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ORIGINAL PAPER

Population trends of king and common eiders from spring migration counts at Point Barrow, Alaska between 1994 and 2016

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Abstract
Most king (*Somateria spectabilis*) and common eiders (*S. mollissima v-nigra)* breeding in the northwestern Nearctic migrate past Point Barrow, Alaska. Spring migration counts have been conducted there since 1953; during 1976–1996, both species declined > 50% for unknown reasons. To evaluate population trends, counts in 2003, 2004, 2015, and 2016 were compared to earlier counts. King eider estimates were 304,966 (95% CI ± 76,254) in 2003, 591,961 (± 172,011) in 2004, 796,419 (± 304,011) in 2015, and 322,381 (± 145,833) in 2016. Common eider estimates were 114,998 (± 28,566) in 2003, 110,561 (± 32,087) in 2004, 96,775 (± 39,913) in 2015, and 130,390 (± 34,548) in 2016. The 2016 estimate was likely biased low for king eiders due to weather (causing large pulses of king eiders to pass within 2 days) and early ice break-up (causing observers to count at greater distances from the flocks). Using all estimates, populations of both species were statistically stable during 1994–2016. Excluding the 2016 count for king eiders indicated a significant increase of 18.63%/year in that population. Photo analysis of flocks in 2016 indicated that observer counts averaged 4% lower, species detection was not different, but females' counts were underestimated by 25%. Methods should be refined to reduce bias and variability. Ice-based spring counts are becoming more difficult due to earlier break-up, less stable ice, and new techniques or locations; or a switch to land-based summer/fall migration counts are needed. Population monitoring is needed to ensure sustainability of harvests for these valuable subsistence resources.

Keywords Beaufort sea · Arctic · Population estimate · *Somateria spectabilis* · *Somateria mollissima* · Chukchi sea

Introduction

King (*Somateria spectabilis*) and common eiders (*S. mollissima v-nigra*) wintering in the Bering Sea and North Pacific Ocean migrate north to nesting areas in Russia, Alaska, and Canada. Most of the eiders nesting in Alaska and Canada pass by Point Barrow when entering and leaving the Beaufort Sea. At Point Barrow, the migration passes very close to shore, and the spring passage can be spectacular. Woodby and Divoky (1982) estimated 113,000 eiders passed in 30 min in the spring of 1976. Although the spring passage of eiders at Point Barrow has been described by researchers (Murdoch 1885; Brueggeman 1980), the actual magnitude of the spring migration has been estimated only on a few occasions (Woodby and Divoky 1982; Suydam et al. 1997, 2000a; Quakenbush et al. 2009).

Suydam et al. (2000a) standardized the estimations of spring and summer/fall migration counts conducted at Barrow in 1953 (Thompson and Person 1963), 1970 (Johnson 1971), 1976 (Woodby and Divoky 1982), 1987, 1994 (Suydam et al. 1997), and 1996 (Suydam et al. 2000a, b), and determined that the king eider population appeared to be stable between 1953 and 1976, but declined by 53% between 1976 and 1996. They also determined that the common eider population declined by 56% during the same time period (Suydam et al. 2000a). The reasons for

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the apparent decline are poorly understood but may be related to effects on survival due to climate change, which has likely affected the benthic invertebrate community (i.e., eider prey), northern expansion of competitors, parasites, and infectious diseases, and increased anthropogenic activities that may have led to increased collisions with infrastructure and habitat loss (Kerr 2002; Lovvorn et al. 2003; Dunton et al. 2005; Grebmeier et al. 2006; Bluhm and Gradinger 2008). Periodic die-off events due to ice and weather conditions also have the potential to impact eider populations (Barry 1968; Fournier and Hines 1994).

In spring, eiders migrate northward from the Bering Sea following the lead system (open water at the interface of shore-fast ice and the moving pack ice or open water formed by cracks within the pack ice) that typically forms along the east coast of the Chukchi Sea, including near Point Barrow. At Point Barrow, eiders turn and head east into the Beaufort Sea. Migration counts have been conducted, approximately every ten years since the 1990s, from the lead edge by observers with binoculars counting the number of birds passing. This allows an index of population size to be calculated and population trends for king and common eiders to be monitored. There are some biases and assumptions that need to be considered. First, counts of eiders may be biased by the number and size of flocks. Second, we assume that most eiders migrate along the lead, past the observation point and are available to be detected by observers. Third, we assume that the proportion of the total population following the shore-fast lead edge has not changed over time, and fourth, we assume that the duration and the intensity (i.e., migration rate) have not changed over time. We addressed the first issue by means of the same methods through time so that bias in total population estimates would be as consistent as possible for each count resulting in comparable estimates to determine population trend. The second assumption was evaluated for fall migration (not spring) using radar to count birds (1997 and 2000) and indicated that nearly all eiders encountered (i.e., those within the 8-km range of the radar) passed within 3 km of the survey location at the base of the Point Barrow Peninsula (Day et al. 2004). Limited data from Canadian nesting eiders tracked via satellite telemetry suggested eiders followed the flaw lead rather than the coastline when crossing the western Beaufort Sea during spring migration (Dickson 2012), and are therefore unlikely to pass the observation point at the lead edge. However, the proportion that pass and the interannual consistency of that proportion are unknown. Subsistence hunters have told us of, and we have observed, flocks of eiders migrating past Point Barrow, beyond the range of where observers at the lead edge could observe them. Lastly, there is no way to assess the third and fourth assumptions of how the migratory route, duration, and intensity have changed over time.

We conducted spring migration counts of eiders near Point Barrow in 2003, 2004, 2015, and 2016 using standardized point-count methods used in prior surveys (Suydam et al. 2000a). Our goal was to examine population trends of king and common eiders over two decades. In addition, we assessed observer bias by comparing observer counts and photographs of specific flocks to correct past and future migration counts.

Methods

Observer locations

Counts were primarily conducted at sites close to the edge of the shore-fast ice northwest of Point Barrow on a pressure ridge and were termed 'perches' (Fig. 1). In 2003, the count was conducted from two locations. From April 26 to May 27, counts were conducted from the ice edge about 8 km southwest of Point Barrow (2003 Perch: 71°20.5′N, 156°44′W), and when the sea ice was no longer safe, the observation site was moved to a 4-m-high platform on the beach (2003 Beach: 71°19.5′N, 156°41′W). In 2004, the count was also conducted from two locations. From April 28 to May 21, we used an observation site about 5 km west of Point Barrow (2004 Perch; 71°23′N, 156°41′W). On May 22, 2004, because of deteriorating ice conditions, we moved to a second site located approximately 3 km southwest of the original observation site. In addition, two surveys were conducted on May 27 and one on May 29 by one observer from the bluffs near the gravel pits approximately 2 km southwest of Utqiaġvik, formerly known as Barrow (Bluff; 71°17′N, 156°46′ W). In 2015, we began the count at the lead edge on April 23 (2015 Perch; 71°21′N, 156°35′W). A bowhead whale was harvested by subsistence hunters nearby on May 7 and its remains attracted polar bears (*Ursus maritimus*). On May 13 we moved south approximately 1 km to another perch that was slightly farther from the lead edge, to be away from the whale remains and bears. The move occurred after peak migration and likely did not lower the count significantly. After the sea ice degraded on May 21, the count was conducted from land, at Bluff. In 2016, the count began on April 24 from the edge of the shore-fast ice (2016 Perch; 71°25′N, 156°30′W), but was moved to land (Bluff) from May 11 to 17 due to the expected effect of strong southwest winds on the sea ice. The count location was moved again, farther south (Monument, 71°09′N, 157°03′W) from May 18 to June 1 for better counting conditions. Previous counts have also begun at the lead edge and moved to on-land as ice conditions deteriorated.

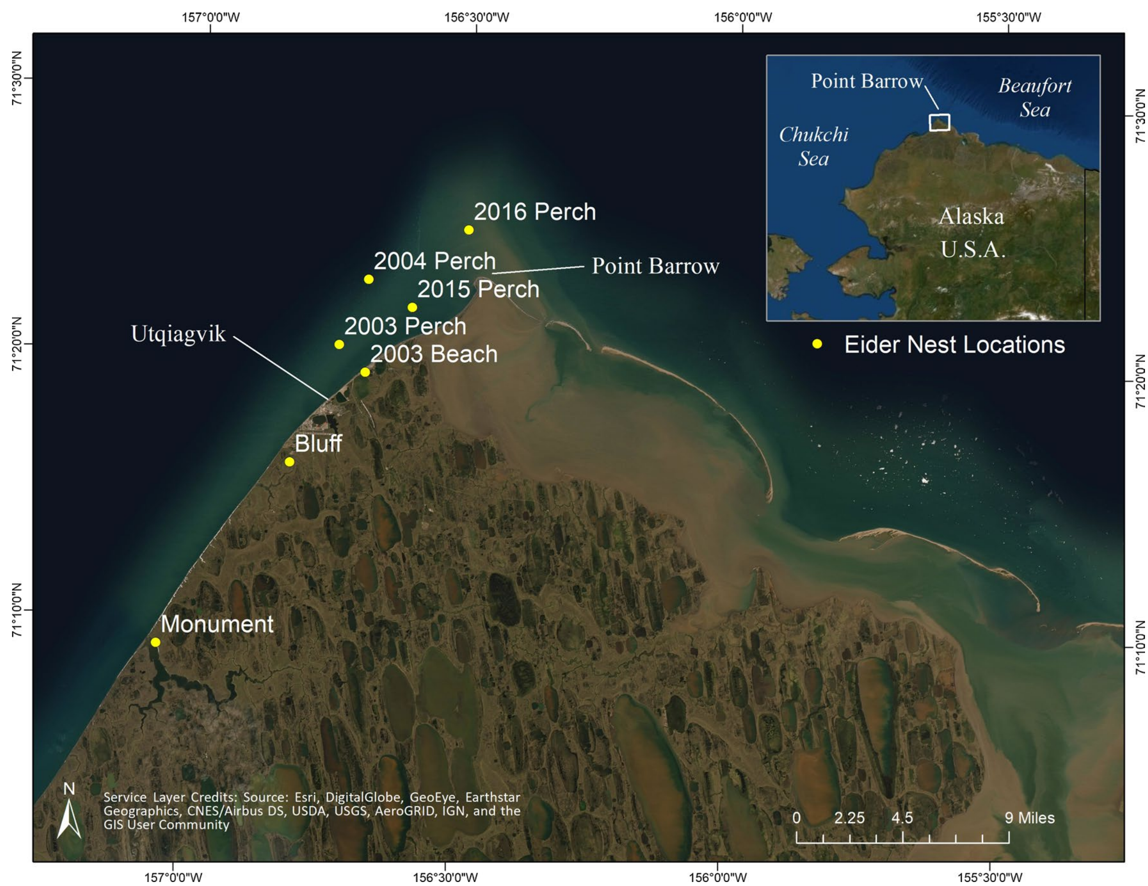

Fig. 1 Locations near Point Barrow, Alaska from which eiders were counted during spring migration in 2003, 2004, 2015, and 2016

Observations

To directly compare estimates among years, we used the same methods to collect and analyze data as those used by Suydam et al. (1997). Four observers, in teams of two, counted eiders for up to 12 h per day. Counts in 2003 and 2004 followed a pattern of 2 h on, 2 h off during daylight hours. During the last week of April and early May, there are still periods of darkness but around-the-clock observations are possible by about 5 May. In those years, no diurnal pattern in migration was observed, therefore in 2015 and 2016 counts were conducted two hours on, one hour off during 0500–1300 and 1700–0100 h. This count schedule better allowed for travel back and forth to the perch between 1300 and 1700 and 0100 and 0500. Occasionally counts ended early due to the proximity of polar bears or high winds causing unsafe ice movement or break-up.

For each counting period, we collected data on weather, including percent cloud cover, the presence of fog and precipitation, air temperature, visibility, wind speed, and wind direction. For each flock sighted, we recorded time, direction of travel, species composition, number sighted, and the ratio of males to females for each species. To ensure that the protocols were standardized, all observers were trained by Suydam and other individuals that assisted with earlier eider migration counts. In addition, early in the season each observer estimated flock size independently, and then arrived at a consensus estimate with the team. Flock size estimates between observers generally were within ± 10% of each other. Discussion of estimates usually resulted in an explanation for discrepancies and convergence on a consensus estimate. Flocks could often be counted multiple times as they approached and moved past the perch, and if observer estimates were disparate another count was made. Flocks passing opposite to the expected direction of travel (i.e., not traveling south to north) were subtracted from the number of eiders flying in the expected direction during each 2-h period. Although we often were unable to identify all birds within a flock to species and sex due to distance, we were able to estimate size of eider flocks; in such cases, the flock was categorized as ‘unidentified eiders’. To estimate passage rates by species, we divided the number of unidentified eiders between king and common eiders based upon the species proportion that were identified during each 2-h survey period. Occasionally no flocks were identified to species within a count period; in these cases we used the proportion of species derived from the next count period of the day to adjust our estimates.

In order to obtain correction factors for total flock size, sex ratio, species ratio, and to determine if sub-adults migrated with adults, we photographed a subset of flocks using a high-resolution camera with 400-mm telephoto lens in 2016. For larger flocks, we attempted to take a photo encompassing the entire flock and then zoomed in and took multiple photos of portions of the flock that could later be 'stitched' together.

Population index estimation

To account for daily variation in our estimate of a total index of population size, we treated our sample as though coming from a stratified design, where each day represents a separate stratum. Within each count, we used the observed ratio of king to common eiders to assign unidentified eiders to one or the other species. We assumed a 1:1 sex ratio for flocks where sex ratio was not determined. Within each day (d), the average number of eiders passing in a 2-h period ($(\bar{y}_d)$) was estimated using all 2-h periods sampled (2 h being the standard observation increment). This average was then multiplied by the total number of 2-h sampling periods that were possible within each day ($N_d = 12$). Borrowing from Thompson (2002, p 119), the index population total thus was defined as the sum of the daily totals:

$$\text{Total} = \sum_{d=1}^{L} N_d \bar{y}_d$$

where L is the total number of days sampled. The variance estimator for the population total accounts for the number of 2-h periods sampled within each day (n_d) and the sampling variance within each day (s_d^2) and was defined as

$$\text{var}(\text{Total}) = \sum_{d=1}^{L} N_d \left(N_d - n_d\right)\left(s_d^2/n_d\right).$$

We used linear regression to estimate population trends between 1994 and 2016 including the population estimates for the years 1994 (king eiders, 345,489 [95% CI ± 147,877]; common eiders, 74,651 [95% CI ± 22,317]) and 1996 (king eiders, 371,452 [95% CI ± 107,697]; common eiders, 72,606 [95% CI ± 13,606]) estimated by Quakenbush et al (2009) for comparable time periods (May 1–June 4), in addition to the results presented here. The population estimates are from comparable count periods in all years (2003: April 26–June 5; 2004: April 28–June 3; 2015: April 23–May 31; 2016: April 24–June 1). We log-transformed the count data and estimated separate trends for king and common eiders. We estimated a population trend for king eiders both with and without the 2016 results due to questions about the accuracy of this count (see "Discussion" section).

Photo analysis

We used the count tool in Adobe Photoshop Professional and examined flock photos to obtain correction factors for total flock size, species ratio, and sex ratio, and to determine if sub-adults migrated with adults. Multiple photos were stitched together for large flocks. We used paired t-tests to compare flock counts by observers with counts determined from photos. Similarly, we used paired t-tests to compare species and sex ratios derived from observers and photos.

Results

Observation periods

In 2003, during a five-day interval (May 14–18), ~68% of the king eiders passed Point Barrow with the peak occurring on May 15 (Fig. 2). In 2004, migration occurred in three distinct peaks widely separated in time; high counts were recorded during April 28–29; and May 10–12 and 17–19. From May 4 to 9, 2004, we recorded more eiders moving southwest than northeast and the daily passages were < 2000 (Fig. 2). Migration peaked during May 7–9 in both 2015 and 2016 (Fig. 2). Numbers of migrating birds varied throughout the day; for example, on May 8, 2016, 36,510 eiders of both species were counted during six 2-h periods throughout the day but 76% of the morning count passed in the last half hour of the count period (0500–1300 h; Fig. 3).

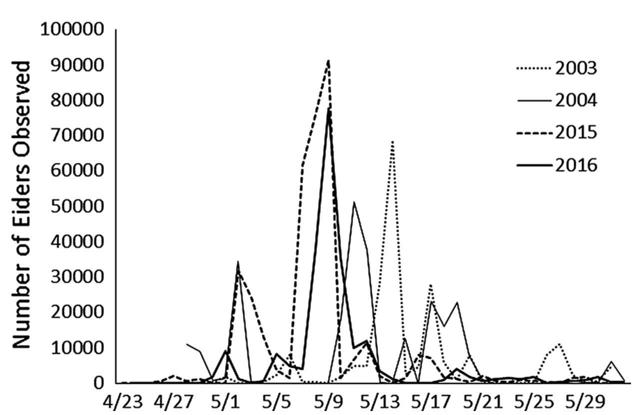

Fig. 2 Number of eiders observed during spring migration, Point Barrow, Alaska, 2003, 2004, 2015, and 2016

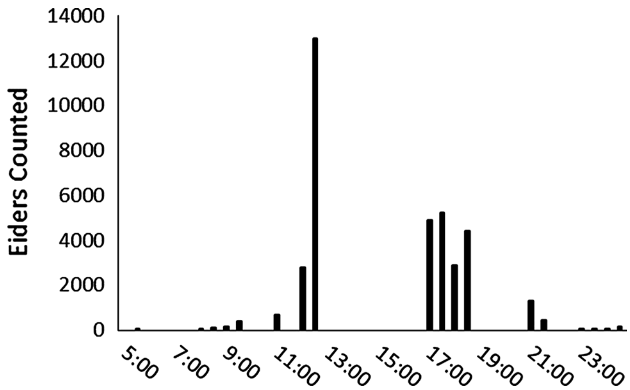

Fig. 3 Number of eiders in half-hour increments observed passing Number of eiders observed passing Point Barrow, Alaska, on spring migration on May 8, 2016. Eiders were counted 0500–0700, 0800–1000, 1100–1300, 1700–1900, 2000–2200, and 2300–0100 h

Population trends

We estimated that 304,966 (95% CI ± 76,254) king eiders passed Point Barrow in 2003, 591,961 (± 172,011) in 2004, 796,419 (± 304,011) in 2015, and 322,381 (± 145,833) in 2016 (Fig. 4). By means of all estimates from 1994 to 2016, no significant population trend for king eiders was observed ($F = 0.99$, $R^2 = 0.2$, $P = 0.37$, $df = 1$; Fig. 4). If we exclude the 2016 estimate, however, the rate of increase for king eiders was significant at 18.63%/year (95% CI 1.85–35.81; $F = 12.45$, $R^2 = 0.81$, $P = 0.04$, $df = 1$; Fig. 4). Justification for not including 2016 in the trend analysis for king eiders can be found in the "Discussion" section.

Common eider estimates were 114,998 (± 28,566) in 2003, 110,561 (± 32,087) in 2004, 96,775 (± 39,913) in 2015, and 130,390 (± 34,548) in 2016 (Fig. 5). Similar to king eiders, the common eider population showed no significant trend from 1994 to 2016 ($F = 5.067$, $R^2 = 0.56$, $P = 0.087$, $df = 1$; Fig. 5).

Photo analysis

We compared counts for a subsample of 298 flocks, which ranged in size from 1 to 1400 individuals (observer count) that had field counts from observers and counts from photos. Counts by observers were significantly lower than counts derived from photos (paired t test; $|t| = 3.26$, $df = 297$, $P < 0.001$). On average, observer counts were 4% lower than the photo counts and the difference did not vary with flock size ($F = 2.42$, $df = 296$, $p = 0.12$). Flocks over 1400 individuals were not evaluated using photos. Species ratios (common to king eiders) determined by observers were not different from those determined by photos for mixed-species flocks (paired t-test; $|t| = 0.69$, $df = 58$, $P = 0.25$). Sex ratio, however, was significantly different. Observers counted significantly fewer females than were determined from photos (paired t-test; $|t| = 7.72$, $df = 171$, $P < 0.001$). On average, the female-to-male sex ratio was 25% higher in photos. Of the 46,852 eiders counted in photos, eight subadult male king eiders were detected in photos that were not counted by observers.

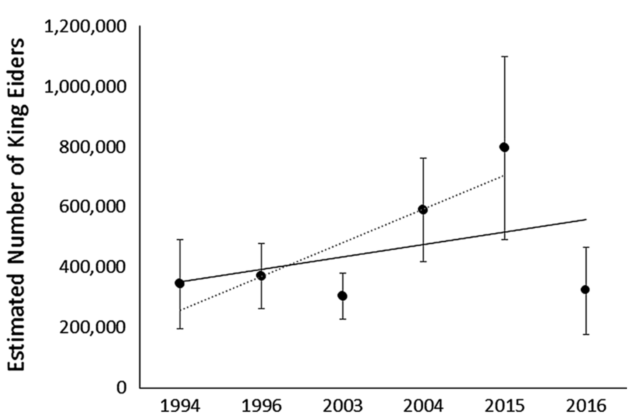

Fig. 4 Estimated numbers of king eiders passing Point Barrow, Alaska during spring migration for the period 1994–2016. The estimates for 1994 and 1996 are from Quakenbush et al. (2009). Population trend from 1994 to 2016 (solid line; $F = 0.99$, $R^2 = 0.2$, $P = 0.37$, $df = 1$); trend from 1994 to 2015 (dotted line; $F = 12.45$, $R^2 = 0.81$, $P = 0.04$, $df = 1$)

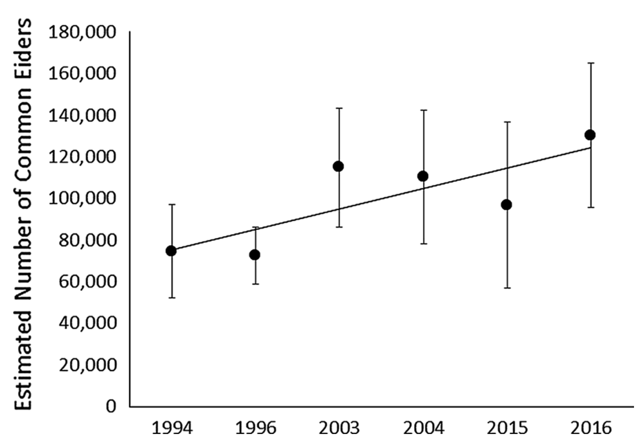

Fig. 5 Estimated numbers of common eiders passing Point Barrow, Alaska during spring migration for the period 1994–2016. Estimates for 1994 and 1996 are from Quakenbush et al. (2009). Population trend (solid line) from 1994 to 2016 ($F = 5.067$, $R^2 = 0.56$, $P = 0.087$, $df = 1$)

Discussion

The eider populations that migrate past Point Barrow in spring declined through the early 1990s but appear to be stable (common eiders) to possibly increasing (king eiders) between 1994 and 2016. This is supported by aerial surveys of the Arctic Coastal Plain of Alaska, which indicated an increase in the king eider population between 1986 and 2017 (+2.5% per year; Wilson et al. 2018). Similarly, the same aerial surveys showed an annual increase of 5.8% per year of breeding common eider pairs (Wilson et al. 2018). Aerial surveys on the Yukon–Kuskokwim Delta showed common eider numbers stabilized during 2003–2012 (Platte and Stehn 2013), following declines of up to 90% from 1957 to 1992 (Stehn et al. 1993; Hodges et al. 1996), consistent with migration count data from Point Barrow during the same time period.

Although population data are available for eiders breeding in north-central and north-eastern Canada and Greenland, they have different movement patterns and population stressors than those wintering around the Bering Sea and may not be comparable. For example, the eastern populations have much higher hunting pressure (Merkel 2004, 2010), have been devastated by avian cholera outbreaks in recent years (Descamps et al. 2012), and are impacted by polar bear predation (Iverson et al. 2014; Prop et al. 2015). Common eiders breeding in eastern Canada have increased at some colonies and decreased at others (Hipfner et al. 2002; Falardeau et al. 2003; Chaulk et al. 2005; Chaulk 2009; Black et al. 2012; Maftei et al. 2015; Pratte et al. 2016), while those breeding in western Greenland declined precipitously between periods of 1960–1965 and 1998–2001 (Merkel 2004), followed by a sharp increase in breeding numbers from the late 1990s to the late 2000s, possibly due to harvest reductions in Greenland that began in 2001 (Merkel 2010; Burnham et al. 2012). Although the pattern is similar to that observed in Alaska, it is likely due to different factors. It is difficult to sort out the factors influencing population dynamics, or even determine what the patterns are, as long-term datasets across the circumpolar north are lacking and localized studies show mixed results.

Our population estimate of king eiders migrating past Point Barrow was more than 50% greater in 2015 than 2016 (Fig. 4). We do not believe that the difference in count estimates for king eiders indicated that the population declined by 50% between the two years. Instead, the difference is likely due to the highly variable nature of the migration and the effect that the early deterioration of the shore-fast ice had on counts in 2016. We appeared to have missed large numbers of migrating birds between our two watch periods (0500–1300 and 1700–0100) on at least May 8 (further discussed, below). In addition, moving our perch to land from May 11 to June 1 likely biased our counts downward as it can be very difficult to see and count low-flying eiders along the lead edge from several km away. For these two reasons, we believe our 2016 estimate was biased low, and hence, removing the 2016 estimate from the analysis of population trend is justifiable. In addition, Wilson et al. (2018) found a moderately high population index for king eiders in 2016. When data from our 2016 counts are excluded, the king eider population trend increased significantly at 18.63%/year from 1993 to 2015. This trend was supported by aerial survey results (Wilson et al. 2018).

During the 2016 count most of the king eider population passed Point Barrow in very large flocks during a few hours within those 2 days. The estimate is based on the average of six count periods per day extrapolated across that day; if only a few birds pass during five periods and thousands pass during one, that variation will be captured in our estimates of population size and variance. However, if the large pulse of birds passed during a time we are not counting, the population estimate will be biased low, as will the variance. For example, on May 8 2016, 76% of the eiders counted in the morning period (0500–1300 h) passed Point Barrow during the last half hour (Fig. 3). Based on the average of the last half hour of the morning count and the first half hour of the evening count, we may have missed as many as 71,000 eiders during the 4 h (1300–1700 h) between count periods. Unfortunately, we were unable to extend the count that day or add an additional period between 1300 and 1700 h for logistical reasons. However, we observed larger flocks than we had seen at any other time during the two years of the count while traveling back to Utqiaġvik that afternoon. The result was that the peak in migration began at the end of our morning count period and ended before our afternoon count period started so that our daily count total was only 37,994 eiders. Sustained north and east winds during the spring migration in 2016 may have held eiders at a staging area south of Point Barrow (Oppel et al. 2009) for an extended period causing a dramatic pulse to occur in the migration over a very short period when the wind let up. This scenario is consistent with the results of other studies which have concluded that eider migration is related to wind speed and direction (Woodby and Divoky 1982; Day et al. 2004; Quakenbush et al. 2009). Ice conditions were also different between the two years. In 2015, we remained on the shore-fast ice, relatively near the lead edge, until May 22, resulting in coverage of most of the migratory period from a good vantage point. In 2016, however, due to degrading ice conditions, we could only remain at the lead edge until 11 May. This move away from the lead edge early in the migration may have resulted in counts being biased low. In 2003 and 2004, observers remained on the ice until 27 May.

We found that observers underestimated flock size by 4% for flocks of less than 1400 individuals when comparing photograph counts to observer counts and that negative bias likely increased with flock size. This negative observer bias is also found in other studies (see Udevitz et al. 2005). Therefore, all population estimates from the 1950s through 2016 are likely to be biased low, not high, because of undercounting, however whether this bias was comparable over the years is unknown. Photo analysis also revealed that observers underestimated the proportion of females in a flock; however, this does not influence estimates of population size. Fortunately, observers correctly distinguished adult male king and common eiders because misidentifying them would impact population estimates of both species.

Very few subadult male king eiders are seen during spring migration past Point Barrow and so the population estimates from those counts represent the adult population and not the population overall. Eight subadult male king eiders were counted in photos representing ~47,000 total eiders; all of these subadults were classified as adult females by observers. Although this confirms that some subadult males migrate with adults past Point Barrow in spring the proportion of subadults is insignificant. The presence of a few subadult male eiders in the spring migration has been observed since the early 2000s and confirmed with satellite telemetry (Bentzen and Powell 2015). It is likely that more immature king and common eiders are now wintering farther to the north because of the increase in the amount of open water in the Chukchi Sea during the winter (Suydam, pers. obs.). Future counts may need to more carefully look and account for immature birds in the spring migrating flocks.

We suspect the eider migration count was negatively biased as we probably did not detect and count all eiders migrating past Point Barrow. A number of methods have been employed to estimate detection bias in count data including paired counts (Smith 1995), double-observer counts (Cook and Jacobson 1979; Grier et al. 1981; Caughley and Grice 1982; Koneff et al. 2008), distance sampling (Burnham et al. 1980; Borchers et al. 1998, 2006; Buckland et al. 2001) and mark-recapture distance sampling (Laake and Borchers 2004; Buckland et al. 2010; Burt et al. 2014). Double-observer methods are analogous to mark–recapture methods (see Alisauskas and Conn 2019). Although most of those studies dealt with aerial surveys, which are not applicable here, some of their findings and methods are applicable to ground based migration counts. Future counts should include a more thorough evaluation of detection probably to reduce bias, and mark-recapture distance sampling (see Alisauskas and Conn 2019) could be employed, although a number of assumptions of this method would need to be addressed. Migration counts of eiders remain an important tool for monitoring the size and health of the population as this is a species that is rarely marked (e.g., banded) and traditional methods of estimating waterfowl abundance (band returns) are not easily applied. We recommend that eider migration counts continue and be conducted for two consecutive years every five years. The longevity of this dataset is valuable and provides population trends for two species that have been corroborated by other methods such as aerial surveys of portions of the breeding grounds. An advantage of migration counts is they observe a larger portion of the population than aerial surveys and are much less expensive. It is important to conduct surveys in two consecutive years to allow for adverse count conditions (e.g., weather, sea ice conditions, and other factors allow at least one year of data collection). We also suggest that breaks between watches be minimized as much as possible to reduce the changes of missing large pulses of migrating birds. It would be beneficial to count birds during all hours of usable light if possible.

Given the increasing difficulties of conducting spring counts on less predictable and less safe sea ice, a switch to summer/fall counts should be considered. Spring counts from the ice edge may not be feasible at some point in the future. Counts during summer/fall migrations have successfully estimated populations (see Suydam et al. 1997, 2000b and Quakenbush et al 2009). The migrations are more extended during the summer/fall lasting from ~ July 10 to at least early September, but possibly until October or later. Most adults appear to migrate past Point Barrow by early September but counts extending later into the autumn would count hatch year birds and provide an index of productivity. The extended migration means that counts are more expensive but the results can be incorporated into evaluation of population trends (see Suydam et al. 2000a, b). The summer/fall counts provide reliable population estimates especially for king eiders but may be more challenging for common eiders because substantial numbers of adults remain in the Beaufort Sea to molt and migrate late in the autumn with young-of-the-year (see Quakenbush et al. 2009).

It is unclear how a changing Arctic will affect eider life history or population dynamics. For example, winter conditions can influence timing of spring migration and overwinter survival. In the Baltic Sea, the North Atlantic Oscillation (NAO) and the timing of ice break-up result in earlier spring migrations of common eiders (Lehikoinen et al. 2006). However, the effects of the NAO on wintering grounds may impact individual eiders differently depending on where they overwinter (Guéry et al. 2017). In some populations, mild winters result in earlier egg laying in the breeding season (D'Alba et al. 2010), which may result in increased reproductive success. In other areas, such as La Pérouse Bay, Canada, breeding populations of common eiders have declined in recent years due to complex interactions between predators, increased abundance of snow geese (*Chen caerulescens*), and climate (Iles et al. 2013). In the Chukchi Sea, common, king, spectacled (*S. fischeri*), and Steller's (*Polysticta stelleri*) eiders stage in and migrate through leads in the sea ice along northwestern Alaska before passing Point Barrow in spring; however, eiders' access to prey and the locations of quality foraging areas vary widely and climatic changes may increase unpredictability of critical food resources (Lovvorn et al. 2015). Finally, king and common eiders are important subsistence resources for Inuit in northern and western Alaska (Bacon et al. 2009; Naves and Otis 2017) and across coastal areas of Canada and Greenland (Fabijian et al. 1997; Merkel 2006; Gilliland et al. 2009). Therefore, it is important to monitor king and common eider population size over time to maintain viable populations and sustainable harvests.

In conclusion, king and common eider populations have stabilized since the 50% declines between the 1970s and the 1990s, and king eiders appear to be increasing. This trend is supported by aerial surveys on the Arctic Coastal Plain of Alaska (Wilson et al. 2018). Estimating population size from counts of animals passing a point location is difficult and prone to bias including the four we mentioned (count bias, detectability, route consistency, and migration rate). Our eider migration count is certainly not exempt from these problems; however, by means of consistent methods, estimating detection bias using photos, conducting counts in consecutive years, and comparing results with aerial surveys of breeding eiders, migration counts are relatively inexpensive ways to monitor the status of two important seaduck species. Eiders are an important subsistence resource for local residents of the Alaskan and Canadian Arctic, and common eiders, in particular, are of high conservation concern due to predicted increases in storm surges and rising sea levels impacting low-lying island breeding areas, increased shipping in Arctic waters, and on- and offshore oil and gas activities. Monitoring their population status is vital for state, local, and federal managers and to the indigenous communities across the western Arctic.

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Compliance with ethical standards

Conflict of interest There are no conflicts of interest to disclose.

Ethical approval All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. As no animals were handled, approached, or interfered with, we did not conduct an official IACUC.

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