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# NESTING STATUS OF THE COMMON EIDER AND OTHER BARRIER ISLAND NESTING BIRDS ON CENTRAL ALASKAN BEAUFORT SEA BARRIER ISLANDS, 1999

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# NESTING STATUS OF THE COMMON EIDER AND OTHER BARRIER ISLAND NESTING BIRDS ON CENTRAL ALASKAN BEAUFORT SEA BARRIER ISLANDS, 1999

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## ABSTRACT

Common eider (*Somateria mollissima v-nigrum)*, glaucous gull (*Larus hyperboreus*), arctic tern (*Sterna paradisaea*), king eider (*Somateria spectabilis*), and American golden plover (*Pluvialis dominica*) nests were located and quantified on barrier islands along the central Alaskan Beaufort Sea coast from Thetis Island to the McClure Islands during 12 to 17 July 1999. Common eider nests were most numerous, accounting for 82% (214 of 260) of all active nests within the approximately 520 ha area searched. Glaucous gulls accounted for 15% (38 of 260) of active nests, and arctic terns accounted for 2% (5 of 260). Mean and 95% confidence intervals of clutch size for common eider nests were $3.03 \pm 0.229$ eggs/nest ($n = 69$), for glaucous gulls $1.80 \pm 0.657$ eggs/nest ($n = 10$), and for arctic terns $1.75 \pm 0.796$ eggs/nest ($n = 4$). When distribution of active common eider nests were compared among the Jones Islands, the Return Islands, the Midway Islands, the McClure Islands, Thetis Island, and Spy Island; active nests were concentrated on the Return Islands (Egg Island) and the McClure Islands ($\chi^2 = 145.55$, df = 5, $p < 0.0001$, Table 2). Egg Island had by far the highest density of active common eider nests with 7.8 active nests/ha followed by Karluk Island with 1.8 nests/ha and Jeanette Island with 1.0 nests/ha. Glaucous gull nests were also most concentrated on Egg Island with 1.5 nests/ha, followed by Karluk Island with 0.6 nests/ha. Of the 295 recorded common eider nest sites for which habitat data were collected, 10 nest sites (3%) had no driftwood, 90 nest sites (31%) were located in low-density driftwood habitat, 125 (42%) were in medium-density driftwood, and 70 (24%) were in high-density driftwood habitat. Common eider nest sites appeared to occur more frequently in medium-density driftwood and less frequently in no driftwood ($\chi^2 = 93.43$, df = 3, $p < 0.0001$). The most productive nesting islands during the period 1970 to 1999 were Cross Island (mean and 95% CI = $122.9 \pm 37.41$ nests/year), Pole Island (mean = $59.8 \pm 40.35$ nests/year), Lion Point (mean = $55.6 \pm 50.59$ nests/year), Egg Island (mean = $42.8 \pm 13.37$ nests/year), Thetis Island (mean = $41.6 \pm 14.94$ nest/year), and Stump Island (mean = $39.6 \pm 22.63$ nests/year). The barrier islands have gradually shifted westward and changed configurations over the years, and the boundaries between islands can be confused or non-existent in some years. Because common eiders are long-lived and exhibit remarkable fidelity to nest sites, nest census activities should focus on these locations. Predation by glaucous gulls and arctic foxes (*Alopex lagopus*) had a marked impact on nesting of common eiders in 1999. Of the 85 failed common eider nests, 74 (87%) failed due to depredation, with 86% (64 of 74) of these due to glaucous gulls or undetermined avian predators, and 5% (4 of 74) due to arctic foxes.



Key words: Common eider, *Somateria mollissima v-nigrum,* Pacific eider, glaucous gull, arctic tern, arctic fox, egg predation, central Alaskan Beaufort Sea, Alaska, barrier islands

## INTRODUCTION

Although several hundred thousand eiders of four species migrate into the Beaufort Sea each spring (Dickson 1997), only 2,000 to 3,000 common eiders (*Somateria mollissima v-nigrum,* Pacific race of the common eider) nest along the Beaufort Sea coast of Alaska (Johnson and Herter 1989, Johnson 2000). Most common eiders nest in loose aggregations or colonies on coastal sand and gravel barrier islands and many of the most productive aggregations occur in driftwood accumulations on relatively high-elevation islands that lie in the flood plumes of large rivers. Common eiders initiate nests during mid- to late June (Johnson and Herter 1989), producing an average of 4 eggs, which are incubated for approximately 26 days. Female common eiders generally select nest sites in areas of relatively dense driftwood and/or lymegrass (*Elymus arenarius*) cover. Peat banks may also be used for nesting, with hens making nest bowls within the eroded and terraced peat shorelines. Hatching success is positively correlated with cover density (Schamel 1977, Johnson et al. 1987). Broods remain near lakes, in tidal ponds or lagoons, or in the nearshore-ocean for up to 6 to 12 weeks (Johnson 2000) before migrating out of the Beaufort Sea. Details on the biology of common eiders in the Alaskan Beaufort Sea are given in Johnson (2000).

Predation on eggs and ducklings by arctic foxes (*Alopex lagopus*) and glaucous gulls (*Larus hyperboreus*) can be heavy in some years (Larson 1960), and has been shown to be a major factor in population declines of common eiders in southern Sweden (Pehrsson 1973). A study that assessed impacts of petroleum development activities on nest success of common eiders on Thetis Island, off the Colville River delta, indicated that restrictions of low-level aircraft over flights, limited human intrusions, and removal of arctic foxes, substantially increased common eider hatching and fledging success compared to most other wild populations (Johnson 1984, Johnson et al. 1987).

Other barrier island nesting species include the glaucous gull and the arctic tern (*Sterna paradisaea*). In the Alaskan Beaufort Sea, glaucous gulls nest on coastal gravel/sand bars and low islands (Johnson and Herter 1989) and are most abundant on barrier islands adjacent to river outflows. As with common eiders, glaucous gulls probably select these islands because they are surrounded by open water during spring runoff, which isolates these sites from terrestrial predators. Arctic terns nest in areas of sparse vegetation, which makes the barrier islands an important nesting habitat for them as well (Hawksley 1957 in Johnson and Herter 1989).

The central Alaskan Beaufort Sea barrier islands included in this study are between Thetis Island and Karluk Island (Fig. 1, Table 1). Most of these islands are composed of sand and gravel substrates, with varying amounts of driftwood cover, although portions of remnant tundra occur on Pingok, Bodfish, and Cottle islands. Search efforts were concentrated on gravel portions of the barrier islands and along the southern edges of peat banks.

### Issues

Issues concerning common eiders and other barrier island gravel-nesting species in the central Beaufort Sea are 1) disturbance and displacement during nesting, 2) loss of nesting habitat, and 3) increased predation by arctic foxes, glaucous gulls, grizzly bears (*Ursus arctos*) and polar bears (*Ursus maritimus*) attracted to the development area.

### Objectives

1. Determine the distribution and abundance of nesting common eiders and other gravel-nesting species on barrier islands in the central Alaskan Beaufort Sea.

2. Determine the presence of foxes and avian predators on these barrier islands and document nest depredations.

3. Visually mark a sample of common eider females to determine nest site fidelity among selected barrier islands.

## METHODS

Nest searches were conducted on coastal barrier islands in the central Alaskan Beaufort Sea: Thetis Island, Spy Island, the Jones Islands (Leavitt, Pingok, Bertoncini, and Bodfish), the Return Islands (Cottle, Long, and Egg), the Midway Islands (Reindeer), and the McClure Islands (Narwhal, Jeanette, and Karluk). Surveys were conducted between 12 and 17 July 1999 and documented the number of nesting common eiders (common eiders), glaucous gulls and arctic terns. During surveys, we recorded the number of active nests, failed nests, and nest attempts by each species, and recorded any evidence of predators or depredation. Access to the islands was by helicopter.

Nests searches were conducted on foot by 2 to 4 observers spaced across the width of the island. Surveys were initiated on the Return Islands, proceeded westward to the Jones Islands, Spy and Thetis islands, and finished with Reindeer and Egg islands, and the McClure Islands. For each nest we recorded the bird species, nest type (pre-nest scrape or actual nest), status, (active nest or depredated), driftwood density near the nest, and the presence and numbers of eggs. Driftwood density was classified into four categories based on the percentage of ground covered with driftwood in a 1-m diameter area centered on the nest bowl. These densities included none (0%), low (1 to 33%), medium (34 to 66%), and high (67 to 100%) density (after Johnson et al. 1987). Observers minimized disturbance to nesting birds by avoiding flushing incubating adults from nests, and by covering nests with down and twigs when birds were accidentally flushed. Nest positions and times were recorded on field maps based on either 1:6000-scale digital mapping or outline figures based on 1:6000-scale enlargements of 12 July 1998 natural color aerial photography. Nests and sightings were then geo-referenced by digitizing these locations with date, time and observer identification; date, time, and observer then linked these two databases. Available island areas were calculated using MapInfo Professional™ (1997) geographic information system (GIS). Gravel habitats mapped on 1:6000-scale digital base maps were used to prepare polygons for area calculations.

Nesting effort for each species on each island was calculated by dividing the total number of nests and scrapes found on one island by the total number of nests and scrapes found on all the islands searched during our surveys. Nests included a pronounced bowl with some associated down and often contained small sticks (Johnson 1990, 2000). Nests were classified as active if they contained one or more live eggs, or were occupied by a laying/incubating female (Fig. 2). Pre-nesting scrapes were depressions in the ground with or without small sticks but with no associated down (Fig. 2, Johnson 1990). Scrapes are frequently made by juvenile females attempting their first nests, or by adult females prospecting for nest sites. These scrapes are subsequently abandoned when the juvenile female fails to nest or the adult female nests in a more suitable or different location.

Nests were considered depredated when eggshell fragments in the nest bowl or vicinity indicated a bird or mammal had eaten or dislodged the eggs, or when nests with down contained no eggs. Predator type was determined by the presence of fox or gull tracks near the disturbed nest, the characteristics of remaining egg fragments, or direct observation of predators on the island. Crushed eggs were generally attributed to arctic fox when there was evidence of foxes on the island. Depredated eggs with rounded openings were generally attributed to avian predators, especially when there were no signs of other predators. Nests with down and no eggs or egg shell fragments were generally considered depredated by avian species when avian predators were also observed and there were no obvious signs of foxes on the island.

In order to determine nest site fidelity among islands, we banded and marked a small sample of female common eiders with nasal disks. We chose Narwhal Island for our capture efforts because few glaucous gulls were nesting on this island. Birds were captured using a salmon dip net while they sat on their nests. Tarsus bands and colored nasal disks were applied. Standard bill and tarsal measurements and body weight were recorded.

## RESULTS

Between 2 and 4 people spent a total of 94.7 person hours searching the gravel portions of the barrier islands over a 6-day period from 12 to 17 July 1999 (Table 1). Search effort included 10.3 person hours on Thetis Island (entire surface not covered), 10.8 person hours on Spy Island, 17.7 person hours on the Jones Islands, 38.1 person hours on the Return Islands, 4.0 person hours on Reindeer Island, and 9.8 person hours on the McClure Islands (Table 1). Two hundred sixty active nests, 127 failed nests, and 570 pre-nesting scrapes were recorded for 5 species on 13 of the 14 islands searched from 12 to 17 July 1999 (Table 2). Fox sign was detected on only the Jones and Return Island groups (7 of the 14 islands searched, Table 1). Four female common eiders were captured and banded on Narwhal Island on 17 July 1999.

### Nesting Effort

Five species, common eider, glaucous gull, arctic tern, king eider (*Somateria spectabilis*), and American golden plover (*Pluvialis dominica*) were recorded nesting on central Alaskan Beaufort Sea islands during July 1999 (Table A-1, Figures 3 to 7). Common eiders dominated the total nesting effort at 85% (812 of 957 total nests and scrapes recorded), followed by glaucous gulls at 14% (134 of 957), and arctic terns at 1% (6 of 957, Table 2). A total of 260 active nests were recorded (Table 2). Common eider nests were most numerous, accounting for 82% of the total active nests (214 of 260 nests), followed by glaucous gulls at 15% (38 of 260), and arctic terns at 2% (5 of 260, Table 2). Mean and 95% confidence intervals (95% CI) of clutch size for common eider nests were $3.03 \pm 0.229$ eggs per nest ($n = 69$), for glaucous gulls $1.80 \pm 0.657$ eggs per nest ($n = 10$), and for arctic terns $1.75 \pm 0.796$ eggs per nest ($n = 4$). Many nests with incubating adults remained undisturbed, which limited data on clutch sizes.

Between 287 and 440 common eiders in 29 to 32 groups were recorded during 3 aerial surveys of the barrier island-lagoon systems between Spy Island and Brownlow Point from 30 July to 5 August 1999 (Noel et al. 2000). These included from 70 to 116 adults and 203 to 324 young-of-year (yoy). Plots of crèche locations on 30 July 1999, based on 30-sec time periods indicate that common eiders nesting on Cottle Island, Stump Island, Reindeer Island, the McClure Islands, the Stockton Islands, and the Maguire Islands may have hatched successfully (Figures A-1 to A-3). Plots of crèche locations on 1 and 5 August indicate that crèches may have moved between islands and to mainland shoreline locations (Figures A-4 to A-9). Mean and

95% CI of crèche size based on these aerial data ranged from 13.7 $\pm$ 4.33 eiders per crèche on 30 July to 9.9 $\pm$ 2.99 eiders per crèche on 1 August. Mean and 95% CI of yoy within crèches ranged from 10.3 $\pm$ 4.22 yoy per crèche on 5 August to 7.0 $\pm$ 2.30 yoy per crèche on 1 August accompanied by 2.4 $\pm$0.65 and 2.9 $\pm$ 0.97 females per crèche, respectively. Extrapolating the expected number of yoy eiders based on mean clutch size and the 214 active eider nests located in 1999 (214 nests * 3.03 eggs/nest = 648 yoy eiders), indicates that the number of yoy based on this aerial survey data is smaller than expected (50%, 324/648). These aerial data may underestimate the number hatched for the following reasons: 1) some eider crèches present may not have been detected or size was underestimated; 2) significant mortality of eider eggs/ducklings may have occurred; or 3) crèches may have moved out of these lagoon systems before 30 July. By 26 August few common eiders and eider crèches remained within our aerial survey area (Noel et al. 2000).

For all 5 species combined and for common eiders, total nesting effort (sum of active, failed and attempted nests) was greatest on Thetis, Spy, and Egg islands followed by Narwhal Island and Long Island-East (Table 2). Glaucous gull nesting effort was greatest on Long Island-East and Egg Island followed by Long Island-West and Thetis Island. Arctic terns nested on Spy, Bodfish, Long Island-West, Narwhal, and Jeanette islands with 1 active nest on each island (Table 2).

When active common eider nests were compared among the Jones Islands, the Return Islands, the Midway Islands, the McClure Islands, Thetis Island, and Spy Island; active nests were concentrated on the Return Islands (Egg Island) and the McClure Islands ($\chi^2 = 145.55$, df = 5, $p < 0.0001$, Table 2). Common eider nest attempts, expressed as the number of pre-nesting scrapes, were also not evenly distributed among island groups. Nesting attempts were also concentrated on the Return and McClure island groups and Thetis Island ($\chi^2 = 146.82$, df = 5, $p < 0.0001$, Table 2). In addition, the distribution of attempted nesting did not reflect the distribution of active nests ($\chi^2 = 29.31$, df = 5, $p < 0.0001$, Table 2). Fewer than expected common eider nests occurred on Thetis and Spy islands, while more nests than expected occurred on the Return and McClure island groups. Conversely more scrapes than expected occurred on Thetis and Spy islands, while fewer scrapes than expected occurred on the Return Islands. These differences reflect differential nesting success across the island groups.

**Habitat**

The total surface area of sand and gravel habitat on each barrier island in the study area was computed in order to compare nest density among islands (Table 1, Figures 3 to 7). Not all available sand and gravel habitats represents good nesting habitat for common eiders, glaucous gulls, or arctic terns, but these numbers provide a basis for comparison among islands. Egg Island had by far the highest density of active common eider nests with 7.8 active nests/ha followed by Karluk with 1.8 nests/ha and Jeanette Island with 1.0 nests/ha (Table 3). Glaucous gull nesting was also most concentrated on Egg Island with 1.5 nests/ha followed by Karluk Island with 0.6 nests/ha. Unfortunately, island configuration and the extent of exposed habitat are not consistent among years. Channels defining individual islands are not consistent year-to-year as well, which further confuses definition of island areas.

Of the 295 recorded common eider nest sites for which habitat data were collected, 10 nest sites (3%) had no driftwood, 90 nest sites (31%) were located in low-density driftwood habitat, 125 (42%) were in medium-density driftwood, and 70 (24%) were in high-density driftwood habitat (Table 4, Fig. 2). Common eider nest sites appeared to occur more frequently in medium-density driftwood and less frequently in no driftwood habitat ($\chi^2 = 93.43$, df = 3, $p < 0.0001$, Table 4). Vegetation was also used as nesting cover by common eiders: common species included lymegrass, seabeach sandwort (*Honckenya peploides*), *Puccinellia phryganodes*, scurvy grass (*Cochlearia officinalis)*, dwarf willow (*Salix* spp.), and wormwood (*Artemisia* spp.). Of the 7 common eider nest sites in vegetation cover, 3 were in lymegrass and 4 were in other vegetation types. Of these 7 nest sites, 5 had no driftwood and 2 were in low-density driftwood cover.

Common eider pre-nesting scrapes occurred more frequently in low-density driftwood cover and less frequently than expected in no and high driftwood covers ($\chi^2 = 491.81$, df = 3, $p < 0.0001$, Table 4). These analyses, however, do not account for the availability of driftwood habitats. Comparison of active and predated common eider nest sites by driftwood cover shows a trend for active nests to occur more frequently within high and medium-density driftwood covers; while predated nests occur less frequently within high and medium-density driftwood covers. This trend was not significant however ($\chi^2 = 3.76$, df = 3, $p = 0.2890$, Table 4). When active and failed common eider nest sites are compared to pre-nesting scrapes, more nest sites and fewer scrapes occur in high and medium-density driftwood covers ($\chi^2 = 118.32$, df = 3, $p < 0.0001$, Table 4).

Glaucous gull nest sites occurred most frequently in low-density driftwood cover ($\chi^2 = 87.40$, df = 3, $p < 0.0001$, Table 4). Active glaucous gull nests were more likely to occur in medium-density driftwood when compared to predated nest sites, which occurred more frequently than expected in low-density driftwood cover. Nests and pre-nesting scrapes had similar driftwood cover ($\chi^2 = 2.74$, df = 3, $p = 0.4336$, Table 4). Arctic terns nested in medium and low-density driftwood cover, with more nests occurring in low-density driftwood (Table 4).

### Predation

Of 299 common eider nests recorded during this study, 214 (72%) were active nests with live eggs or already hatched young (Table 2). Of the 85 failed nests, 74 (87%) failed due to depredation with 86% (64 of 74) of these due to glaucous gull or undetermined avian predators and, 5% (4 of 74) due to arctic foxes (Table 3). There was evidence of possible human depredation of common eider nests on Thetis Island. Bodfish and Spy islands had the highest proportion of depredated eider nests (4 of 4, 100% and 36 of 63, 57%, respectively, Table 3). The scarcity of common eider nests and pre-nesting scrapes on the Jones Islands are likely due to the presence of an arctic fox (Table 1). This fox was likely on the islands prior to nest initiation and resulted in low nesting effort on these islands (Table 2).

Fate of glaucous gull nests was more difficult to determine than fate of common eider nests. The use of a nest site during the current nesting season was based on the presence of feathers. It is likely that some glaucous gull nests determined to be active in 1999 may not have been active. This could lead to an overestimate of the number of failed glaucous gull nests. Of the 42 failed glaucous gull nests recorded, there was direct evidence of avian depredation at 2 nests (Table 3).

### Banding

Four female common eiders were captured on Narwhal Island between 12:40 and 14:50 on 17 July 1999. Capture locations on Narwhal Island along with color codes for nasal disks put on each female are illustrated in Figure 8. Weights, measurements, nest identification, clutch size, and band codes are listed in Table 5.

## DISCUSSION

### Nesting Effort

Common eiders, glaucous gulls, and arctic terns use Beaufort Sea barrier islands as nesting sites (Johnson and Herter 1987). Nest searches on barrier islands from the Maguire Island group to Flaxman Island in 1998 indicated that nesting success on Flaxman, Northstar, and Duchess islands was low, probably because of arctic fox predation. Nesting success on

Challenge and Alaska islands in 1998, where no fox signs were evident, appeared to be high (Noel et al. 1999a). During 1999, we concentrated efforts on the Jones-Return Islands, which were contiguous from Bertoncini Island eastward through to Long Island. There was evidence that a fox had traveled the length of these islands and an arctic fox was sighted on Pingok Island. Fifteen percent of recorded common eider nesting effort was expended on this length of the Jones-Return Island group, which represented nearly 61% of the habitat searched (Tables 1 and 2). The highest concentration of active nests was on Egg Island with 7.8 nests/ha. Nests and pre-nesting scrapes on Egg Island represented 19% of the total recorded effort, while they occurred on 2% of the total nesting habitat searched (Tables 1 and 2).

Data on active common eider nests along barrier islands in the central Alaskan Beaufort Sea have been recorded from 1970 to 1999 (Table 6). The most productive islands have included Cross Island (mean and 95% CI = 122.9 $\pm$ 37.41 nests/year), Pole Island (mean = 59.8 $\pm$ 40.35 nests/year), Lion Point (mean = 55.6 $\pm$ 50.59 nests/year), Egg Island (mean = 42.8 $\pm$ 13.37 nests/year), Thetis Island (mean = 41.6 $\pm$ 14.94 nest/year), and Stump Island (mean = 39.6 $\pm$ 22.63 nests/year). Because common eiders are long-lived and exhibit remarkable fidelity to nest sites (Reed 1975 in Johnson 2000; Wiggins and Johnson 1992), it seems reasonable to concentrate nest census activities at these locations. Although it is not apparent from these data, the barrier islands have shifted configurations over the years and the boundaries between islands can be confused or non-existent in some years. Mapping of the Jones-Return Islands based on 1997 aerial photography indicates that divisions between islands remained distinct, however in 1999, islands from Long Island-East to Bertoncini Island were contiguous.

### Habitat

The presence of remnant tundra on an island may lead to lower nesting success for common eiders; even though remnant tundra can provide nesting habitat along the peat shorelines. Pingok, Cottle, Bodfish and Flaxman islands, all with remnant tundra, have averaged < 3 nests/year (Table 6). Although we did identify 5 active common eider nests on Cottle Island in 1999, these nests were located on the peat bank above the beach. Many previous searches may not have included these shoreline tundra habitats, and may have missed these inconspicuous nests. However, it is also likely that the larger size and presence of tundra provides habitat for arctic foxes, which prey heavily on common eiders and decrease nesting success. An arctic fox was sighted in 1998 on Flaxman Island (Noel et al. 1999a) and in 1999 on Pingok Island.

Female common eiders select nest sites with medium to heavy cover generally composed of lymegrass, driftwood, and other debris (Schamel 1977, Johnson et al. 1987, Wiggins and

Johnson 1991, 1992). Lymegrass cover was rare on the islands searched during 1999. Small lymegrass patches where common eiders attempted nesting occurred on Bodfish Island, Long Island-East, and Spy Island. Seven common eider nest sites included vegetation cover; of these, 3 were in lymegrass and 4 included other vegetation types. Schamel (1977) and Johnson et al. (1987) found that hatching success was positively correlated with cover density in the vicinity of the nest site. Although we could not determine hatching success in this study, there were significantly more common eider nest sites than pre-nesting scrapes in high- and medium-density driftwood habitats (Table 4). Although there was a trend toward more active nest sites and fewer predated nest sites in high- and medium-density driftwood these differences were not significant (Table 4).

The concentration of eider nests and scrapes in low- and medium-density driftwood cover may be a reflection of greater abundance of these habitat types compared to high-density driftwood habitats. Nests located in low and medium-density driftwood may be more conspicuous and more available to predators. Wiggins and Johnson (1991, 1992) stated that eiders prefer areas with dense driftwood cover partly for protection from predators.

Two other factors, which are related to each other, that probably influence common eider nesting habitat selection were (1) elevation and (2) the location of driftwood above the waterline. Johnson (2000) stated that common eiders that occupy high-elevation barrier islands have the highest nesting success and are the most productive. Height of driftwood above the waterline is determined by the elevation of the barrier island (Wiggins and Johnson 1991). Fall storm surges typically move driftwood to the highest points on the barrier islands thus it follows that the sand-gravel barrier islands with the highest elevation typically accumulate the most driftwood. Driftwood patches deposited high above the waterline can essentially protect nests from future storms and inclement weather. Another beneficial characteristic of high elevation islands is the potential for accumulation of wind-blown soil and the establishment of vegetation, which may also be used as nesting cover.

## Predation

Wiggins and Johnson (1991, 1992) found that arctic foxes and common ravens (*Corvus corax*) were the main predators of common eider eggs and that glaucous gulls were the main predators of common eider ducklings along the Endicott Causeway, which was constructed in 1984-1985 and colonized by common eiders in 1988. Most recently, Johnson (2000) reported that predation by foxes, ravens, and gulls on common eider eggs and young is likely the major factor regulating the abundance of common eiders in the North Slope oil fields. These findings correspond to our data, which show that both arctic foxes and glaucous gulls prey heavily on barrier island nesting birds. The principal predators identified on islands searched in 1998 were arctic foxes (Noel et al. 1999a), and in 1999 were glaucous gulls. The arctic fox present on the contiguous Jones-Return Islands (Long Island to Bertoncini Island) during 1999, probably influenced common eider nesting during nest initiation resulting in fewer nesting attempts on these islands rather than more predated nests. Female common eiders do not feed while they are incubating their eggs and thus are on a strict energy budget (Gorman and Milne 1971, 1972). Because of this, eiders may not have sufficient energy reserves to deal with disturbances by predators during incubation and still successfully incubate their clutch.

Predation pressures on individual islands can be variable from year to year (Johnson 2000) and this variability may account for some of the differences in nest activity and success among the islands. Access of mammalian predators, such as arctic fox, grizzly bears or polar bears, to large nesting colonies can severely depress nesting success (Johnson et al. 1993, Noel et al. 1999b). Predation pressure also accounts for some of the annual variation in nesting success on individual islands apparent in the historical data (Table 6, Johnson 2000). Other researchers have also found that arctic foxes prey heavily on common eider eggs (Quinlan and Lehnhausen 1982, Wiggins and Johnson 1991, 1992). The Endicott Causeway, situated in the Sagavanirktok River delta, was constructed during winter 1984-1985. Driftwood and other debris that serve as nesting cover for common eiders, began to accumulate and five years after construction, the causeway had a healthy and increasing common eider population. Johnson et al. (1993) described the dramatic decline in the number of eider nests and eider nest success after an arctic fox gained access to the causeway in 1992.

In general, predation on marine birds nesting on the barrier islands appears to be directly related to the degree of accessibility to the island by foxes. In particular, accessibility to the barrier islands by arctic foxes in the spring may have dramatic detrimental effects on the nesting birds of an island and likely is the primary cause of variability in predation from island to island and from year to year. Ice corridors to the islands and the timing of the ice melt are two possible factors that can create accessibility for foxes, isolating them on the island. Generally, according to Johnson et. al. (1987), common eiders begin nesting on the barrier islands after ice connections to the mainland have melted and after delta islands have become isolated due to river flooding. In 1998, sea ice on the northern sides of Flaxman, Northstar, and Duchess islands remained intact past the initiation of nesting (Noel et al. 1999a); and in 1999, the sand-gravel connections between the Jones-Return Islands allowed an arctic fox access to nearly this entire island group. It was likely that arctic foxes on the sea ice moving in to the mainland accessed these islands via the sea ice.

Most avian predation on common eider eggs that we observed was attributable to glaucous gulls. During the summer months, glaucous gulls opportunistically prey on the eggs of other birds (Eberhardt et al. 1982; Hiruki and Sterling 1989), but because common eiders and glaucous gulls often nest in close proximity to each other, glaucous gulls prey most heavily on eider eggs (Johnson and Herter 1989). Parasitic jaegers (*Stercorarius parasiticus*) and common ravens also prey on eggs of common eiders.

### Development

Oil development activities may affect predator abundance in various ways. Oil development and production infrastructure may attract, and even create new habitat for certain avian predators, such as common ravens and glaucous gulls. Some of the abandoned offshore exploration islands support colonies of nesting glaucous gulls. Ravens may be attracted to man-made structures such as towers and production modules for nest sites. Landfill sites provide food sources for ravens and glaucous gulls. Oil field activities and garbage around landfill sites and dumpsters may also attract terrestrial predators such as foxes and brown bears.

Certain types of industrial development may not adversely affect common eider nest success. Wiggins and Johnson (1991, 1992) found that common eiders could colonize man-made permanent gravel islands and causeways, such as the Endicott Causeway. Johnson et al. (1987) found that mitigation measures implemented during industrial activities on Thetis Island helped increase common eider hatching and fledging success on the island. This was at least in part due to the mitigation program implemented during the nesting season which controlled certain development activities that had the potential to disturb nesting common eiders, such as aircraft over flights and human intrusions. The development permit also called for the removal of arctic foxes from Thetis Island. In addition, Johnson (1984) found that man-made nesting structures placed on barrier islands did attract nesting females and could also be used as a mitigative tool during industrial development on barrier islands.

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