Habitat associations of nesting Spectacled Eiders on the Arctic Coastal Plain of Alaska

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Abstract

We studied nesting Spectacled Eiders *Somateria fischeri* and their habitats on the Colville River Delta and in the Kuparuk Oilfield on the Arctic Coastal Plain of Alaska in 1992–1995. On the Colville River Delta, most Spectacled Eider nests were found in aquatic sedge with deep polygons, nonpatterned wet meadows, and wet sedge–willow tundra. Most nests were located <1 m from water. In the Kuparuk Oilfield, we found 69% of all nests in basin wetland complexes, a mosaic of water bodies with stands of emergents and complex shorelines with numerous islands and peninsulas. Other habitats used for nesting included the margins of *Carex* ponds, *Arctophila* ponds, shallow ponds without emergents, and deep open lakes. As on the Colville River Delta, nests were usually located near water.

Résumé

De 1992 à 1995, nous avons étudié les Eiders à lunettes nicheurs (*Somateria fischeri*) et leurs habitats dans le delta de la rivière Colville et dans les champs pétrolifères de Kuparuk, dans la plaine côtière de l'Arctique en Alaska. Dans le delta de la rivière Colville, la plupart des nids d'Eiders à lunettes se trouvaient parmi des carex aquatiques avec des polygones profonds, en sol de prairie humide irrégulier et en toundra humide de carex et de saule. La plupart des nids étaient situés à moins de 1 m de l'eau. Dans les champs pétrolifères de Kuparuk, nous avons trouvé 69 p. 100 des nids dans des complexes de bassins en terres humides, une mosaïque de plans d'eau aux peuplements émergents et complexes comprenant de nombreuses îles et péninsules. Les autres habitats de nidification comprenaient les bords d'étangs *Carex*, les étangs *Arctophila*, les étangs peu profonds sans émergent et les lacs profonds ouverts. Comme dans le delta de la rivière Colville, les nids se trouvaient généralement près de l'eau.

1.0 Introduction

Spectacled Eiders *Somateria fischeri* have recently undergone severe declines in abundance in Alaska, particularly on the Yukon–Kuskokwim Delta (Stehn et al. 1993). Because of this decline, the species was listed under the *Endangered Species Act* as a "threatened species" on 9 June 1993 (U.S. Fish and Wildlife Service 1993). Prior to the listing, little research had been conducted on Spectacled Eiders in the northernmost portion of their breeding range (i.e., the Arctic Coastal Plain) in Alaska. Spectacled Eiders were included, however, in more general studies of waterbirds in the National Petroleum Reserve – Alaska (Derksen et al. 1981), at Storkersen Point, near Prudhoe Bay (Bergman et al. 1977), and in the early monitoring studies in the Prudhoe Bay area (ABR, Inc., unpubl. data; D.M. Troy, pers. commun.). Johnson and Herter (1989) reviewed the status and distribution of Spectacled Eiders along the Arctic Coastal Plain, including their abundance in the oilfields.

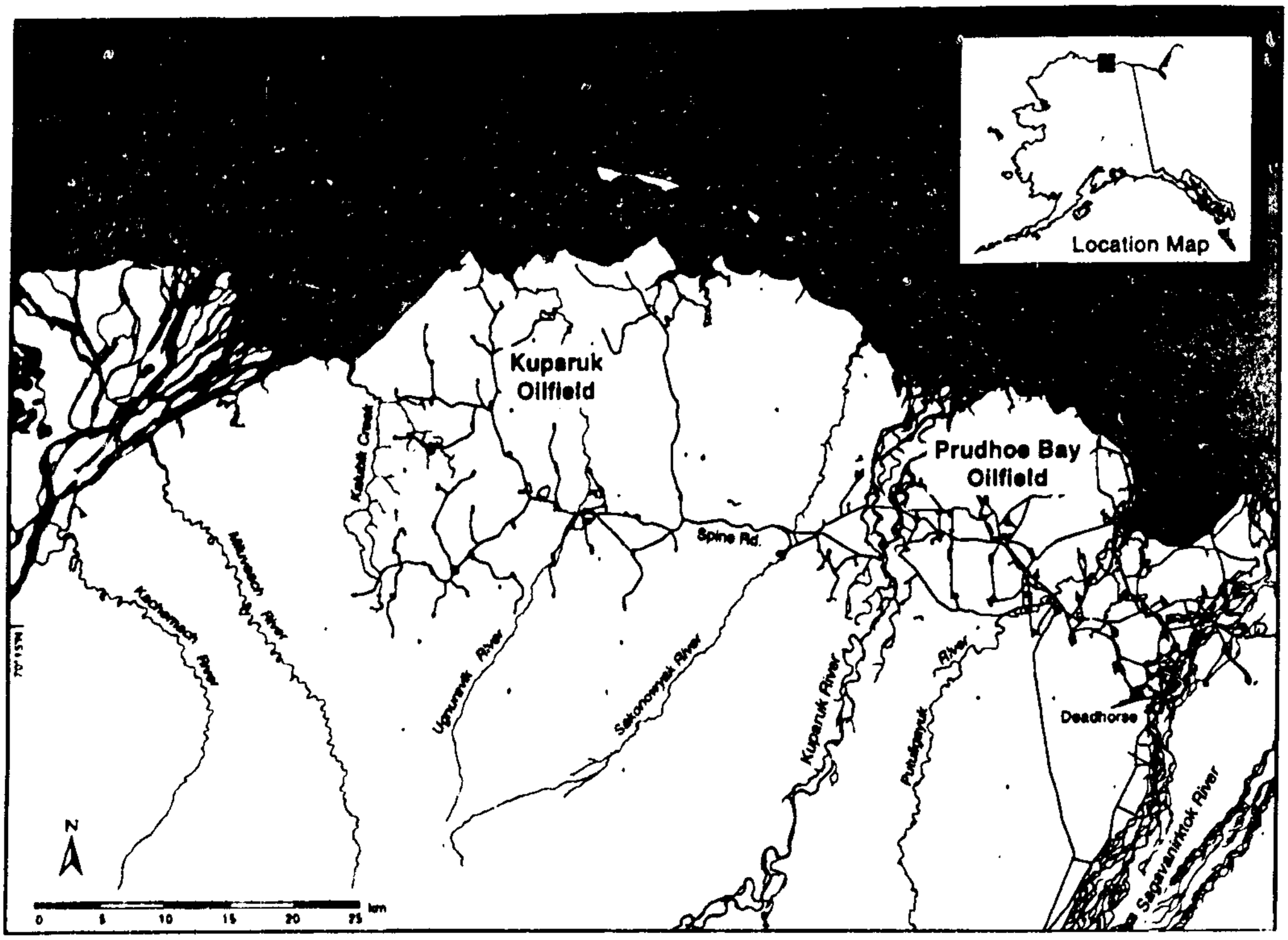
The general lack of data on breeding Spectacled Eiders on the Arctic Coastal Plain of Alaska and the interest of federal agencies in monitoring endangered species in areas of industrial development (e.g., the North Slope oilfields) spurred an increase in research on eiders in the oilfields and elsewhere on the coastal plain. Whereas the U.S. Fish and Wildlife Service has focused its research efforts on aerial surveys for eiders across the entire coastal plain, we and other biologists working in the oilfields have concentrated our research on determining breeding populations within the oilfields, monitoring nesting effort and success, and identifying habitats used by breeding eiders. In this paper, we present the results to date (1992–1995) of our studies on nesting habitats and discuss the habitat associations that we have determined for nesting Spectacled Eiders on the Arctic Coastal Plain of Alaska.

2.0 Study areas

The Colville River Delta is the largest river delta in arctic Alaska (~600 km²); its drainage basin encompasses 60 000 km², or 30% of all drainages on the Arctic Coastal Plain of Alaska (Walker 1983). The high discharge volume and heavy sediment load of the river produce a dynamic deltaic system that is characterized by diverse geomorphological and biological processes, creating a mosaic of wetland habitats. Some habitats unique to river deltas on the coastal plain have been formed, such as tapped lakes (lakes that are connected to the river by a narrow channel) and wetlands composed of coalesced ice-wedge polygons that retain permanent water (Walker 1983).

The Kuparuk Oilfield is located approximately 65 km west of Prudhoe Bay, between the Colville and Kuparuk rivers (Fig. 1). The area is dominated by landforms and habitats created by thaw lake cycles, fluvial process from the

Figure 1
Location of the Colville River Delta and Kuparuk Oilfield on the Arctic Coastal Plain of Alaska



rivers, and coastal processes of erosion, sediment deposition, and flooding. Wetland types created by the thaw lake cycle include large, wind-oriented thaw lakes, small ponds, drained lake basins, and seasonally flooded lowland areas (Walker and Acevedo 1987). Predominant wetland community types include wet sedge (*Carex* spp.) meadows, moist sedge–dwarf shrub (*Salix* spp.) meadows, and emergents (*Carex* and the pendant grass *Arctophila fulva*) along the margins of ponds and lakes. In coastal areas, brackish ponds and halophytic (saline) wet meadows (often referred to as arctic salt marshes) and salt-killed tundra also occur. Landforms and vegetation in the general region are similar to those described for the Prudhoe Bay area (Walker et al. 1980).

The habitat classification system used for our studies is a hierarchical system developed originally for the Lisburne Terrestrial Monitoring Program in the Prudhoe Bay Oilfield and modified to include habitat types found on the Colville River Delta that do not occur in the oilfields (Murphy et al. 1989; Johnson et al. 1996). The habitat classification system incorporates three components of the landscape to differentiate habitat types: landscape structure, hydrology, and vegetative composition. The habitat system incorporates a hierarchical system of vegetation composition similar to that used by Walker and Acevedo (1987) for the Prudhoe Bay area. Water bodies were classified similarly to Bergman et al. (1977) and included identification of important emergent species (e.g., *Carex* spp. or *Arctophila fulva*) in each type. Habitat types discussed in this paper are described in Appendix 1 at the end of the paper.

3.0 Methods

We used two methods to locate nests of Spectacled Eiders during our studies. On the Colville River Delta in 1992, we searched two 10-ha study plots randomly located in areas under consideration for exploratory drilling on the delta. We searched each plot by walking the edges of all water bodies and walking systematically (observers spaced 2 m apart) across areas away from water bodies. In subsequent years, we searched areas where we found nests in previous years and areas where we saw breeding pairs during aerial surveys. In the Kuparuk Oilfield, we searched only in the vicinity of water bodies where we had seen breeding pairs of Spectacled Eiders during pre-nesting surveys or in areas where we had found nests in previous years. During the first year (1993) of our study in the oilfield, we searched within 400 m of the water bodies containing breeding pair sightings; because we found all nests <5 m from the edge of water bodies, however, we limited our searches in subsequent years to within 25 m of water bodies. Both methods were successful at locating eider nests, although not all water bodies used by pre-nesting eiders later supported a nest. When we found

Table 1
Number of Spectacled Eider nests by microsite and macrosite habitats on the Colville River Delta, Alaska, 1992–1995

	Microsite habitat				Total	
Macrosite habitat	Salt-killed tundra	Aquatic sedge with deep polygons	Nonpatterned wet meadow	Wet sedge–willow meadow	n	%
Brackish water		5			5	20
Tapped lake with high-water connection				1	1	4
Salt marsh			1		1	4
Salt-killed tundra	1	1		1	3	12
Shallow open water without islands		1			1	4
Aquatic sedge with deep polygons		7			7	28
Nonpatterned wet meadow		2	3		5	20
Wet sedge–willow meadow				2	2	8
Total						
n	1	16	4	4	25	
%	4	64	16	16		

nests after they had been destroyed, we determined species (either Spectacled Eider or King Eider *Somateria spectabilis*) by examining contour feathers left in the nest.

Once a nest was located, we described the habitat within 1 m of the nest site (the microsite habitat) and the larger-scale habitat surrounding the nest (the macrosite habitat). Whereas the microsite habitat was the habitat type immediately at the nest site, the macrosite habitat was determined by identifying the primary habitat type in a 0.25-ha area surrounding the nest site. This area for the macrosite habitat was considered to be the minimal mapping size for the scale (1:18 000) of aerial photographs available for the study area, and thus the habitat type that would be identified during any habitat mapping used for planning purposes in the oilfield. At each nest, we also recorded the landform on which the nest was situated (e.g., island, peninsula, polygon ridge) and estimated the distance to permanent open water.

Habitats of Spectacled Eider nests on the Colville River Delta were determined from a digitized habitat map prepared for the delta (Johnson et al. 1996). For nests in the Kuparuk Oilfield, we delineated habitat types on acetate overlays of true-colour aerial photographs (1:18 000) to determine the proportion of each habitat type within a 250-m radius surrounding the nest. We used a 250-m radius buffer size because it was sufficiently large to encompass all habitats near the nest that are likely used by eiders during nesting. A few wetlands in the oilfield supported 2–5 nesting pairs of Spectacled Eiders each year. We have called these areas "colonies," although the term is used only in its most general sense to mean sites supporting more than one nesting pair of eiders. Because 250-m buffers around nests within these colonies could overlap both within and between years and tend to overemphasize the importance of some habitats, we described habitats for the entire wetland (as visible on the aerial photograph), rather than individual nest sites. This approach was also used because we were interested in determining the habitat characteristics of the wetlands that supported greater numbers of nesting eiders, which then could be used to identify potentially important wetlands to eiders in areas proposed for future oilfield developments. As for individual nests, we mapped habitats within the wetland on acetate overlays of true-colour aerial photographs. A geographic information system program was then used to determine the areal coverage of each habitat type for individual nests and for the colony wetlands.

4.0 Results

We located 25 nests of Spectacled Eiders in a variety of habitat types on the Colville River Delta during nest searches in 1992–1995 (Table 1). The primary microsite habitat of eider nests was aquatic sedge (*Carex* spp.) with deep polygons containing permanent water. The importance of polygonized ground on the delta to nesting eiders was apparent, because 84% of all nests were in microsite habitats that included some variant of this landform (essentially all microsite habitats except nonpatterned wet meadows). At the macrosite level, 80% of all eider nests occurred in four habitat types, including two types influenced by input of marine waters from the Beaufort Sea (brackish water and salt-killed tundra) and two wet tundra types (aquatic sedge with deep polygons and nonpatterned wet meadow). Most (84%) nests were located ≤1 m from water; only one nest was located ≥10 m from water. Eider nests were located primarily on small islands (48%), but peninsulas (24%) and polygon ridges (28%) were also commonly used.

In the Kuparuk Oilfield, we found 45 Spectacled Eider nests during searches in 1993–1995 (Table 2). The primary microsite habitat for most (78%) nests was nonpatterned wet meadow, with the remaining nests occurring in low-relief and high-relief moist meadows. Landforms used for eider nests included shorelines of water bodies (33%), islands (33%), peninsulas (24%), polygon rims (7%), and hummocks (2%). Vegetation at nest sites was similar to that of the surrounding tundra and was dominated by sedges (*Carex* spp.), mosses, and lichens. Willows (*Salix* spp.) occurred at 14 of 45 nests. Although a variety of macrosite habitats were used by nesting Spectacled Eiders, basin wetland complex was the most common habitat (69% of all nests). The importance of basin wetland complexes is further supported by the analyses of habitat composition within the buffers around nests (Table 3). In all years, basin wetland complex was the primary habitat within 250 m of nests and accounted for a mean of 35% of total area (SD = 22, n = 18). Basin wetland complex was also an important habitat component of the wetlands supporting small nesting colonies in the Kuparuk Oilfield and represented the primary

Table 2
Number of Spectacled Eider nests by microsite and macrosite habitats in the Kuparuk Oilfield, Alaska, 1993–1995

	Microsite habitat				
		Moist meadow		Total	
Macrosite habitat	Nonpatterned wet meadow	high relief	low relief	n	%
Deep open lake	1		1	2	4.4
Shallow open water					
Without islands	1			1	2.2
With islands	1		1	2	4.4
Aquatic sedge					
Without islands			1	1	2.2
With islands	3			3	6.7
Aquatic grass					
Without islands	2			2	4.4
With islands	3			3	6.7
Basin wetland complex	24	1	6	31	68.9
Total					
n	35	1	9	45	
%	77.8	2.2	20		

habitat in three of five sites (Table 4). Both the habitat composition around individual nests and that at nesting colonies indicated that a variety of habitat types were used by nesting Spectacled Eiders, including terrestrial (wet and moist meadows) and aquatic habitats (deep open lakes and water bodies with emergent sedges and grasses). As on the Colville River Delta, Spectacled Eider nests in the Kuparuk Oilfield were located near water (58% at ≤1 m, 40% at >1–10 m, and 2% at >10 m; n = 45).

5.0 Discussion

Nesting Spectacled Eiders used a variety of habitats on the Arctic Coastal Plain of Alaska, and the most commonly used habitats differed between our two study areas. On the Colville River Delta, most eider nests are located in habitats that are formed of coalesced polygons supporting permanent water or on the polygonized margins of more distinct water bodies. Much of the Arctic Coastal Plain is composed of ice-wedge polygon tundra that forms from freeze–thaw processes (Walker et al. 1980). On the Colville River Delta, these polygons form in ice-rich, fine-grained sediments that become unstable and are affected by thermokarst processes, eventually slumping to produce deep (>1 m), permanently flooded polygon centres (Walker 1983). In some areas, the polygon fields gradually erode into adjacent water bodies such as deep open lakes or tapped lakes, forming a distinctive margin of coalescing polygons. On the delta, polygonized habitats provide a rich variety of nesting sites for eiders in the form of water bodies containing complex shorelines with many peninsulas and small islands (usually formed from remnant polygon ridges) and stands of emergent vegetation. The coastal influences of the Beaufort Sea are more pronounced on the Colville River Delta than in the neighbouring Kuparuk Oilfield, primarily because of the influence of the major channels and distributaries of the Colville River. Spectacled Eiders nest in several coastally influenced habitats on the delta, including salt marsh, salt-killed tundra, brackish water (which includes coalesced polygon fields — as described above — that contain brackish water), and tapped lakes (lakes that are breached periodically by channels of the Colville River and receive input of saline water).

In the Kuparuk Oilfield, Spectacled Eiders nest most commonly in basin wetland complexes that, like the polygonized habitats on the Colville River Delta, are complex habitats with extensive shorelines, islands, and islets. Basin wetland complexes are also important nesting habitats for other large waterbirds on the Arctic Coastal Plain, including Red-throated *Gavia stellata* and Pacific *G. pacifica* loons, Brant *Branta bernicla*, King Eiders, Oldsquaw *Clangula hyemalis*, and Glaucous *Larus hyperboreus* and Sabine's *Xema sabini* gulls (Bergman et al. 1977; ABR, Inc., unpubl. data).

The nesting habitats used by Spectacled Eiders in other parts of their breeding range (i.e., western Alaska and Siberia) are superficially similar to those used by eiders on the Arctic Coastal Plain of Alaska. On the Yukon–Kuskokwim Delta in western Alaska, Spectacled Eiders nest on shorelines, islands, and peninsulas, in areas dominated by sedges, and usually within 2 m of water (Johnsgard 1964; Dau 1974; Mickelson 1975). Dau (1974) concluded that the physical characteristics of the site and the distance to water were more important than the surrounding vegetation in affecting the location of nests. Johnsgard (1964) found most eider nests on the shorelines of ponds, but a few were on islands. He also noted that several females nested in the same wetland and that nests tended to be "slightly clustered," with the closest nests being only 4 m apart.

On the Indigirka River Delta of northeastern Russia, Kistchinski and Flint (1974) found two types of nesting habitat used by Spectacled Eiders: scattered locations on the tundra ("rich in lakes") and islets in lakes where several females usually nested close together, which they suggested indicates a degree of incipient colonization. They also found that eider nests on islets in lakes were often associated with breeding colonies of gulls (Glaucous, Sabine's, Herring *Larus argentatus*, and Ross' *Rhodostethia rosea*), Arctic Terns *Sterna paradisaea*, and Pacific Loons. Vegetation near the islet nests was a dense growth of *Dupontia psilosantha*, *Carex stans*, and *Arctophila fulva*. Eider nests that were scattered on "uniform" (polygonized) tundra also were found near ponds and often were located on wet mossy tussocks. Coastally influenced habitats (up to 40–50 km from the coast) on the Indigirka River Delta appeared to support more nesting eiders than inland areas. In Chaun Bay, northeastern Russia, Kondratyev and Zadorina (1992) found Spectacled Eiders nesting singly near lakes of the Chaun River Delta and on coastal tundra and in small colonies in larger lakes that also supported gulls (*Larus* spp.).

Although the specific vegetation types and habitats used by nesting Spectacled Eiders do differ somewhat across their breeding range, eiders tend to place nests on shorelines, peninsulas, and islands close to water. The results of our studies on the Colville River Delta and in the Kuparuk Oilfield support this general conclusion. The results of our more detailed habitat mapping at nesting colonies and at solitary nests also suggest the importance of a variety of different habitat types in areas used by nesting Spectacled Eiders. The small colonies of nesting Spectacled Eiders that we found in the Kuparuk Oilfield appear to be similar to the incipient colonies described for the Yukon–Kuskokwim Delta in western Alaska and for Russia (Johnsgard 1964; Kistchinski and Flint 1974; Kondratyev and Zadorina 1992).

Table 3
Habitat composition in a 250-m radius surrounding solitary Spectacled Eider nests in the Kuparuk Oilfield, Alaska, 1993–1995

	Habitat composition (% of total area)											
	1993			1994			1995			All years		
Habitat	Mean	SD	Rank[a]	Mean	SD	Rank[a]	Mean	SD	Rank[a]	Mean	SD	Rank[a]
Deep open lake	14.5	20.2	3	5.4	12.1	7	13.3	18.3	4	11.7	17.2	3
Shallow open water												
Without islands	3.7	6.0	6	10.0	11.8	4	8.9	11.5	5	6.9	9.4	5
With islands	1.6	4.6	9	8.3	11.8	5	5.9	13.2	6	4.7	9.5	7
Lower perennial stream	0.1	0.2	13							0.1	0.1	15
Aquatic sedge												
Without islands	2.0	4.0	8				1.3	2.9	10	1.2	3.0	12
Aquatic grass												
Without islands	3.7	8.1	6	2.6	3.6	10	1.4	3.2	9	2.8	5.8	9
With islands	15.8	19.6	2	13.8	16.1	2	16.4	23.1	2	15.4	18.6	2
Basin wetland complex	23.0	40.3	1	33.8	16.8	1	31.9	23.3	1	34.9	22.4	1
Wet meadow												
Nonpatterned	10.4	20.7	4				13.4	29.5	3	8.4	20.2	4
Low relief	1.3	3.0	10	10.2	9.4	3	3.2	7.2	7	4.3	7.2	8
High relief				3.1	6.9	9	2.4	5.3	8	1.5	4.4	11
Moist meadow												
Low relief	7.4	8.4	5	7.1	6.9	6	1.1	1.6	11	5.6	7.0	6
High relief	1.0	2.2	11	3.5	3.7	8	0.6	0.9	12	1.6	2.6	10
Gravel fill	1.0	1.8	11	1.5	2.1	11	0.1	0.2	13	0.9	1.6	13
Partially vegetated sod				0.6	1.3	12	0.1	0.3	13	0.2	0.7	14
Number of nests	8			5			5			18		

[a] Ranks are the relative contribution of each habitat type (1 = greatest mean area)

Table 4
Habitat composition of colony locations used by nesting Spectacled Eiders in the Kuparuk Oilfield, Alaska, 1993–1995

	Habitat composition									
	Colony 1		Colony 2		Colony 3		Colony 4		Colony 5	
Habitat	ha	%[a]	ha	%[a]	ha	%[a]	ha	%[a]	ha	%[a]
Shallow open water										
Without islands	0.3	0.4	4.7	6.5	6.5	15.4	17.0	6.2		
With islands	24.8	31.8			3.2	7.5	19.5	7.1		
Lower perennial stream							0.3	0.1		
Aquatic grass										
Without islands					2.5	6.0	1.5	0.6		
With islands			18.9	26.5	2.6	6.2	22.8	8.3	8.4	10.9
Basin wetland complex	24.4	31.3	16.6	23.3	24.9	58.6	125.7	45.6	33.4	43.5
Wet meadows										
Nonpatterned	6.9	8.8			1.3	3.0	27.2	9.9	22.3	29.0
Low relief	19.9	25.5	31.0	43.6			22.6	8.2	4.3	5.5
High relief							19.0	6.9		
Moist meadow										
Low relief	1.7	2.2	0.0	0.0	1.4	3.4	7.6	2.7	7.3	9.5
High relief							12.1	4.4	1.3	1.6
Total	77.9		71.2		42.5		275.4		76.9	
Mean number of nests/year	2		4.3		2		2		2	

[a] Percentage of total area.

Additional research will be required to determine whether nesting in these small colonies, often in association with gulls and other waterfowl, provides some benefits to the eiders.

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Appendix 1
Descriptions of habitat types used to quantify habitat associations at Spectacled Eider nest sites, Colville River Delta and Kuparuk Oilfield, Alaska

Habitat class	Habitat description
COASTAL ZONE	
Brackish water	Coastal ponds and lakes that are flooded periodically with salt water during storm surges. Salinity levels are often increased by subsequent evaporation of impounded saline water. The substrate may contain peat, reflecting its freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay. This type may contain aquatic sedge with deep polygons that contain brackish water.
Tapped lake with high-water connection	Water bodies that have been partially drained through erosion of banks by adjacent river channels, but which are connected to rivers by distinct, permanently flooded channels. The connecting channels are dry during low water, and the lakes are connected only during flooding events. Water tends to be fresh. Small deltaic fans are common near the connecting channels as a result of deposition during seasonal flooding. Deeper lakes in this habitat do not freeze to the bottom during winter. These lakes provide important fish habitat.
Salt marsh	On the Beaufort Sea coast, arctic salt marshes generally occur in small, widely dispersed patches, most frequently on fairly stable mudflats associated with river deltas. The surface is flooded irregularly by brackish or marine water during high tides, storm surges, and river flooding events. Salt marshes typically include a complex assemblage of small brackish ponds, halophytic sedge and grass wet meadows, halophytic dwarf willow scrub, and small barren patches. Dominant plant species usually include *Carex subspathacea*, *C. ursina*, *Puccinellia phryganodes*, *Dupontia fisheri*, *P. andersonii*, *Salix ovalifolia*, *Cochlearia officinalis*, *Stellaria humifusa*, and *Sedum rosea*. Salt marsh is important habitat for brood-rearing and moulting waterfowl.
Salt-killed tundra	Salt-killed tundra occurs along the Beaufort Sea coast in areas where saltwater inundation, caused by storm surges, has killed much of the original vegetation, but where salt-tolerant plants are colonizing. Colonizing plants include *Puccinellia andersonii*, *Dupontia fisheri*, *Braya purpurascens*, *B. pilosa*, *Cochlearia officinalis*, *Stellaria humifusa*, *Cerastium beeringianum*, and *Salix ovalifolia*. Typically, this habitat occurs either on low-lying areas that originally supported wet sedge–willow meadows and basin wetland complexes or, less commonly, along drier coastal bluffs that formerly supported moist sedge–shrub meadows or upland dwarf shrubland. Plant cover is generally <5%, but vegetation may be more abundant around pond margins.
FRESH WATER	
Deep pen water (lakes and ponds) / with islands or polygonized margins	Deep (≥1.5 m) water bodies ranging in size from small ponds in ice-wedge polygons to large open lakes; most have resulted from thawing of ice-rich sediments, although some are associated with old river channels. Emergent vegetation is present in <5% of the lake surface, and generally the lakes are larger than 10 ha. Deep lakes have jagged, low bluffs along a portion of the shoreline and remain frozen until at least late June. On the Colville River Delta, margins of this habitat may be composed of polygons that grade into the lake surface, forming peninsulas and islands.
Shallow open water / without islands / with islands / polygonized margins	This habitat includes ponds and small lakes <1.5 m deep with emergent vegetation present in <5% of the area. Owing to shallow water depths, ice cover melts by early to mid-June, and summer temperatures are warmer than in deep water. For this habitat to be considered to be with islands, it must have at least one island larger than 0.5 m² that is at least 5 m from shore. / On the Colville River Delta, margins of these habitats may be composed of polygons that grade into the lake surface.
Aquatic sedge / without islands / with islands / deep polygons with permanent water	Aquatic sedge habitat includes both uniform sedge marshes and small ponds in which sedges are present in at least 5% of the pond; at least 70% of the emergents must be sedges. *Carex aquatilis* is the dominant emergent sedge and occurs in water 10–30 cm deep. Water and bottom sediments of this habitat freeze completely during the winter, but ice melts in early June. / Islands as described above. / On the Colville River Delta, this type may be composed of coalesced polygons that retain permanent water (>1 m deep).
Aquatic grass / without islands / with islands	The habitat includes small ponds, lake margins, and marshes in which *Arctophila fulva* is present in at least 5% of the pond and in which at least 30% of the emergents are grasses. Areas of open water >1 ha in pond centres are classified separately as open water. Owing to shallow water depths (<1 m), the water freezes to the bottom in winter and ice melts by early June. / Islands as described above.
Lower perennial stream	In this stream habitat, water is slow-moving, and the gradient of the stream is low. This habitat is not tidally influenced, and some water flows throughout the summer month; the stream is frozen during winter. Stream substrates consist primarily of sand and mud, although some gravel does occur.
BASIN WETLAND COMPLEX	Basin wetland complexes form in drained, thaw lake basins and are characterized by high interspersion of open water, water with emergents, and wet and moist meadows. This habitat complex has at least three habitat types present, although no single habitat type dominates (>70%) the area.
MEADOWS	
Wet meadows / nonpatterned / wet sedge–willow / low relief / high relief	These habitats typically are found as extensive meadows within younger drained lake basins, as narrow stands adjacent to receding water bodies, and along edges of small stream channels. Nonpatterned wet meadows have not yet undergone extensive ice-wedge polygonization and hence are subject to more movement of groundwater and surface water than are polygonized areas. Disjunct polygon rims and strangmoor (undulating raised sod ridges) cover less than 5% of the area. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but movement of water and dissolved nutrients results in more robust growth of sedges than in polygonized habitats. Wet sedge–willow meadows include low-centred polygons occurring on lowland areas within drained lake basins and on level to gently sloping floodplains and terraces. Polygon rims and strangmoor are <5 cm high and cover <30% of the area. Lower microsites are dominated by wet sedge tundra, whereas higher microsites are dominated by moist tundra. Low-relief wet meadows have polygon rims and strangmoor <0.5 m high and cover <30% of the area. High-relief wet meadows are similar to above, but polygon rims are higher than 0.5 m.
Moist meadows / low relief / high relief	Moist meadows occur on better-drained upland areas between thaw basins, on riverbanks, on the lower slopes of pingoes on thaw lake plains, and on foothill slopes. This habitat is free of surface water during the summer, although some sites may be inundated briefly during breakup. Moist sedge–shrub tundra covers less than 70% of the area. / For low-relief meadows, micro-topographic relief is <0.5 m. / High-relief meadows are found on upland areas between thaw basins and are distinguished by the presence of high-centred (>0.5 m) polygons. This habitat is more complex than low-relief moist meadows and usually contains high-centred polygons that support sedge–dwarf shrub vegetation, interspersed with polygon troughs and thermokarst pits, which support wet and aquatic sedge vegetation.
ARTIFICIAL	
Gravel fill	This human-made habitat has resulted from gravel fill placed on natural terrain during industrial development. Most fill consists of gravel roads and pads 1.5 m thick.
Partially vegetated sod	This human-made habitat includes "peat" roads and overburden stockpiles that have organic material mixed in with the mineral soil. Vegetation covers 5–30% of the surface.