Common Eider Wintering Trends in Nova Scotia, 1970–2019

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Abstract

Common eiders Somateria mollissima have been a focus of conservation and management efforts in eastern North America for over a century; however, the complex population structure and multiple subspecies make assessing the status of populations challenging. The coastlines of Nova Scotia, Canada, are an important wintering area for common eiders, and significant harvests of common eiders occur in the province. We analyzed trends in the number of wintering common eiders using the coasts of Nova Scotia from dedicated waterfowl surveys flown since 1970, and every year since 1992. We used Generalized Additive Models to assess the apparent non-linear trends in the counts of common eiders over the past 50 y. We found that numbers of common eiders wintering in Nova Scotia increased from 1970 to the early 2010s, with strong growth in the 2000s (peaking at 7% growth/y). Since the early 2010s, the growth has stopped, and the numbers are now declining. Recent declines in the population wintering in Nova Scotia corroborate other evidence that common eiders are declining in the region, and may also indicate distributional shifts of common eiders in eastern North America.

Keywords: common eider; population trend; Somateria mollissima; winter surveys

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Introduction

Common eiders Somateria mollissima have been the focus of conservation and management for over a century. Along with wood ducks Aix sponsa, common eiders were specifically mentioned in the original 1916 Migratory Bird Convention signed by the United States of America and the United Kingdom (on behalf of Canada; Krohn et al. 1992) because of concerns about their population status. Protections offered by the Migratory Bird Convention and other initiatives were successful and common eider populations in eastern North America generally recovered throughout the 20th century (Reed 1986; Krohn et al. 1992).

Unlike most ducks, common eider populations are highly structured, with six subspecies globally, four of which are in North America (Sonsthagen et al. 2011; Waltho and Coulson 2015; Goudie et al. 2020). Somateria mollissima mollissima breeds in northwest Europe, while S. mollissima faeroenensis is restricted to the Faroe Islands and the islands of north and west Scotland. Somateria mollissima v-nigrum is the only subspecies in the Pacific basin, breeding throughout the East Siberian, Chukchi, Bering, and Beaufort Seas. Somateria mollissima sedentaria is a large subspecies restricted to Hudson Bay year-round. The two remaining subspecies are subject to recreational harvests in eastern North America. Somateria mollissima dresseri nest at the southern edge of the species’ range in New England and Atlantic Canada and winters in the same general area. Somateria mollissima borealis breed throughout the Atlantic Arctic, including the eastern Canadian Arctic (Reed 1986), and a small portion of the eastern Canadian Arctic breeders migrate south to winter in southeastern Canada (Mosbech et al. 2006). Common eiders nesting in Labrador are believed to be mainly S. mollissima dresseri and S. mollissima borealis hybrids (Mendall 1980, 1986), and they winter in southeastern Canada and northern New England (Gilliland and Robertson 2009). Even within subspecies, there are regional populations, with their own breeding and wintering ground affinities, that overlap with other populations at different times of the year (Mosbech et al. 2006; Gilliland et al. 2009; Mallory et al. 2020). This complex population structure makes monitoring efforts challenging.

The current status of the common eider in eastern North America, which includes S. mollissima dresseri, S. mollissima borealis, and their hybrids, is unclear. Trends vary in different regions and at different times of year (Noel et al. 2021). Expert opinion suggests that recent breeding and wintering populations in the Canadian Maritime provinces, including Nova Scotia, are declining (Noel et al. 2021). Since 1970, and annually since 1992, a winter survey of waterfowl along the coast of Nova Scotia has been conducted (Allard et al. 2014), which may provide an opportunity to quantify the trends of common eiders wintering in Nova Scotia over the past 50 y. Surveys during the winter period can be an effective monitoring tool, allowing a large component of populations to be counted at a time of year relevant to harvesting activities (Bourget et al. 1986; Bordage et al. 1998). Nova Scotia has traditionally been an important wintering area for common eiders S. mollissima dresseri breeding throughout eastern Canada (Reed and Erskine 1986), and is also used by wintering S. mollissima borealis and S. mollissima dresseri/S. mollissima borealis hybrids (Mosbech et al. 2006; Gilliland and Robertson 2009). Nova Scotia represents a significant portion of the common eiders wintering in eastern North America (averaging 9.4% of all wintering common eiders counted in the U.S. Atlantic Flyway since 1992; United States Fish and Wildlife Service 2016). However, like many older surveys, the Nova Scotia wintering waterfowl survey is challenging to analyze and interpret; there are unbalanced temporal and spatial gaps in this survey and methodological changes have occurred (Robertson et al. 2017). In this paper we analyze trends in common eider numbers wintering in Nova Scotia, acknowledging the specific challenges when inferring trends from this data set.

Methods

Details of the Nova Scotia coastal survey, based on the United States Midwinter Waterfowl survey, are found in Robertson et al. (2017). In summary, the surveys were conducted by a core of 2–3 consistent and experienced observers counting all waterfowl observed along pre-defined stretches of coastline (coastal blocks; Lock et al. 1996; Allard et al. 2014), flying in a range of aircraft (starting with fixed wing and transitioning to helicopters exclusively by 1993). All flights were conducted during daylight hours, under good visibility conditions, at speeds of 30–150 km/h and altitudes of 100–150 m. Flights generally followed the coastline, with some circling back in areas with numerous islands. For small numbers of waterfowl, observers counted individuals directly; they estimated larger flocks in a variety of ways. Large flocks were typically estimated by the observer first counting a small unit (~ 50 birds), obtaining a visual image of the area involved, and then counting the number of areas this unit covered to estimate the number of total birds likely in the flock. In some cases, observers brought images with known number of dots with them as templates. In more recent years (~ since 2005), surveyors had the option to take digital images of flocks and count them after the survey.

To capture the wintering period, we considered only surveys occurring in January or February in the analysis (Table S1, Supplemental Material), after the hunting season when birds may be moving as a result of hunter disturbance. If more than one survey was conducted in a year, we used the survey occurring at a time when most of the coastline was surveyed in the analysis to minimize the opportunity for birds to move among coastal blocks. We excluded from the analysis any coastal blocks with either < 3 surveys or < 10 common eiders counted over the 1970–2019 period. To further concentrate the analysis on areas consistently used by common eiders, we also removed from the analysis coastal blocks in Northumberland Strait (northwestern Nova Scotia facing Prince Edward Island; Figure 1), which are generally ice
covered in winter. There were only four non-zero counts from this area along Northumberland Strait.

On account of the inconsistent survey coverage across coastal blocks and years, we explored a variety of statistical methods in an attempt to extract a meaningful overall trend. Important numerical features of this data set are that all counts were binned into coastal blocks and they ranged widely, from 0 (38% of observations) to 3,859 (mean = 96, standard deviation = 250, median = 12). We initially used Generalized Linear Models with negative binomial distributions and log link functions to model these data (using lme4 in Program R; Bates et al. 2015), but these initial data explorations showed clear evidence that trends were not linear over the years of survey. Therefore, we explored Generalized Additive Models (GAMs), to provide nonlinear fits over time (using R package mgcv; Wood 2017). We also fit Generalized Additive Mixed Models treating coastal blocks as random effects, but similar to Robertson et al. (2017), who analyzed the same data set for American black ducks Anas rubripes, residual patterns for coastal blocks were not satisfactory, likely due to the occasional coastal block having very large means (coastal block means ranged from 0.6 to 611, averaging 97). Therefore, we treated coastal block as a fixed effect in the GAM. To obtain estimates of trend (i.e., the rate of change) directly, we calculated the first derivative of the fitted smooth using the R package grtia (Simpson 2020).

A key assumption of generalized models with a time covariate is that residuals are not serially correlated (Barker and Sauer 1992). To assess serial correlation, we used the time series when data were collected annually (1992–2019) and calculated autocorrelations (using the function acf in base R [R Core Team 2020]) on the residuals from the fitted GAMs for each coastal block. Autocorrelation values were generally low, averaging 0.044 ± 0.249 (SD), indicating serial correlation was not an important issue for this time series. Additionally, we calculated an index of overdispersion, the sum of squared Pearson residuals divided by the residual degrees of freedom, with values close to 1 indicating good model fit (Zuur et al. 2009).

Results

For a range of logistical (mainly aircraft availability) and weather-related reasons, a complete survey of all coastal blocks in the province was never achieved. After removing data from coastal blocks with few surveys (<3) or few eiders (<10 total), 129 coastal blocks were available for analysis, with a range of 6–126 blocks surveyed in any one year (median = 80). In the 50-y period from 1970 to 2019, surveys were available for 39 y, with 6 y of surveys in the 1970s and 1980s, and annual surveys starting in 1992. In general, the negative binomial GAM provided a good fit to the data. The effective degrees of freedom of the smooth was 5.7, indicating clear nonlinear patterns; the negative binomial dispersion parameter was 0.215, showing the variance indeed accelerated with the mean; while overdispersion indicated good fit at 0.838. Based on the fitted model, numbers of common eiders wintering in Nova Scotia generally increased during 1970–2019 (Figure 2). Strong growth (>5%/y) appeared to have occurred during the early part of the time series (1970s, but with wide confidence intervals), and during the mid-2000s (Figure 3). Around 2012, the first negative trajectory was indicated, and the trajectory since 2012 indicates the population is continuing to decline, although confidence intervals still bound 1.0 (Figure 3).

Discussion

The challenges of visually counting sea ducks, including eiders, from aerial platforms have long been known (Stott and Olson 1972); consistently estimating the size of large flocks is particularly problematic (Gillespie and Learning 1974). Common eiders are notoriously challenging to survey because they often form few, but large and dense, flocks (Bordage et al. 1998). This survey was designed to count all species of wintering waterfowl, so was not specifically designed to address issues related to detecting and counting large flocks (Heusmann 1999). Additionally, this survey is restricted to the coastlines, so flocks of common eiders farther offshore were not surveyed. However, the survey was not designed to estimate population size, where issues of bias in detecting and counting large flocks are significant, but rather the survey was designed to provide a total minimum count in each coastal block over the years. We acknowledge that the minimum counts in each coastal block may not represent complete counts of common eiders over the years, but they...
hopefully represent an index of population size. Other multispecies waterbird surveys have shown that basic counts are a fair representation of total numbers, especially for larger bodied and abundant species (Laursen et al. 2008; Gilbert et al. 2021). Simple methods were employed and relatively few observers participated in the survey; therefore, the variation from observer error should be relatively stable and random over the years of the survey. There was one important change in methodologies that could account for some of the strong growth around 2005—digital photo counts replaced direct visual estimates of large waterfowl flocks in the survey at that time. Larger flocks are generally, but not always, underestimated by aerial observers when compared with photo counts (Bordage et al. 1998). Additionally, the bright white males can be easier to detect than the darker females and immature birds, and these darker birds are less likely to be detected in larger flocks when relying solely on visual estimates (Bordage et al. 1998). However, a change to more accurate photo counts in 2005 would not explain the reduction in the growth rate and eventual declines that followed over the next 15 y. In fact, large flocks have become rare since 2012, and photo counts have been rarely needed since then (S.G. Gilliland, Canadian Wildlife Service, personal communication). Further, although the types of aircraft have changed over the years of surveys, helicopters have been consistently used since the mid-1990s, again suggesting trends in recent decades likely reflect true changes in abundance rather than methodological changes.

Increases in common eider numbers were observed in the northeastern United States from 1970 to 1988 (Krohn et al. 1992). Similarly, common eiders wintering in Nova Scotia from 1970 to 2019. Counts are summed within coastal blocks (Lock et al. 1996), sections of predefined coastline for all of Atlantic Canada, including Nova Scotia, traditionally used to summarize bird survey information. Coastal block was treated as a fixed effect in the model. Derivatives were exponentiated to show as discrete (annual) growth rates ($\lambda$).
Scotia appeared to increase substantially from 1970 right up to 2010, with a particularly strong growth period in the middle 2000s. After that, growth slowed and the population began to decline in the early 2010s. Since 2003, tri-annual winter surveys dedicated to estimating common eider numbers have occurred in the northern part of the wintering distribution (Newfoundland and the northern Gulf of St. Lawrence) with the goal of tracking trends in a region where more *S. mollissima borealis* are expected to be wintering. These northern surveys show a generally stable population from 2003 to 2018 (Canadian Wildlife Service Waterfowl Committee 2020), with possible peaks in 2012 and 2018. Increases to 2012 in this northern survey are consistent with the results from the Nova Scotia waterfowl coastal block surveys. However, the recent declines are not reflected in the northern survey, suggesting that more northern breeding populations are currently stable, while the declines seen in Nova Scotia coastal block survey reflect the declines seen in the more southern breeding populations, notably Nova Scotia breeding populations and/or a redistribution of common eiders to more northern wintering areas (Noel et al. 2021).

Recent declines may be attributed to a number of factors. Predation and disturbance on nesting colonies are increasing concerns raised by a number of jurisdictions (Milton et al. 2016; Allen et al. 2019; Canadian Wildlife Service Waterfowl Committee 2020). From 1997 to 2011, breeding female survival rates were reduced in Nova Scotia (Milton et al. 2016) and may have contributed to recent declines in Nova Scotia. Harvest rates on breeding females have remained steady and relatively low (Milton et al. 2016) and are not a likely driver of the recent decline of birds wintering in Nova Scotia. In fact, harvest in Nova Scotia has declined steeply since the early 1990s (Canadian Wildlife Service Waterfowl Committee 2020). Larger intertidal ecosystem disruption and reduced benthic food sources have also been raised as concerns for common eiders wintering in southern Canada and the northeastern United States (Milton et al. 2016; Allen et al. 2019; Mallory et al. 2020; Noel et al. 2021). A shift in the wintering distribution of common eiders to other regions may also explain the reduced numbers in Nova Scotia, possibly shifting to the north and the Gulf of St. Lawrence where the ice-free season has been growing longer since 1990 (Gallbraith et al. 2018). The southern Gulf of St. Lawrence remains a gap in terms of dedicated winter survey coverage.

Although this survey was implemented as a general survey to count wintering waterfowl, does not include methods to account for interobserver count and detection bias, and may not survey all areas occupied by common eiders (Heusmann 1999), it appears to be successful in describing overall trends. We do not feel the increases, followed by declines in the recent decade, are artefacts of the survey itself because a similar analysis in American black ducks found an increase in numbers over time but no recent decline (Robertson et al. 2017). Generalized Additive Models (GAMs) with a negative binomial distribution appeared to effectively capture the important features in the data. As with American black ducks (Robertson et al. 2017), we found that introducing coastal block as a random effect led to poor residual patterns, likely because the effect of coastal block is not simply random variation, but a function of habitat features within the coastal block that may lead to very low or quite high counts of certain species. Although including coastal block as a fixed effect was costly in terms of adding many parameters to the model, the length of the time series appeared to be sufficient to allow for estimation of independent means for each coastal block. Although we feel the overall trends detected by this survey reflect general changes of common eider abundance in Nova Scotia, further standardization and documentation of survey methods, including comparing old methods with new methods when there are changes, would continue to improve the value of this survey.

Common eiders wintering in Nova Scotia increased throughout the latter part of the 1900s, similar to populations wintering in northeastern United States (Krohn et al. 1992), but are recently showing signs of decline. A range of factors is likely leading to these recent declines (Noel et al. 2021). Further understanding the affinities between breeding and wintering populations, determining the key factors driving common eider populations in the region, and mitigating negative impacts, are necessary to diagnose and reverse recent declining trends (Noel et al. 2021).

**Supplemental Material**

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

**Table S1.** Number of wintering common eiders *Somateria mollissima* counted on aerial surveys in Nova Scotia, Canada, 1970–2019. Counts are summed within coastal blocks (Lock et al. 1996), sections of predefined coastline for all of Atlantic Canada, including Nova Scotia, traditionally used to summarize bird survey information.

| Year | Count |
|------|-------|
| 1970 |       |
| 1971 |       |
| 1972 |       |
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Available: [https://10.3996/JFWM-20-087.S1](https://10.3996/JFWM-20-087.S1) (47 KB CSV)

**Reference S1.** Krohn WB, Corr PO, Hutchinson AE. 1992. Status of the American eider with special reference to northern New England. Washington, D.C.: United States Department of the Interior, Fish and Wildlife Service Research Report 12.

Available: [https://10.3996/JFWM-20-087.S2](https://10.3996/JFWM-20-087.S2) (1.17 MB PDF)

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Any use of trade, product, website, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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