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Seasonal Movement of Pacific Common Eiders Breeding in Arctic Canada

D. Lynne Dickson

Prairie and Northern Region

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SEASONAL MOVEMENT OF PACIFIC COMMON EIDERS BREEDING IN ARCTIC CANADA

D. Lynne Dickson[1]

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Canadian Wildlife Service
Prairie and Northern Region

[1] Author can be contacted through
Myra Robertson
Environment Canada
P.O. Box 2310
5019 – 52 Street, 4th Floor
Yellowknife NT X1A 2P7
myra.robertson@ec.gc.ca

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Myra Robertson
Canadian Wildlife Service
Environment Canada
P.O. Box 2310
5019 – 52 Street, 4th Floor
Yellowknife NT X1A 2P7
Or by emailing: myra.robertson@ec.gc.ca

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ABSTRACT

Pacific Common Eiders (*Somateria mollissima v-nigrum*) were tagged with satellite transmitters at a site in central arctic Canada and their year-round movement was tracked to determine migration routes, timing of movement, and location of moulting, wintering and staging areas. Males departed the nesting colony in the second week of July about a week after median date of start of incubation. Two thirds of the males remained in arctic Canada to moult, primarily in outer Bathurst Inlet, Dolphin and Union Strait and off Cape Parry, while the rest moulted closer to the wintering area, mostly at Kolyuchin Bay in northern Russia. Females remained on the nesting colony until time of hatch, and then moved to marine waters within 45 km of the colony to moult. Males that moulted in Canada departed on fall migration in early October, whereas females departed approximately two weeks later. Fall migration through the Beaufort and Chukchi seas took an average (± SD) of 11 ± 4 days, and none of the eiders staged until they reached the Chukotsk Peninsula in the northern Bering Sea. All but one eider wintered in the polynyas and flaw leads off the southeast coast of Chukotsk Peninsula and St. Lawrence Island; the exception likely wintered north of Nunivak Island, Alaska. Spring migration of birds destined for breeding areas in North America lasted 2.4 ± 0.7 months. Four key spring staging areas were identified: off Chukotsk Peninsula just north of the wintering area, eastern Chukchi Sea, southeast Beaufort Sea, and Lambert Channel in Dolphin and Union Strait. Eiders arrived on their breeding grounds in mid-June. All females returned to within 2 km of the nest site used the previous year (n = 7). By contrast, males were widely distributed across the breeding range in the second year from northeastern Russia to central arctic Canada. Assuming a male follows a female to her breeding area, the dispersal of males in the second breeding season suggests that Pacific Common Eiders from across eastern arctic Russia, northern Alaska and western arctic Canada are all part of the same population that winters in the northern Bering Sea. All females (n = 4), plus those males that returned to Canada to breed in the second year (n = 3), moulted within 24 km of the moult site used the previous year. However, two males that bred in Russia in the second year remained in Russia to moult, thus using an entirely different area. All wintered in the same general location in two consecutive years (n = 5). Due to their tendency to congregate in large numbers in a few select locations especially during spring migration and winter, Pacific Common Eiders are vulnerable to changes in their environment such as oil spills and altered ice conditions brought about by climate change.

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INTRODUCTION

The Pacific Common Eider (*Somateria mollissima v-nigrum*) spends most of its annual cycle in marine waters, coming ashore only during the breeding season. It nests primarily on small islands in coastal areas from northeast Russia to Queen Maud Gulf in central arctic Canada (Goudie et al. 2000). Nests occur in colonies of several to several hundred, but there are also many that are solitary and scattered (Barry 1986). Given that much of their breeding area is remote and they are at sea for all but one month of the year, eiders are logistically a challenge to study, and a great deal remains unknown about their life history. For example, although roughly 70 000 Pacific Common Eiders breed in Canada (Suydam et al. 2000), surveys for nesting pairs can account for only about half of them (Cornish and Dickson 1997, Dickson unpubl. data). This suggests that much of their breeding habitat has not yet been located. Some key marine areas used by the eiders have been relatively well documented, such as the spring staging area in the southeastern Beaufort Sea (Alexander et al. 1997) and a major wintering area off Russia's Chukotsk Peninsula (Kistchinski 1973). However, there is little information on moult site locations or staging areas used during fall and moult migration, especially in arctic Canada (Barry 1986). Furthermore, affiliations between breeding, moulting and wintering areas for eiders breeding in arctic Canada are unknown. Identification of key habitats and delineation of populations are both essential steps towards management and protection of the species.

Pacific Common Eiders that breed in Canada and northern Alaska declined by >50% over a 20-year period from 1976 to 1996 (Suydam et al. 2000). Reasons for the decline are unknown, thus raising concern about our ability to manage the Pacific Common Eider. Potential threats to the population include over-hunting, periodic severe ice conditions, predation and marine pollution such as oil spills, but the relative importance of each threat is unknown (USFWS 2007). Resource development including offshore oil and gas development has expanded in the Arctic in recent years, and is expected to continue doing so in the future. The effect of climate change on ice conditions, hence availability of prey for eiders, is also a growing concern (Dickson and Gilchrist 2002, Petersen 2009). These sorts of issues may necessitate more active management and protection of the Pacific Common Eider in the future, and to address this challenge, more information is clearly needed.

This study used satellite technology to track the year-round movement of Pacific Common Eiders tagged on their breeding grounds in arctic Canada. The program objectives were: 1) to determine migration routes and staging areas for Pacific Common Eiders that breed in arctic Canada; 2) to determine timing of migration; 3) to document spatial relationships of migration corridors to pack ice, water depth and other physical features in the Beaufort Sea; 4) to identify moulting and wintering areas, and their affiliation with breeding areas; and 5) to determine breeding, moult and winter site fidelity.

The detailed movement of individual eiders, presented in both map and table format, is available in progress reports documenting each of the four years of deployment of transmitters (Dickson et al. 2003a, 2003b, 2005, 2009). Dickson and Smith (in review) describe the location of eiders during spring migration in the southeastern Beaufort Sea in relation to ice, water depth and other physical features, and assess the potential impact of nearby oil and gas development to eiders. This report summarizes the year-round locations and timing of movement of eiders obtained in all four years of tracking. Key moulting, wintering and staging areas are identified, and dates when eiders are present in those areas are provided. Information obtained on breeding, moult and winter site fidelity is presented, and contribution of results to the understanding of population structure of the Pacific Common Eider is discussed.

METHODS

Satellite transmitters were deployed on 36 male and 34 female Pacific Common Eiders in central arctic Canada at Nauyak Lake, Nunavut (68° 20.762´ N; 107° 40.919´ W) in June of 2001–2003 and 2006 (Fig. 1). A 23 gauge 130 mm mesh mist net was used to capture the eiders. The net (90 m long and 6 m high) was extended across a narrow valley with a creek that flowed from Nauyak Lake to the ocean. The eiders were caught prior to nesting as pairs flew back and forth through the narrows between a nesting colony on the lake and areas of early open water at sea.

A veterinarian surgically implanted the transmitters following a technique described by Korschgen et al. (1996) and modified by Mulcahy and Elser (1999). Isoflurane administered with compressed air was used as the anaesthetic and Bupivicaine/Lidocaine (2:1) as the analgesic. The transmitter was placed in the abdominal cavity of the bird with the antenna exiting dorsally near the base of the tail. Prior to surgery, the transmitter was fitted with a sleeve of surgical mesh so that it could be secured to the ventral body wall with stitches (Mulcahy 2001). The transmitter was further anchored by stitching the eider's skin to a dacron collar fitted around the base of the antenna. Each duck was held in captivity for 2–3 hours following surgery to ensure recovery from anaesthesia. Each individual also received a 60 cc hydration solution prior to release at the capture site.

The 38–43 g satellite transmitters (Microwave Telemetry Inc. Columbia, Maryland) were programmed to send signals to Argos satellites (CLS America, Inc., Largo, Maryland) over a 4–6 hour period generally every 3–4 days. However, during migration period some transmitters were programmed to send signals as frequently as three times a day, and during winter most were programmed to send signals every eight days. The variable duty cycles (i.e. period of transmissions followed by a period of no transmissions) were intended to maximize the amount of information obtained while the birds were migrating, while preserving battery life when the birds were relatively stationary. Transmitted information included location of bird, body temperature and transmitter battery voltage. The latter two parameters were useful in determining why a transmitter stopped sending signals. A drop in body temperature indicated the bird was dead, whereas a sudden drop in voltage indicated the battery was depleted.

Both the Standard and Auxiliary Location Processing Service available from Service Argos were used to obtain eider locations. Usually there were several locations for a given transmission period. The most precise and plausible location for each eider within a transmission period was selected using the SAS Argos filter algorithm (Douglas 2006). Locations were selected based on the best Argos precision rating (Service Argos, Inc. 2007), and if there was more than one location of equal precision, the one derived from the largest number of transmissions was selected. The filter program eliminated locations deemed implausible based on distance, angle and rate of movement to previous and subsequent locations.

Definitions of seasonal movements

The following terms were used to describe the annual cycle for the eiders: nesting, moult migration, moulting, fall migration, wintering and spring migration. The date first and last seen in the area was used to define departure and arrival dates on the nesting, moulting, staging and wintering areas (Petersen et al. 1999). Duration of stay was calculated as the difference between the first and the last known date a bird was in the area plus one duty cycle (Petersen et al. 2006). Number of days of migration was calculated as date first seen at destination minus date last seen at departure site minus one duty cycle. A duty cycle was added (or subtracted), because the exact dates of arrival and departure were unknown (Oppel et al. 2009). If there was ≥10 day gap in locations received at time of arrival and departure, the individual was eliminated from the analysis. Start of migration was defined by the bird leaving and not returning. In most cases, departure distance travelled was >50 km, although in a few cases it was <50 km, but the first in a series of unidirectional distances travelled within seven days that totalled >50 km (Petersen and Flint 2002). Similarly, end of migration was marked by the last of a series of long-distance movements in a similar direction >50 km. For eiders that remained within 50 km of the nesting colony to moult, transition from nesting to moulting area occurred when the eider left the lake where the nesting colony was located and did not return. Staging area was defined as a location where one or more individuals remained for at least seven days during migration (Petersen and Flint 2002). Distance travelled between locations on the staging area was <50 km unless the bird returned to within 25 km of the original site within a seven-day time period.

Moulting area was defined as the location where the eider remained relatively stationary (moved <0.1 kph) over a 21-day period between late July and late October (Petersen et al. 2006). A site was designated as a nesting area for a female if the bird remained there for at least 10 days (Petersen et al. 2006) between 25 June and 25 July (dates based on Hoover et al. 2010). For males, in the year of capture we assumed they were with females from the Nauyak Lake nesting colony. The breeding area for a male in the second year was the site where it remained relatively stationary for at least a week between 25 June and 15 July. Eiders were considered breeding site faithful if the centroids for each year were within 2 km of each other.

Centroid locations were determined by using the Mean Center Tool within Spatial Statistics in ArcGIS (http://www.esri.com). Mean centre identifies the geographic centre for a set of points by averaging the *x* and *y* coordinates of all the locations within a particular dataset. Since the data were usually spatially skewed, mean centre was used rather than minimum convex polygon to avoid potential biases that could occur with the latter approach (Burgman and Fox 2003).

To examine the distribution of eiders on their moulting, wintering and staging areas, probability contours of 50% and 95% were created using ArcGIS Spatial Analyst and Hawth's Tools (Beyer 2004). A density surface was first created using Spatial Analyst based on the eider locations and by accepting the default search radius. The Percent Volume Contour Tool of Hawth's Tools was then used to create the 50% and 95% probability contours. A maximum of 10 locations per eider were used, so that no single eider unduly influenced the map. In most situations nearly all of the eiders provided at least 10 locations, but some eiders provided up to four times more. Thus, for individuals with >10 locations, a subset of 10 locations was randomly selected.

Migration distances were measured by summing the orthodromes between locations obtained during migration (Petersen et al. 2006).

Non-parametric Mann-Whitney *U* or Kruskal-Wallis tests were used to examine whether timing of movement from nesting to moulting and wintering areas differed by sex or among years or among populations. Effect of year was examined first and found to have no effect on arrival or departure dates for moult, fall and spring migration. Thus, all years of data were combined for subsequent analysis. A significance level of 0.05 was used for all statistical tests, and data presented as mean ± SD and ranges.

RESULTS

All but 3 of 70 surgical implants were successful: a male and female died during surgery and another female died within a week of release (Table 1). Three others died within the first year of transmission: a female near the nesting colony during fall migration, a female near Point Franklin, Alaska, during fall migration, and a male confirmed shot at Point Barrow, Alaska, during moult migration. Overall, 74% of the transmitters provided locations for at least six months and 28% lasted over a year (Table 2).

Moult migration and moult

Date of departure of males on moult migration from the nesting colony and nearby marine areas ranged from late June to late July (average 10 July ± 7 d; Table 3; Appendices A and B). Males dispersed widely to moult, some remaining within 100 km of the nesting colony and others migrating westward up to 3000 km to moult off Russia (Fig. 2). The majority of males from the Nauyak Lake nesting colony moulted in four areas: Bathurst Inlet, Dolphin and Union Strait and Cape Parry in arctic Canada, and Kolyuchin Bay on the north coast of Chukotsk Peninsula in Russia (Fig. 2). Date of departure from the breeding area was unaffected by distance to moulting area (U = 70.0, P = 0.051, n = 33), but period of migration was considerably longer (average of 28 ± 9 d compared to 5 ± 5 d) and date of arrival nearly a month later (12 Aug. ± 7 d compared to 16 July ± 9 d) for males moulting in the Chukchi and Bering seas than those moulting closer to the nesting colony (Table 4).

Roughly half of the males staged (i.e. stopped for a period of at least 7 days) at some point during moult migration, and remained on the staging area for 12 ± 5 d (range 7–19 d). Staging occurred only along the eastern portion of the migration route: at Bathurst Inlet, Dolphin and Union Strait, Cape Parry and Cape Bathurst (Figs. 3 and 4). None of the 10 males that migrated to Russia to moult staged once they had departed from the eastern Beaufort Sea. Males were present on the staging areas in peak numbers in the second half of July (Table 5).

Males that moulted in arctic Canada remained on their moulting area from mid-July to the beginning of October (Table 6). Those males that moulted at Kolyuchin Bay, Russia, were present from mid-August to mid-October.

Females remained at the nesting colony three weeks longer on average than males, departing 30 July ± 8 d (U = 50.0, P < 0.001, n = 67) (Table 3). All females moulted within 45 km of the nesting colony. About a third (12 of 32) moulted amongst the islands in north-central Parry Bay; however, the others were quite widespread throughout Parry Bay and to a lesser extent Melville Sound (Figs. 5 and 6). Dispersal pattern on the moulting area was similar in all four years (Fig. 5).

Fall migration

The males that moulted in arctic Canada departed on fall migration around 2 Oct. ± 5 d (24 Sept.–12 Oct., n = 22), whereas females departed 13 days later on average (U = 20.0, P < 0.001, n = 52; Table 7). Number of days of migration from arctic Canada to the northern Bering Sea off Chukotsk Peninsula, Russia, was the same for both sexes (U = 276.0, P = 0.933, n = 48), and took an average of 11 ± 4 d (female range: 4–23 d, n = 28; male range: 6–21 d, n = 20). During fall migration, none of the eiders staged at any location between moulting areas in arctic Canada and Chukotsk Peninsula (Fig. 7). However, upon arrival off the east coast of Chukotsk Peninsula, 63% (17 of 27) of the females and 44% (7 of 16) of the males stopped off Cape Nunyagmo just north of their winter destination for 1–10 weeks (Fig. 8). Consequently, arrival of eiders on the wintering area varied greatly from 6 October to 30 December (11 Nov. ± 24 d, n = 47). The staging area off Chukotsk Peninsula was most heavily used from mid-October to mid-November (Table 8).

Males that moulted in the Chukchi and Bering seas departed on fall migration two weeks later on average than males that had remained in arctic Canada to moult (U = 14.5, P <0.001, n = 32; Table 7). Six of 10 staged off Chukotsk Peninsula for 2–7 weeks before moving a short distance to the wintering area. Like the eiders that moulted in arctic Canada, date of arrival on the wintering area was highly variable (14 Oct.–23 Dec., 10 Nov. ± 23 d, n = 10).

Distance travelled during fall migration ranged from 200–3000 km, and none of the eiders remained on their moulting area to winter.

The route taken by eiders during both moult and fall migration was similar in all four years. From Bathurst Inlet, the eiders crossed Coronation Gulf then followed the mainland coast through Dolphin and Union Strait and Amundsen Gulf to Cape Bathurst (Figs. 3 and 7). They then crossed the southeast Beaufort Sea on a broad front up to 180 km from shore, coming closer to land again off Alaska: near Camden Bay for males and farther west near Prudhoe Bay for females. From there they followed the coast, generally within 15 km of shore, past Point Barrow into the eastern Chukchi Sea, continued along the Alaskan coast to Cape Lisburne, and then across the Chukchi Sea to Chukotsk Peninsula. During moult migration eiders staged only in areas east of the Beaufort Sea, whereas during fall migration none staged until they had reached Chukotsk Peninsula.

Winter

The core winter location for the eiders was located off the southeast tip of Chukotsk Peninsula (Fig. 9). However, eiders wintered from the north shore of Anadyr Bay as far north as Mechigmen Bay, and 11% (5 of 46) of eiders wintered off St. Lawrence Island. An additional male eider likely wintered near Nunivak Island, Alaska; it arrived off the island in mid-October and remained there until the transmitter quit functioning in mid-December.

There was little discernible directional movement of the eiders on their wintering area from early to mid- to late winter (Fig. 10). Nor was there much difference in the distribution pattern of males versus females on the wintering area (Fig.11).

Spring migration

Based on 18 eiders with transmitters that functioned throughout spring migration, all females and all but 2 males returned to breeding areas in northern Alaska and Canada in the second year. Eiders migrating to North American breeding areas departed the wintering area over a two-month period from late February to the end of April (mean: 28 March ± 19 d, n = 29) (Table 9). Spring migration proceeded more slowly than moult and fall migration taking an average of 72 ± 21 d (Appendix C). The eiders arrived on the nesting areas in North America over a three-week period from 9–29 June (mean: 16 June ± 6 d, n=16). There was no difference between males and females in date of departure from wintering area or date of arrival on nesting area (U = 88.0, P = 0.556, n = 29 and U = 27.5, P = 0.681, n = 16). The two males migrating to breeding areas in northern Russia departed the wintering area later (on 26 May) than the eiders that went to North America, but they arrived on the breeding area during the same time period (12 and 26 June). Migration period was short (15 and 29 d) by comparison; however distance travelled was less than half that of any of the eiders that returned to North America to nest (400 and 1100 km versus 2500–3500 km).

Spring migration to breeding areas in North America consisted of rapid long-distance movements between four staging areas where the eiders stopped for a period of 1–4 weeks (Fig. 12; Table 10). The staging areas were located as follows:

– off east coast of Chukotsk Peninsula, Russia (Fig. 13),

– Ledyard Bay, Alaska, in eastern Chukchi Sea (Fig. 14),

– off Tuktoyaktuk Peninsula, Canada, in southeast Beaufort Sea (Fig. 15), and

– Lambert Channel in Dolphin and Union Strait, Canada (Fig. 16).

The most heavily used staging areas were the eastern Chukchi Sea and southeast Beaufort Sea, where 94% and 100% of the eiders respectively stopped for 2-4 weeks (n = 16, Table 10). Most (11 of 13) of the birds that wintered off the Chukotsk Peninsula initially staged just north of the wintering area for about a month prior to departing for the Chukchi Sea in late April. However, the three eiders that wintered off St.

Lawrence Island bypassed the staging area off Chukotsk Peninsula. The only other location where eiders staged during spring migration was the early open water in southeast Dolphin and Union Strait where 73% of the eiders that migrated that far east stopped for an average of 7 ± 6 days (n = 11).

Nest site fidelity

All but two of the females marked at Nauyak Lake remained at the lake at least 10 days in the year of capture, suggesting they were part of that nesting colony. The two exceptions stayed for at least 10 days at freshwater lakes within 4 km of Nauyak Lake. In the second year, seven of the eight females with transmitters still functioning returned to within 2 km of the nesting area used in the previous year (Appendix D). The exception was located once on 30 June at the Nauyak Lake nesting colony where it had been the previous year, but spent most of the nesting period at various locations along the north shore of Parry Bay, 12 km from the colony on average. It likely did not nest in the second year since there was no 10-day period when the bird was stationary. One transmitter lasted an additional year, and that female returned to the nesting colony at Nauyak Lake for a third consecutive year.

By contrast, none of the males returned to Nauyak Lake nesting colony (n = 9); instead, they were widely distributed across the breeding range up to 2970 km away from Nauyak Lake (Fig. 17; Appendix D).

Moult site fidelity

Transmitters on five males and four females provided locations through two moult cycles, allowing an assessment of moult site fidelity for those birds. The three males that returned to arctic Canada to breed in the second year all moulted within 15 km of where they had moulted in the previous year (Fig. 18). Conversely, the two males that were in Russia during the second breeding season moulted in entirely different areas 220 km and 2000 km from the site used the previous year (Appendix E). Three of four females moulted within 7 km of the site used the previous year, and the other moulted 24 km across the bay from where it had been the previous year (Fig. 19). The transmitter on one female lasted an additional year, and that eider again moulted within about 2 km of the site where she had been the previous two years.

Winter site fidelity

Winter locations were obtained over two consecutive years for two male and three female eiders. Based on the centroid location calculated for an eider each winter, four returned to within 30–50 km of where they had wintered the previous year, and one male returned to a site about 120 km away (Fig. 20). However, because each eider shifted locations typically by >50 km during the winter period, the wintering areas over two consecutive years for each eider overlapped. This was the case even for the eider with centroids 120 km apart.

Beaufort Sea migration corridor

Timing and location of eiders in the Beaufort Sea during migration were examined more closely to better understand what effect offshore oil and gas development may have on Pacific Common Eiders. About a third of the males crossed the Beaufort Sea in mid-summer (late July–early August) on route from the breeding area to moult sites in the Chukchi and Bering seas (Table 11, Fig. 3). These birds moved through the Beaufort Sea over a period of 11 ± 6 d, and 42% of them staged 1–2 weeks off Cape Bathurst (Tables 5 and 11). The rest of the males crossed the Beaufort Sea after the moult with peak numbers moving through in the second week of October (Table 11, Fig. 7). Females came through a week or two later in the second half of October ($U = 6.5$, $P < 0.001$, n = 40). Both sexes crossed the Beaufort Sea on fall migration in just 4 ± 3 d.

During spring migration, eiders crossed the western Beaufort Sea in just 1–2 days (based on 11 eiders with transmitters programmed to provide daily locations). However, upon arrival in the flaw lead in the southeast Beaufort Sea, they all stopped and remained for an average of 19 ± 11 d (Table 11, Fig. 12). The area used by eiders for staging extended from the Alaska–Yukon border east to Cape Bathurst, with highest densities of eiders occurring off Tuktoyaktuk Peninsula (Fig. 15; based on 10 locations/bird for 11 eiders, plus 1–4 locations/bird for an additional 5 eiders). Most Pacific Common Eiders were along the landfast ice edge of the flaw lead and in water 22 m deep on average (see Dickson and Smith [in review] for more details regarding habitat). They were present from 8 May to 28 June, with peak numbers occurring from 20 May to 6 June. Once departed from the staging area, the eiders moved rapidly to either the next staging area in Dolphin and Union Strait or their breeding area.

DISCUSSION

Moult sites

Prior to this study, little was known about the location of moulting areas used by Pacific Common Eiders breeding in Canada (Barry 1986, Goudie et al. 2000). Large numbers of moulting males had been noted only at three locations: off Cape Parry, in Prince of Wales Strait on the west side of Banks Island, and in Safety Channel on the north side of Prince Albert Sound (Barry and Barry 1982, Cotter et al. 1997). Two thirds of the males in this study remained in Canada to moult, resulting in the identification of five additional moulting areas: outer Bathurst Inlet, Dolphin and Union Strait, Cape Bathurst, south-central Coronation Gulf, and outer Minto Inlet near Berkeley Point. The previously identified moulting area off Cape Parry was also relatively heavily used by males tagged at Nauyak Lake. The majority of males that moulted outside of Canada were in Kolyuchin Bay, Russia, which is a known moulting area for Pacific Common Eiders (Kistchinski 1973).

Historically, small flocks of moulting females have been reported in coastal bays in the western Canadian Arctic including at Cape Parry, Harrowby Bay near Cape Bathurst and the north side of Minto Inlet (Barry 1986, Barry et al. 1981, Cotter et al. 1997). However, until this study it was believed that, like the King Eider (*Somateria spectabilis*), most female Pacific Common Eiders migrated to the Bering and Chukchi seas to moult, and that only eiders attending juveniles remained on the breeding area to moult (Barry 1986). To the contrary, all tagged females from Nauyak Lake moulted within 45 km of the nesting colony. Similarly, Petersen and Flint (2002) found that 92% of females (n = 39) tagged at two sites in Alaska remained within 30 km of the nesting area. Mosbech et al. (2006) reported that females in Greenland moulted near the nesting colony, but that at East Bay in eastern arctic Canada about half migrated to a distant moulting area, and suggested that this was perhaps because of the risk of early ice formation near the East Bay nesting colony.

Moult sites are presumably selected because they provide shelter, protection from predators and an abundance of food required to replace flight feathers. Birds become flightless during the moult, hence are unable to move to another suitable site. Thus, it is important to minimize human activity at moult sites while the eiders are present.

Winter sites

All but one tagged eider from Nauyak Lake nesting colony wintered in the same area in the northern Bering Sea off the southeast tip of Chukotsk Peninsula and St. Lawrence Island. The northern Bering Sea is covered in ice in winter, but there are polynyas and flaw leads in the area where the eiders winter. These areas of open water are maintained by north-northeasterly winds that transport ice away from the lee coast (Barber and Massom 2007). The tagged eiders used the same general area in all four years of the study. Most (84%) of the female eiders tagged by Petersen and Flint (2002) on a breeding area in northern Alaska wintered in this same area, although eiders nesting farther south in Alaska wintered elsewhere.

Staging areas used during spring migration

During spring migration, Pacific Common Eiders migrating to breeding areas in northern Alaska use the same staging areas in the northern Bering Sea and eastern Chukchi Sea as eiders returning to arctic Canada (Petersen 2009). Some of the Alaskan eiders also use the western extreme of the staging area in the southeast Beaufort Sea even though it is located over 250 km east of their breeding destination, thus lengthening their migration by over 500 km.

The pattern of distribution of eiders on the spring staging area in the southeast Beaufort Sea reported in this study is similar to what Alexander et al. (1997) observed during four years of aerial surveys in 1986, 1987, 1992 and 1993. Both studies noted that the highest concentrations of eiders occurred along the shorefast ice edge of the flaw lead off Tuktoyaktuk Peninsula. Furthermore, Alexander et al. (1997) noted that the eiders used this same area even in years when ice conditions were more severe there than elsewhere in the Beaufort Sea. This suggests that the location of the eiders on the staging area is influenced not only by the presence of open water, but also by the availability of benthic prey. Thus, water depth, water clarity and prey densities are all likely factors affecting the location of eiders within the flaw lead.

Common Eiders rely primarily on body reserves to produce eggs, and incubate for 25 days without feeding (Parker and Holm 1990). Although it is unknown where the Pacific Common Eider obtains those reserves, the timing of movement observed in this study suggests that spring staging areas are likely important feeding areas for the eiders that migrate to arctic Canada to breed. Eiders in this study departed the wintering area nearly three months prior to nesting. They then spent 10 weeks migrating a distance that took <2 weeks to travel in the fall. Such a protracted period of migration would give the eiders ample time to obtain the nutrients needed for reproduction.

It is unknown to what degree Common Eiders obtain energy reserves at breeding areas, but it likely varies geographically depending on availability of prey for the eiders. Mosbech et al. (2006) noted Northern Common Eiders in their study area arrived 3–4 weeks prior to nesting, and concluded local feeding areas contributed considerably to their reproductive success. By comparison, female eiders arrive at Nauyak Lake nesting colony about two weeks prior to start of incubation (based on mid-June arrival obtained during this study and 28 June median nest initiation date for the colony obtained by Hoover et al. (2010) from 2002–2005). Open water in the vicinity of Nauyak Lake is limited to a small <40 km^2 polynya about 30 km away. Given the limited opportunity for foraging and shorter period birds are present prior to nest initiation, local feeding areas likely contribute less to accumulation of nutrient reserves for eiders in western arctic Canada than at colonies off Greenland and in eastern arctic Canada.

Female Pacific Common Eiders migrating to breeding areas in arctic Canada departed from the open water off Chukotsk Peninsula in late April, whereas eiders headed for northern Alaska, which is less than half the distance away, departed 1–4 weeks later (Petersen 2009). Mosbech et al. (2006) reported the opposite for Northern Common Eiders; those with the longest distance to travel started migration last. Mosbech et al. (2006) also reported a much shorter period of migration for Northern Common Eiders than reported for Pacific Common Eiders in this study (5 compared to 10 weeks). The difference in spring migration patterns between Pacific and Northern Common Eiders might be due to better feeding opportunities for the Pacific Common Eider along the migration route. After departing Chukotsk Peninsula, there are two major staging areas available to eiders migrating to northern Alaska and Canada, plus an additional staging area for eiders passing through Dolphin and Union Strait. Prey-depletion on the wintering area might also contribute to the early departure of Pacific Common Eiders (Guillemette et al. 1996, Merkel et al. 2007). Waters off southeast Chukotsk Peninsula are heavily used not only by Pacific Common Eiders, but also by King Eiders (Kistchinski 1973, Phillips et al. 2006, Dickson 2012). Regardless, the early departure from the wintering area suggests energy reserves for reproduction are accumulated on the staging areas, not the wintering area. Merkel et al. (2006) came to a similar conclusion based on eider weight loss in late winter and early spring on a wintering area off Greenland.

In summary, evidence suggests that the spring staging areas are crucial to Pacific Common Eiders destined for breeding areas in arctic Canada, not only to fuel migration, but also for reproduction. They depart the wintering area well in advance of the start of nesting, spend about 2.5 months on the staging areas, and arrive on the breeding grounds just two weeks prior to nest initiation. At that time, there is very little open water near the breeding sites, hence limited habitat for foraging. Thus, it is likely that the body reserves needed for successful reproduction are accumulated to a large extent on the spring staging areas. Suitable habitat for staging is restricted to flaw leads and polynyas where the water is shallow enough for the eiders to forage on benthic prey. Due to the predominance of ice, there are likely no alternative areas for the eiders to use during spring migration. Given their importance and limited extent, all four spring staging areas identified in this study should be assigned special protective status. At a minimum, restrictions should be applied to any human activity that would either degrade the habitat or prevent eiders from using the staging area.

Timing of migration

Based on nesting chronology obtained by Hoover and Dickson (2007) for three of the years that marked birds were tracked, males depart the nesting colony 5–7 days after median date of start of incubation, whereas females remain on the nesting colony until time of hatch. From 2001–2003, median date of hatch at Nauyak Lake ranged from 25–29 July, compared to mean date of departure for females that ranged from 30 July to 2 August.

Departure of females and juveniles from marine waters near the breeding area on fall migration coincides with shallow coastal bays starting to freeze (Barry 1986, Hoover et al. 2010). Assuming adult females migrate with juveniles, females are maximizing the number of juveniles ready for migration by waiting as long as possible. Based on nesting chronology provided by Hoover and Dickson (2007), and assuming a 60–65-day period until fledged (Goudie et al. 2000), median date when juveniles from Nauyak Lake fledge occurs in the last week of September, with the last juvenile ready to fledge on 25 October. Young hatched on nearby marine islands fledge even later, in the first week of October. The mean departure date for marked females was 15 October, with the last one departing on 29 October. This tight timing suggests that the length of the open water season likely limits breeding success, at least in some years, in this part of the breeding range.

There was no difference in timing of departure from the wintering area for males and females in this study, which is further evidence that Pacific Common Eiders pair on the wintering area (Spurr and Milne 1976, Suydam et al. 1997, Goudie et al. 2000).

Timing of migration of marked birds across the Beaufort Sea in both spring and fall was similar to previous studies. Suydam et al. (1997) noted that 50% of the Pacific Common Eiders migrated past Point Barrow, Alaska, from 10–19 October in 1994. This is comparable to the mean date of departure for eiders from the Beaufort Sea during this study (10 and 22 October for males and females respectively). In spring of 1987 and 1994, Suydam et al. (1997) found that over half of the Pacific Common Eiders entered the Beaufort Sea in the third week of May, compared to the average arrival date of 20 May for this study. Based on a series of aerial surveys of the flaw lead in the southeast Beaufort Sea, Alexander et al. (1997) observed peak numbers of Pacific Common Eiders in late May in one year and the second week of June in two years. By comparison, marked birds in this study were present in peak numbers in the last week of May and first week of June. This difference suggests that timing of spring migration in the southeast Beaufort Sea varies by about a week in some years.

Alexander et al. (1997) observed that peak numbers of eiders occurred in Dolphin and Union Strait 1–2 weeks later than in the Beaufort Sea, which is in agreement with this study.

Migration strategies

Two thirds of the males tagged with transmitters at Nauyak Lake moulted close to the breeding area, then in October moved rapidly (in <2 weeks) to coastal waters just north of the wintering area. The rest of the males moulted closer to the wintering area than the breeding area, thus completing their long-distance migration before the moult. They proceeded more slowly, taking four weeks on average to complete migration, and staged in at least one area in arctic Canada on the way. Mosbech et al. (2006) likewise noted different patterns in timing of post-breeding migration for Northern Common Eiders and suggested that these differences represented subpopulations of eiders. Petersen (2009) examined spring migration patterns of Pacific Common Eiders from northern Alaska and identified three migration strategies based on whether the birds spent most of spring migration near the wintering area, on the staging area in eastern Chukchi Sea or near the breeding destination in the Beaufort Sea. The different migration strategies likely arose in response to differences in ice conditions, hence food availability, which in turn would affect survival and productivity (Petersen 2009). Both Mosbech et al. (2006) and Petersen (2009) concluded that by having several strategies, the species is better able to adapt to climatic variations, since certain conditions would favour one strategy over another.

Site fidelity

The high degree of breeding site fidelity demonstrated by female Pacific Common Eiders at Nauyak Lake concurs with what Petersen and Flint (2002) found in Alaska, and what others have reported for Northern Common Eiders (Swennen 1990, Bustnes and Erikstad 1993). Dispersal of males up to 2970 km away from the colony at Nauyak Lake in the second year is similar to what Swennen (1990) reported for Northern Common Eiders breeding in the Netherlands.

Although sample sizes are small (five males and four females), the results suggest that females moult in the same general area each year, whereas males may not if they have moved to a distant breeding area in the second year. Unlike the males that returned to Canada in the second breeding season, the two males that bred in Russia migrated to a moult site that was distant from the one used the previous year, but closer to the current year breeding site. For males, there is likely a trade-off between familiarity with food and shelter available at a specific moulting area, and the additional energy required to fly the extra distance to get there. By contrast, both male and female King Eiders return to the same moulting area each year (Dickson 2012, Phillips and Powell 2006). However, male King Eiders generally moult near the wintering area, whereas over half of the male Pacific Common Eiders moult closer to the breeding site.

All five of the eiders tracked over two winters returned to the same wintering area off the southeast Chukotsk Peninsula. Indeed, the one eider tracked for three years returned to the same wintering area each year. Philopatry to specific wintering areas has been previously suggested by Mosbech et al. (2006), but to my knowledge, this is the first direct evidence that it occurs.

Population delineation

Marked males did not return to Nauyak Lake in the second year; rather, they dispersed widely across the breeding range from Chaunskaya Bay, Russia, to the east end of Kent Peninsula in Nunavut, Canada. Assuming Pacific Common Eiders form pairs on the wintering area and males follow the females to their breeding area, the pattern of dispersal of males in the second year adds considerably to our knowledge of the population structure of the Pacific Common Eider. It suggests that the Pacific Common Eiders that breed in northeast arctic Russia, northern Alaska and western arctic Canada are all part of the same population that winters off southeast Chukotsk Peninsula and St. Lawrence Island in the northern Bering Sea. The connection between the breeding area in northern Alaska and wintering area in the northern

Bering Sea has been previously documented by Petersen and Flint (2002), but further investigation is needed to confirm that eiders breeding in northeast Russia do winter primarily in the northern Bering Sea.

One of 45 eiders marked at Nauyak Lake wintered further south off the Alaska coast, in an area used by Pacific Common Eiders that breed in the Yukon–Kuskokwim (Y-K) Delta, Alaska. Petersen and Flint (2002) similarly found that a small number (2 of 19) of the eiders tagged in northern Alaska wintered with the Y-K Delta eiders. They examined the year-round movement of the two breeding populations, noted little geographic overlap throughout their annual cycle, and concluded that they should be managed as two separate populations. Although genetically similar, many of the pressures affecting survival and productivity would be quite different for each population (Petersen and Flint 2002). Conversely, Pacific Common Eiders breeding in Canada, northern Alaska and eastern arctic Russia all appear to be one population, and should be managed as such. For example, when examining harvest pressure, the take in all three countries should be considered.

Conclusions

Information gained from tracking the year-round movement of the Pacific Common Eider will enhance our ability to manage and protect the species. By connecting breeding areas to wintering, moulting and staging areas, wildlife managers have a more complete understanding of year-round habitat requirements of the eider. This allows a more comprehensive examination of key areas needing special protective status. It also enables wildlife managers to examine pressures such as hunting, climate change and resource development (e.g. offshore oil and gas development) not in isolation, but throughout the annual cycle. Timing of movement is useful in environmental assessments, particularly when setting restrictions on development activity that might disturb or pose undue risk of an oil spill while the eiders are present. Information obtained on delineation of populations and timing of movements will also be useful in design of surveys to monitor population trends, as well as design of research studies.

This study suggests the Pacific Common Eiders that breed across much of northeastern Russia, northern Alaska and Canada winter in just one area and are highly philopatric to that location. Females return to their natal breeding site (Swennen 1990), and are highly philopatric to that area (this study, Petersen and Flint 2002). There is some variation in the timing of migration and staging areas used (this study, Petersen and Flint 2002), which allows some resilience at the species level to environmental change. However, their tendency to congregate in large numbers throughout the year at nesting colonies, and moulting, wintering and staging areas, means they are particularly vulnerable to changes in their environment, whether they are natural or human-induced. As human activity in the Arctic increases, so will the need to determine management actions needed to preserve the species.

Recommended research

This study identified several previously unknown moulting areas for male Pacific Common Eiders in arctic Canada, as well as several staging areas used by males during moult migration. Aerial surveys are needed to better define the boundaries and level of use of these areas by the eiders.

Within Canada, Pacific Common Eiders have been tagged with satellite transmitters at only one breeding site. Tagging them at another location would help to confirm the location and timing of use of key marine areas for the eiders, as well as contribute to our growing knowledge of population structure, and site fidelity to breeding, moulting and wintering areas.

To date no juvenile Pacific Common Eiders have been tagged with satellite transmitters. Tracking their movement would provide new information on their at-sea distribution, especially in the second summer.

Studies of Northern Common Eiders suggest that about half of the energy required for successful reproduction is obtained in the last 4–6 weeks before egg laying (Gorman and Milne 1971) and at staging areas closer to the breeding grounds than the wintering area (Jamieson 2003). The southeast Beaufort Sea is the last staging area for many of the eiders migrating to breeding areas in arctic Canada, and average length of stay is about three weeks. The staging area is in close proximity to offshore oil and gas reserves that may be developed in the near future. To better assess the potential impact of such development, it would be useful to determine to what extent Pacific Common Eiders rely on the southeast Beaufort Sea to accumulate energy reserves needed for both migration and successful reproduction.

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Table 1. Number of satellite transmitters implanted in Pacific Common Eiders at Nauyak Lake, Nunavut, and summary of mortality from time of capture until transmitters quit functioning.

	2001		2002		2003		2006		
	M	F	M	F	M	F	M	F	
Surgeries	8	8	10	8	8	8	10	10	
Deaths									*Cause of death*
prior to surgery						1			suspect hyperthermia
during surgery		1	1						anaesthetic related based on necropsies
2 weeks post surgery		1							likely surgery related
2 months post surgery							1		shot by hunter
4 months post surgery		1							unknown
5 months post surgery						1			unknown

Table 2. Amount and quality of data obtained from the satellite transmitters implanted in Pacific Common Eiders at Nauyak Lake in central arctic Canada in June, 2001–2003 and 2006.

Year of deployment	Number of transmitters	Tracking period in days		Number of locations		% of locations Class 1, 2 or 3[1]	
		Median	Range	Median	Range	Median	Range
2001	15	154	7–458	53	3–105	87	46–100
2002	17	306	186–328	112	58–123	84	53–95
2003	16	400	139–561	131	43–166	83	57–95
2006	20	254	64–1053	129	43–369	99	95–100

[1]Locations ranked as Class 1, 2 or 3 were accurate to within 1500 m according to Service Argos, Inc. (2007).

Table 3. Timing of movement of Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake in central arctic Canada in June, 2001–2003 and 2006.

	Male				Female			
	Mean	± SD	Range	n	Mean	± SD	Range	n
Depart nesting area	10 Jul	± 7	28 Jun–30 Jul	35	30 Jul	± 8	7 Jul–14 Aug	32
Arrive moulting area	25 Jul	± 15	2 Jul–25 Aug	33	2 Aug	± 8	10 Jul–18 Aug	32
Depart moulting area	7 Oct	± 10	24 Sep–12 Nov	32	15 Oct	± 5	4–29 Oct	30
Arrive fall staging area	16 Oct	± 7	5 Oct–4 Nov	21	28 Oct	± 9	17 Oct–19 Nov	28
Arrive wintering area	3 Nov	± 23	6 Oct–28 Dec	29	19 Nov	± 22	21 Oct–30 Dec	28
Depart wintering area	8 Apr	± 26	4 Mar–26 May	14	26 Mar	± 20	23 Feb–30 Apr	17
Arrive nesting area	18 Jun	± 8	9–29 Jun	9	15 Jun	± 4	9–24 Jun	9

Table 4. Effect of distance between breeding and moulting area on timing and duration of moult migration for male Pacific Common Eiders from a breeding area in central arctic Canada.

Moult location	Number of eiders	Distance from nesting colony (km)	Departure from nesting area Mean ±SD	Arrival on moulting area Mean ±SD	Days of migration Mean ±SD
Beaufort Sea eastward to colony	22	18–1600	8 Jul ± 6	16 Jul ± 9	5 ± 5
Chukchi and Bering seas	11	2200–3000	12 Jul ± 6	12 Aug ± 7	28 ± 9

Table 5. Location, timing and level of use of staging areas by male Pacific Common Eiders from a breeding area in central arctic Canada during moult migration.

Staging area	No. of migrants[1]	% that stopped	% that staged	Arrival[2]		Departure[2]		Duration of stay (d)[2]	
				Mean	± SD	Mean	± SD	Mean	± SD
Bathurst Inlet	26	35	12	12 Jul	± 6	15 Jul	± 7	6	± 4
Dolphin and Union Strait	20	65	30	16 Jul	± 7	20 Jul	± 8	6	± 4
Off Cape Parry	13	38	8	23 Jul	± 7	27 Jul	± 10	7	± 7
Off Cape Bathurst	12	50	42	24 Jul	± 8	1 Aug	± 6	11	± 5

[1]Excluding the 7 male eiders that remained in Bathurst Inlet to moult.
[2]Based on all males that stopped.

Table 6. Timing of use of key moulting areas by male Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake in central arctic Canada in June, 2001–2003 and 2006.

	Arrival date			Departure date	
	n	Mean	± SD	Mean	± SD
Bathurst Inlet	7	8 Jul	± 4	1 Oct	± 6
Dolphin and Union Strait	5	19 Jul	± 9	2 Oct	± 3
Cape Parry	5	13 Jul	± 3	2 Oct	± 4
Kolyuchin Bay	7	11 Aug	± 4	15 Oct	± 14

Table 7. Timing and duration of fall migration for Pacific Common Eiders from two different moulting regions.

Moulting region	Sex	Distance to wintering area (km)	Departure from moulting area Mean ± SD (n)	Arrival staging area off Chukotsk Peninsula Mean ± SD (n)	Arrival wintering area Mean ± SD (n)	Days of migration to staging area Mean ± SD	Days of migration to winter area Mean ± SD
Beaufort Sea and areas to east	F	3000	15 Oct ± 5 (30)	28 Oct ± 9 (28)	19 Nov ± 22 (28)	10 ± 4	32 ± 22
	M	1200–2900	2 Oct ± 5 (22)	16 Oct ± 7 (20)	30 Oct ± 23 (19)	11 ± 4	24 ± 21
Chukchi and Bering seas	M	200–1000	16 Oct ± 11 (10)	17 Oct ± 6 (8)	10 Nov ± 23 (10)	2 ± 1	22 ± 21

Table 8. Timing and level of use of the staging area off Chukotsk Peninsula in the northern Bering Sea by Pacific Common Eiders from Nauyak Lake nesting colony during fall migration.

Moulting region	Sex	No. of migrants	% that stopped	% that staged	Arrival[1] Mean	± SD	(n)	Departure[1] Mean	± SD	(n)	Duration of stay (d)[1] Mean	± SD
Beaufort Sea and areas to east	F	27	85	63	29 Oct	± 10	(27)	19 Nov	± 20	(22)	25	± 21
	M	19	81	44	17 Oct	± 8	(19)	2 Nov	± 24	(13)	19	± 23
Chukchi and Bering seas	M	10	70	60	17 Oct	± 7	(8)	11 Nov	± 20	(7)	28	± 20

[1]Based on all birds that stopped.

Table 9. Timing and duration of spring migration for Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake in central arctic Canada the previous June.

Breeding destination (distance in km)	Sex	Departure from wintering area Mean ± SD (n)	Arrival breeding area Mean ± SD (n)	Number of days of migration Mean ± SD (n)
North America (2400–3500)	F	26 Mar ± 20 (17)	15 Jun ± 4 (9)	75 ± 19 (9)
	M	31 Mar ± 17 (12)	17 Jun ± 8 (7)	69 ± 24 (7)
	All	28 Mar ± 19 (29)	16 Jun ± 6 (16)	72 ± 21 (16)
Siberia (400–1100)	M	26 May ± 0 (2)	19 Jun ± 10 (2)	22 ± 10 (2)

Table 10. Location, timing and level of use of spring staging areas by Pacific Common Eiders migrating to North America to breed.

Staging area	No. of migrants	% that stopped	% that staged	Arrival[1] Mean	± SD	Departure[1] Mean	± SD	Duration of stay (d)[1] Mean	± SD
Off Chukotsk Peninsula	16	68	62	30 Mar	± 18	26 Apr	± 16	33	± 23
East Chukchi Sea	16	94	75	28 Apr	± 11	16 May	± 7	22	± 11
Southeast Beaufort Sea	16	100	94	20 May	± 6	5 Jun	± 10	19	± 9
Dolphin and Union Strait	11	72	36	7 Jun	± 9	12 Jun	± 7	7	± 6

[1]Based on all birds that stopped.

Table 11. Timing of migration across the Beaufort Sea for Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake in central arctic Canada in June, 2001–2003 and 2006.

Migration period	Sex	Arrival Mean ± SD (range)	Departure Mean ± SD (range)	Duration of stay (d) Mean ± SD (range)	n
Moult migration	Male	28 Jul ± 8 (16 Jul–12 Aug)	5 Aug ± 5 (29 Jul–12 Aug)	11 ± 6 (1–21)	13
Fall migration	Male	7 Oct ± 5 (29 Sep–17 Oct)	10 Oct ± 6 (2–25 Oct)	4 ± 3 (2–16)	16
	Female	20 Oct ± 4 (14–27 Oct)	22 Oct ± 6 (14 Oct–1 Nov)	4 ± 3 (1–11)	24
Spring migration	Combined	20 May ± 6 (8–30 May)	6 Jun ± 11 (8 May–28 Jun)	19 ± 11 (2–49)	14

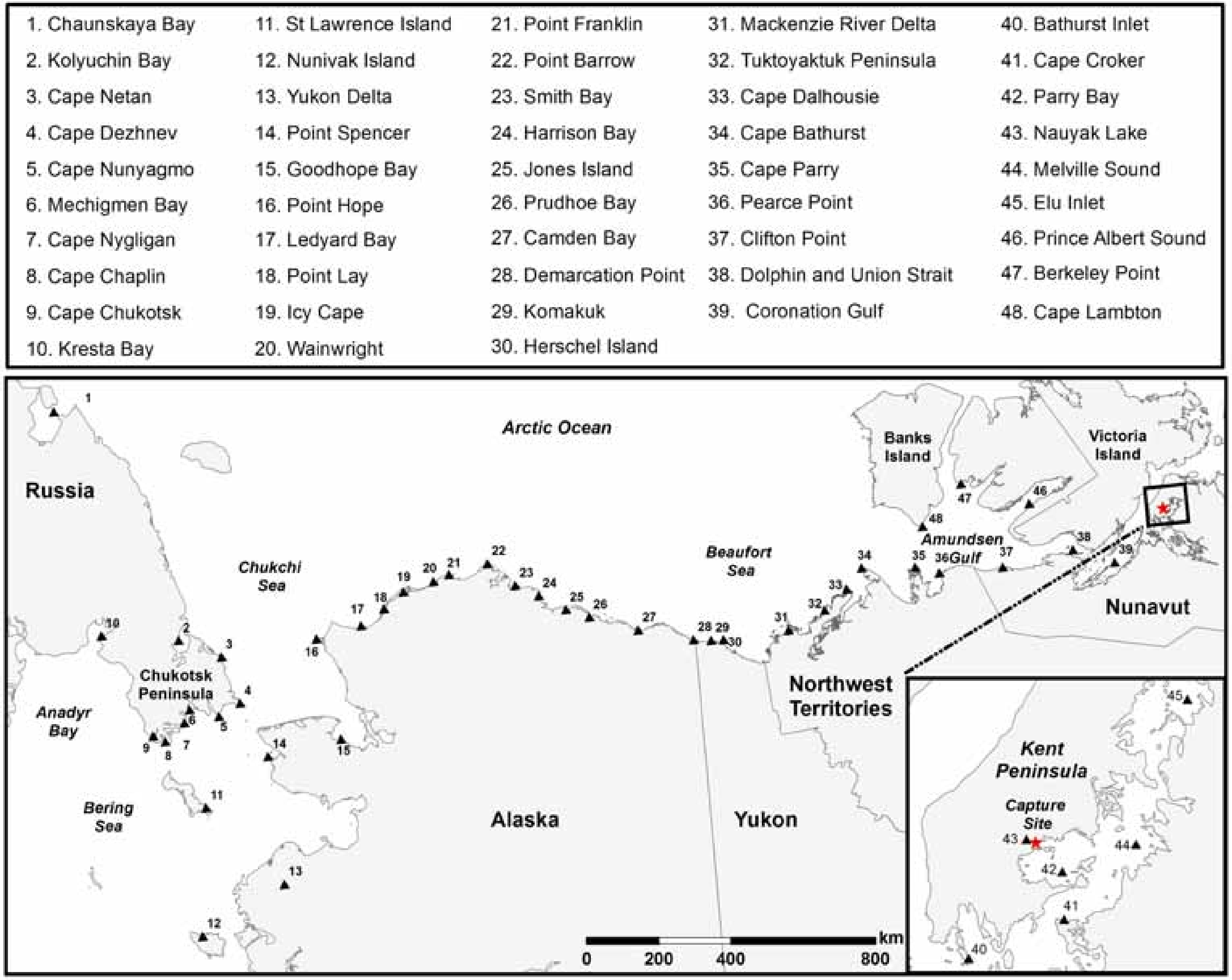


Figure 1. Location of place names mentioned in text. Red star indicates location of capture site near the nesting colony at Nauyak Lake.

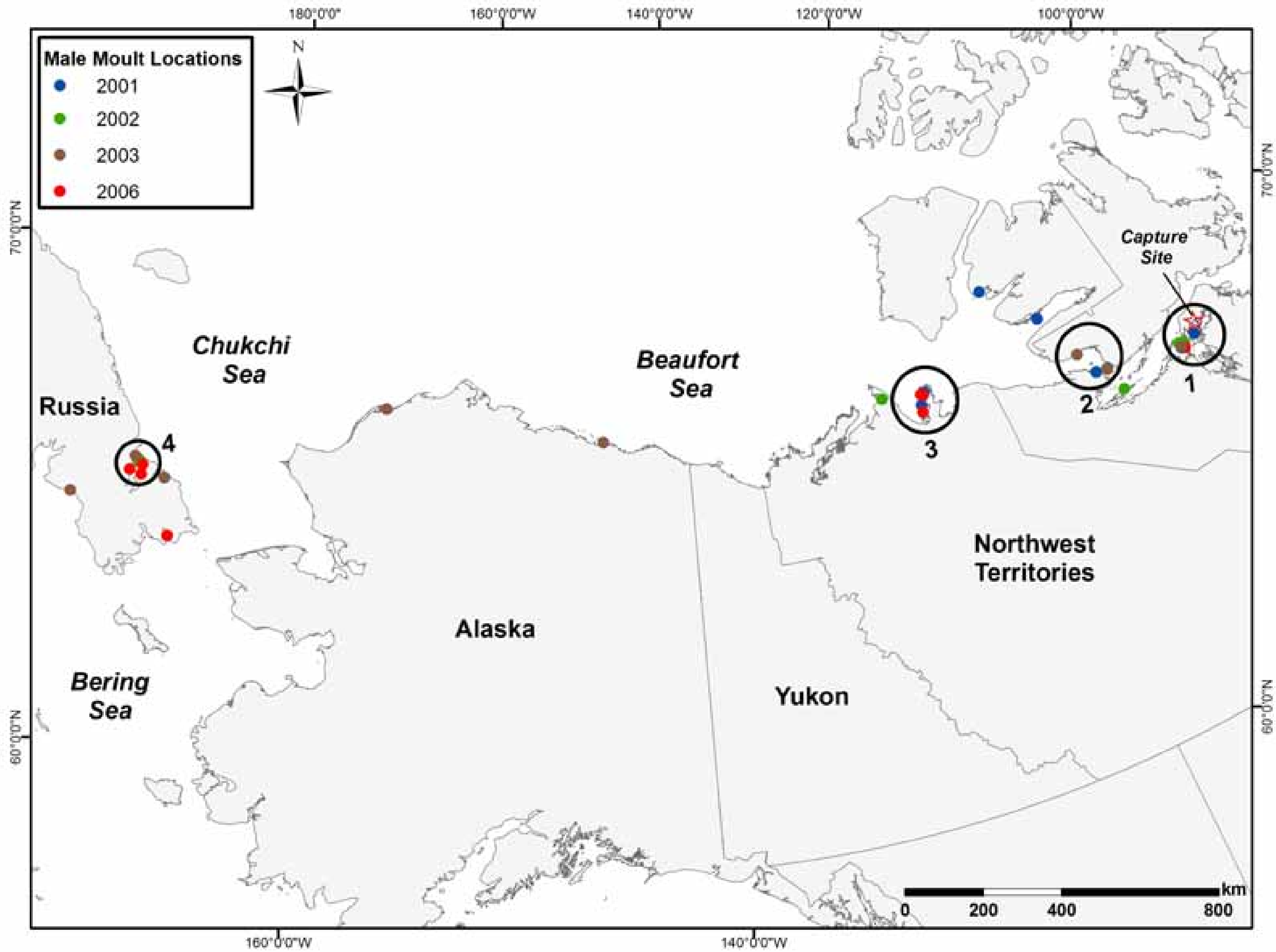


Figure 2. Moult locations of 33 male Pacific Common Eiders tagged near Nauyak Lake nesting colony. Each dot represents the centroid moult location of an eider. Key moulting areas were: 1 – Bathurst Inlet (7 males); 2 – Dolphin and Union Strait (5 males); 3 – Cape Parry (5 males); and 4 – Kolyuchin Bay (7 males).

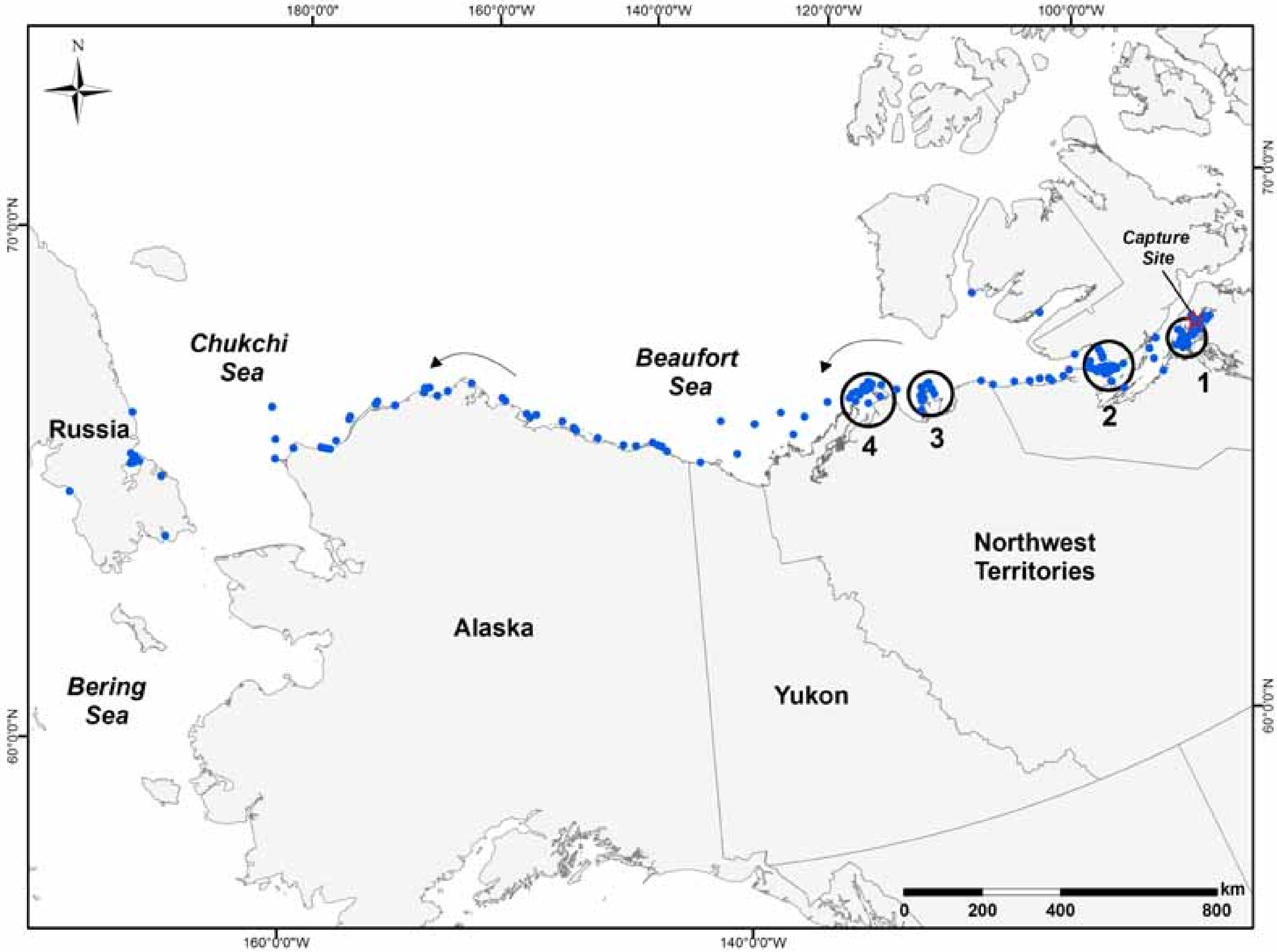


Figure 3. Moult migration route and staging areas of 33 male Pacific Common Eiders tagged near Nauyak Lake nesting colony. Each blue dot represents an eider location. Arrows indicate direction of travel. Open circles indicate staging areas: 1 – Bathurst Inlet; 2 – Dolphin and Union Strait; 3 – Cape Parry; and 4 – Cape Bathurst.

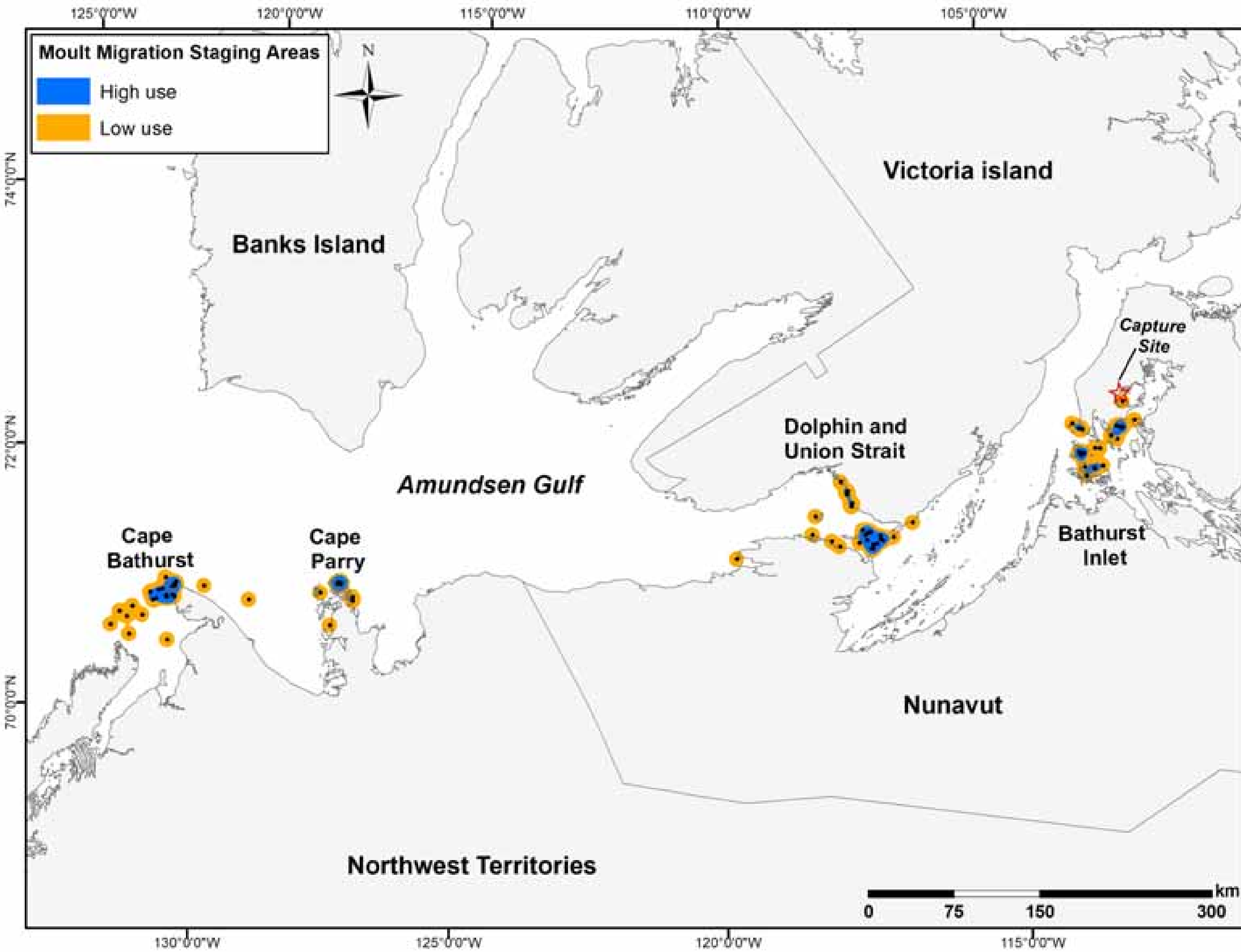


Figure 4. Distribution of male Pacific Common Eiders at each of the four staging areas used during moult migration: Bathurst Inlet (9 eiders, 22 locations); Dolphin and Union Strait (12 eiders, 32 locations); Cape Parry (5 eiders, 15 locations); and Cape Bathurst (6 eiders, 31 locations). Black dots represent eider locations; yellow shaded areas show the 95% volume contour; blue shaded areas show the high use 50% volume contour.

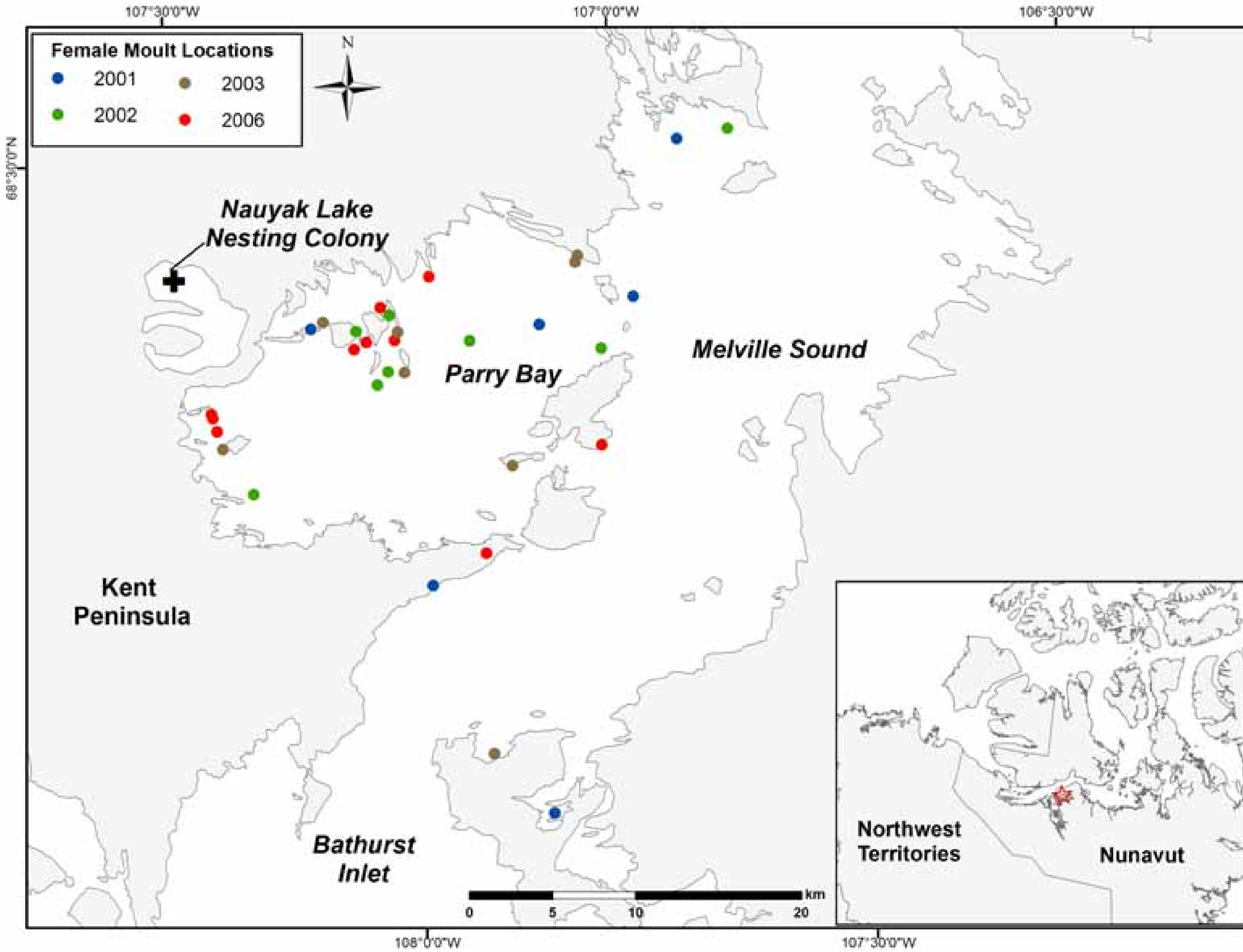


Figure 5. Moult locations of 32 female Pacific Common Eiders. Each dot represents the centroid moult location of an eider.

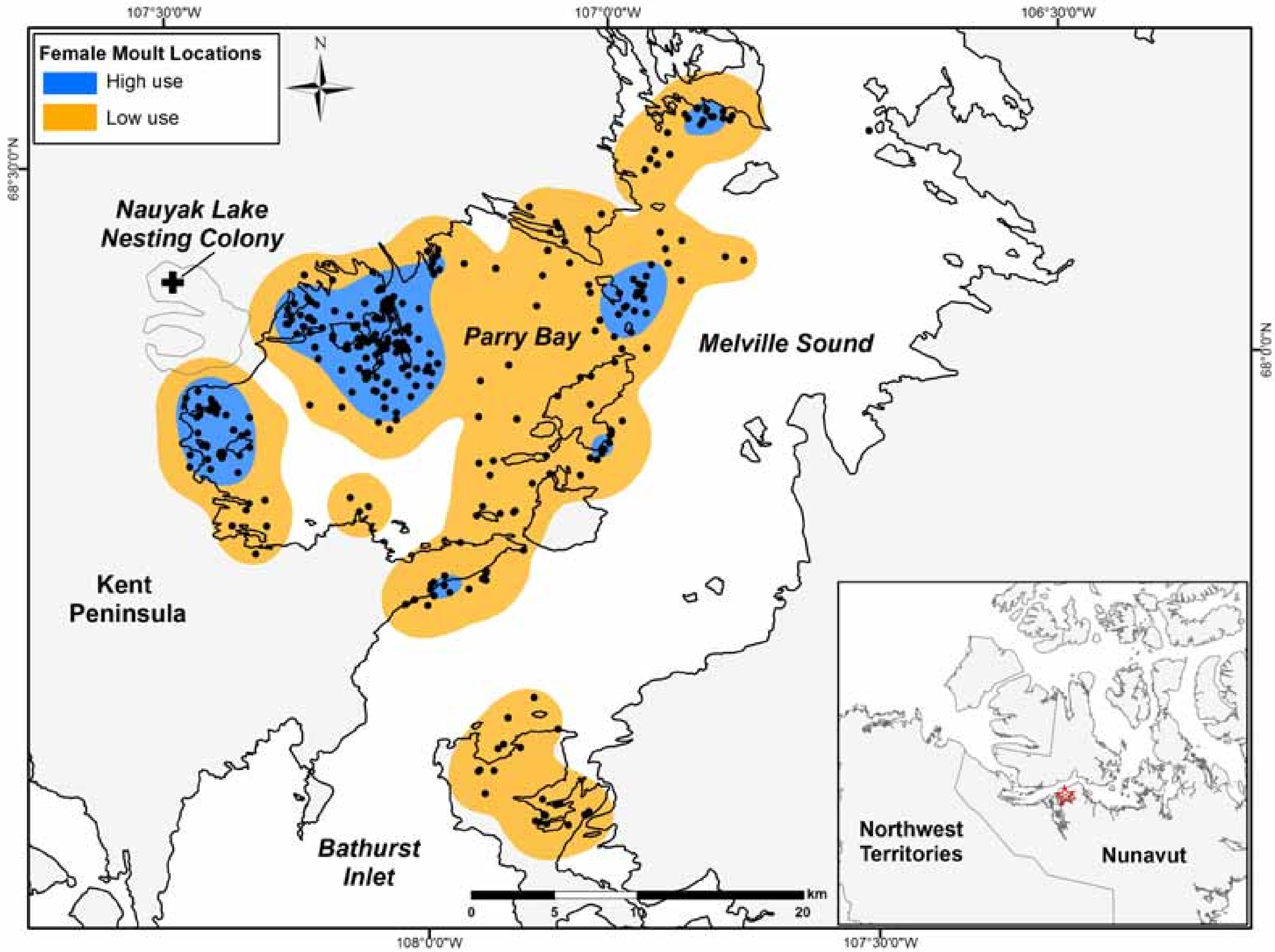


Figure 6. Areas where 32 female Pacific Common Eiders from Nauyak Lake nesting colony tended to concentrate during moult. Black dots represent eider locations (n = 317); yellow shading represents 95% volume contours; dark blue shading indicates high use 50% volume contours.

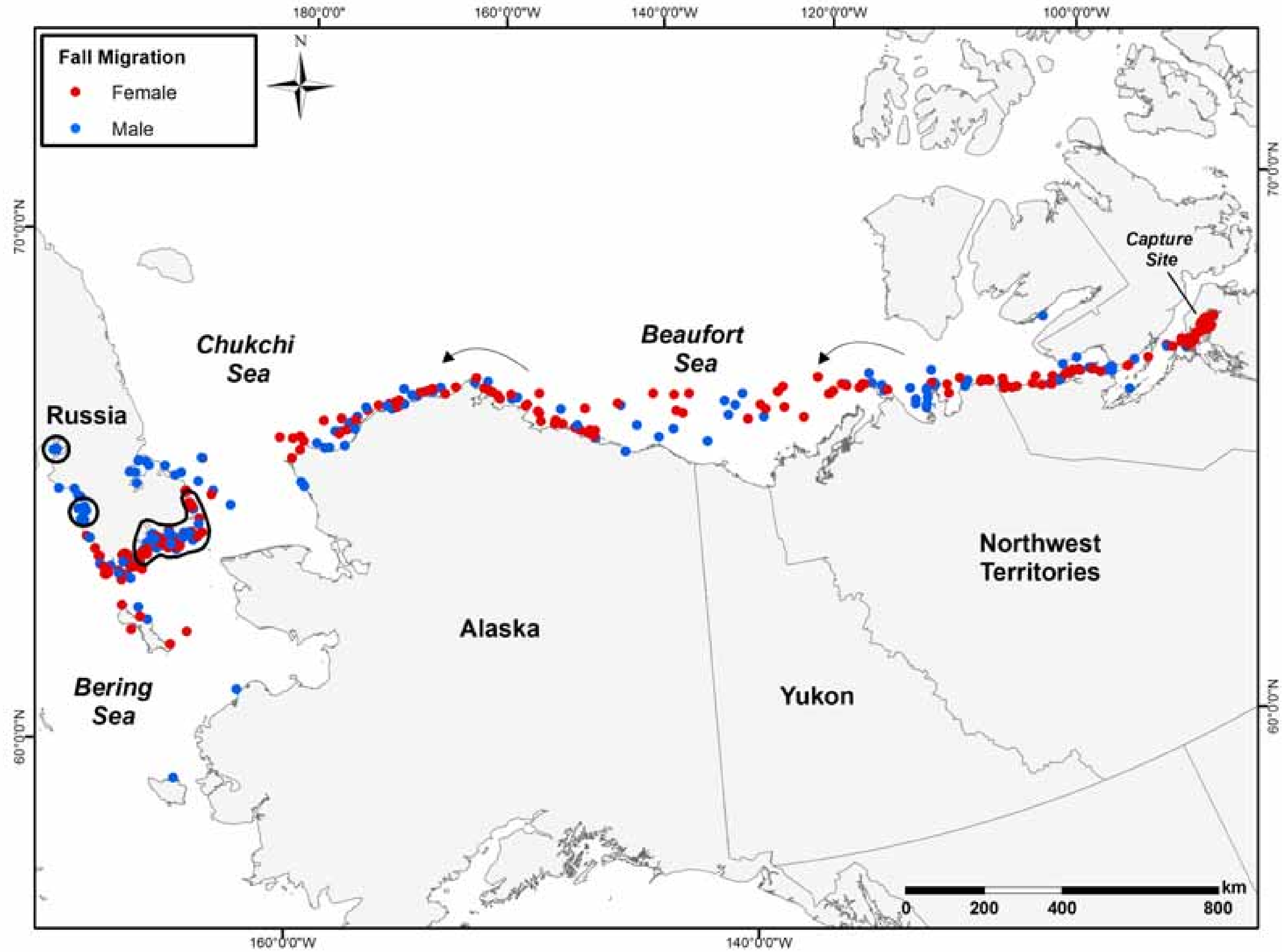


Figure 7. Fall migration of 29 male and 28 female Pacific Common Eiders. Each dot represents an eider location. Arrows indicate direction of travel. Bold black lines off Chukotsk Peninsula, Russia, show location of fall staging area.

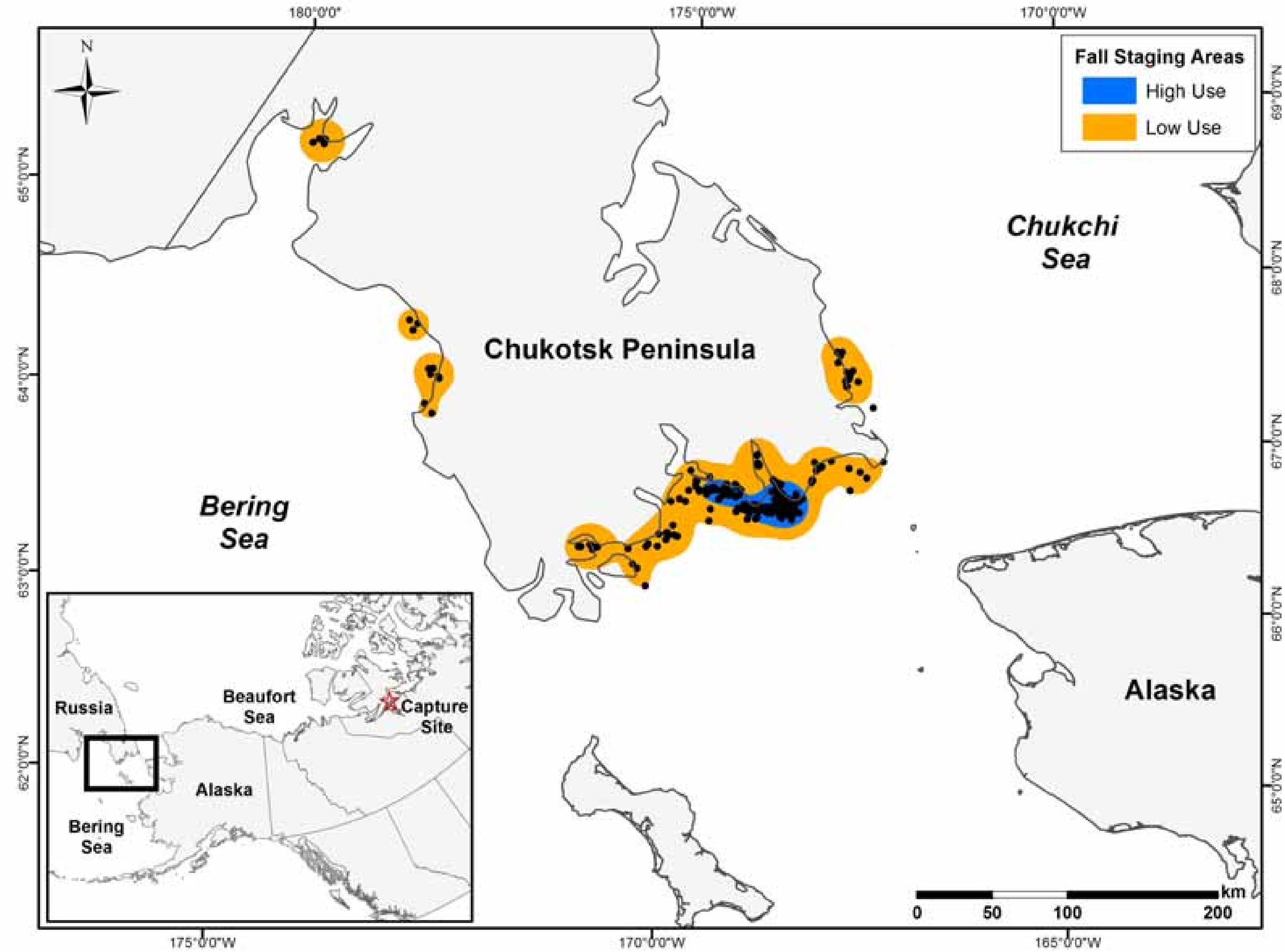


Figure 8. Distribution of 29 Pacific Common Eiders on fall staging area off Chukotsk Peninsula, Russia. Black dots represent eider locations (n = 237); dark blue shading indicates 50% volume contour and yellow shading represents 95% volume contour.

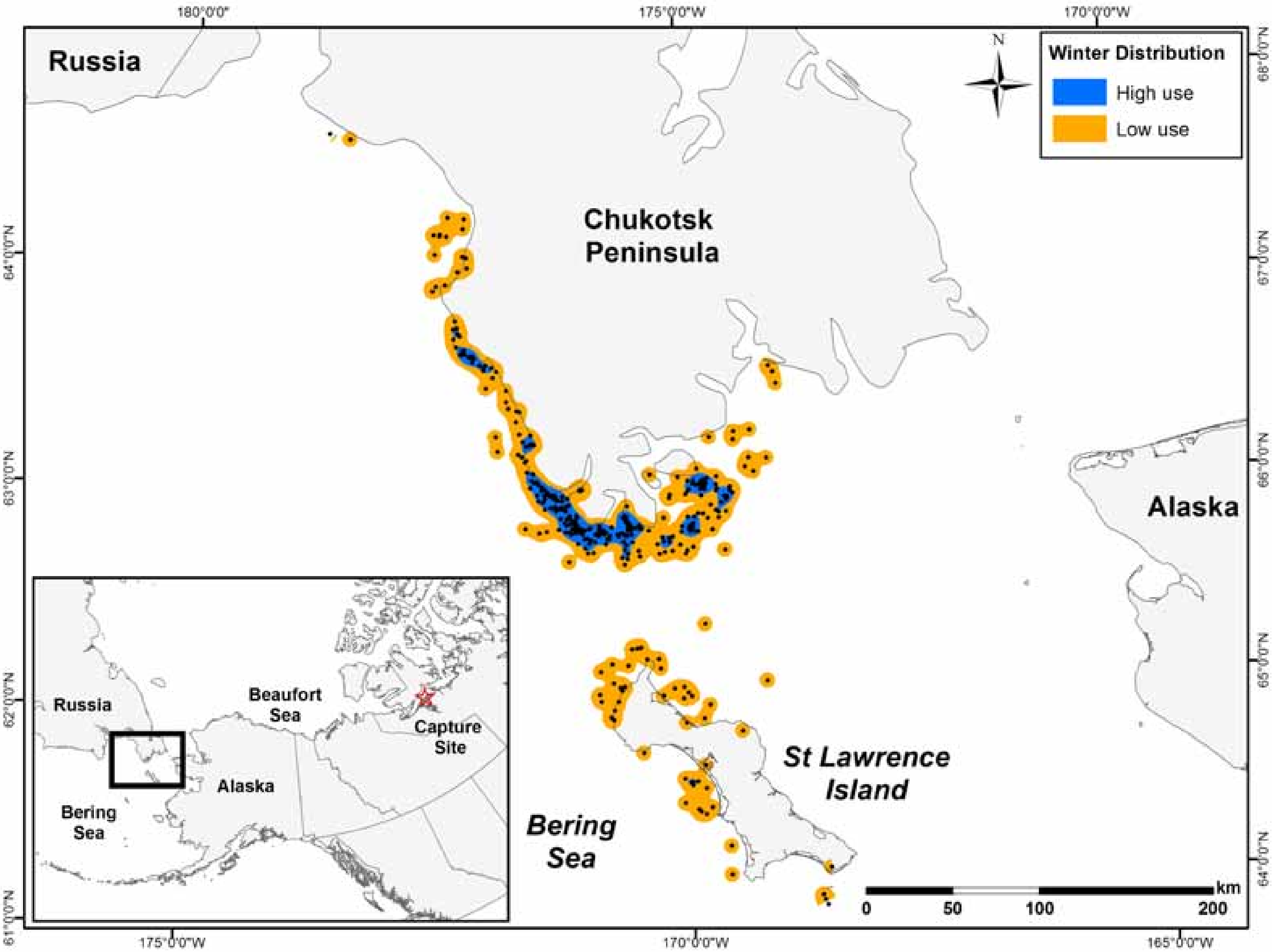


Figure 9. Distribution of 37 Pacific Common Eiders on their wintering area. Black dots represent eider locations (n = 365); dark blue shading indicates 50% volume contour and yellow shading indicates the 95% volume contour.

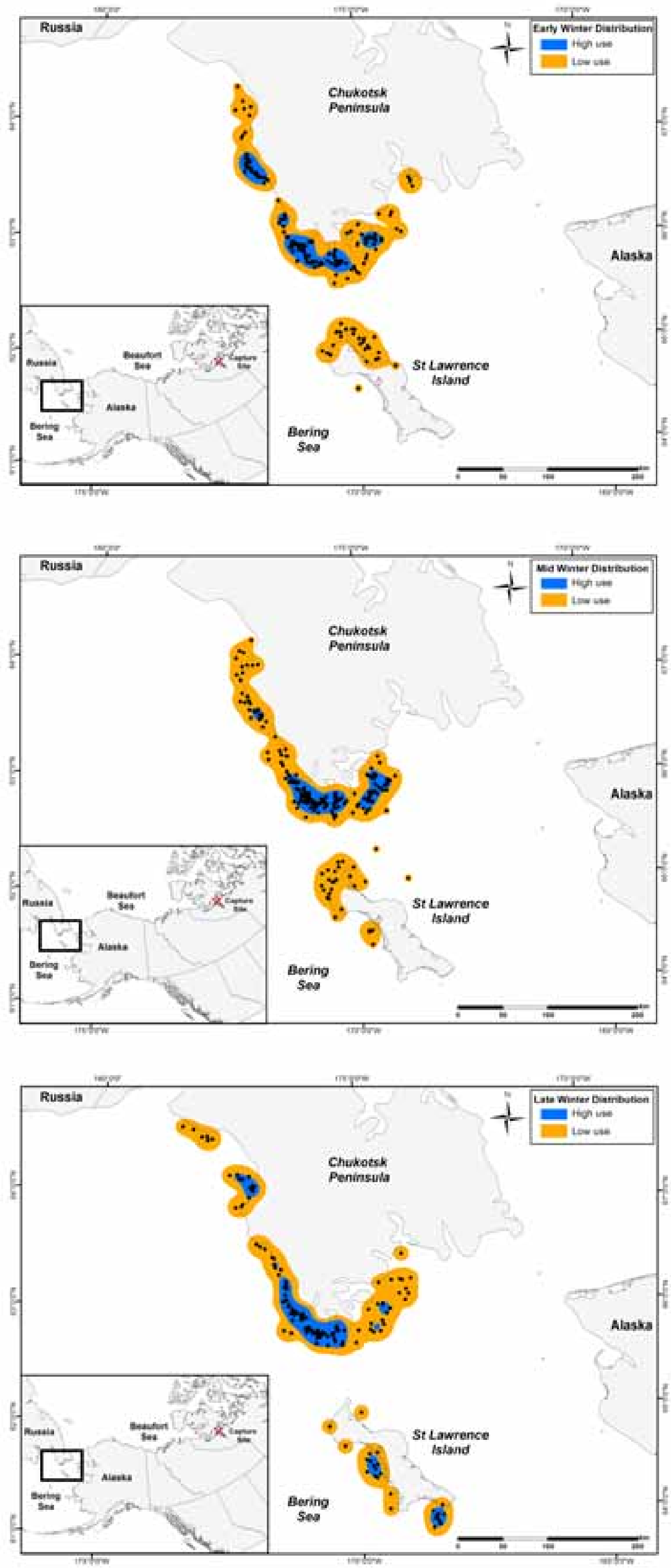
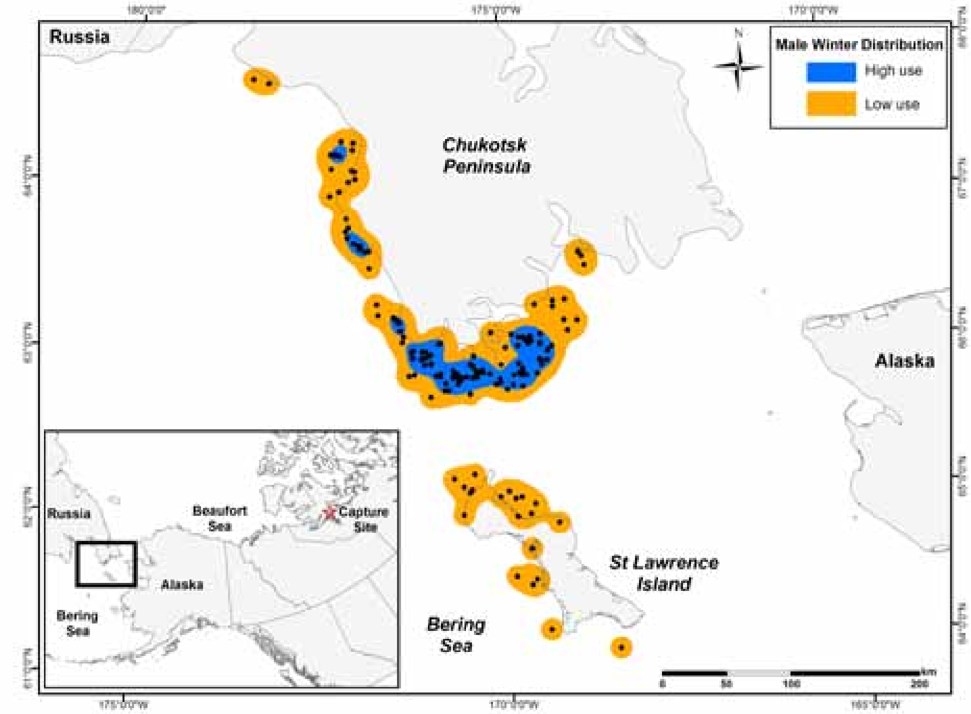


Figure 10. Distribution of Pacific Common Eiders in early winter (up to 31 Dec.), compared to mid- (1 Jan. to 29 Feb.) and late (after 28 Feb.) winter. Black dots represent eider locations; yellow shaded areas show the 95% volume contour and the darker blue shaded areas show the 50% volume contour.



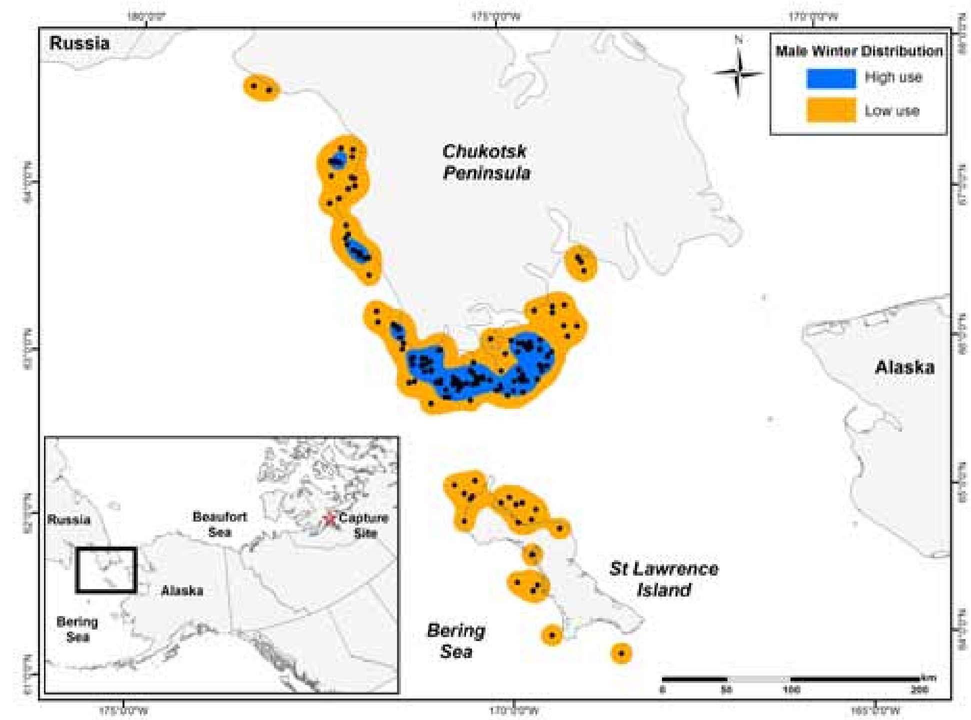


Figure 11. Comparison of distribution of male (n = 16) versus female (n = 21) Pacific Common Eiders on the wintering area. Black dots represent eider locations; yellow shaded areas show the 95% volume contour and the darker blue shaded areas show the 50% volume contour.

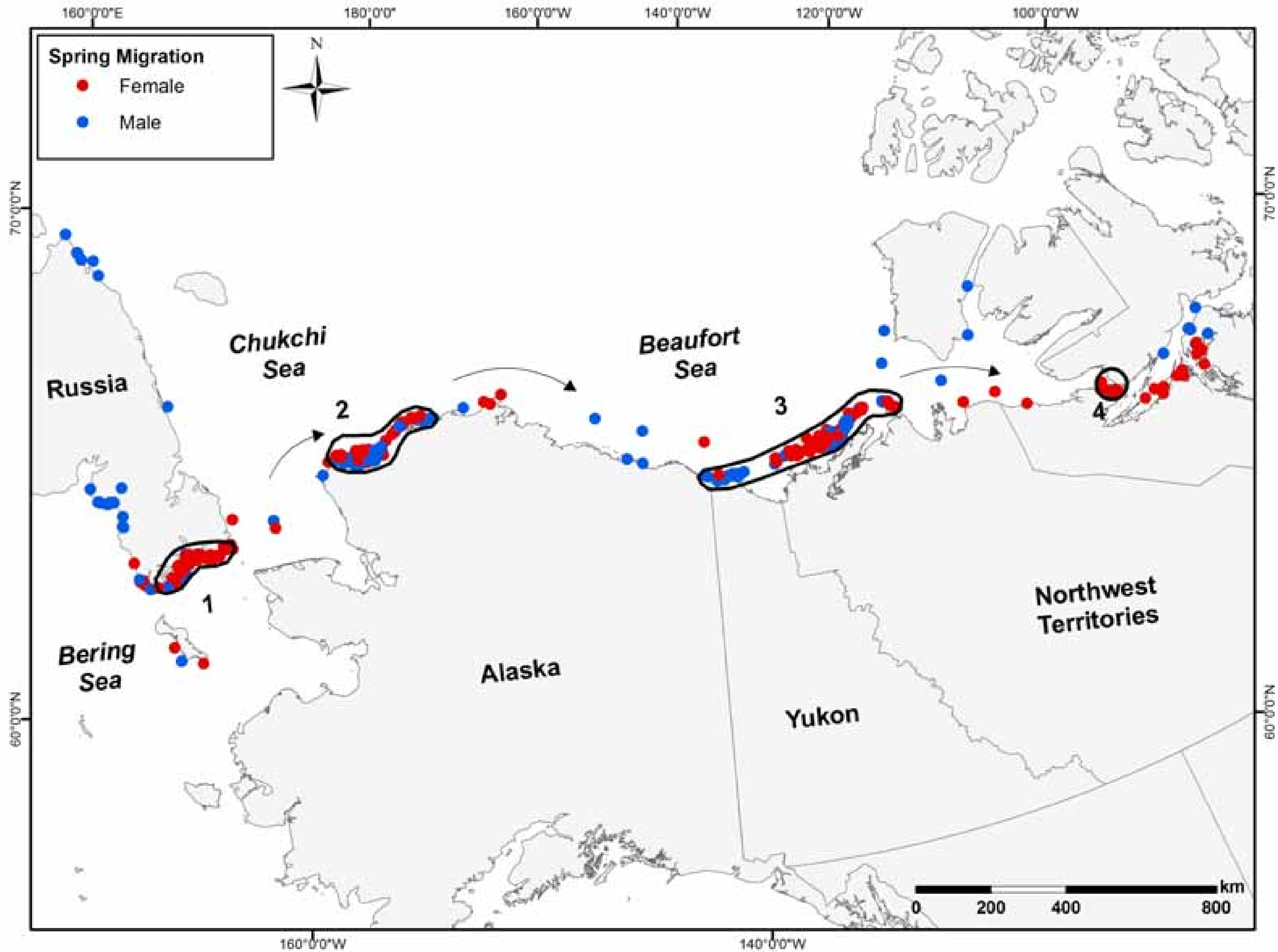


Figure 12. Spring migration of nine male and nine female Pacific Common Eiders. Each dot represents an eider location, and arrows indicate direction of travel. Bold black lines indicate spring staging areas: 1 – off Chukotsk Peninsula; 2 – east Chukchi Sea; 3 – southeast Beaufort Sea; and 4 – Dolphin and Union Strait.

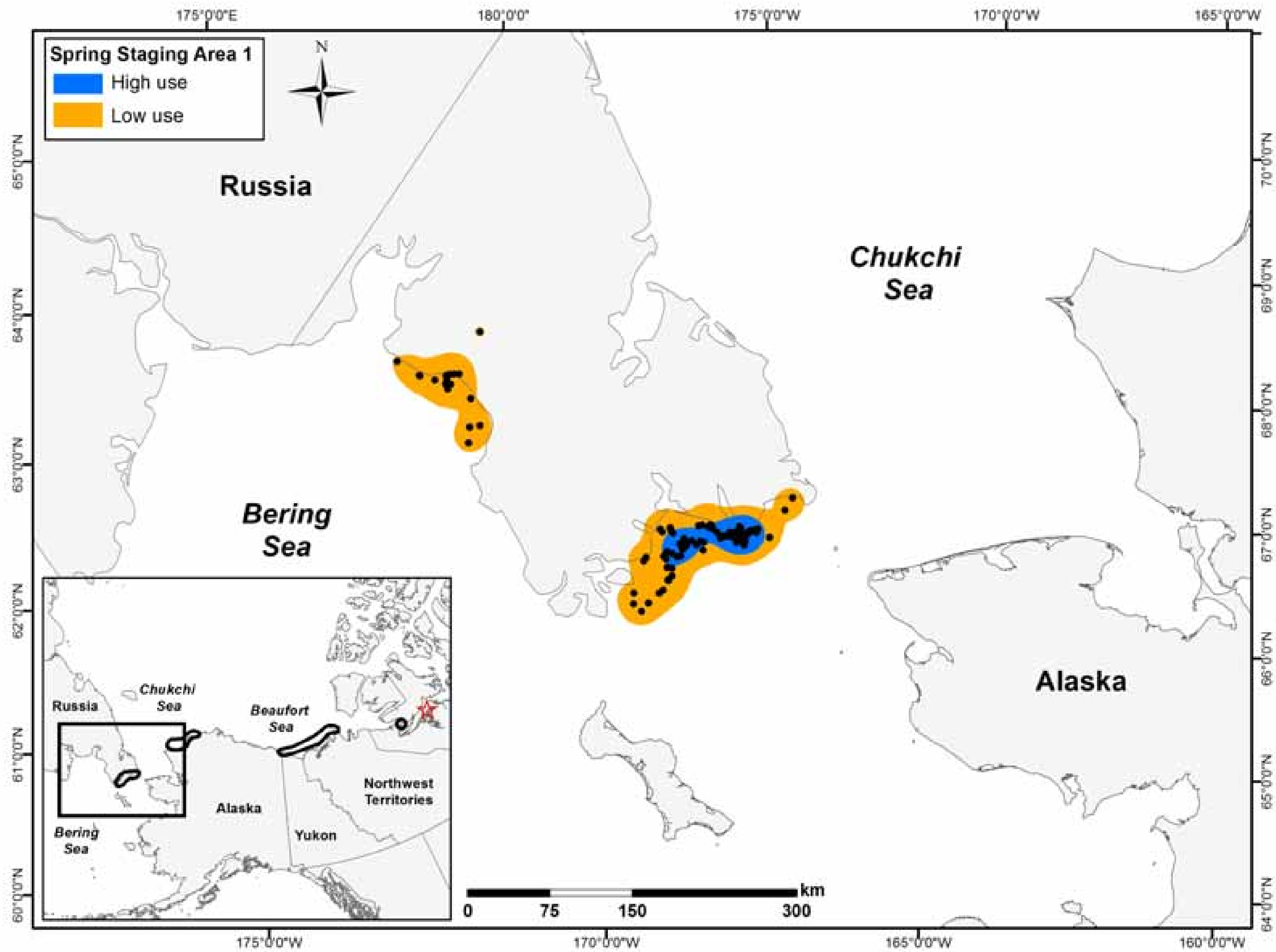


Figure 13. Distribution of 11 Pacific Common Eiders on the spring staging area off Chukotsk Peninsula, Russia. Black dots represent eider locations (n = 103); dark blue shading indicates 50% volume contour; yellow shading represents 95% volume contour.

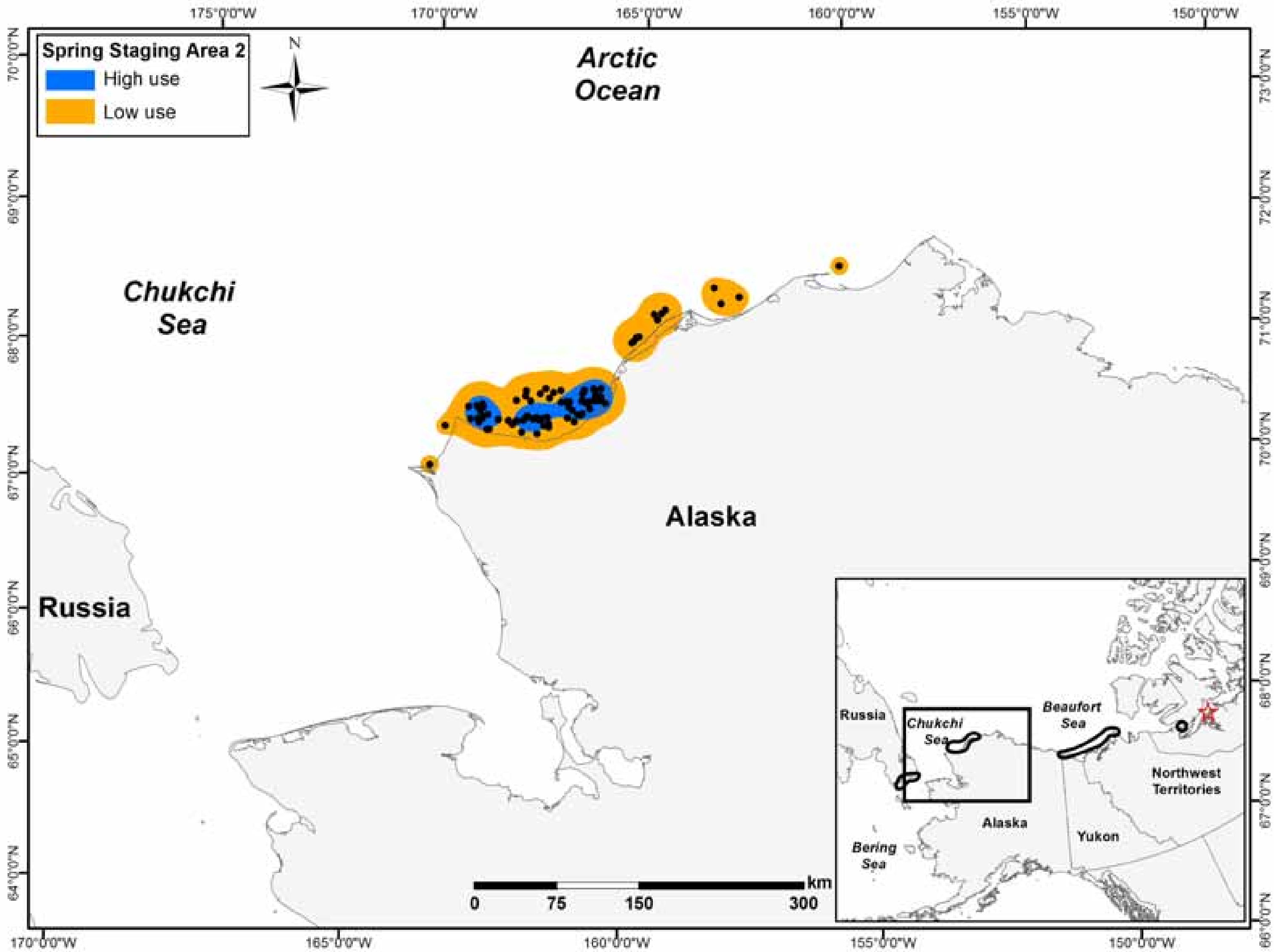


Figure 14. Distribution of 15 Pacific Common Eiders on the spring staging area off Alaska in eastern Chukchi Sea. Black dots represent eider locations (n = 94); dark blue shading indicates 50% volume contour; yellow shading represents 95% volume contour.

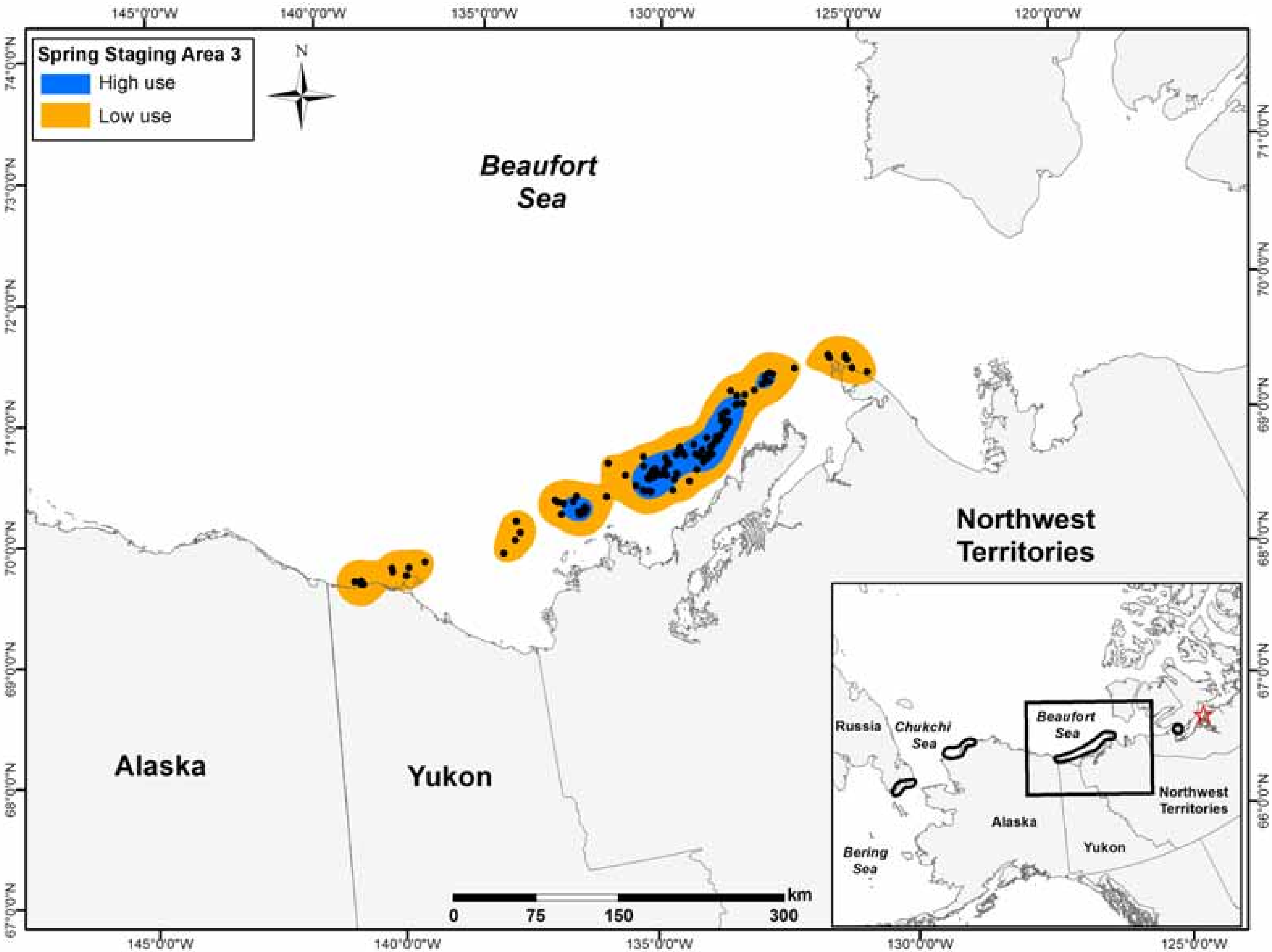


Figure 15. Distribution of 16 Pacific Common Eiders on the spring staging area in the southeast Beaufort Sea. Black dots represent eider locations (n = 122); dark blue shading indicates 50% volume contour; yellow shading represents 95% volume contour.

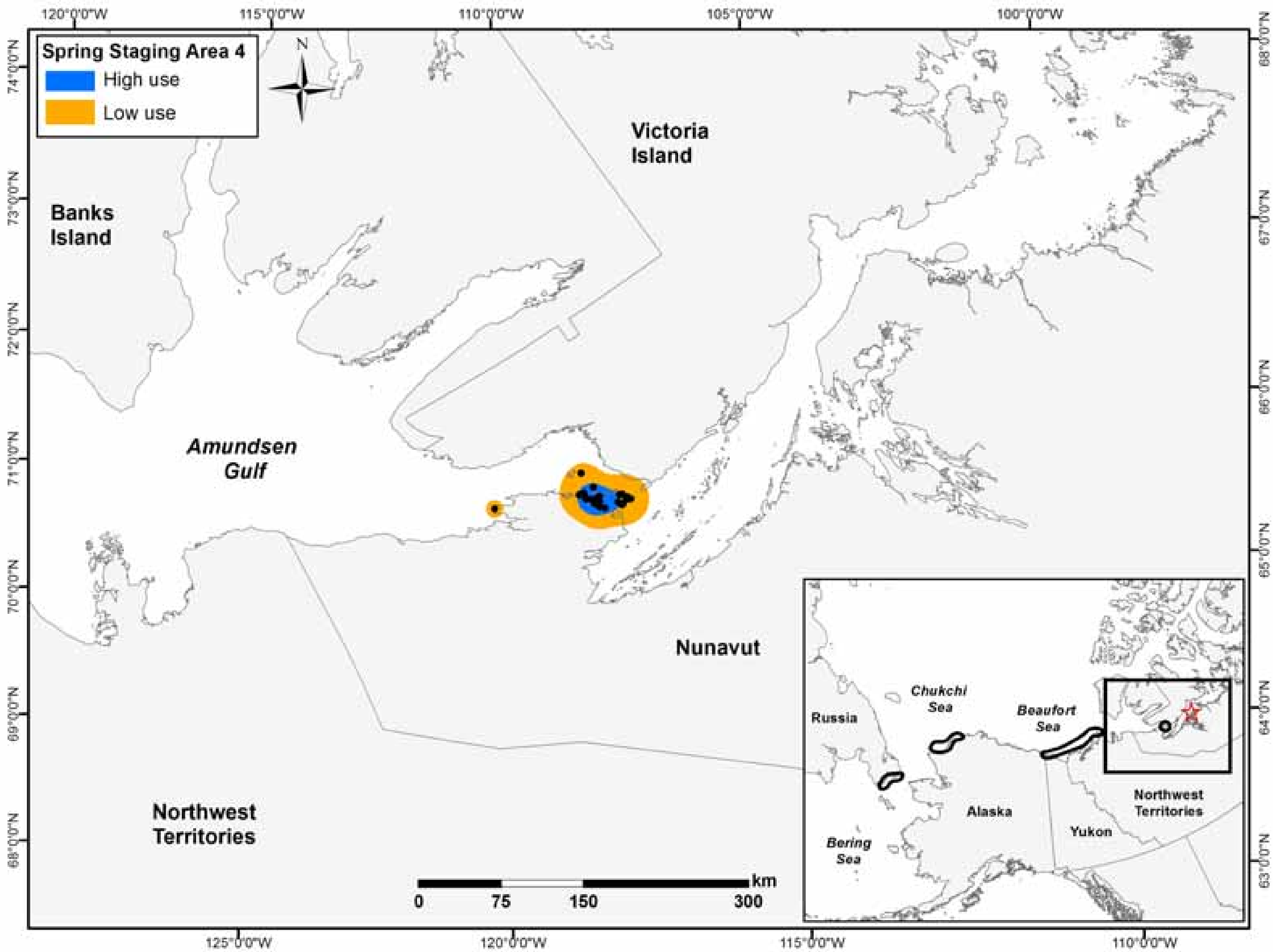


Figure 16. Distribution of eight Pacific Common Eiders on the spring staging area in Dolphin and Union Strait, Nunavut. Black dots represent eider locations (n = 31); dark blue shading indicates 50% volume contour; yellow shading represents 95% volume contour.

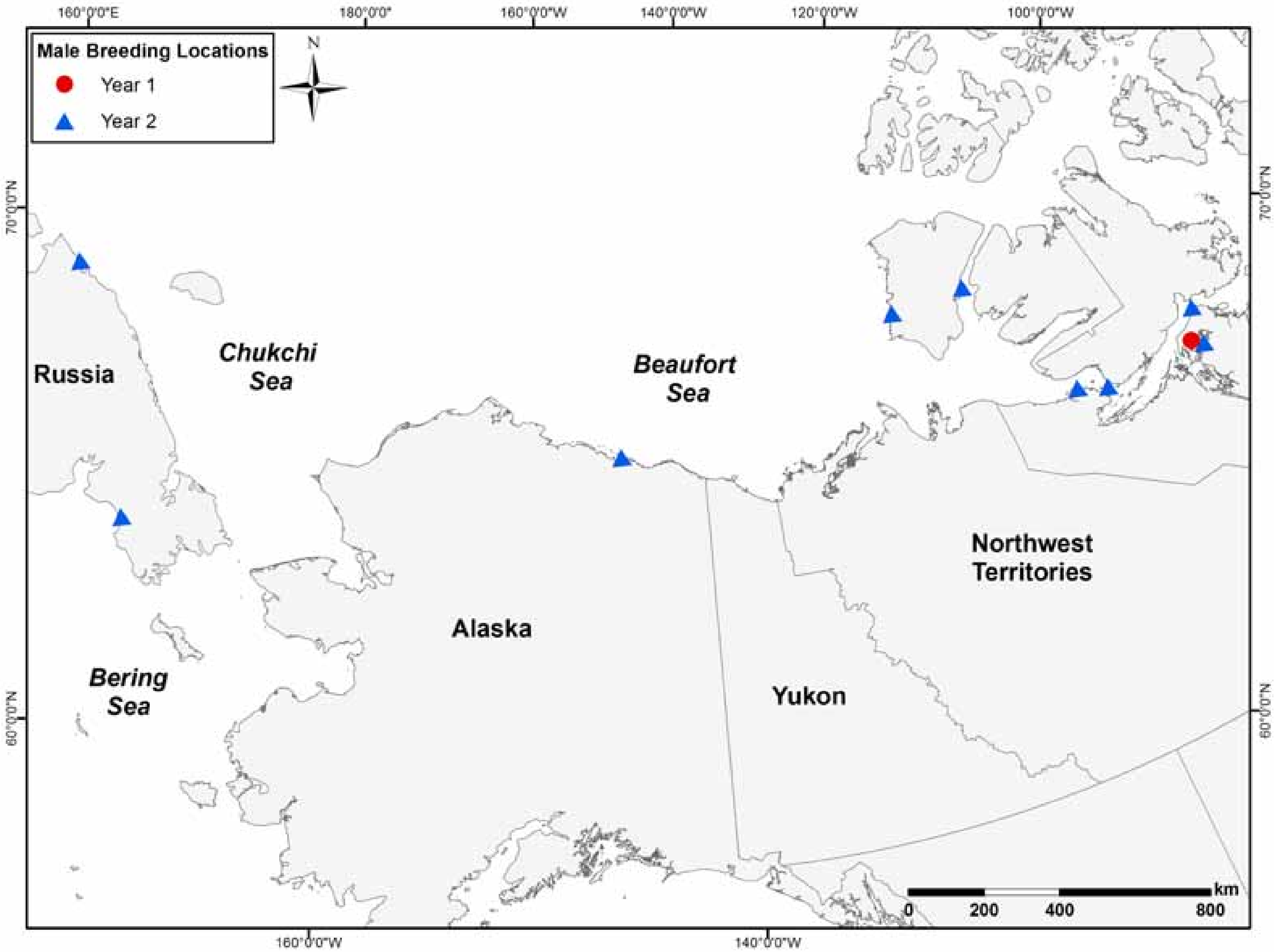


Figure 17. Location of nine male Pacific Common Eiders during the breeding season in the second year. The red dot represents the approximate breeding location of all of the eiders in the first year, and the blue triangles represent the centroid breeding location of each male eider in the subsequent year.

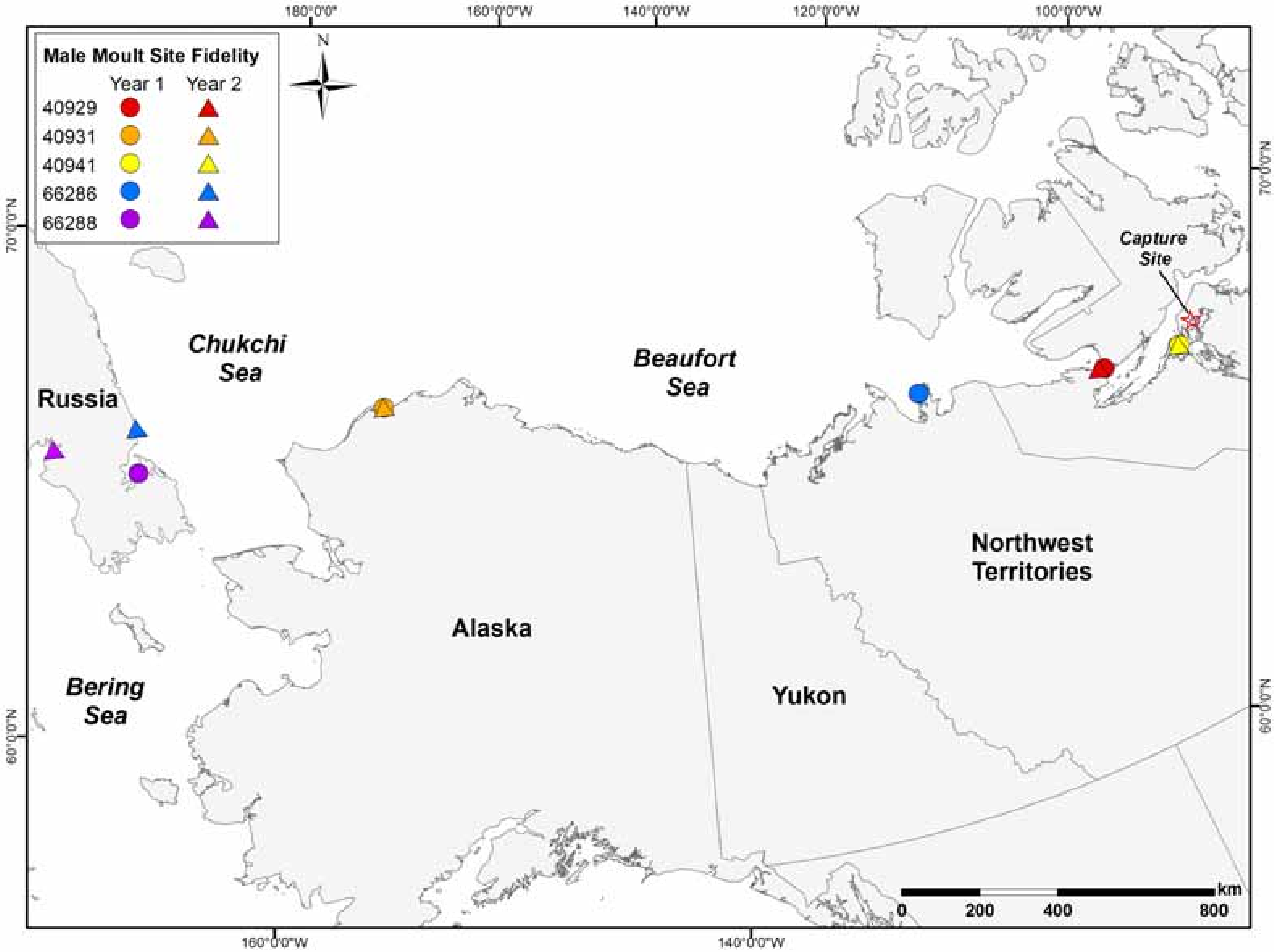


Figure 18. Moult location of five male Pacific Common Eiders in two consecutive years. The circle represents the centroid moult location in the first year, and the triangle shows the centroid location in the second year.

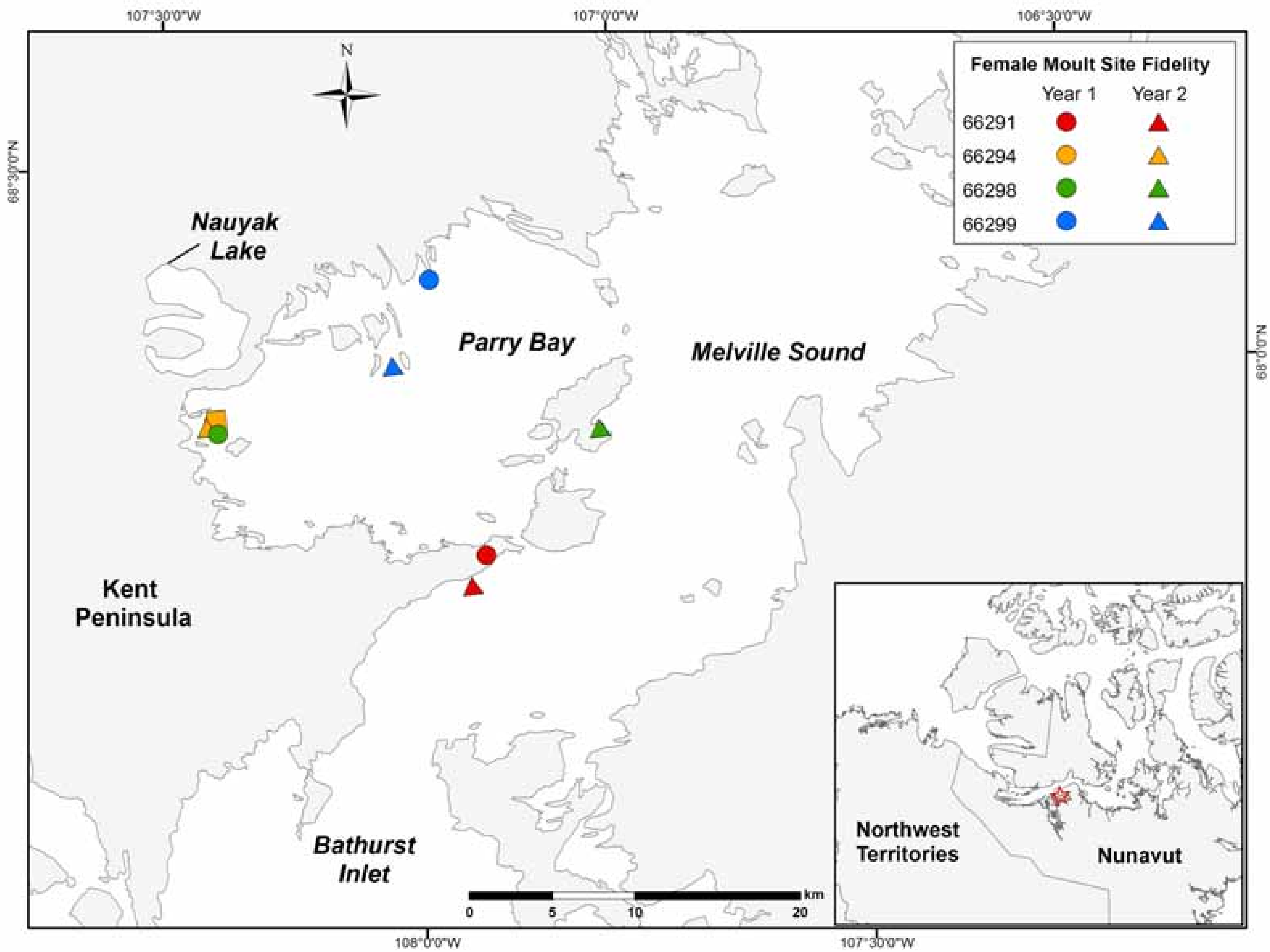


Figure 19. Moult location of four female Pacific Common Eiders in two consecutive years. The circle represents the centroid moult location in the first year, and the triangle shows the location in the second year.

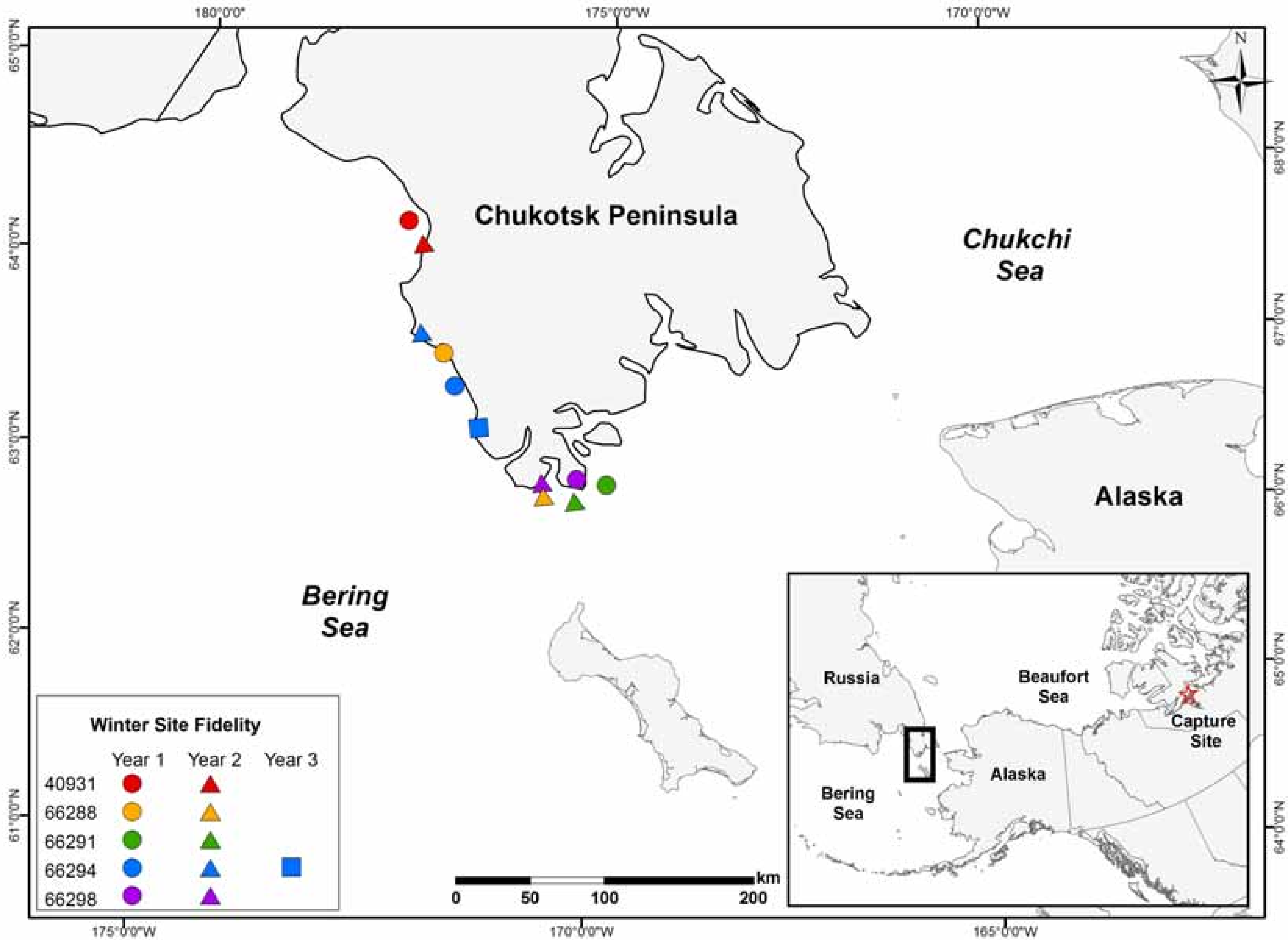


Figure 20. Winter location of two male (red, yellow) and three female (green, blue, purple) Pacific Common Eiders in two consecutive years. The circle represents the centroid moult location in the first winter, and the triangle shows the location in the second year. The square shows the location of a female in the third year.

Appendix A. Timing of movement of Pacific Common Eiders with transmitters deployed at Nauyak Lake, Nunavut from 2001–2003 and 2006.

		Date[1]							
		Male				Female			
	Year PTT deployed	Mean	SD in days	Range	n	Mean	SD in days	Range	n
Depart nesting area	2001	09 Jul	±8	2–24 Jul	8	30 Jul	±7	22 Jul–8 Aug	6
	2002	07 Jul	±7	28 Jun–19 Jul	9	02 Aug	±6	22 Jul–8 Aug	8
	2003	08 Jul	±6	1–18 Jul	8	30 Jul	±8	19 Jul–14 Aug	8
	2006	14 Jul	±7	5–30 Jul	10	27 Jul	±11	7 Jul–9 Aug	10
	All years	**10 Jul**	**±7**	**28 Jun–30 Jul**	**35**	**30 Jul**	**±8**	**7 Jul–14 Aug**	**32**
Arrive moulting area	2001	18 Jul	±9	8 Jul–3 Aug	8	03 Aug	±7	26 Jul–11 Aug	6
	2002	23 Jul	±17	2 Jul–13 Aug	9	05 Aug	±6	25 Jul–11 Aug	8
	2003	01 Aug	±18	10 Jul–25 Aug	8	04 Aug	±8	23 Jul–18 Aug	8
	2006	26 Jul	±14	13 Jul–15 Aug	8	30 Jul	±11	10 Jul–12 Aug	10
	All years	**25 Jul**	**±15**	**2 Jul–25 Aug**	**33**	**02 Aug**	**±8**	**10 Jul–18 Aug**	**32**
Depart moulting area	2001	05 Oct	±3	30 Sep–10 Oct	8	12 Oct	±2	10–15 Oct	5
	2002	09 Oct	±14	24 Sep–12 Nov	9	12 Oct	±2	9–15 Oct	7
	2003	08 Oct	±10	28 Sep–24 Oct	8	19 Oct	±8	4–29 Oct	8
	2006	04 Oct	±7	27 Sep–13 Oct	7	16 Oct	±4	9–20 oct	10
	All years	**07 Oct**	**±10**	**24 Sep–12 Nov**	**32**	**15 Oct**	**±5**	**4–29 Oct**	**30**
Arrive Chukotsk Pen.	2001	17 Oct	±4	13–23 Oct	7	20 Oct	±2	19–24 Oct	5
	2002	19 Oct	±9	11 Oct–4 Nov	5	25 Oct	±5	17–31 Oct	7
	2003	16 Oct	±5	11–24 Oct	5	05 Nov	±12	17 Oct–19 Nov	6
	2006	08 Oct	±5	5–16 Oct	4	29 Oct	±7	18 Oct–7 Nov	10
	All years	**16 Oct**	**±7**	**5 Oct–4 Nov**	**21**	**28 Oct**	**±9**	**17 Oct–19 Nov**	**28**
Arrive wintering area	2001	31 Oct	±11	22 Oct–16 Nov	7	22 Oct	±1	21–24 Oct	5
	2002	19 Nov	±26	16 Oct–28 Dec	8	25 Nov	±26	26 Oct–30 Dec	8
	2003	04 Nov	±27	11 Oct–23 Dec	8	25 Nov	±9	15 Nov–7 Dec	6
	2006	14 Oct	±8	6–26 Oct	6	25 Nov	±18	6 Nov–27 Dec	9
	All years	**03 Nov**	**±23**	**6 Oct–28 Dec**	**29**	**19 Nov**	**±22**	**21 Oct–30 Dec**	**28**
Depart wintering area[2]	2001	–	–	–	–	04 Apr	–	–	1
	2002	28 Mar	±17	4 Mar–15 Apr	5	20 Mar	±19	23 Feb–12 Apr	6
	2003	03 Apr	±19	14 Mar–26 Apr	7	24 Mar	±12	12 Mar–9 Apr	5
	2006	26 May		26 May	2	02 Apr	±29	24 Feb–30 Apr	5
	All years	**08 Apr**	**±26**	**4 Mar–26 May**	**14**	**26 Mar**	**±20**	**23 Feb–30 Apr**	**17**
Arrive nesting area	2001	–	–	–	–	11 Jun	–	–	1
	2002	–	–	–	–	–	–	–	
	2003	17 Jun	±8	9–29 Jun	7	13 Jun	±3	9–16 Jun	4
	2006	19 Jun	±10	12–26 Jun	2	18 Jun	±5	14–24 Jun	4
	All years	**18 Jun**	**±8**	**9–29 Jun**	**9**	**15 Jun**	**±4**	**9–24 Jun**	**9**

[1] Excluded data with >10 day gap between locations.
[2] Second year of transmissions.

Appendix A continued

		Date[1]							
		Male				Female			
	Year PTT deployed	Mean	SD in days	Range	n	Mean	SD in days	Range	n
Depart nesting area[2]	2001	–	–	–	–	27 Jul	–	–	1
	2002	–	–	–	–	–	–	–	–
	2003	13 Jul	±6	7–24 Jul	5	–	–	–	–
	2006	15 Jul	±16	4–26 Jul	2	28 Jul	±4	25 Jul–4 Aug	4
Arrive moulting area[2]	2001	–	–	–	–	–	–	–	–
	2002	–	–	–	–	–	–	–	–
	2003	22 Jul	±11	15 Jul–4 Aug	3	–	–	–	–
	2006	02 Aug	–	–	1	01 Aug	±4	29 Jul–7 Aug	4
Depart moulting area[2]	2001	–	–	–	–	–	–	–	–
	2002	–	–	–	–	–	–	–	–
	2003	17 Oct	–	–	1	–	–	–	–
	2006	21 Sep	–	–	1	11 Oct	±2	9–13 Oct	4
Arrive wintering area[2]	2001	–	–	–	–	–	–	–	–
	2002	–	–	–	–	–	–	–	–
	2003	–	–	–	–	–	–	–	–
	2006	16 Dec	–	–	1	01 Dec	±23	15 Nov–28 Dec	3

[1] Excluded data with >10 day gap between locations.
[2] Second year of transmissions.

Appendix B1. Summary of movement of eight male and six female Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake in June 2001.

Sex	PTT #	Depart nesting	Moult migration # of days	Arrive moulting	Moult locations 2001	Depart moulting	Fall migration # of days	Arrive winter	Winter location[1]
Males	33049	04-Jul	10	17-Jul	Cape Parry	07-Oct	8	23-Oct	Cape Nygligan
	33051	17-Jul	3	23-Jul	Dolphin and Union Strait	08-Oct	18	30-Oct	(Anadyr Bay)
	33052	24-Jul	5	03-Aug*	Dolphin and Union Strait	02-Oct*	11	23-Oct	Anadyr Bay
	33054	05-Jul	1	08-Jul	Cape Croker	10-Oct	10	22-Oct	(Cape Chaplin)
	33056	02-Jul	3	08-Jul	Cape Parry	04-Oct	41	16-Nov	(Anadyr Bay)
	33058	05-Jul	3	11-Jul	Bathurst Inlet	05-Oct	22	29-Oct	(Cape Chaplin)
	33060	09-Jul	6	18-Jul	Berkeley Point	30-Sep	–	–	–
	33063	12-Jul	10	25-Jul	Prince Albert Sound	04-Oct	39	16-Nov	–
Females	33050	26-Jul	2	29-Jul	Melville Sound	10-Oct	9	22-Oct	Cape Chukotsk
	33053	dead within 1 wk.		–	–	–	–	–	–
	33055	08-Aug	2	11-Aug	Cape Croker	14-Oct	7	24-Oct	(C. Chukotsk)
	33057	31-Jul	2	04-Aug	Melville Sound	15-Oct	7	24-Oct	Anadyr Bay
	33059	28-Jul	2	01-Aug	Cape Croker	12-Oct	7	21-Oct	Cape Chukotsk
	33061	22-Jul	2	26-Jul	Parry Sound	–	–	–	–
	33062	08-Aug	2	11-Aug	Melville Sound	10-Oct	9	22-Oct	Cape Nygligan

* means data gap >6 days
** means data gap >10 days
[1]Wintering area in brackets if no locations after December 30.

Appendix B1 continued

Sex	PTT #	Depart winter 2002	Spring migration # of days	Arrive nesting 2002	Nest location	Depart nesting	Moult migration # of days	Arrive moult	Moult locations 2002
Males	33049	–	–	–	–	–	–	–	–
	33051	–	–	–	–	–	–	–	–
	33052	–	–	–	–	–	–	–	–
	33054	–	–	–	–	–	–	–	–
	33056	–	–	–	–	–	–	–	–
	33058	–	–	–	–	–	–	–	–
	33060		–	–	–	–	–	–	–
	33063	–	–	–	–	–	–	–	–
Females	33050	04-Apr	62	11-Jun	E of Nauyak L.	27-Jul	3	02-Aug	Melville Sound
	33053	–	–	–	–	–	–	–	–
	33055	–	–	–	–	–	–	–	–
	33057	–	–	–	–	–	–	–	–
	33059	27-Mar**	–	–	–	–	–	–	–
	33061	–	–	–	–	–	–	–	–
	33062	–	–	–	–	–	–	–	–

* means data gap >6 days
** means data gap >10 days
[1]Wintering area in brackets if no locations after December 30.

Appendix B2. Summary of movement of nine male and eight female Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake in June 2002.

Sex	PTT #	Depart nesting	Moult migration # of days	Arrive moulting	Moult locations	Depart moulting	Fall migration # of days	Arrive winter	Winter location	Depart winter
Males	36642	07-Jul	2	11-Jul	Bathurst Inlet	27-Sep	64	02-Dec	Cape Chaplin	04-Apr**
	36643	19-Jul	13	05-Aug	Cape Bathurst	08-Oct	–	–	–	–
	36644	28-Jun	2	02-Jul	Bathurst Inlet	08-Oct	6	16-Oct	Cape Nygligan	–
	36645	18-Jul	17	08-Aug	Kolyuchin Bay	05-Oct	44	20-Nov	Cape Chaplin	04-Mar
	36646	09-Jul	31	13-Aug	Kolyuchin Bay	16-Oct	24	11-Nov	Cape Chaplin	–
	36651	01-Jul	1	03-Jul	Bathurst Inlet	24-Sep*	15	17-Oct*	Cape Chukotsk	22-Mar
	36653	09-Jul	1	12-Jul	Dolphin & Union Str.	03-Oct*	78	28-Dec*	Cape Chukotsk	01-Apr
	36654	30-Jun	40	11-Aug	Kolyuchin Bay	12-Nov*	5	21-Nov*	Cape Chukotsk	15-Apr
	36656	08-Jul	9	19-Jul	Coronation Gulf	12-Oct*	55	14-Dec*	Cape Chaplin	09-Apr
Females	36647	06-Aug	2	10-Aug	Parry Bay	11-Oct	28	10-Nov	Cape Chukotsk	18-Mar
	36648	25-Jul	2	29-Jul	Parry Bay	14-Oct	75	30-Dec	Cape Chaplin	01-Apr**
	36649	07-Aug	2	11-Aug	Parry Bay	15-Oct	9	26-Oct	Cape Chukotsk	12-Apr
	36650	03-Aug	2	06-Aug	Parry Bay	09-Oct	74	24-Dec	Cape Chukotsk	04-Mar
	36652	06-Aug	1	08-Aug	Melville Sound	10-Oct*	66	23-Dec*	Cape Chaplin	23-Feb
	36655	22-Jul	2	25-Jul	Parry Bay	15-Oct**	–	08-Nov*	Cape Yakum	04-Apr**
	36657	08-Aug	2	11-Aug	Parry Bay	13-Oct*	31	21-Nov*	Cape Chaplin	10-Apr
	36658	01-Aug	1	03-Aug	Parry Bay	15-Oct*	8	31-Oct*	Cape Chukotsk	22-Mar

* means data gap >6 days
** means data gap >10 days

Appendix B3. Summary of movement of eight male and eight female Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake in June 2003.

Sex	PTT #	Depart nesting 2003	Moult migration # of days	Arrive moulting 2003	Moult locations 2003	Depart moulting 2003	Fall migration # of days	Arrive winter 2003	Winter locations 2003/04	Depart winter 2004
Males	40928	18-Jul	34	25-Aug	Cape Netan	22-Oct	21	17-Nov*	St Lawrence Is.	25-Apr*
	40929	09-Jul	3	14-Jul	Dolphin & Union Str.	02-Oct	22	24-Oct	St Lawrence Is.	07-Apr*
	40930	01-Jul	8	13-Jul	Dolphin & Union Str.	29-Sep	17	16-Oct	–	–
	40931	11-Jul	22	04-Aug	Icy Cape	15-Oct	1	16-Oct	Anadyr Bay	26-Apr*
	40940	05-Jul	43	21-Aug	Anadyr Bay	24-Oct	54	23-Dec*	C. Chukotsk	17-Mar*
	40941	02-Jul	4	10-Jul	Bathurst Inlet	28-Sep	9	11-Oct	C. Chaplin	15-Mar*
	40942	08-Jul	22	03-Aug	Prudhoe Bay	03-Oct	13	20-Oct	C. Chaplin	10-Apr*
	40943	12-Jul	29	14-Aug	Kolyuchin Bay	07-Oct	53	05-Dec*	C. Chaplin	14-Mar*
Females	40932	27-Jul*	4	04-Aug	Parry Bay	15-Oct	–	04-Dec**	–	–
	40933	31-Jul	2	04-Aug	Parry Bay	24-Oct	17	15-Nov*	St Lawrence Is.	09-Apr*
	40934	14-Aug	2	18-Aug	Parry Bay	29-Oct	–	–	–	–
	40935	19-Jul	2	23-Jul	Parry Bay	20-Oct	41	04-Dec*	C. Chaplin	04-Apr*
	40936	06-Aug	2	10-Aug	Parry Bay	22-Oct	31	28-Nov*	C. Chukotsk	12-Mar*
	40937	03-Aug	2	07-Aug	Cape Croker	24-Oct	23	22-Nov*	C. Chukotsk	16-Mar
	40938	28-Jul	3	02-Aug	Melville Sound	04-Oct	58	07-Dec*	C. Chukotsk	–
	40939	24-Jul	2	28-Jul	Parry Bay	19-Oct	23	17-Nov*	C. Chukotsk	19-Mar*

* means data gap >6 days
** means data gap >10 days

Appendix B3 continued

PTT #	Spring migration # of days	Arrive nesting 2004	Nest location 2004	Depart nesting 2004	Moult migration # of days	Arrive moulting 2004	Moult locations 2004	Depart moulting 2004	Fall migration # of days	Arrive winter 2004	Winter location 2004/05
40928	36	09-Jun*	Dolphin & Union Str.	24-Jul*	–	–	–	–	–	–	–
40929	54	10-Jun*	Dolphin & Union Str.	11-Jul**	–	22-Jul**	Dolphin & Union Str.	06-Sep**	–	–	–
40930	–	–	–	–	–	–	–	–	–	–	–
40931	45	19-Jun*	east Banks Island	07-Jul*	19	04-Aug*	Icy Cape	17-Oct*	–	25-Nov**	Anadyr B.
40940	81	11-Jun	Cape Kellet	13-Jul	–	–	–	–	–	–	–
40941	95	23-Jun	Cape Colborne	11-Jul	3	16-Jul	Bathurst Inlet	–	–	–	–
40942	76	29-Jun	Prudhoe Bay	–	–	–	–	–	–	–	–
40943	96	23-Jun	Melville Sound	13-Jul	1	15-Jul	Parry Bay	–	–	–	–
									–	–	–
40932	–	–	–	–	–	–	–	–	–	–	–
40933	62	16-Jun	–	–	–	–	–	–	–	–	–
40934	–	–	–	–	–	–	–	–	–	–	–
40935	–	–	–	–	–	–	–	–	–	–	–
40936	91	15-Jun	Nauyak Lake	–	–	–	–	–	–	–	–
40937	79	09-Jun	Nauyak Lake	–	–	–	–	–	–	–	–
40938	–	–	–	–	–	–	–	–	–	–	–
40939	81	13-Jun	Nauyak Lake	–	–	–	–	–	–	–	–

* means data gap >6 days
** means data gap >10 days

Appendix B4. Summary of movement of 10 male and 10 female Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake in June 2006.

Sex	PTT #	Depart nesting 2006	Moult migration # of days	Arrive moulting 2006	Moult locations 2006	Depart moulting 2006	Fall migration # of days	Arrive winter 2006	Winter location 2006/07[1]	Depart Winter 2007
Males	66281	11-Jul	2	15-Jul	Cape Parry	28-Sep	7	06-Oct	Cape Chaplin	–
	66282	16-Jul	18	05-Aug	Cape Nunyagmo	10-Oct	2	14-Oct	(Nunivak Island)	–
	66283	11-Jul	2	14-Jul	Cape Parry	04-Oct	15	20-Oct	Cape Nygligan	–
	66284	12-Jul	33	15-Aug	Kolyuchin Bay	11-Oct	14	26-Oct	Cape Chaplin, Cape Nygligan	–
	66285	14-Jul	–	–	–	–	–	–	–	–
	66286	11-Jul	1	13-Jul	Cape Parry	27-Sep	8	07-Oct	Anadyr Bay	26-May
	66287	30-Jul	–	–	–	–	–	–	–	–
	66288	11-Jul	23	05-Aug	Kolyuchin Bay	13-Oct	2	16-Oct	Anadyr Bay, Cape Chaplin	26-May
	66289	21-Jul	19	11-Aug	Kolyuchin Bay	–	–	–	–	–
	66290	05-Jul	7	13-Jul	Bathurst Inlet	27-Sep	–	–	–	–
Females	66291	09-Aug	2	12-Aug	Melville Sound	20-Oct	59	23-Dec*	Cape Chaplin	10-Mar*
	66292	02-Aug	2	05-Aug	Parry Bay	19-Oct	36	26-Nov	Cape Chukotsk	13-Apr
	66293	20-Jul	2	23-Jul	Parry Bay	10-Oct	28	08-Nov	(Cape Chukotsk)	–
	66294	05-Aug	2	08-Aug	Parry Bay	14-Oct	33	17-Nov	Cape Chukotsk, Anadyr Bay	30-Apr
	66295	18-Jul	2	21-Jul	Parry Bay	13-Oct	23	06-Nov	St Lawrence Island	–
	66296	21-Jul	2	24-Jul	Melville Sound	18-Oct	23	11-Nov	Cape Chukotsk	–
	66297	23-Jul	2	26-Jul	Parry Bay	19-Oct	–	–	–	–
	66298	05-Aug	2	08-Aug	Parry Bay	19-Oct	35	24-Nov	Cape Chaplin	24-Feb*
	66299	07-Jul	2	10-Jul	Parry Bay	09-Oct	74	27-Dec*	St Lawrence Island	27-Apr
	66300	07-Aug	2	11-Aug	Parry Bay	20-Oct	33	23-Nov	(Cape Chaplin)	–

* means data gap >6 days; ** means data gap >10 days; if >10 day gap, then range in dates provided;
[1]Wintering area in brackets if no locations after Dec. 30.

Appendix B4 continued

PTT #	Spring migration # of days	Arrive nesting 2007	Nest location 2007	Depart nesting 2007	Moult migration # of days	Arrive moulting 2007	Moult locations 2007	Depart moulting 2007	Fall migration # of days	Arrive winter 2007	Winter location 2007/08[1]	Depart Winter 2008
66281	–	–	–	–	–	–	–	–	–	–	–	–
66282	–	–	–	–	–	–	–	–	–	–	–	–
66283	–	–	–	–	–	–	–	–	–	–	–	–
66284	–	–	–	–	–	–	–	–	–	–	–	–
66285	–	–	–	–	–	–	–	–	–	–	–	–
66286	15	12-Jun	Chaunskaya Bay	26-Jul	5	02-Aug	Kolyuchin Bay	–	–	–	–	–
66287	–	–	–	–	–	–	–	–	–	–	–	–
66288	29	26-Jun	Anadyr Bay	04-Jul	6–18	11–23 Jul	Kresta B.	21-Sep	83	16-Dec	C Chaplin	27-Mar
66289	–	–	–	–	–	–	–	–	–	–	–	–
66290	–	–	–	–	–	–	–	–	–	–	–	–
66291	91	14-Jun	Nauyak Lake	28-Jul	2	01-Aug	Parry Bay	13-Oct	73	28-Dec*	C Chaplin	–
66292	–	–	–	–	–	–	–	–	–	–	–	–
66293	–	–	–	–	–	–	–	–	–	–	–	–
66294	52	24-Jun	Nauyak Lake	25-Jul	2	29-Jul	Parry Bay	10-Oct	39	21-Nov	Anadyr B	05-Apr
66295	–	–	–	–	–	–	–	–	–	–	–	–
66296	–	–	–	–	–	–	–	–	–	–	–	–
66297	–	–	–	–	–	–	–	–	–	–	–	–
66298	107	15-Jun	Nauyak Lake	26-Jul	1	29-Jul	Parry Bay	13-Oct	30	15-Nov	C Chaplin	–
66299	51	19-Jun	Parry Bay	04-Aug	1	07-Aug	Parry Bay	09-Oct	–	–	–	–
66300	–	–	–	–	–	–	–	–	–	–	–	–

* means data gap >6 days; ** means data gap >10 days; if >10 day gap, then range in dates provided;
[1]Wintering area in brackets if no locations after Dec. 30.

Appendix B4 continued

PTT #	Spring migration # of days	Arrive nesting 2008	Nest location 2008	Depart nesting 2008	Moult migration # of days	Arrive moulting 2008	Moult locations 2008	Depart moulting 2008	Fall migration # of days	Arrive winter 2008	Winter location 2008/09[1]	Depart Winter 2009
66281	–	–	–	–	–	–	–	–	–	–	–	–
66282	–	–	–	–	–	–	–	–	–	–	–	–
66283	–	–	–	–	–	–	–	–	–	–	–	–
66284	–	–	–	–	–	–	–	–	–	–	–	–
66285	–	–	–	–	–	–	–	–	–	–	–	–
66286	–	–	–	–	–	–	–	–	–	–	–	–
66287	–	–	–	–	–	–	–	–	–	–	–	–
66288	65	4-Jun	C Nunyagmo	03-Jul	–	–	–	–	–	–	–	–
66289	–	–	–	–	–	–	–	–	–	–	–	–
66290	–	–	–	–	–	–	–	–	–	–	–	–
					–							
66291	–	–	–	–	–	–	–	–	–	–	–	–
66292	–	–	–	–	–	–	–	–	–	–	–	–
66293	–	–	–	–	–	–	–	–	–	–	–	–
66294	66	12-Jun	Nauyak Lake	8-Aug	1	11-Aug	Parry Bay	11-Oct	36	19-Nov	Anadyr Bay	05-Apr
66295	–	–	–	–	–	–	–	–	–	–	–	–
66296	–	–	–	–	–	–	–	–	–	–	–	–
66297	–	–	–	–	–	–	–	–	–	–	–	–
66298	–	–	–	–	–	–	–	–	–	–	–	–
66299	–	–	–	–	–	–	–	–	–	–	–	–
66300	–	–	–	–	–	–	–	–	–	–	–	–

* means data gap >6 days; ** means data gap >10 days; if >10 day gap, then range in dates provided;
[1]Wintering area in brackets if no locations after Dec. 30.

Appendix C. Number of days of migration for Pacific Common Eiders tagged at Nauyak Lake, Nunavut 2001–2003 and 2006.

		Number of days							
	Year tagged	Male				Female			
		Mean	SD	Range	n	Mean	SD	Range	n
Moult migration*	2001	5	3	1–10	8				
	2002	13	14	1–40	9				
	2003	21	15	3–43	8				
	2006	13	12	1–33	8				
Fall migration	2001	21	14	8–41	7	8	1	7–9	5
	2002	36	28	5–78	8	42	30	8–75	7
	2003	24	20	1–54	8	32	15	17–58	6
	2006	8	6	2–15	6	38	17	23–74	9
Spring migration**	2001	–	–	–	–	62	–	–	1
	2002	–	–	–	–	–	–	–	–
	2003	69	24	36–96	7	78	12	62–91	4
	2006	22	10	15–29	2	75	28	51–107	4

* Moult migration for females was completed in <3 days. Since distance traveled was <45 km, it likely took <1 day.
** In 2006, both males remained in Russia during breeding season.

Appendix D. Distances between breeding sites used in two consecutive years by Pacific Common Eiders tagged with satellite transmitters at Nauyak Lake. Centroid locations were determined for each nesting period, then distance between centroids measured..

Sex	Year tagged	Distance (km)	Breeding location first year	Breeding location second year
Male	2003	329	Nauyak Lake	Dolphin and Union Strait
		255	Nauyak Lake	Dolphin and Union Strait
		628	Nauyak Lake	East side of Banks Island
		805	Nauyak Lake	West side of Banks Island
		90	Nauyak Lake	Cape Colborne, Dease Strait
		1549	Nauyak Lake	Prudhoe Bay
		32	Nauyak Lake	Melville Sound
	2006	2968	Nauyak Lake	Chaunskaya Bay
		2890	Nauyak Lake	Anadyr Bay
Female	2001	<2	lake NE of Nauyak Lake	lake NE of Nauyak Lake
	2003	<2	Nauyak Lake	Nauyak Lake
		<2	Nauyak Lake	Nauyak Lake
		<2	Nauyak Lake	Nauyak Lake
	2006	<2	lake NE of Nauyak Lake	lake NE of Nauyak Lake
		<2	Nauyak Lake	Nauyak Lake
		<2	Nauyak Lake	Nauyak Lake
		12	Nauyak Lake	North side of Parry Bay

Appendix E. Distance between moulting sites used in two consecutive years by Pacific Common Eiders tagged at Nauyak Lake, Nunavut. Centroids were created for each moult period, then distance between centroids measured.

Sex	Year tagged	Distance (km)	Moult location first year	Moult location second year	Nest location second year
Male	2003	15.3	Dolphin and Union Strait	Dolphin and Union Strait	Canada
		1.7	Icy Cape	Icy Cape	Canada
		2.7	Bathurst Inlet	Bathurst Inlet	Canada
	2006	2004.4	Cape Parry	Kolyuchin Bay	Russia
		222.2	Kolyuchin Bay	Kresta Bay	Russia
Female	2006	3.4	Melville Sound	Melville Sound	Canada
		0.3	Parry Bay	Parry Bay	Canada
		7.1	Parry Bay	Parry Bay	Canada
		23.6	Parry Bay	Melville Sound	Canada

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Additional information can be obtained at:

Environment Canada
Inquiry Centre
10 Wellington Street, 23rd Floor
Gatineau QC K1A 0H3
Telephone: 1-800-668-6767 (in Canada only) or 819-997-2800
Fax: 819-994-1412
TTY: 819-994-0736
Email: enviroinfo@ec.gc.ca