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POPULATION STRUCTURE OF PACIFIC COMMON EIDERS BREEDING IN ALASKA

MARGARET R. PETERSEN[1] AND PAUL L. FLINT
USGS BRD, Alaska Biological Science Center, 1011 East Tudor Road, Anchorage, AK 99503

Abstract. We used satellite telemetry to study the migration routes and wintering areas of two allopatric breeding populations of Pacific Common Eiders (*Somateria mollissima v-nigrum*) in Alaska: the Yukon-Kuskokwim Delta, and the western Beaufort Sea coast. Only 6% (2 of 36) of females wintered within the wintering area of the other breeding population. Both breeding populations wintered in the closest available ice-free habitat, perhaps to minimize migratory distance. Two Beaufort Sea females wintered in areas used by Yukon-Kuskokwim Delta females, implying potential gene flow among breeding areas. Yet, we conclude that these two populations are largely geographically isolated throughout the annual cycle and the environmental factors influencing survival and reproduction likely differ between these groups of birds. Thus, regardless of the potential gene flow among breeding populations, we suggest that birds from these two breeding areas should be managed as separate populations.

Key words: Alaska, Pacific Common Eider, population structure, Somateria mollissima v-nigrum, *winter.*

Estructura Poblacional Reproductiva de *Somateria mollissima v-nigrum* en Alaska

Resumen. Usamos telemetría satelital para estudiar las rutas de migración y áreas de invernada de dos poblaciones alopáticas reproductivas de *Somateria mollissima v-nigrum* en Alaska: la del Delta Yukon-Kuskokwim, y la de la costa oeste del Mar de Beaufort. Solo el 6% (2 de 36) de las hembras invernaron dentro del área de invernada de la otra población reproductiva. Las dos poblaciones invernaron en el hábitat libre de hielo más cercano, tal vez para minimizar la distancia de migración. Dos hembras del Mar de Beaufort invernaron en áreas usadas por hembras del Delta de Yukon-Kuskokwim, implicando un potencial flujo génico entre las áreas de reproducción. Sin embargo, concluimos que estas dos poblaciones están aisladas geográficamente a lo largo del ciclo anual y que los factores ambientales que afectan la supervivencia y reproducción son probablemente diferentes entre estos grupos de aves. Por lo tanto, a pesar del flujo génico potencial entre las poblaciones reproductivas, sugerimos que las aves de estas dos áreas de reproducción deben ser manejadas como poblaciones separadas.

INTRODUCTION

The Pacific Common Eider (*Somateria mollissima v-nigrum*) is morphologically distinct from other subspecies of Common Eiders (Livezey 1995) and breeds primarily along coastal areas of the Bering, Chukchi, and Beaufort Seas (AOU 1998, Goudie et al. 2000). Within Alaska two important breeding areas are the coastal fringe of the Yukon-Kuskokwim (Y-K) Delta in western Alaska (currently 1100–2300 nesting females; U.S. Fish and Wildlife Service, unpubl. data) and barrier islands along the Beaufort Sea in northern Alaska (currently 2000–3000 birds; Johnson 2000). Numbers of Pacific Common Eiders nesting along the Beaufort Sea east of Barrow, Alaska, have declined substantially over the past 40 years (53%; Suydam et al. 2000) as have the number breeding on the Y-K Delta (>90%; Stehn et al. 1993, Hodges et al. 1996). The causes of these population declines are unknown. However, populations of King Eiders (*Somateria spectabilis*), Spectacled Eiders (*Somateria fischeri*), and Steller's Eiders (*Polysticta stelleri*) that winter in the Bering Sea have also declined (Kertell 1991, Stehn et al. 1993, Ely et al. 1994, Dickson et al. 1997). At this point it is not clear if a single factor may be causing all eider species to decline, or if separate factors may be influencing specific populations.

Common Eider females tend to show very high fidelity to specific breeding areas (Bustnes and Erikstad 1993). In that context, distinct breeding populations might be considered separate populations. Because pairs form during

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[1] E-mail: margaret_petersen@usgs.gov

winter (Spurr and Milne 1976), breeding populations wintering in the same area would likely experience gene flow via male dispersal (Scribner et al. 2001). Coulson (1999) suggested that reproductive parameters of Common Eiders such as clutch size are influenced by reserves obtained during winter and spring migration. Therefore, if distinct breeding populations winter and stage in the same areas, then simultaneous declines might be attributed to habitat conditions or mortality factors encountered while populations are sympatric. Alternatively, if breeding aggregations are isolated throughout the annual cycle, they should be considered unique populations, and specific parameters influencing population trends are likely to differ among these populations. Thus, knowledge of population structure and patterns of habitat use are keys to understanding changes in numbers of breeding birds and interpreting estimates of reproductive parameters (Schamel 1977, Flint et al. 1998).

Our objectives were to determine the staging and wintering areas for two distinct breeding populations in Alaska. These data will allow assessment of population structure and further interpretation of site-specific life history parameters. This assessment will aid managers in defining options to achieve specific goals for each population. Finally, determination of concentration areas, either wintering or staging, may facilitate aerial surveys and thereby allow more precise estimation of overall population size (Petersen et al. 1999).

METHODS

We used satellite telemetry to document timing and routes of migration and wintering locations (see Harris et al. 1990). Due to logistical considerations we marked adult female Common Eiders from relatively dense, accessible nesting aggregations and did not randomly sample birds from each nesting area. However, we see no reason why the sampled birds should not be representative of the local breeding populations. The sample of eiders from the Beaufort Sea included birds nesting at Alaska Island (70.24°N, 146.47°W; n = 10), Egg Island (70.44°N, 148.73°W; n = 8), and Spy Island (70.56°N, 149.85°W; n = 3); the sample from the Y-K Delta included birds nesting south of the Tutakoke River (61.17°N, 165.59°W; n = 20). Data collection began two weeks after transmitter deployment to minimize the effects of surgery on locations and subsequent survival.

Migrations (molt, fall, and spring) were defined as periods of total movement in a particular direction in excess of 200 km. The date migration began is defined here as the date by which an individual was recorded at >50 km from its breeding or wintering area. Dates are approximate because locations were not taken on consecutive days at the beginning of either autumn or spring migration. Differences between populations were tested for statistical significance by a Mann-Whitney U-test. Dates of migration are presented as median and minimum-maximum. If there was no discernible movement between time periods, for kernel analysis (see below) molt was defined as 1 to 30 September, autumn migration/staging as 1 October to 30 November, winter as 1 December to 14 May (Beaufort Sea) or 1 December to 30 March (Y-K Delta), and spring migration/staging from 15 May to 20 June (Beaufort Sea) or 1 April to 20 May (Y-K Delta). An area was identified as a staging location if one or more individual was present for at least one week during migration.

DATA COLLECTION AND ANALYSIS

Satellite transmitters (i.e., platform transmitting terminals or PTTs) were deployed using an implant technique developed by Korschgen et al. (1996) as modified by Petersen et al. (1995, 1999) and others. Adult female eiders were captured on nests within a week of hatching during June 2000 on the Y-K Delta and during July 2000 on the Beaufort Sea, Alaska (Fig. 1). All radios were programmed to transmit one pulse every 60 sec for each 6-hr transmission period. Transmitters deployed on the Y-K Delta were programmed to transmit data for one transmission period every 94 hr (3.9 days) until 15 April 2001 after which they switched to one period every 26 hr (1.1 days) for the life of the battery. Transmitters used in the Beaufort Sea were designed to transmit for one period every 78 hr (3.2 days) for the life of the battery. All satellite transmitters were equipped with sensors to monitor the body temperature of each individual, as an indication of survival, and battery voltage, to assess the likelihood of future transmitter failure.

Data were received through the ARGOS data collection and location system in Landover, Maryland (Service Argos 2001). Both standard

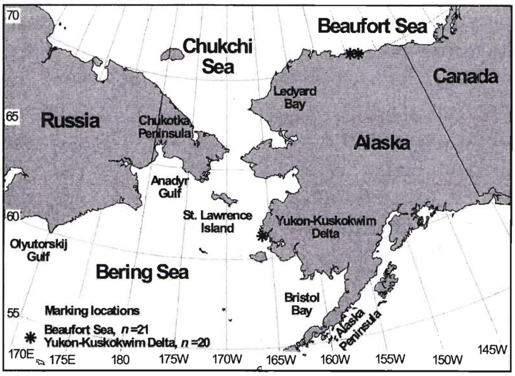


FIGURE 1. Locations of breeding sites where Common Eiders were marked along the western Beaufort Sea coast and Yukon-Kuskokwim Delta, Alaska, and other locations mentioned in the text.

and auxiliary location-processing services were used as described in Petersen et al. (1995, 1999). To reduce autocorrelation due to consecutive locations, only one location per transmission period was used for each individual. When there was more than one location within a transmission period, the location with the best precision was selected. In cases where multiple locations were obtained of equal precision within a sampling period, we selected the location with the largest sample size of received signals or the last location if sample sizes were equal.

Location data from fall, winter, and spring were analyzed separately for each marked population. Kernel analysis (Hooge and Eichenlaub 1997) was used to describe 95% to 35% utilization distributions. Core areas were then defined as the utilization distribution which simultaneously minimized the proportion of total area used while maximizing the proportion of locations contained within that area. That is, the relationship between size of core area and proportion of locations contained within that area was not linear, and we identified the point on this curve where additional increases in core area size resulted in diminishing returns in terms of proportion of locations contained within that area. Data from a single bird that wintered in Olyutorskij Gulf was excluded from the kernel analysis of winter distribution because it wintered >1000 km from the next nearest marked bird.

RESULTS

ARGOS reported 23 797 total locations; locations per individual varied from 117–1072. Of

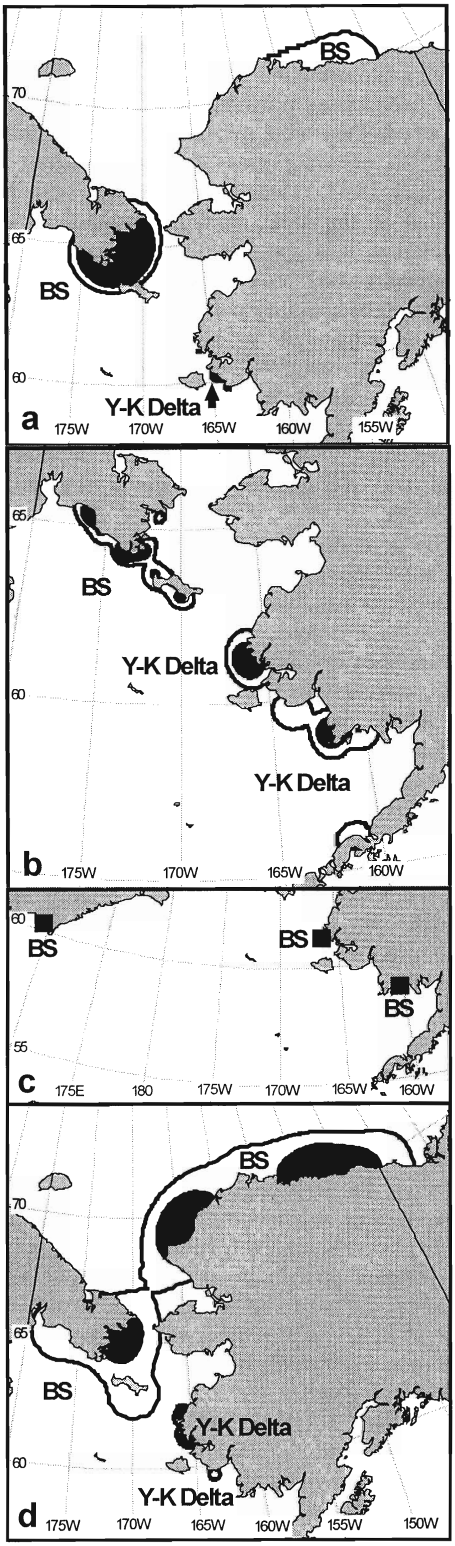
TABLE 1. Mean ± SE number of locations per individual (number of individuals) used in kernel analysis of Common Eider migration and wintering areas in Alaska.

	Breeding population	
Season	Beaufort Sea	Yukon-Kuskokwim Delta
Autumn	5.7 ± 1.3 (17)	10.0 ± 1.2 (16)
Winter	24.1 ± 4.3 (19)	24.7 ± 2.3 (18)
Spring	10.0 ± 1.9 (14)	21.1 ± 1.7 (17)

this total, 2606 locations for 39 individuals were used for these analyses (Table 1). Sample sizes within a season included only individuals with usable locations and vary because some birds died, some transmitters failed prematurely, and no data were received from some transmitters during some seasons.

The breeding populations of Common Eiders we sampled remained nearly allopatric throughout the annual cycle. Only three individuals (8% of 39; two Beaufort Sea, one Y-K Delta) went on distinct molt migrations; none of these birds molted in areas used by other marked birds. Eighteen of 20 individuals (90%) marked on the Beaufort Sea remained within 30 km of their nest site in waters ≤20 m deep from July until early October, and local movement patterns suggest that they molted during this period. Similarly, 95% (18 of 19) of adult females marked on the Y-K Delta remained within 20 km of their nest site in waters ≤20 m deep from June through late September and likely molted during this period. No females from the Beaufort Sea staged or migrated during autumn through areas used simultaneously by birds from the Y-K Delta breeding area; core staging areas were disjunct between breeding populations (Fig. 2a) and contained the 75% (Y-K Delta) and 85% (Beaufort Sea) utilization distributions. We detected no significant difference in the beginning of autumn migration between nesting areas ($U_{18,17}$ = 146.0, $P > 0.5$); median = 11 October 2000, range 24 September–27 October, n = 35). All locations of staging birds were in waters ≤20 m deep and within 25 km of land.

Mixing of populations during winter was very low; 6% (2 of 36) of individuals wintered within the 95% utilization distribution of the other breeding population. Two females from the Beaufort Sea breeding area wintered in areas used by females from the Y-K Delta population.



Most (84%; 16 of 19) birds marked on the Beaufort Sea spent the winter near St. Lawrence Island or along the Chukotka Peninsula (Fig. 2b); however, three Beaufort Sea eiders moved (one to each location) to the Olyutorskij Gulf, northern Bristol Bay, and off the coast of the Y-K Delta (Fig. 2c). Eiders marked on the Y-K Delta wintered primarily along the coast of the Y-K Delta (50%; 9 of 18) and northwest Bristol Bay (50%; 9 of 18; Fig. 2b), approximately 25 km and 325 km, respectively, from their nesting area; 17% (3 of 18) of individuals spent some of the winter along the north coast of the Alaska Peninsula (Fig. 2b). The winter core areas (70% utilization distribution, Y-K Delta; 80% utilization distribution, Beaufort Sea) were generally similar in size between the two breeding populations, approximately 650 km and 625 km of coastline, respectively. Locations of wintering birds were within 40 km of land in waters ≤25 m deep.

In addition to the isolation observed during winter, the two breeding populations remained separate during spring migration and staging. Most (87%; n = 31) eiders staged north of their wintering area in spring; the others remained at the wintering area during spring before leaving for the nesting area. Core spring staging areas of birds from the Beaufort Sea included coastal areas off the Chukotka Peninsula, northwestern Alaska, and the Beaufort Sea (Fig. 2d). In spring 2001, 42% (5 of 12) of the eiders returning to the Beaufort Sea staged 150–300 km east of their nesting area in open water near the coast, and then moved west to the areas where they were marked the previous year. Also in spring 2001, 53% (9 of 17) of eiders marked on the Y-K Delta staged along the coast 110–160 km north of the nesting area and subsequently moved south just before nesting, or staged offshore (47%; 8 of 17) within 40 km of the nesting

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FIGURE 2. Core (darkened areas) and 95% utilization distribution (heavy lines) of marked adult female Common Eiders that nested on islands in the Beaufort Sea (BS), Alaska, and on the Yukon-Kuskokwim Delta (Y-K Delta), Alaska. (a) Autumn 2000 staging and migration (BS, n = 17; Y-K Delta, n = 16). (b) Winter 2000–2001 (BS, n = 19; Y-K Delta, n = 18). (c) Wintering areas of three individuals outside the 95% utilization distribution for their respective breeding population. (d) Spring 2001 staging and migration (BS, n = 14; Y-K Delta, n = 17).

area (Fig. 2d). Variation in size of spring core areas among breeding populations was primarily a function of variation in migratory distance (1300–2700 km for Beaufort Sea, 10--300 km for Y-K Delta).

Dates of initiation of spring migration differed significantly between birds from each nesting area ($U_{17,15} = 66.0$, $P < 0.02$). Birds marked on the Y-K Delta began migration by 6 April 2001 (range 1–22 April; $n = 17$); birds marked on the Beaufort Sea began migration by 26 April 2001 (range 10 March–3 June; $n = 14$).

In spring 2001, all 29 females with functioning transmitters returned to the general nesting area where they had been marked. Two birds were not included in the analysis: one bird died (Y-K Delta) and one transmitter failed (Beaufort Sea) before data collection began. Two radios each failed during fall and winter, and three radios failed during spring migration; the fate of these birds but one is unknown. Three females in winter were confirmed to have died based on changes in body temperature. Thus, 71% (29 of 41) of transmitters provided data throughout the project. One female whose transmitter failed during spring migration was subsequently shot at Barrow, Alaska (71.17°N, 156.47°W).

Apparent maximum annual survival for the 39 nesting adult female Common Eiders monitored during this study was 0.92 (36 of 39, assuming all birds whose radios failed survived); minimum survival was 0.74 (29 of 39, assuming all birds whose radios failed died). Assuming that half of the birds whose radios failed died, apparent annual survival was 0.83; this is similar to the annual survival estimated from ongoing studies of nesting adult female Common Eiders on the Y-K Delta (PLF, unpubl. data).

No systematic surveys were conducted in Alaska or Russia when marked birds were present; no winter surveys have ever been conducted at these areas. However, flocks of Common Eiders have been reported in all areas where marked birds were located in the Bering Sea (Portenko 1981, Goudie et al. 2000, U.S. Fish and Wildlife Service, unpubl. data).

DISCUSSION

Our data show that the breeding aggregations of adult female Common Eiders on the Y-K Delta and the Beaufort Sea are largely allopatric and should be considered unique populations. Few (6%, $n = 36$) females wintered in areas used predominantly by the other breeding population; there was no overlap in distributions during molt, migration, or staging. Further, all birds with functioning transmitters returned to the areas where they were marked, confirming that fidelity to breeding areas is high (Bustnes and Erikstad 1993). Because there was very little overlap in the areas used by females of each population, it is possible that different factors at the postbreeding areas could be responsible for the different breeding population declines. However, as suggested for King Eiders staging in spring in the Beaufort Sea (Barry 1968, Fournier and Hines 1994), major climatic events occurring throughout the Bering Sea in winter and spring, such as late, dense ice, may depress survival and recruitment throughout the nesting range.

The populations of Common Eiders we studied appeared to move the minimum distance possible to suitable ice-free wintering areas in waters ≤25 m deep. The Y-K Delta nesting population is essentially nonmigratory with half the birds wintering in the nearshore waters of western Alaska within 100 km and the other half primarily within 400 km of their nesting area. Most females nesting along the western Beaufort Sea moved 1300–1600 km south through the Bering Strait and wintered in the northernmost recurring polynyas and areas of broken, discontinuous pack ice in waters ≤25 m deep. However, we cannot dismiss the fact that wintering areas used in a given year may be influenced by annual variation in sea-ice conditions. Interannual variation in sea-ice conditions is considerable (Brower et al. 1977). The winter of 2000–2001 was relatively mild, and sea-ice was less extensive and less continuous than in a typical year. In that context, the distribution of eiders we observed likely reflects the preferred wintering areas for each population.

In years of severe ice conditions, eiders might be displaced from preferred locations resulting in different distributions of wintering areas. However, winter site fidelity has been documented in several species of seaducks including Common Eiders (Spurr and Milne 1976) and Harlequin Ducks (*Histrionicus histrionicus*; Robertson et al. 1999, 2000, Cooke et al. 2000). This site fidelity fits with the fact that coastal polynya occur regularly along the southern Chukotka Peninsula (Sireniki Polynya) and St. Lawrence Island (Gloersen et al. 1992) in the northernmost core wintering areas we identified. Further, several studies have documented catastrophic die-offs of Common Eiders associated with severe ice conditions or displacement from wintering habitat, suggesting that alternative foraging areas of sufficient quality may not be available for wintering eiders (Camphuysen 2000, Gilchrist and Robertson 2000). Under this scenario, changes in sea-ice conditions would not be expected to have dramatic effects on winter distributions of Common Eiders. Therefore, we suspect that Pacific Common Eiders have relatively high winter site fidelity, and that variation in winter ice conditions has a minimal effect on our conclusions regarding population structure.

Common Eiders rely almost entirely on stored nutrient reserves for egg production and maintenance during incubation (Korschgen 1977, Parker and Holm 1990). Accordingly, Coulson (1999) hypothesized that reproductive parameters such as clutch size are influenced by reserves obtained over winter and during spring staging. Female Common Eiders increase body mass about 20% during the 4–6 weeks prior to egg laying (Gorman and Milne 1971, Milne 1976, Korschgen 1977, Parker and Holm 1990). Therefore, for birds nesting on the western Beaufort Sea coast, productivity is likely influenced by conditions encountered in May to early June, particularly along the coasts of the eastern Chukotka Peninsula, Ledyard Bay, and the Beaufort Sea. For birds nesting on the Y-K Delta, the critical period would be from April to early May, and the primary areas used are just offshore and north of the nesting area. Managers should consider the protection of these habitats and the possibility of aerial surveys in these locations as an index of population size.

The fact that both of our study populations are classified as the same subspecies implies a common, historic origin and genetic similarity. Ploeger (1968) thought that the breeding distribution of Common Eiders in the Pacific was restricted to the southern edge of the Bering Land Bridge during the last glacial period; this would be the likely source for both our study populations. Pair formation in Common Eiders occurs during winter (Spurr and Milne 1976). If males from each breeding population show a wintering pattern similar to females, it is likely that the two Beaufort Sea females that wintered off the Y-K Delta formed pair bonds with Y-K Delta males. Thus, there may be gene flow between populations, mediated by male dispersal (Scribner et al. 2001). In that sense, these breeding populations might not be unique based on their degree of genetic differentiation. However, if the high site fidelity observed for breeding females is combined with natal philopatry (Sweenen 1990), frequencies of maternally inherited genes (i.e., mitochondrial DNA) might differ among populations (Scribner et al. 2001). For example, Spectacled Eiders nesting in Russia and along the Beaufort Sea were more closely related to each other than either was to the Y-K Delta breeding population in spite of the fact that all three populations winter sympatrically (Scribner et al. 2001). Therefore, we hypothesize that the population segregation we observed for Common Eiders between the Beaufort Sea and the Y-K Delta nesting females has led to genetic differentiation among these populations. Analyses of genetic variation within and among breeding populations of Pacific Common Eiders would aid our understanding of metapopulation dynamics.

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