

Declines amongst breeding Eider *Somateria mollissima* numbers in the Baltic/Wadden Sea flyway

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We report on the status of the Baltic/Wadden Sea flyway Eider population based on trends in breeding and wintering numbers throughout the region, supplemented by changes in the sex ratio and proportion of young Eiders as monitored in the Danish hunting bag. At the flyway scale, total numbers of breeding pairs decreased by 48% during 2000–2009, after relatively stable breeding numbers in 1991–2000. The majority of the population nest in Finland and Sweden, where the number of breeding pairs has halved over the same period. After initial declines in winter numbers between 1991 and 2000, during 2000–2009, national wintering numbers increased in the Baltic Sea, but decreased in the Wadden Sea. The annual proportion of adult females in the Danish hunting bag data de-

creased from ca. 45% (1982) to ca. 25% (2009) and simultaneously the proportion of first-winter birds fell from ca. 70% to ca. 30%, indicating dramatic structural changes in the Danish wintering numbers. These results suggest that the total flyway population will experience further declines, unless productivity increases and the factors responsible for decreasing adult female survival are identified and ameliorated. We discuss potential population drivers and present some recommendations for improved flyway-level monitoring and management of Eiders.

1. Introduction

The Baltic/Wadden Sea Eider *Somateria mollissima* population winters mainly in Denmark, Germany and The Netherlands, where wintering numbers declined by c. 36% between 1991 and 2000 (Desholm *et al.* 2002). To identify the drivers of this decline, Desholm *et al.* (2002) reviewed the breeding status and numbers of wintering Eiders in Finland, Estonia, Sweden, Denmark, southern Norway, Germany, Poland and the Netherlands, and compared changes in the numbers of both breeding and wintering Eider numbers throughout the entire Baltic/Wadden Sea flyway. Surprisingly, despite the dramatic decrease in wintering numbers, changes in breeding abundance showed no consistent trend (Desholm *et al.* 2002, BirdLife International 2004).

The discrepancy between declining wintering numbers and stable breeding numbers at that time could simply have resulted from count error or bias. Alternatively, a decline in the overall population size in this long-lived species may have been masked if there was a surplus of non-breeders available to recruit into the breeding population. Indeed, even under normal circumstances, the total potential breeding pool of Eiders may include 20–30% of individuals which only initiate breeding under suitable conditions and hence buffer the breeding numbers against overall population declines (Alerstam *et al.* 1974, Almkvist *et al.* 1974, Coulson 1984). Such floaters will not be detected in bird censuses on the nesting grounds and hence a decrease in the wintering population may not initially be evident amongst breeding numbers (Svensson *et al.* 1986).

Desholm *et al.* (2002) predicted that decreases would eventually be evident also in Eider breeding numbers at the flyway scale, given that the hypothesized buffering effect of non-breeders was real. Such a decrease would signal that the buffering co-

hort of non-breeding Eiders had been depleted in the region. Recently, national declines in breeding numbers of Eiders have been reported from Finland (Hario & Rintala 2008), Estonia (Elts *et al.* 2009) and Sweden (M. Green, unpubl. data), suggesting that such changes may indeed have occurred at the flyway scale. However, the buffering effect hypothesis was criticized by Hario and Rintala (2009), who showed that the age of first breeding increased rather than decreased during a decline in breeding numbers in the eastern Gulf of Finland. Given current declines in breeding numbers, a new assessment of the population drivers is highly timely.

We here present more recent information on the status of the Baltic/Wadden Sea Eider population, supplemented with data from 1991–2000 which were unavailable during the early 2000s and hence omitted from Desholm *et al.* (2002). We present up-to-date estimates of breeding and wintering Eiders in the region and assess the hypothetical population drivers presented by Desholm *et al.* (2002) for the current population trajectory of the species. We also update changes in annual sex- and age-ratios amongst Danish samples of birds shot in winter. We discuss plausible mechanisms behind recent changes in the Baltic/Wadden Sea Eider population by contrasting national numbers of both wintering and breeding Eiders before and after 2000, and by comparing changes in sex ratios and offspring production with changes in summer and winter numbers.

2. Material and methods

We compiled available information to estimate numbers of breeding pairs and wintering Eiders in the different countries from published and other sources (Table 1).

Table 1. The number of breeding and wintering Eiders in the Baltic/Wadden Sea flyway in 1991, 2000 and the most recent available estimates (2009 unless otherwise stated).

Country	Breeding numbers (pairs)			Wintering numbers (individuals)		
	1991	2000	2009	1990	2000	2009
the Netherlands	7,621 ^a	9,000 ^{b,1}	4,650 ^{c,2}	103,299 ^a	101,052 ^d	58,831 ^d
Germany	971 ^a	1,166 ^a	1,200 ^{e,3}	236,451 ^a	248,663 ^a	297,000 ^{f,4}
Denmark	25,000 ^a	24,000 ^a	25,000 ^{g,5}	797,000 ^a	370,000 ^a	500,000 ^{g,6}
Sweden	270,000 ^{b,h}	315,000 ^{b,h}	161,000 ^h	20,000 ^a	20,000 ^{a,*}	68,900 ^{i,7}
Norway		30,000 ^a	15,000 ^{j,8}		10,000 ^a	46,500 ^{g,6}
Finland	165,000 ^{a,9}	170,000 ^a	80,000 ^{k,10}	30 ^a	200 ^a	200 ^{**}
Poland		0 ^b	0 ^m	24,000 ^a	10,000 ^a	4,900 ^{m,11}
Estonia	12,000 ^a	12,000 ^a	5,000 ^{n,12}	100 ^a	100 ^a	60 ^{n,13}
Total flyway	480,592	561,166	291,850	1,180,880	760,015	976,391

^a Desholm *et al.* (2002), ^b BirdLife International (2004), ^c Boele *et al.* (2011), ^d Arts (2010); the numbers for 2000 re-evaluated, ^e Südbeck *et al.* (2007), ^f S. Garthe & J. Wahl (unpubl.), ^g Christensen & Bregnballe in prep., ^h M. Green (unpubl. data), ⁱ Nilsson (2009), ^j Barrett *et al.* (2006), ^k Hario & Rintala (2008), ^m W. Meissner (unpubl. data), ⁿ Elts *et al.* (2009).

¹ Estimated number 8,000–10,000, ² estimated number 4,300–5,000, ³ 1,100–1,300 pairs in 2005, ⁴ 99,000 in the North Sea (2008 for coastal data and 2006–2010 for offshore data) and 198,000 in the Baltic Sea (2008 for coastal data and average for 2006–2010 for offshore data), ⁵ estimate for 2010, ⁶ estimate for 2008, ⁷ combined estimates for 2009 (west coast), 52,000 individuals, and 2007 (Baltic Sea), 16,900 individuals, ⁸ estimated breeding number in southern Norway in 2005, ⁹ estimated number 150,000–180,000, ¹⁰ estimate for 2007, ¹¹ estimated number 4,800–5,000 in 2011, ¹² estimated number 3,000–7,000 in 2003–2008, ¹³ estimated number 20–100 in 2003–2008, * the estimate for 2000 was probably too low; a survey conducted in 2004 resulted in 50,000 wintering eiders and it is likely that this was the case also in 2000 (M. Green, unpubl. data), ** no data available, but no recent changes according to an expert opinion (Aleksi Lehikoinen, pers. comm.).

2.1. Assessing changes in breeding abundance

Survey methods for monitoring breeding sites ranged from counts of nests and/or breeding females in sample areas (e.g., in Finland) to surveys covering 60–70% of the total breeding national numbers (Estonia, see Kuresoo 1998). The vast majority of breeding Eiders in the Baltic/Wadden Sea occur in Finland and Sweden (Desholm *et al.* 2002). Recent estimates on annual change in abundance were provided by M. Green (unpublished data) and Hario and Rintala (2008) for Sweden and Finland, respectively. Annual Finnish population estimates were based on nest count data (Koskimies & Väisänen 1988) from 36 sites distributed evenly along the entire coastline (11 sites from the Gulf of Finland, 10 sites from the southwestern archipelago, 8 sites from the southern Bay of Bothnia and 6 sites from the northern Bay of Bothnia; Hario & Rintala 2008).

The selected sites were the most intensively monitored throughout the monitoring period, although annual census data were not available from all years from each site. Annual Swedish estimates

were based on data gathered at 41 sites more or less annually surveyed, supplemented by multi-annual censuses from larger regions. In Sweden, nest counts were undertaken in Blekinge, pairs present at breeding sites monitored in Västra Götaland, and male counts undertaken in the Stockholm region. These count data were combined following a standardized procedure (M. Green, unpubl. data) to yield a total estimate of breeding pairs. The changes in annual estimates presented here were derived using the software TRIM (Trends and Indices for Monitoring data) (Pannekoek & van Strien 2003), which fits log-linear Poisson models allowing for over-dispersion and serial correlation in the data, generating annual estimates with 95% confidence intervals. Based on these confidence limits, it is possible to detect statistically different annual estimates, despite large inter-annual variation. The programme also estimates an annual index between observations based on imputation of data missing from sites in specific years.

Annual estimates of national breeding numbers were available only from Finland and Sweden. Elsewhere, breeding numbers have been as-

sessed intermittently, typically once or twice per decade. In Denmark, breeding abundance was estimated based on counts in 2010 from 191 sites, combined with data from 37 supplementary sites sampled in 2007–2009 (but not in 2010) to produce a total national estimate of breeding Eider numbers in 2010. Nest counts were carried out at most sites, with male counts (including those close to breeding islands) at some sites, corrected to represent nest numbers based on the established relationship between the numbers of paired males and nests from 20 sites undertaken in 2010 (Christensen & Bregnballe, in prep.).

In Estonia, c. 70% of all breeding eiders have been counted annually using direct nest counts and the current estimate of breeding numbers are considered reliable (Elts *et al.* 2009). Breeding counts in Germany have been conducted with various methods (Desholm *et al.* 2002). Breeding counts in Norway were carried out by both pre- and post-breeding aerial counts of males (Desholm *et al.* 2002). In the Netherlands, the Wadden Sea constitutes a special monitoring area in which breeding seabirds are monitored annually. The programme strives to achieve full coverage of the region's Eider colonies (Boele *et al.* 2011).

2.2. Assessing overall population size

The majority of Eiders in the region winter in Denmark, Germany and the Netherlands. Annual mid-winter censuses have been carried out in these countries based on aerial surveys. In the Wadden Sea, Eiders have been subject to coordinated mid-winter aerial survey annually under the Trilateral Monitoring and Assessment Programme (TMAP) of the Netherlands, Germany and Denmark since 1993 (Laursen *et al.* 2011) as well as national census programmes in each country (e.g., Arts 2010, de Jong *et al.* 2010). Throughout Denmark, prior to 2004, Eiders were counted in all areas using the “total count method” using aerial survey (Aursen *et al.* 1997), but since 2004, numbers have been assessed by a combination of this method in certain areas, complemented by transect counts subjected to distance sampling and spatial modelling to generate density surfaces (and hence total estimates with confidence intervals; Petersen *et al.* 2006). This change in survey method may mean we can

only detect relative, rather than absolute, changes in winter abundance of Eiders in Danish waters between 2000 and 2009 (Petersen *et al.* 2006). In Sweden, land-based counts have been carried out since the early 1990s and flight counts covering all the important marine areas in the country, comprising the southern parts of both the west and east coasts (Nilsson 2009). In Germany, data were collected in coastal areas by aerial surveys and by land-based counts. Offshore areas were covered by both aerial and ship-based surveys. Combined, these surveys cover the vast majority of Eiders wintering in the Baltic/Wadden Sea. For a detailed description of census methods used in the different countries, see Desholm *et al.* (2002).

2.3. Changes in productivity and sex ratio

Danish hunters voluntarily contributed wings from shot birds to long established surveys (1982–2009). These have provided an average of 1 838 Eider wings per year ($SD=788.9$, $n=51\,468$), from which the annual proportions of adult females (of all adults) and juveniles (of the total sample) were calculated and used as proxies for changes in these ratios in the Baltic/Wadden Sea population as a whole. The wing survey data are adjusted for a shortening of the hunting season of female Eiders since 2004, and have been shown not to be biased in terms of spatial or temporal occurrence (Noer *et al.* 1995, Christensen 2005; see also Lehikoinen *et al.* 2008). Likewise Eider hunters in Denmark did not prefer males over females (Noer *et al.* 1995, Christensen 2005).

3. Results

Annual breeding number estimates from Finland and Sweden (Fig. 1a–b) showed remarkably similar patterns throughout the study period, with an initial increase of ca. 40% from 1986 to the early 1990s, and a subsequent decrease beginning in the late 1990s. Taken together, a statistically significant overall decline in numbers between the first and last year was apparent in both time-series (Fig. 1a–b). In Finland, the rate of decline has been fairly constant from 1998 to 2007. Swedish numbers showed a particularly marked decline between 2007 and 2009.

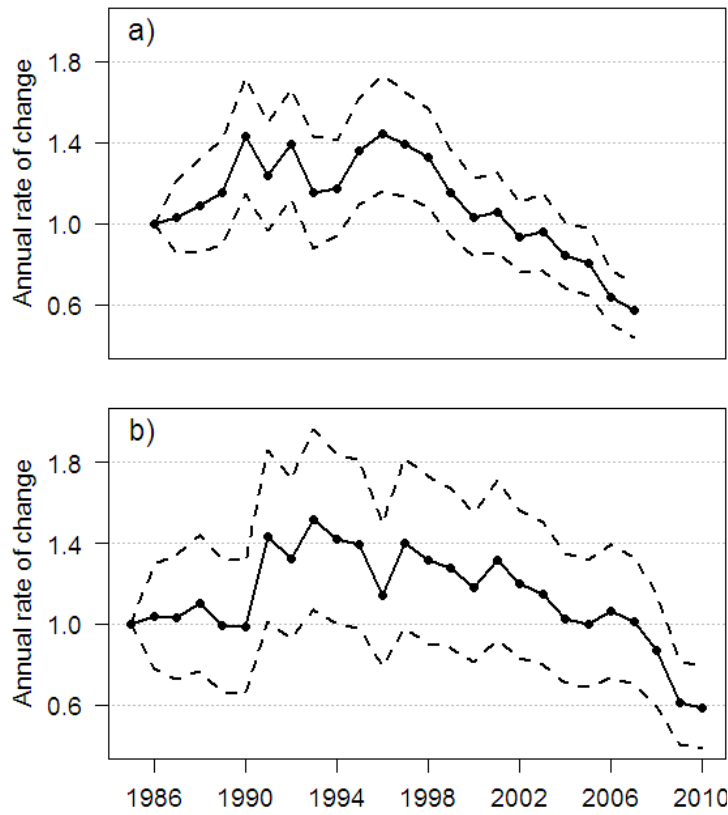


Fig. 1. Population development of the Eider in (a) Finland during 1986–2007 and (b) Sweden during 1985–2010. Population development is expressed as annual rates of change, where 1985 is set as the baseline year with the index value 1. Dashed lines represent the 95% confidence intervals of annual change indices.

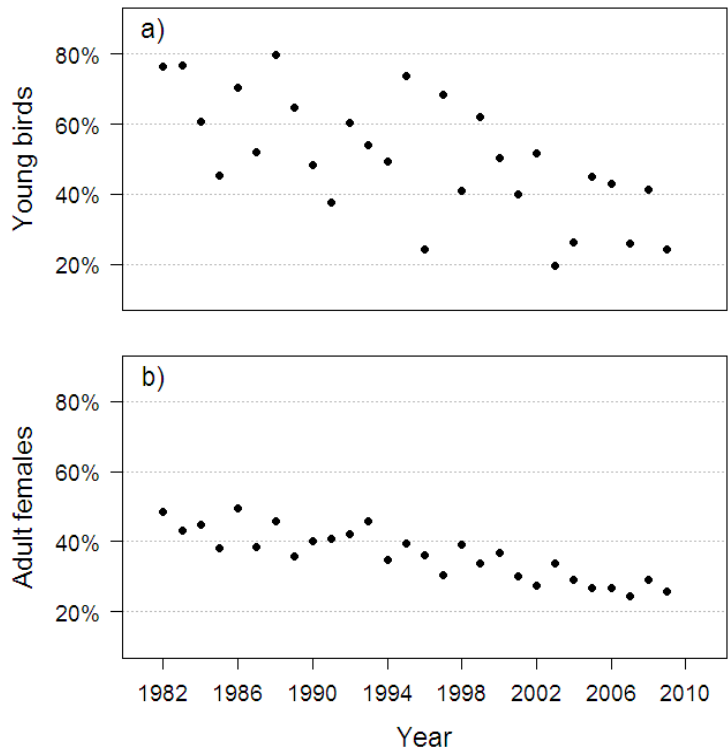


Fig. 2. The percentage of (a) first-year Eiders (of all individuals) and (b) adult females (of all adults) shot in Denmark during the years 1980–2009 according to the Danish wing survey data.

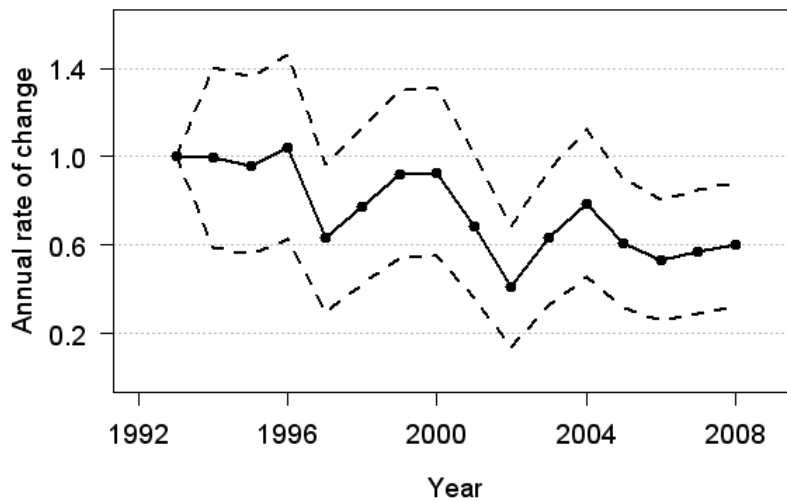


Fig. 3. Annual rate of change in Eider trend in the Wadden Sea (the Netherlands, Germany and Denmark) during 1993–2008 based on co-ordinated counts from aircraft during midwinter. The baseline year with value 1 is set to 1993. Dashed lines represent the 95% confidence intervals of annual change indices. Data from the Joint Monitoring Migratory Bird Group of the Wadden Sea.

The wing survey data showed that the proportion of juvenile Eiders wintering in Danish waters decreased steadily from around 57% in the early 1980s to only ca. 25% in 2009 ($r_s = -0.67$, $P = 0.0002$; Fig. 2a). There was also a concomitant decrease in the proportion of adult females from around 50% in the early 1980s to only around 25% in 2009 ($r_s = -0.87$, $P < 0.0001$; Fig. 2b).

The total number of wintering Eiders initially decreased during the period 1991–2000, but increased slightly to 2009 (Table 1). However, the wintering numbers decreased in the Dutch, German and Danish Wadden Sea area during 2000–2009 (Fig. 3). In the other countries along the flyway, the wintering numbers apparently increased during this time period (Table 1). In contrast, the overall breeding numbers for all countries combined were stable between 1991 and 2000 but showed a dramatic decline between 2000 and 2007–2009 (Table 1).

4. Discussion

4.1. Causes of recent population changes

This paper provides compelling evidence that the Baltic/Wadden Sea population of Eiders is in a remarkably different state compared to the situation in the early 2000s (Desholm *et al.* 2002). The numbers counted on the winter quarters decreased between 1991 and 2000, yet recent counts suggest increases in winter numbers. However, we cannot

exclude the possibility that this increase was due to improvements in survey methods in Denmark (changing from total count coverage to transect density estimation) and Germany (by including data from offshore areas, especially in the western Baltic Sea) between 2000 and 2009. The total breeding numbers show a fundamentally different pattern, being stable during the 1990s but decreasing in all countries except Germany after 2000. The decrease has been particularly dramatic in Finland and Sweden where the majority of the flyway population breeds.

The current decrease in breeding numbers was correctly predicted by Desholm *et al.* (2002), based on the assumption that the population will eventually run short of surplus recruits. However, the apparent increase in winter Eiders suggests that this mechanism alone cannot explain current changes in breeding numbers. Most likely there are multiple explanations for these contradicting patterns, including changes in Eider breeding behaviour and methodological factors. Firstly, a delay in age of first breeding combined with an increasing incidence of non-breeding by experienced breeders could reduce annual numbers of breeding females without affecting their overall numbers. Delays in age of first breeding have been associated with recent declines in breeding numbers in the eastern Gulf of Finland (Hario & Rintala 2009), but whether non-breeding among experienced females has increased over time is unknown. Non-breeding among experienced female Eiders can approach 70% during some years, and

because peaks in the incidence of non-breeding can last for several successive years (Coulson 2010), nest counts may underestimate the actual number of reproductive females. The potential for such bias is particularly pronounced if breeding numbers are assessed intermittently (Coulson 2010).

Secondly, the White-tailed Sea Eagle *Haliaeetus albicilla* has increased dramatically during the last 15 years in Finland (Stjernberg *et al.* 2009), associated with higher rates of Eider nest failure (J. Ekroos & M. Öst in prep.) and higher frequencies of predated females (Lehikoinen *et al.* 2008, Jaatinen *et al.* 2011). Recent results (J. Ekroos, M. Öst, P. Karell, K. Jaatinen & M. Kilpi in prep.) demonstrate much greater mortality of adult female Eiders in areas with abundant predators compared to those relatively predator-free (cf. Hario *et al.* 2009). Increased predator pressure may contribute to increased non-breeding and biased adult sex ratios, since nesting females are especially vulnerable to predation (Kilpi *et al.* 2003, Lehikoinen *et al.* 2008; but see Krasnov *et al.* 2010). In combination, these factors are likely to reduce annual breeding numbers which adversely affects annual productivity, as reflected in the declines in proportions of young birds in the Danish wing survey. It is unlikely that any geographical bias in the occurrence of young birds in Denmark would explain the long-term negative trend in productivity, since Finnish ring recovery data suggest that first-winter and older Eiders share common geographical winter quarters, which have remained similar over time for both age classes (J. Valkama, pers. comm.).

4.2. Sources of uncertainty

Apart from changes in the breeding behaviour of female Eiders, there are at least three other possible reasons for the discrepancy between estimates of breeding and overwintering numbers. First, since forested islands provide better cover against predation than open islands (J. Ekroos, M. Öst, P. Karell, K. Jaatinen & M. Kilpi in prep.), predation pressure may have induced a shift in breeding Eider numbers from open islands to forested islands. This could over-estimate declines in breeding numbers as the islands monitored are primarily

open islands (Kilpi & Öst 2002). However, the magnitude of this bias is reduced by the fact that established breeders show extremely high breeding philopatry to islands (Öst *et al.* 2011) even when exposed to elevated predation pressure, such as that which occurred recently on open islands (J. Ekroos, M. Öst, P. Karell, K. Jaatinen & M. Kilpi in prep.). Hence, any shifts in the relative proportion of breeders on open vs. forested islands are more likely to be caused by natural selection than by dispersal from open to forested islands, and hence the observed decreases in breeding numbers reflect a true decline.

Second, as climatic conditions, particularly during winter, are projected to change; short-distance migrants may exhibit range-shifts in their wintering distributions (e.g., Austin & Rechfisch 2005). The increasing number of wintering Eiders in Denmark and Sweden, as well as the simultaneous decrease in Eider numbers in the Wadden Sea, suggest that Eiders may have changed wintering behaviour, increasingly “short-stopping” closer to breeding grounds. Lehikoinen *et al.* (2008) found a statistically significant yet biologically trivial (24 km) shift in mean ringing recovery position of wintering Eiders from Finland ringed before and after 1985. It may nevertheless be premature to dismiss the possibility of gradual climate-induced shifts in wintering distribution, and such a change could result in enhanced detection of birds in recent years compared to those in earlier surveys, posing serious challenges for the organisation of comprehensive censuses.

Thirdly, our ability to count birds on the wintering grounds with sufficient accuracy to detect a change between 2000 and 2009 may be compromised, complicated by the shift to more accurate census methods (in Denmark) and better coverage (in Germany). If so, the recent apparent increase in midwinter numbers reported here may not reflect a real change in abundance.

4.3. Implications for population monitoring and management

The most cost-effective means of monitoring the entire Baltic/Wadden Sea flyway population is to carry out simultaneous co-ordinated counts when the entire Eider population is conspicuous on the

open sea and concentrated within a relatively small area in mid-winter. However, current winter censuses are designed to meet mainly national requirements and would clearly benefit from a better coordination in the future in order to generate robust overall population estimates. We therefore consider unified and coordinated flyway-scale winter counts as a top priority to ensure that national winter Eider surveys also generate reliable flyway-level population estimates.

Summer counts representative of large contiguous areas are laborious and likely to always suffer from variable data collection methods and effects of localized disturbance on site-specific estimates. Large-scale coordinated summer counts may not be a realistic goal, although the advent of advanced time-series analysis tools makes it increasingly possible to generate more accurate annual rates of change despite missing data from some years. Summer counts therefore provide an extremely valuable complement to winter censuses despite potential sampling gaps, bias or variable census methods. The Swedish annual population size estimates provide a prime example of this, showing that a significant negative trend can be identified despite annual variation in census methods and temporal coverage.

Duckling production is dependent on the number of mature females attaining fitness thresholds, the fecundity of which is dependent on their body reserves (Kilpi *et al.* 2001, Öst *et al.* 2003, 2008). Eiders in the western Gulf of Finland are in better body condition at breeding following warmer winters (Lehikoinen *et al.* 2006), although blue mussels *Mytilus edulis* on the wintering grounds are in better condition and offer better forage during cold winters (Beukema *et al.* 1993). Therefore the most important feeding areas are of considerable conservation value for the entire Eider population (Laursen & Frikke 2008, Laursen *et al.* 2009, 2010). As the ratio of adult females in the population continues to fall, it is likely to become increasingly urgent to recommend hunting mainly male Eiders during the winter. Management recommendations to be implemented on the breeding grounds to increase productivity and/or adult survival are not as straightforward: many factors affect breeding success, which may vary in relative importance between local populations. Prioritisation and coordination of research and conserva-

tion management actions would be greatly enhanced by the development of a management plan for the Baltic/Wadden Sea Eider population to balance the various conflicting interests.

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Haahkan viimeaikainen kannankehitys Itämerellä ja Vattimerellä

Tässä artikkelissa käsitellään haahkan (*Somateria mollissima*) viimeaikaista kannankehitystä Itämeren ja Vattimeren alueella. Aineisto on kerätty alueen kansallisista linnustoraporteista sekä tutkijoilta Suomessa, Ruotsissa, Tanskassa, Norjassa, Virossa, Saksassa, Puolassa ja Alankomaissa. Aineisto käsittää tuoreimpia saatavilla olevia arvioita kansallisista parimääristä sekä talvehtivan kannan suuruudesta. Lisäksi tarkastelimme Tanskassa ammuttujen haahkojen ikä- ja sukupuolijakauman ajallista muutosta.

Koko alueen pesimäkanta pieneni 53 % vuosina 2000–2009. Pääosa alueen haahkoista pesi Suomessa ja Ruotsissa, missä pesimäkanta on vähentynyt romahdusmaisesti 40–60 % viimeisen kymmenvuotiskauden aikana. Saksaa lukuun ottamatta haahkan pesimäkanta on vähentynyt myös kaikissa alueen muissa maissa. Siitä huolimatta talvehtiva kanta on runsastunut Itämeren alueella mutta Vattimeren alueella talvikanta väheni noin 40 % 1990-luvun puolivälin tilanteesta. Tanskan metsästysaineiston perusteella vanhojen naarai-

den osuus on vähentynyt 45 prosentista 25 prosenttiin vuosien 1982–2009 aikana. Samalla ajanjaksolla nuorten haahkojen osuus väheni 70 prosentista 30 prosenttiin.

Vähentyneen pesimäkannan sekä nuorten lintujen osuuden romahtamisen perusteella alueen kokonaiskannan laskusuuntauksen voidaan olettaa jatkuvan lähivuosina. Pesimäkannan laskun on uskottu johtuvan heikosta poikastuotosta, mutta aikuisiin naaraisiin kohdistunut lisääntynyt petopaine on myös saattanut vaikuttaa kannankehitykseen merkittävästi. Suurin pesimäkannan arviointiin liittyvä epävarmuustekijä on pesimättömien aikuisten naaraiden osuus, joka voi olla huomattava. Koska haahkat ovat suhteellisen helposti laskeutuvissa talvehtimisalueilla, tulisi talvilaskentojen kansallisia käytäntöjä yhtenäistää jotta voitaisiin saada nykyistä tarkempia kannanarvioita koko Itämeren ja Vattimeren alueelta. Haahkakantojen suojelemisen ja kestävän hyödyntämisen kannalta olisi tärkeää laatia kansainvälinen koko tarkastelu-alueetta käsittelevä yhtenäinen toimintasuunnitelma.

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