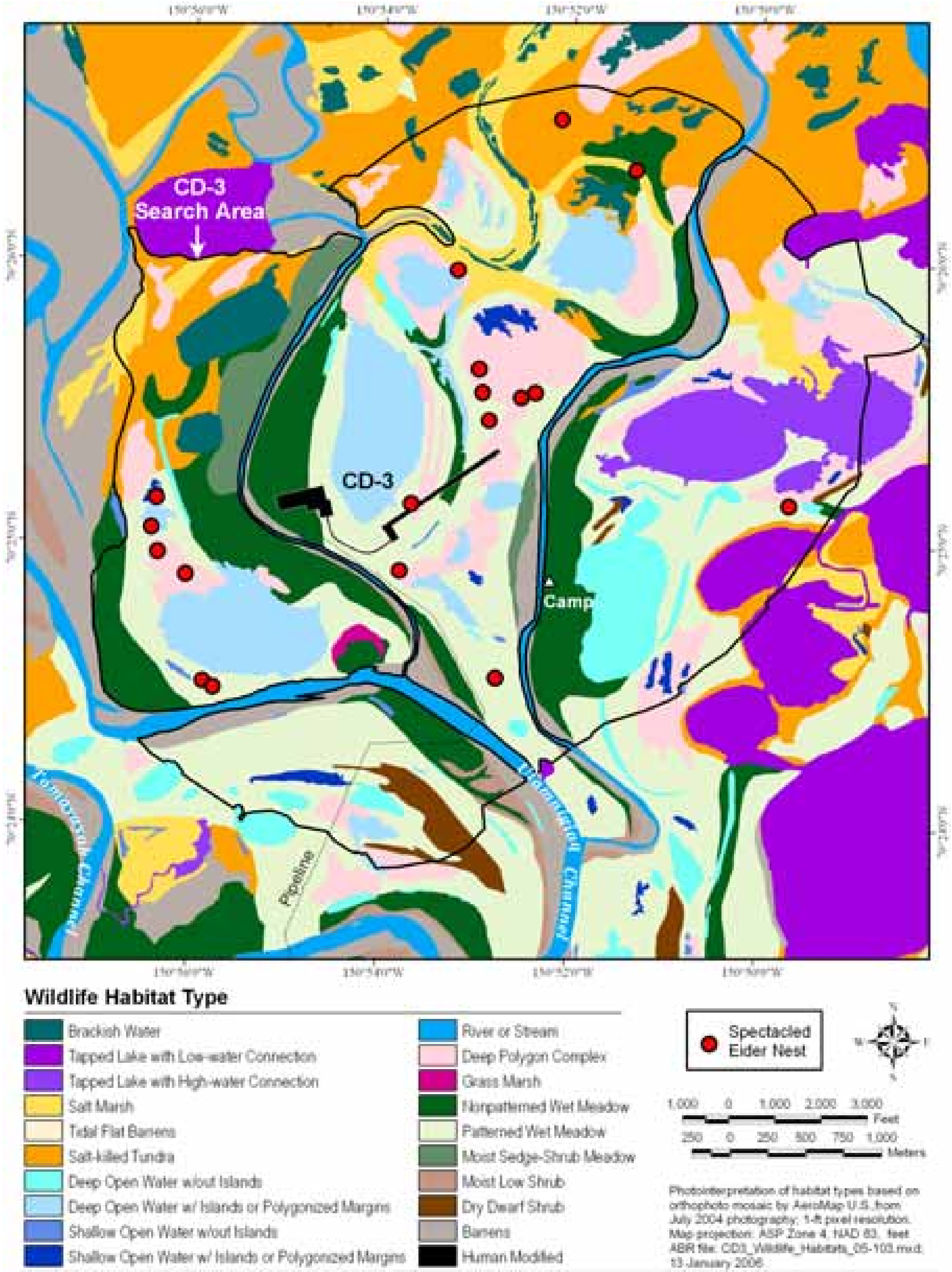
Nesting success typically is low for Spectacled Eiders, averaging 37% in the CD-3 nest-search area since 1993. In 2005, 12 of 18 nests failed for a success rate of 33%. Predators ultimately were involved in all but one nest failure, whether they attacked incubated nests or took eggs from unattended nests (while the hen was on normal recess or a recess caused by disturbance). Nest failures clearly were caused by arctic foxes in 3 cases where they drove off incubating Spectacled Eiders, and causality was less clear at 3 nests where disturbance, poor nest attendance, and avian predation all were involved. Avian predators ultimately took the eggs at these 3 nests and at 1 more nest where disturbance was not observed

Table 10. Habitat selection of nesting Spectacled Eiders in the CD-3 project area, Colville Delta, Alaska, 2005.

	2001–2004					2005				
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	0	0	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	5.6	4.2	ns	low
Salt-killed Tundra	3	6.7	11.8	ns		1	5.6	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	1	5.6	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	5.6	0.9	ns	low
Deep Polygon Complex	13	28.9	12.1	prefer		5	27.8	12.2	ns	low
Grass Marsh	0	0	0.2	ns	low	0	0	0.2	ns	low
Nonpatterned Wet Meadow	2	4.4	14.7	ns		0	0	14.6	ns	low
Patterned Wet Meadow	19	42.2	25.9	prefer		9	50.0	26.1	ns	low
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			18	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



Photointerpretation of habitat types based on orthophoto mosaic by AeroMap U.S. from July 2004 photography; 1-ft pixel resolution. Map projection: ASP Zone 4, NAD 83, feet ABR file: CD3_Wildlife_Habitats_05-103.mxd 13 January 2006

Figure 7. Habitat map and nest locations in the CD-3 nest-search area, Colville Delta, Alaska, 2005.

directly (not monitored by cameras). Avian predators identified on camera images were Parasitic Jaegers (at 3 nests) and Glaucous Gull (at 1 nest following Parasitic Jaeger predation). The cause of failure was unknown at 5 nests, of which 2 nests were abandoned or failed prior to discovery and apparently not affected by construction related disturbance (both nests were >1,200 m from CD-3 and not in the primary helicopter flight paths). Further analyses are planned to evaluate the effects of helicopter and other sources of disturbance on the incubation activities of monitored Spectacled Eiders; these analyses should shed light on whether nesting Spectacled Eiders are responding behaviorally to identified disturbances (other birds, people, predators, helicopters, or vehicles) and whether those responses increase the probability of nest failure.

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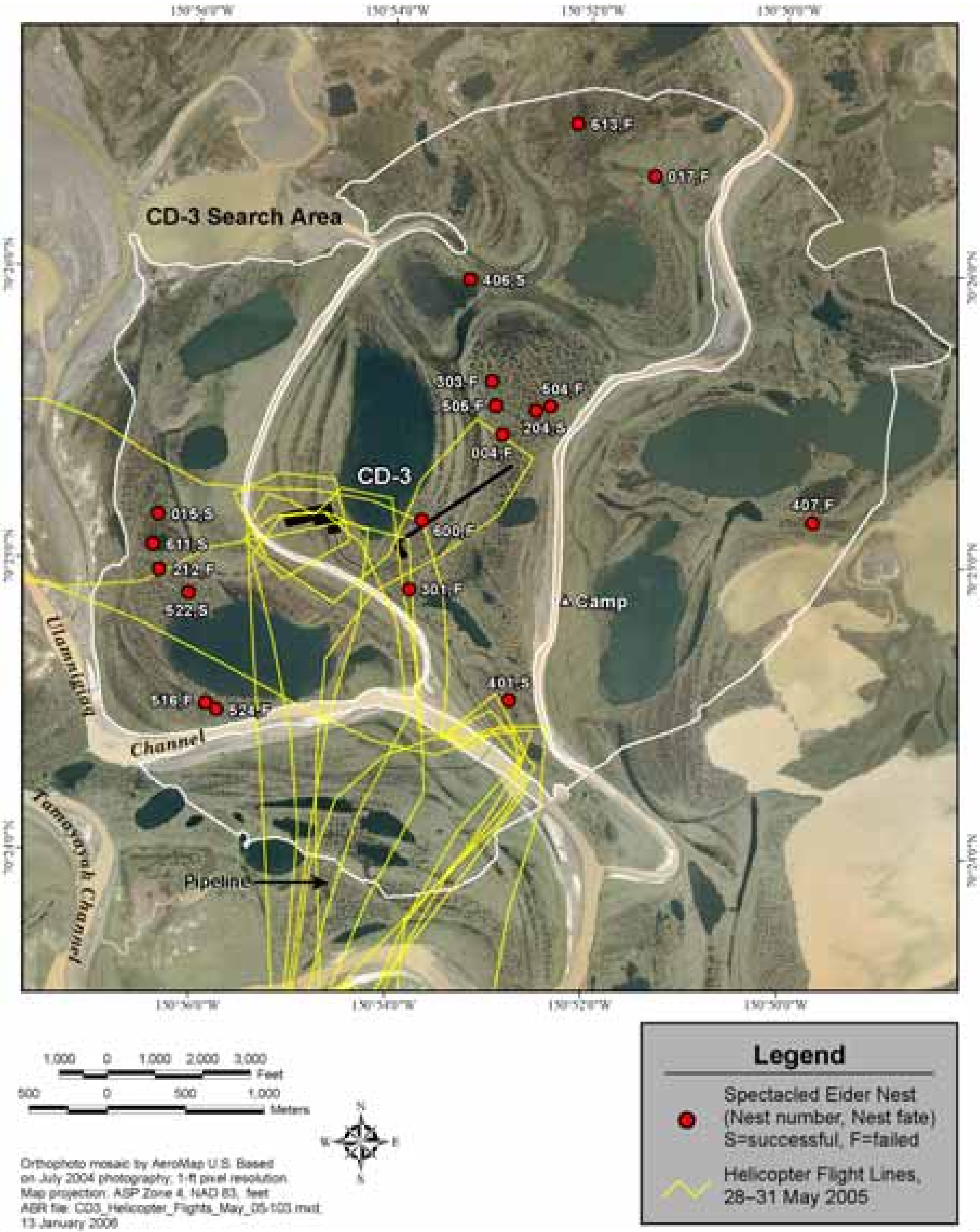
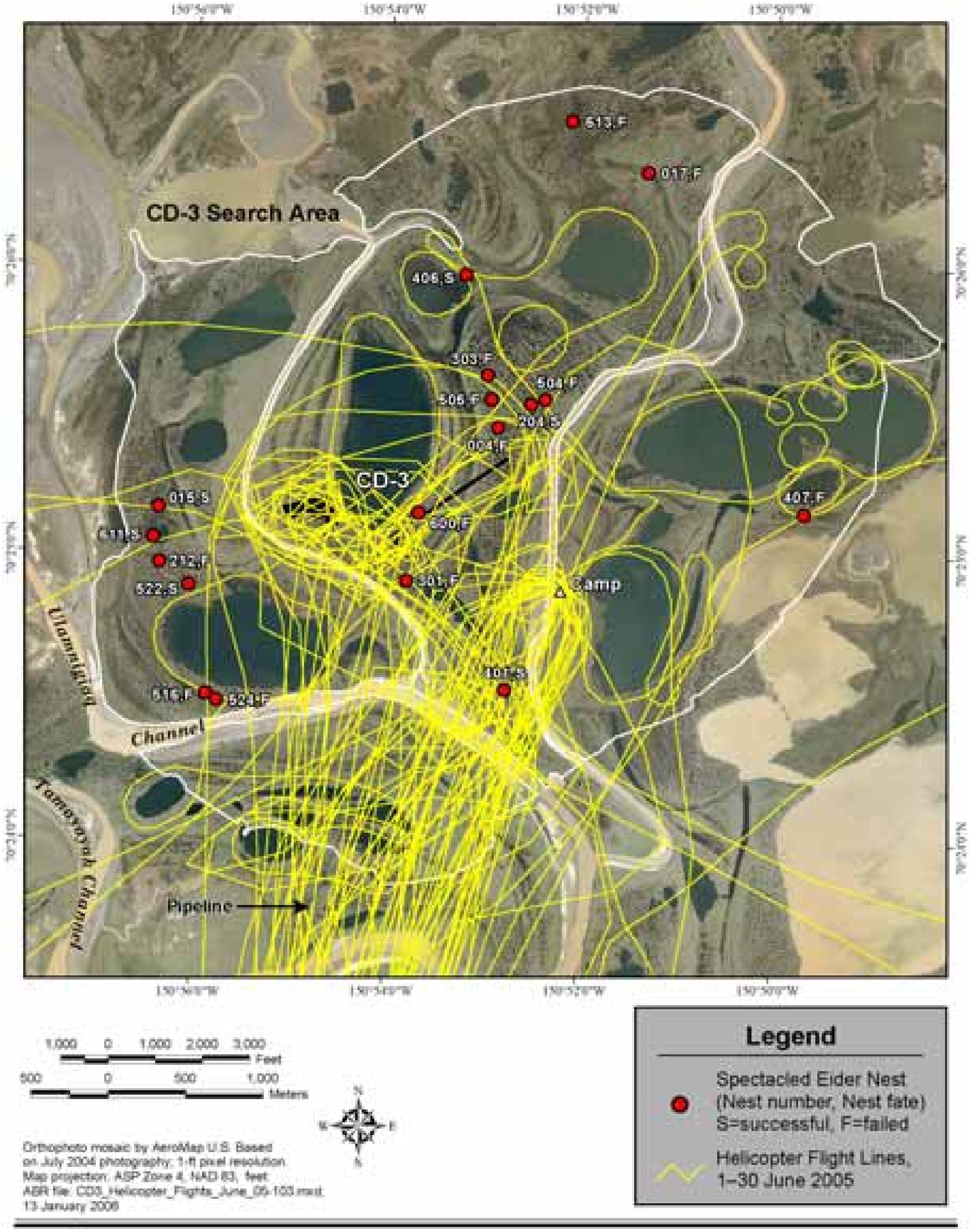
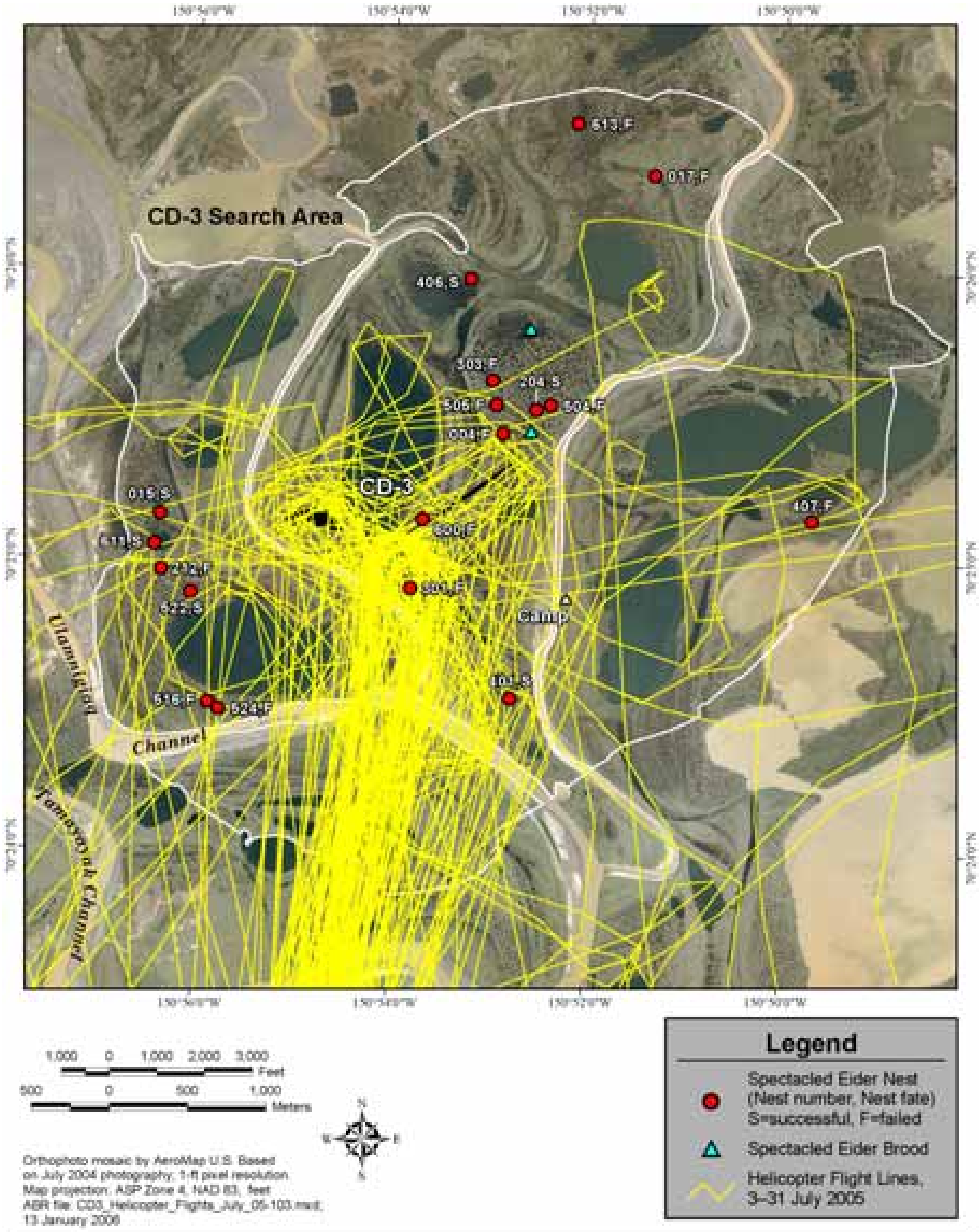


Orthophoto mosaic by AeroMap U.S. Based on July 2004 photography; 1-ft pixel resolution
Map projection: ASP Zone 4, NAD 83, feet
ABR file: CD3_Helicopter_Flights_May_05-103.mxd; 13 January 2006

Appendix 1. Helicopter flight lines and Spectacled Eider nests in the CD-3 project area, Colville Delta, Alaska, May 2005.

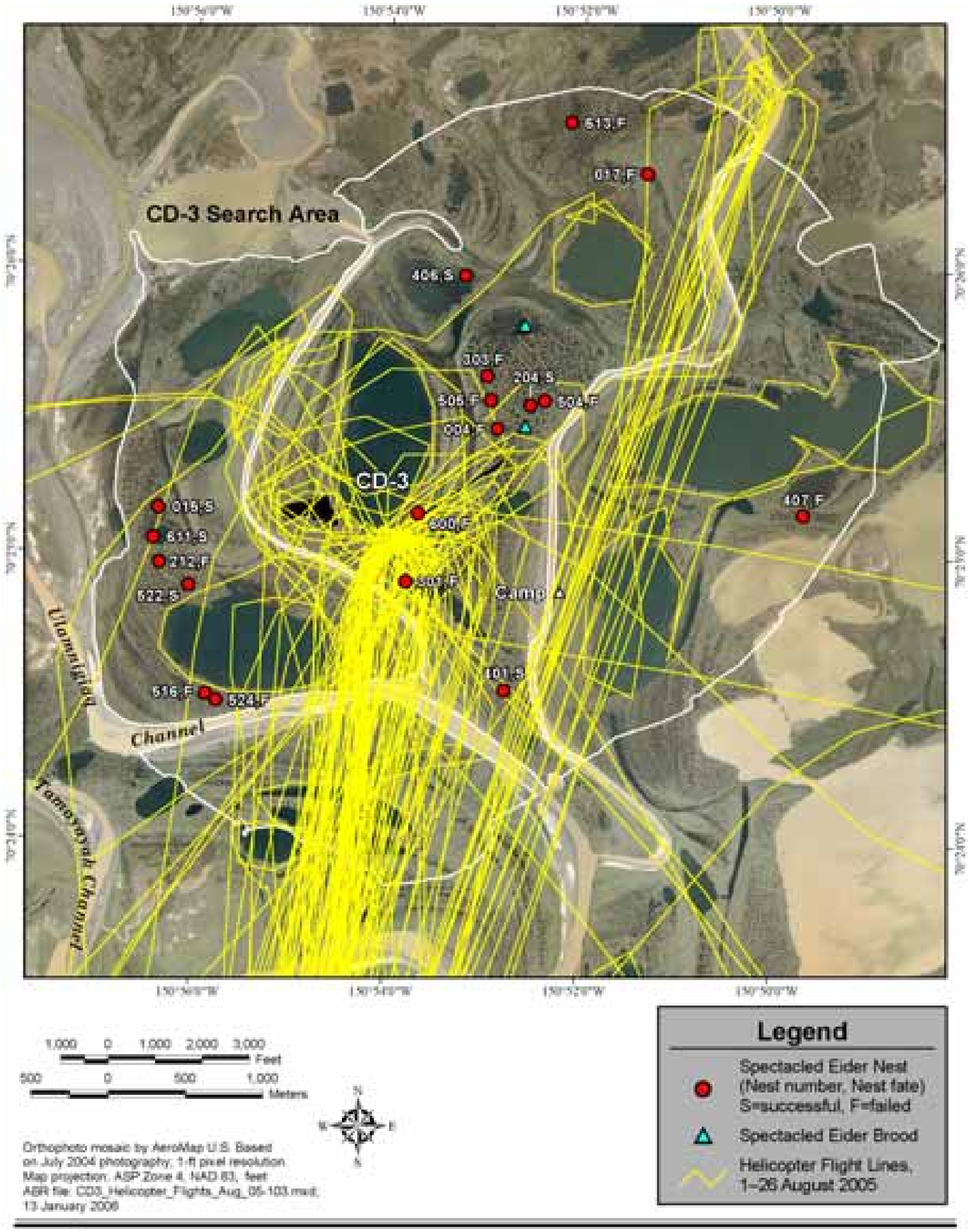


Appendix 2. Helicopter flight lines and Spectacled Eider nests in the CD-3 project area, Colville Delta, Alaska, June 2005.



Orthophoto mosaic by AeroMap U.S. Based on July 2004 photography; 1-ft pixel resolution
Map projection: ASP Zone 4, NAD 83, feet
ABR file: CD3_Helicopter_Flights_July_05-103.mxd; 13 January 2006

Appendix 3. Helicopter flight lines and Spectacled Eider nests and broods in the CD-3 project area, Colville Delta, Alaska, July 2005.



Orthophoto mosaic by AeroMap U.S. Based on July 2004 photography; 1-ft pixel resolution
Map projection: ASP Zone 4, NAD 83, feet
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Appendix 4. Helicopter flight lines and Spectacled Eider nests and broods in the CD-3 project area, Colville Delta, Alaska, August 2005.