Factors affecting the bag size of the common eider Somateria mollissima in Denmark, 1980–2000

Author: Christensen, Thomas Kjær

Source: Wildlife Biology, 11(2) : 89-99

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/0909-6396(2005)11[89:FATBSO]2.0.CO;2

Factors affecting the bag size of the common eider *Somateria mollissima* in Denmark, 1980-2000

Thomas Kjær Christensen

Christensen, T.K. 2005: Factors affecting the bag size of the common eider *Somateria mollissima* in Denmark, 1980-2000. - Wildl. Biol. 11: 89-99.

Based on data compiled from the official Danish Bag Record and from the annual wing surveys of waterfowl, analyses of long-term trends in the bag of common eiders *Somateria mollissima* were performed for the period 1958-2000, while more detailed analyses of factors affecting bag size were made for the period 1980-1999. The bag size increased from ca 100,000 in the late 1950s to ca 140,000 in the 1970s and 1980s. During the 1990s, the bag size decreased to ca 83,000 in parallel with a decrease in the number of eiders wintering in Danish waters and in parallel with a significant decrease in the number of eider hunters. Assessed from both national and regional developments in bag size, hunter numbers and numbers of eiders bagged per hunter during 1980-1999, there were no indications that bag size was related to the number of wintering eiders. Stepwise multiple regression on data from 1983-1999 showed that the number of eider hunters significantly explained 71.3% of the variation in bag size, and the annual juvenile:adult female ratio in October significantly explained 10.6% of the variation. Marked decreases in the number of eider hunters during the mid-1980s and between the hunting seasons of 1992/93 and 1993/94 coincide with public debates and introductions of legislative restrictions on waterfowl hunting in Denmark. My results stress the importance of detailed analyses of factors contributing to variation in the bag size of waterfowl before accepting an apparent correlation between bag size and population size.

Key words: common eider, hunting, hunting bag, hunting statistics, Somateria mollissima, waterfowl

Thomas Kjær Christensen, National Environmental Research Institute, Department of Wildlife Ecology and Biodiversity, Grenåvej 12, Kalø, DK-8410 Rønde, Denmark - e-mail: tk@dmu.dk

Received 25 October 2002, accepted 30 March 2004

Associate Editor: Kjell Einar Erikstad

Danish waters constitute internationally important wintering and staging areas for common eiders *Somateria mollissima* belonging to the Baltic/Wadden Sea flyway population (Cramp & Simmons 1977, Noer 1991, Laursen et al. 1997, Scott & Rose 1996, Pihl et al. 2001). While eiders originating from West Sweden and southern Norway mostly occur in the Kattegat region, Baltic eiders occur in all areas (Noer 1991). Parts of the Danish and Baltic populations use Danish waters as autumn staging areas and use Danish, German and Dutch Wadden Sea waters in December and January before returning to southern Danish waters in February. Spring migration to the breeding grounds occurs during March and April (Noer 1991).

Midwinter counts found up to 800,000 eiders within Danish waters during 1987-1991 (Laursen et al. 1997), but only ca 370,000 birds in 1999/2000 (Pihl et al. 2001), suggesting that both Scandinavian and Baltic eider populations have declined. The cause of the decline over the last decade is unknown. However, mass

mortality as a result of avian cholera (Pasteurellosis) in Danish and Swedish colonies in 1996 (Christensen et al. 1997, Ziesmer & Rüger 1997, Persson 1998) have almost certainly contributed to the reduction in the flyway population, as have die-offs from starvation in the Netherlands and Germany during the winter of 1999/2000 (Camphuysen et al. 2002, Fleet 2001). Despite the decline, Danish waters supported internationally important numbers (i.e. > 20,000 birds) in six of 15 count areas during the 1999/2000 winter survey (Pihl et al. 2001).

Among the diving ducks, the eider is an abundant quarry species in Denmark, with an open hunting season extending from 1 October to 29 February. In Denmark, the annual bag increased from ca 105,000 in 1958 to ca 140,000 in the late 1980s (Noer et al. 1995), but declined to an average of ca 83,000 per season in the late 1990s (Asferg 2001).

In this paper, I analyse the Danish eider bag record covering the period 1958-2000 in order to determine long-term trends. For the period 1980-1999, more detailed analyses are presented to identify factors responsible for variation in the total bag size on a national and regional scale and to assess the contribution of these factors to the recent decrease in the total eider bag, or alternatively, to assess whether the bag size is affected by population declines.

Material

The analysis is based on data from the official annual Danish Bag Record and the annual wing survey of waterfowl compiled by the National Environmental Research Institute (NERI).

The official Danish Bag Record relies on mandatory annual reports (questionnaires) returned from all hunters holding a hunting license. Records of the eider bag size have been compiled since 1958 as part of the Danish Hunting Bag Record (Strandgaard & Asferg 1980, Asferg 2001). Hunters have to report on size and species composition of the bag on a county level (*cf.* Strandgaard & Asferg 1980; Fig. 1). Before 1985, hunting licenses were not renewed until personal bag reports were received, but after 1985 hunters have been asked to report their personal bags on their licence renewal ticket, making it possible to renew a hunting licence without reporting the previous year's bag. This administrative change reduced the annual reporting frequency from ca 94% in 1980-1984 to ca 78% in 1985-1999, while the total number of annual licenses remained relatively stable at 164,000-175,000. Corrections of the number of missing bag reports were based on the assumption that this proportion represented a random subsample of the received reports with respect to both numbers of eider hunters and the average number of eiders bagged per hunter (Asferg 1996). Thus the total number of eiders bagged (N_{total}) was calculated as:

$$N_{total} = \frac{N_{shot}}{N_{report}} \times N_{licence\ holders} \qquad (1),$$

where N_{shot} is the numbers reported shot in the filed reports, N_{report} is the number of filed reports and $N_{license\ holders}$ is the total number of license holders.

These corrections were made for the annual bag on a county basis. A small number of birds reported shot but not assigned to a county were omitted from the analyses as were a small number of eiders shot by hunters from abroad. On average, the number of eiders omitted from the analysis constituted 1.5% of the total annual bag.

In the Danish Bag Record, the hunters are registered by county of residence, but report their bags by county of retrieval. As a proportion of eider hunters hunt in coun-

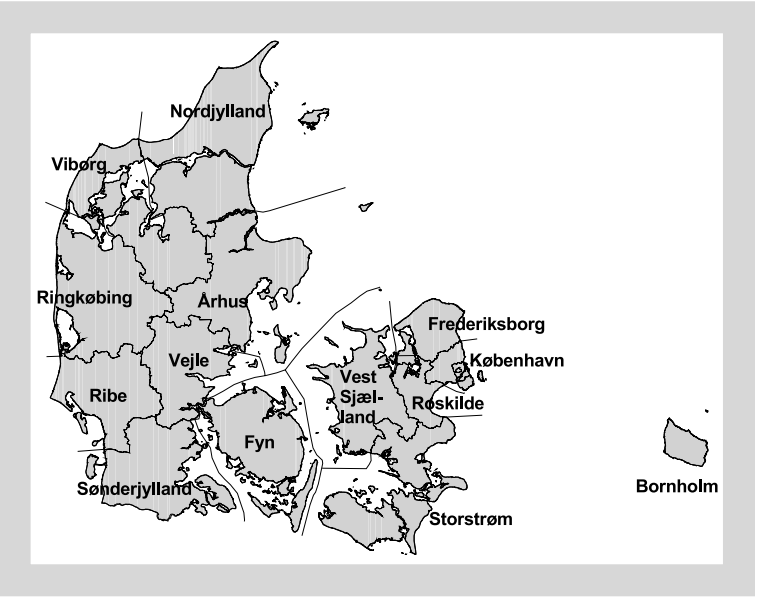

Figure 1. Location of the 14 Danish counties and their offshore boundaries.

ties other than their home county, estimates of hunting activity (the number of eider hunters) in the separate counties were obtained by distributing the number of hunters for each 'county of residence' among all counties according to the specific county-wise distribution of the reported eider bags. Thus, for each of the 14 counties the number of hunters ($H_{county\ x}$) was calculated as:

$$H_{county\ x} = \sum_{i=1}^{14} H_{hunters\ i} \times \frac{N_{shot\ xli}}{N_{shot\ i}} \qquad (2),$$

where $H_{hunters\ i}$ is the number of eider hunters in county i, $N_{shot\ xli}$ is the number of eiders shot in county x by hunters from county i, and $N_{shot\ i}$ is the total number of eiders shot by hunters from county i.

Annual wing surveys based on material provided by hunters that voluntarily forward wings of bagged waterfowl to NERI have been carried out since 1982 (Clausager 2000 and references therein). Each year, 7,000-21,000 wings were determined to species, aged and sexed. Of these, eider wings constituted 900-4,100 annually. Based on plumage characters, wings from first-year (juvenile) eiders can readily be discerned from older birds of both sexes, allowing the calculation of an index of reproductive success. Since 1983, day of retrieval has been reported by the hunters, so from this year on the annual number of days on which eiders were hunted is known. However, as some eiders may have been bagged during other hunting activities than offshore sea duck hunting, e.g. shot during dabbling duck hunting in coastal areas, days with less than five eider wings were excluded. This cut reduced the mean annual number of days on which eider wings were received by 29.2 ± 1.6% (SE).

Methods

Data representability

Estimates of the annual spatial, temporal and sex and age distribution of the eider bag are based on extrapolations from the wing survey data and thus rely on the representativeness of the data. Noer et al. (1995) have previously shown a significant correlation ($r > +0.79$) between the number of eider wings received from separate counties and the county bag size in the 1980s. They also found that the seasonal distribution of wings over month corresponded to the seasonal distribution of ring recoveries of bagged birds confirming similarity in the temporal distribution. For the period 1992/93-1998/99, correlations between the number of wings and bag size in separate counties were highly significant in five of seven seasons (correlation coefficients between +0.85 and +0.98, $t_{12} > 5.6$, $P < 0.0005$), whereas slightly weaker but still significant correlations were found in the seasons 1993/94 ($r = 0.71$, $t_{12} = 3.5$, $P < 0.005$) and 1995/96 ($r = 0.61$, $t_{12} = 2.7$, $P < 0.05$). Similarly, significant correlations were found between the average percentage of wings and bag size among individual counties ($r = 0.93$, $t_{12} = 8.9$, $P < 0.0001$). Accordingly, the wing survey data are considered representative in relation to the spatial distribution of the eider bag among counties.

Statistical analyses

Long-term changes and trends in the eider bag were analysed using a program designed to dissect time-series index values into periods (segments) of more uniform development (Kirby & Bell 1996). This analysis, called Segment Analysis, allows changes to be identified and quantified within separate segments of the time period under consideration. Segments are contiguous when the underlying rate of change is effectively constant, and the index values of all years included in separate segments contribute to quantify the change. Changes are expressed as the annual rate of change, given in percent.

Dissection of the time series of eider bag index values into separate segments was done using a combination of random and directed searches. The overall strategy of these searches was to minimise a criterion measuring the lack-of-fit (residual mean square) of regressions of all segments. Kirby & Bell (1996) showed that to ensure detection of a global rather than a local minimum, a search strategy which first included a small number of random searches, then directed searches and ultimately a large number (> 1,000) of random searches was very successful. This strategy was applied in analyses of the full eider bag time series. Assessed from Akaike's Information Criterion (AIC; Lindsey 1997) in comparison of models including 1-8 segments, the most appropriate number of segments to fit the series was three (AIC = -134.8).

In order to identify and evaluate the importance of factors that potentially were responsible for the total annual bag size the following variables were included in a stepwise multiple regression analysis (Proc REG, model-selection = stepwise; SAS Institute 1988): the annual number of eider hunters, the annual number of days on which eiders were bagged (for separate months) and the annual ratio of juveniles to adult females (for separate month). The annual number of hunters and the number of hunting days were initially considered as inde-

pendent variables as they were not correlated (r^2 = 0.14, t_{16} = 1.54, P > 0.05). Since recordings of offshore hunting days, as defined above, started in 1983, the analysis was restricted to the period 1983/84-1999/2000. Values of P = 0.20 were used for variables to enter and P = 0.05 for variables to stay in the model. In all other analyses, the level of significance was set at 0.05.

As annual counts of the wintering population of eiders in Danish waters do not exist, the potential effect of changes in population size on bag size was not assessed using this analysis. Thus to assess the influence of the size of the winter population of eiders on the size of the eider bag, the changes in bag size were compared to the development in hunter numbers and to the number of eiders bagged per hunter in separate counties using standard linear regression analysis (Sokal & Rohlf 1981). Linear regression was accepted as residual variation in these time series was normally distributed assessed by both skewness and kurtosis values (ranging between -2.0 and 2.0) and by Shapiro-Wilks test of normality (Proc UNIVARIATE; SAS Institute 1988). Only in a few cases, mostly in counties with small bag sizes, were the criteria of normality not met (see Table 1). In all county-wise comparisons it was assumed that if a change in the bag size was influenced by eider numbers, then the number of eiders bagged per hunter would follow changes in bag size given that hunter numbers were stable, e.g. a decreasing bag size and a decreasing number of eiders bagged per hunter would be indicative of lower bird numbers present. Conversely, corresponding changes in bag size and in the number of hunters coupled with a stable number of eiders bagged per hunter, would suggest that bag size was not related to eider numbers.

Results

Long-term trends in the eider bag

During the hunting seasons of 1958/59-2000/01, the total annual bag of eiders in Denmark increased from ca 100,000 in the late 1950s to ca 140,000 during the 1970s and 1980s and decreased during the 1990s to ca 83,000 (Fig. 2).

Segment analysis separated the eider bag time series into three periods: a period with an annual rate of increase of 4.76% (95% confidence limits: 2.33%, 7.25%) from 1958/59 to 1969/70, a stable period (annual change: -0.38%; 95% c.l.: -1.18%, 0.43%) from 1970/71 to 1992/93, and a period with an annual decrease of -5.28% (95% c.l.: -9.74%, -0.61%) from 1993/94 to 2000/01 (see Fig. 2). The decrease during the period 1993/94-2000/01 is considered to be significant since the 95% c.l. do not encompass zero.

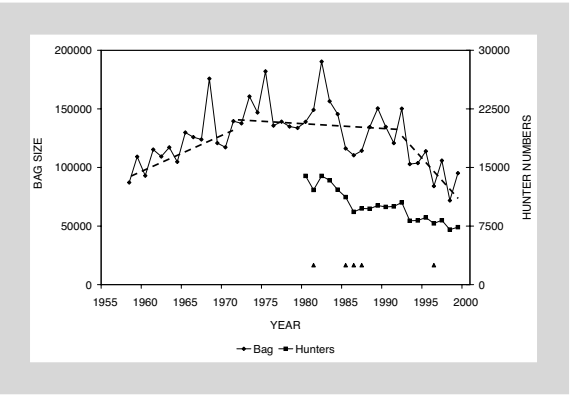

Figure 2. Danish bag of eiders during 1958/59-2000/01 and the number of hunters that bagged eiders during 1980/81-1999/2000. Regression lines obtained from Segment Analysis of the bag size are fitted by eye (see text for details). ▲ indicates the occurrence of ice-winters.

Eider hunting 1980-1999

The total size of the eider bag and the total number of active eider hunters have decreased markedly during 1980-1999 (bag size: r^2 = 0.58, t_{19} = -4.97, P < 0.001; hunter numbers: r^2 = 0.84, t_{19} = -9.83, P < 0.001; see Fig. 2 and data in Appendix I). The decrease in the number of eider hunters from ca 13,000 to ca 7,200 during this period was related to a specific reduction in the number of hunters that reported having shot eiders since the total number of hunter licenses in Denmark did not change during this period (r^2 = 0.18, t_{19} = -2.02, P > 0.05). The proportion of successful eider hunters declined from ca 7.5% (N = 13,915) in the 1980/81 season to 4.4% (N = 7,359) in the 1999/2000 season.

Despite some year-to-year variation in hunter numbers, marked decreases were evident between the seasons 1985/86 and 1986/87 and between the seasons 1992/93 and 1993/94 (see Fig. 2). The decrease in hunter numbers between 1992/93 and 1993/94 coincides with a marked decline in bag size, but no corresponding relationship was evident for the decrease between 1985/86 and 1986/87.

The results of linear regression of national and county-wise development in bag size, in the number of hunters and in the average individual bag size per hunter during 1980/81-1999/2000 is shown in Table 1 (data in Appendix I). Most eiders were bagged in the central counties with long coastlines bordering southwest Kattegat (Vestsjælland, Fyn and Århus) and in counties adjacent to the southwest Baltic Sea and the Wadden Sea (Storstrøm, Sønderjylland and Ribe). The smallest numbers were bagged in the counties of Ring-

Table 1. Average proportion of total bag size of individual counties during 1980-1999, and results of regression statistics of the development in bag size, hunter numbers and bag size per hunter in separate counties and of pooled data during the hunting seasons 1980/81-1999/2000; df = 19 in all cases (see data in Appendix I). Cases where data deviated from a normal distribution (see Methods) are shown in italics.

		Regression statistics					
	Average of total	Bag size		Hunter numbers		Bag size/hunter	
County	bag size (%)	t	P	t	P	t	P
København	1.4 ± 0.2	-5.57	< 0.001	-6.99	< 0.001	-0.90	NS
Frederiksborg	4.6 ± 0.2	-2.64	< 0.05	-4.64	< 0.001	0.70	NS
Roskilde	4.1 ± 0.3	-4.77	< 0.001	-6.54	< 0.001	*-0.25*	*NS*
Vestsjælland	11.6 ± 0.4	-7.29	< 0.001	-9.81	< 0.001	-2.93	< 0.01
Stormstrøm	5.6 ± 0.5	-5.99	< 0.001	-8.48	< 0.001	-0.92	NS
Bornholm	0.8 ± 0.1	*-5.34*	*< 0.001*	-8.44	< 0.001	*-2.18*	*< 0.05*
Fyn	31.9 ± 0.7	-3.18	< 0.01	-6.84	< 0.001	-0.07	NS
Sønderjylland	5.4 ± 0.2	-1.24	NS	-4.70	< 0.001	1.96	NS
Ribe	5.9 ± 0.5	-0.02	NS	-2.68	< 0.05	7.76	< 0.001
Vejle	5.8 ± 0.1	*-3.53*	*< 0.01*	-7.33	< 0.001	1.66	NS
Ringkøbing	0.8 ± 0.1	2.17	< 0.05	0.14	NS	*3.05*	*< 0.01*
Århus	14.4 ± 0.5	-1.46	NS	-4.06	< 0.001	0.63	NS
Viborg	0.3 ± 0.0	-0.17	NS	-0.68	NS	*0.80*	*NS*
Nordjylland	7.5 ± 0.4	-1.70	NS	-3.79	< 0.01	1.01	NS
All counties		-4.97	< 0.001	-9.83	< 0.001	0.52	NS

køb ing and Viborg in western Denmark adjacent to the North Sea and in the county of Bornholm in the Baltic Sea. In general, significant decreases in bag size were found in the eastern parts of Denmark, whereas those in western Denmark remained unchanged or even, in the county of Ringkøbing, significantly increased. Hunter numbers have significantly decreased everywhere, except in Ringkøbing and Viborg. In most counties the average number bagged per hunter has been stable (see Table 1).

Factors affecting bag size

Given that annual counts of the huntable wintering population of eiders in Danish waters do not exist, the potential influence of the size of the wintering population on the bag size was assessed from the development in bag size, number of hunters and average individual bag size of the different counties during 1980-1999 (see Table 1 and data in Appendix I). Comparisons of the trend in these variables between counties showed a consistent pattern in six of 14 counties (København, Frederiksborg, Roskilde, Storstrøm, Fyn and Vejle,) all having a significant decreasing bag size, significant decreasing number of hunters and stable individual bag sizes. A similar pattern was found in the counties of Sønderjylland, Århus and Nordjylland, although the tendency of a declining bag size was not significant. However, in these nine counties, representing on average ca 80% of the total annual eider bag, there was no indication that the total number of eiders available to hunters decreased as a result of a population decline. In the county of Vestsjælland a significant decrease in all variables suggests that the decline in bag size may not only be related to a decreasing number of eider hunters, but may also be affected by a decrease in the number of eiders during 1980-1999. In the county of Ribe bag size has remained stable, hunter numbers have declined whereas individual bag size has increased significantly. Thus, in this county fewer hunters have shot a similar number of eiders during 1980-1999 by improving individual bag size, which may indicate that the number of eiders available have increased or remained stable. Due to very low numbers shot (< 1% of the annual bag; see Table 1) in each of the last three counties, Bornholm, Ringkøbing and Viborg, these counties were not considered.

At a national level, no changes were found in the annual average number of eiders bagged per hunter during 1980-1999 ($r^2 = 0.01$, $t_{19} = 0.52$, $P = 0.612$). Eider hunters bagged on average a stable number of 12.2 ± 0.29 (SE) birds per season, giving no indications that the decrease in bag size was related to a decrease in eider numbers, nor that the decrease in the number of eider hunters should be related to a decrease in individual bag size (see Table 1). As hunter numbers may decrease in response to lower bird numbers in the preceding season rather than to low bird numbers in the actual season, a positive correlation between changes in hunter numbers and changes in individual bag size in the preceding season(s) would be expected if hunter numbers decline due to lower numbers of eiders present. However, no significant relationship was found between changes in hunter numbers and preceding changes in individual bag size (one-year delay: $r^2 = 0.007$, $t_{17} = -0.34$, $P = 0.736$; two-year delay: $r^2 = 0.042$, $t_{16} = 0.81$, $P = 0.431$; three-year delay: $r^2 = 0.064$, $t_{15} = 0.98$, $P = 0.343$). Likewise, the two marked departures of hunters recorded in 1986 and 1993 were not preceded by marked declines in hunting success. In the counties of Nordjylland and Århus hunter numbers have declined less marked-

Table 2. Results of stepwise multiple regression of the variability in annual bag size during 1983/84-1999/2000. Model 1 includes the juvenile ratio in separate months, and model 2 includes the annual average juvenile ratio.

Source of variation	R^2	df	F	P
Model 1	0.819	2.14	31.75	< 0.0001
Number of hunters	0.713		37.26	< 0.0001
Juvenile ratio in October	0.106		8.25	0.012
Days with bagged eiders[1]	0.042		3.94	NS
Model 2	0.786	2.14	53.83	< 0.0001
Number of hunters	0.713		37.26	< 0.0001
Juvenile ratio in October-February	0.052		4.16	NS
Days with bagged eiders[1]	0.073		4.81	0.046

[1] only days when > 4 wings were received are included.

ly than in the counties of Fyn, Vejle, Sønderjylland and Ribe (see Table 1), even though the number of wintering eiders in the former counties have declined much more dramatically during the last 10-year period (see Pihl et al. 2001). Consequently, these analyses on both regional and national scales did not show any indications that bag size and hunter numbers were significantly affected by the size of the winter population of eiders.

The influence of the annual number of hunters, annual number of offshore hunting days and of the annual monthly ratios of juveniles to adult females in the hunted population on the annual size of the eider bag was assessed by stepwise multiple regression. This analysis showed that the number of hunters reporting to have shot eiders was the most important factor explaining 71.3% of the variation in bag size (see Model 1 in Table 2). The juvenile:adult female ratio in October significantly explained 10.6% of the variation. Thus more than 80% of the variation in the bag size was explained by these factors. The number of hunting days explained 4.2%, but did not significantly affect bag size. There was no significant contribution from the annual average juvenile:female ratios when included in the model instead of monthly ratios (see Model 2 in Table 2).

No significant correlation existed between the juvenile ratio and the number of offshore hunting days in October for the period 1983/84-1999/2000 ($r^2 = 0.07$, $t_{16} = 1.09$, $P > 0.05$). Thus the significant effect of the juvenile ratio on the bag size was considered to reflect variation in the reproductive success and/or juvenile survival in a given year and not differences in the number of hunting days during the period of high juvenile hunting kills. During the period 1983/84-1999/2000 there was no significant trend in the annual number of hunting days (76.4 ± 3.2 (SE); $r^2 = 0.15$, $t_{16} = -1.67$, $P > 0.05$), nor in the number of hunting days in separate months (ANOVA: $F = 2.27$, $df = 84$, $P > 0.05$), averaging 15.3 ± 0.78 (SE) days per month. Although a few years with severe ice condition (i.e. 1981/82, 1984/85-1986/87 and 1995/96) had a lower number of hunting days, this result suggests that annual variation in hunting activity caused by weather generally is negligible.

Discussion

The present analyses of the Danish eider bag showed that the numbers shot have declined by ca 5.3% per annum since 1993 to the present level of ca 83,000 birds. This decline follows ca 20 years, 1970-1992, when the numbers of eiders bagged were levelling around ca 140,000 individuals per year.

The annual number of eider hunters was the main factor influencing the annual numbers shot. Hunter numbers explained 71.3% of the variation in bag size during 1982-1999, while the relative number of juveniles shot in October significantly explained 10.6%.

The decreasing bag size was not found to be related to a decrease in the wintering eider population as comparisons of the national and regional developments in bag size, hunter numbers and in the number of eiders bagged per hunter gave no indications of any direct or indirect major effect on bag size from changes in local abundance (viz. unchanged individual bag size) and from differentiated changes in phenology (viz. a negative trend in bag size in all but one county). Consequently, the overall decrease in bag size was most likely related to decreasing hunter numbers even though the size of the eider bag seems to parallel the development in the winter population size, which has been estimated at ca 500,000 eiders during 1968-1973 (Joensen 1974), ca 800,000 during 1987-1991 (Laursen et al. 1997) and ca 400,000 during 1999/2000 (Pihl et al. 2001). That individual bag size has remained stable during a period of overall population decrease, can be explained if the overall decline in eider numbers is not related to specific areas or regions, but is related to a general decline in flock size throughout Danish waters. Since eider hunters generally have only a few shots when approaching a flock of eiders, individual hunting success will not be markedly affected if the hunters encounter smaller, but not fewer, flocks of eiders than usual.

Hunter numbers and activity

The strong explanatory power of hunter numbers on the size of the eider bag puts emphasis on the performance and activity of hunters in Denmark. Although the number of eider hunters has declined during the periods 1983/84-1985/86 and 1993/94-1999/2000, very marked declines were found between 1985/86 and 1986/87 and between 1992/93 and 1993/94 (see Fig. 2). The low

number of hunters reporting having shot eiders in 1993/94 coincide with a ban against lead shot for sea duck hunting and a national ban on the sale of several game species including the eider. The lead shot ban which was implemented to encourage use of steel shot was probably the main cause for the decrease in the number of eider hunters since this matter was, and still is, a very sensitive and widely discussed subject among hunters and environmentalists in Denmark.

The reason for the gradual decline in the number of eider hunters after 1983/84 is unknown, but may relate to several factors. The three successive ice-winters, 1984/85-1986/87, may have lead to a reduction in hunting opportunities affecting the number of active hunters. Such an explanation seems, however, unlikely, since both Noer et al. (1995) and my study showed a decrease in hunter numbers in the counties of København, Roskilde and Storstrøm, where most eiders are bagged during the autumn (Noer et al. 1995), and thus are not susceptible to winter conditions. Likewise, no reduction in hunter numbers and bag size occurred after the severe winter of 1995/96 (see Fig. 2). A reduction in reporting frequency occurring from the season 1986/87 has been corrected for (see the section Methods), and thus should not result in lower numbers of hunters reporting to have shot eiders. However, an extensive public debate during the mid-1980s leading to prohibition of motorboat hunting in most Danish fjords in 1987, may have resulted in a marked decline in the number of active eider hunters during this period.

Eider hunting opportunities in the offshore environment are reduced during periods of strong wind and ice formation. Undoubtedly, wind speeds of > 5 m/second negatively affect the predominant motorboat hunting activity, but no correlation was found in the present data between the annual number of days with wind speeds of < 5 m/second and the annual number of days with > 4 eider wings ($r = 0.27$, $t_{11} = -0.90$, $P > 0.05$) or compared to all days with reported eider wings ($r = 0.23$, $t_{11} = -0.77$, $P > 0.05$), suggesting that weather had little influence on eider hunting activity. This may relate to alternative hunting methods, such as hunting from punts with decoys, which in certain parts of Denmark is practised at wind speeds of 5-10 m/second.

The significant decline in the number of eider hunters in all but two counties strongly suggests a general decline in eider hunting throughout Denmark since 1980. However, while the number of eiders retrieved per hunter was generally stable, hunter numbers dropped markedly two times during 1980-1999, with no known reports of dramatic population declines. Thus, it seems unlikely that declines in the number of hunters should be the result of sudden changes in the numbers of wintering eiders. Likewise, the similar development in hunter numbers among counties do not suggest that the winter distribution of eiders have changed markedly within Danish waters during the study period. This result contrasts somewhat with those of Noer et al. (1995), who found that changes in bag size between the 1970s and 1980s were mostly affected by changes in phenology of migrating and wintering eiders in Denmark, with increasing numbers taken in south and southwest Denmark.

Hunted populations

Recoveries of ringed eiders wintering in Denmark indicate that the majority of eiders bagged in Danish waters originate from the Baltic and Danish breeding populations (Noer 1991; NERI, unpubl. data). The seasonal distribution of these recoveries shows that Danish eiders are bagged mainly during October-November, while the frequency of Baltic eiders increases throughout the hunting season. Since the Baltic populations represent approximately 400,000 breeding pairs, while Danish populations account for ca 20,000-25,000 pairs (Noer et al. 1995, Lyngs 2000; NERI, unpubl. data.), the majority of Danish birds are bagged at the start of the hunting season, while the proportion of Baltic birds increases throughout the season.

Given the difference in both population size and in the temporal occurrence between Baltic and Danish eiders, the significant relationship between the high number of juvenile birds bagged per adult female in October and the annual bag size suggests that variation in reproductive success of Danish breeding colonies has a small, but significant effect on the annual bag size. However, since the highly variable annual reproductive output in eider populations (Mendenhall & Milne 1985, Swennen 1989, 1991a) will also have an effect on overall population size, the lack of a significant effect of the annual juvenile ratio, i.e. embracing both the Danish and Baltic populations, on the total bag size, is taken to suggest that overall population size has no marked effect on total bag size.

The significant contribution of the juvenile ratio in October to the total eider bag size most likely relates to a high proportional kill of juveniles in Danish waters during this month, as found by Noer et al. (1995). The large number of juvenile eiders bagged during the start of the hunting season, is probably also influenced by selective hunting close to breeding colonies where the majority of juvenile eiders are bagged at this time (NERI, unpubl. data on ringing recoveries) in combination with juvenile birds generally being more vulnerable to hunting

than adults birds (see Krementz et al. 1987, Nichols et al. 1990, Caithness et al. 1991). Thus, despite the relatively small number of juvenile eiders compared to total population size (incl. adults and non-breeding immature birds; see Swennen 1991b), these relationships are believed to explain the observed significant contribution of juveniles in October to total annual bag size.

Conclusion

The number of eiders bagged in Danish waters has shown a marked and general decline during the last two decades. My analysis strongly suggests that the decline in number of the hunters over the same period was the main explanation for the general decrease in bag size, whereas annual variation in reproductive success in Danish breeding colonies contributes to the seasonal variation in the eider bag. Although a general decline in the Baltic and Scandinavian populations wintering in Danish waters has occurred concurrently with the decline in the Danish bag size, the present analyses did not find indications that bag size was affected by overall numbers of wintering eiders. Thus, the present results stress the use of national bag statistics of game waterfowl as indicators of population trends. Without detailed analyses of the factors contributing to variation in bag size, wildlife managers should be very careful in accepting apparent correlations between bag size and population size and in using long-term changes in bag size as indicators of populations trends, especially for species which have been subject to different protection schemes or where changed conditions for hunting may otherwise have affected the activity of hunters.

Acknowledgements - special thanks go to Tommy Asferg and Ib Clausager who kindly provided data from the Danish Bag Record and the Danish Wing Survey databases. A.D. Fox, P. Clausen, T. Bregnballe, T. Asferg, I. Clausager and H. Noer are acknowledged for valuable discussions and for comments on earlier drafts of this paper.

References

Asferg, T. 1996: Fejlkilder i den danske vildtudbyttestatistik. Omfang og effekt af manglende indberetninger. - The Danish National Environmental Research Institute, Report no. 167, 27 pp. (In Danish with an English summary).

Asferg, T. 2001: Vildtudbyttet i Danmark i jagtsæsonen 2000/2001. - The Danish National Environmental Research Institute. Report no. 393, 36 pp. (In Danish with an English summary).

Caithness, T., Williams, M. & Nichols, J.D. 1991: Survival and band recovery rates of sympatric grey ducks and mallards in New Zealand. - Journal of Wildlife Management 55: 111-118.

Camphuysen, C.J., Berrevoets, C. M., Cremers, H.J.W.M., Dekinga, A., Dekker, R., Ens, B.J., van der Have, T.M., Kats, R.K.H., Kuiken, T., Leopold, M.F., van der Meer, J. & Piersma, T. 2002: Mass mortality of common eider (Somateria mollissima) in the Dutch Wadden Sea, winter 1999/2000: starvation in a commercially exploited wetland of international importance. - Biological Conservation 106(3): 303-317.

Christensen, T.K., Bregnballe, T., Andersen, T.H. & Dietz, H.H. 1997: Outbreak of Pasterellosis among wintering and breeding common eiders Somateria mollissima in Denmark. - Wildlife Biology 3: 125-128.

Clausager, I. 2000: Vingeindsamling fra jagtsæsonen 1999/2000. Wing survey from the 1999/2000 hunting season in Denmark. - The Danish National Environmental Research Institute, Report no. 324, 50 pp. (In Danish with an English summary).

Cramp, S. & Simmons, K.E.L. (Eds.) 1977: Handbook of the Birds of Europe the Middle East and North Africa. The Birds of the Western Palearctic, Vol 1: Ostrich to Ducks. - Oxford University Press, 722 pp.

Fleet, D.M. 2001: Numbers of Common Eiders Beached on the German North Sea coast during the mass mortality in the winter 1999/2000. - Wadden Sea Newsletter 2001(1): 6-7.

Joensen, A.H. 1974: Waterfowl populations in Denmark 1965-73. A survey of the non-breeding populations of ducks, swans and coot and their shooting utilization. - Danish Review of Game Biology 9(1), 206 pp.

Kirby, J.S. & Bell, M.C. 1996: Surveillance of non-breeding waterfowl populations: methods to trigger conservation action. - Gibier Faune Sauvage, Game and Wildlife Science 13: 493-512.

Krementz, D.G., Hines, J.E., Corr, P.O. & Owen, R.B., Jr. 1989: The relationship between body mass and annual survival in American Black Ducks. - Ornis Scandinavica 20: 81-85.

Laursen, K., Pihl, S, Durinck, J., Hansen, M., Skov, H., Frikke, J. & Danielsen, F. 1997: Numbers and Distribution of Waterbirds in Denmark 1987-1989. - Danish Review of Game Biology 15(1), 180 pp.

Lindsey, J.K. 1997: Applying generalized linear models. - Springer Verlag, New York, Inc., 256 pp.

Lyngs, P. 2000: Status of the Danish breeding population of Eiders Somateria mollissima 1988-93. - Dansk Ornitologisk Forenings Tidskrift 94: 12-18.

Mendenhall, V.M. & Milne, H. 1985: Factors affecting duckling survival of Eiders Somateria mollissima in Northeast Scotland. - Ibis 127: 148-158.

Nichols, J.D., Williams, M. & Caithness, T. 1990: Survival and band recovery rates of mallards in New Zealand. - Journal of Wildlife Management 54: 629-636.

Noer, H. 1991: Distributions and movements of Eider So-

materia mollissima populations wintering in Danish waters, analysed from ringing recoveries. - Danish Review of Game Biology 14(3), 32 pp.
Noer, H., Clausager, I. & Asferg, T. 1995: The bag of Eider Somateria mollissima in Denmark 1958-1990. - Danish Review of Game Biology 14(5), 24 pp.
Persson, L. 1998: Fågelkolera på ejder och andra fåglar på Västergarns utholme. - Bläcku 24: 91-93. (In Swedish).
Pihl, S., Petersen, I.K., Hounisen, J.P & Laubek, B. 2001: Landsdækkende optælling af vandfugle, vinteren 1999/2000. - The Danish National Environmental Research Institute, Report no. 356, 46 pp. (In Danish).
SAS Institute Inc. 1988: SAS/STAT User's guide version 6.12 ed. - SAS Institute Inc., Cary, N.C., 1028 pp.
Scott, D.A. & Rose, P.M. 1996: Atlas of Anatidae Populations in Africa and Western Eurasia. - Wetlands International Publication no. 41, 336 pp.
Sokal, R.R. & Rohlf, F.J. 1981: Biometry. Second edition. - W.H. Freeman and Company, New York, 859 pp.
Strandgaard, H. & Asferg, T. 1980: The Danish Bag Record II. - Danish Review of Game Biology 11(5), 112 pp.
Swennen, C. 1989: Gull predation upon Eider Somateria mollissima ducklings: Destruction or elimination of the unfit. - Ardea 77: 21-45.
Swennen, C. 1991a: Fledging production of Eiders Somateria mollissima in The Netherlands. - Journal of Ornithology 132: 427-437.
Swennen, C. 1991b: Ecology and population dynamics of the Common Eider in the Dutch Wadden Sea. - Proefscrift, Rijksuniversiteit Groningen, pp. 109-141.
Ziesmer, F. & Rüger, A. 1997: Massdöd av Ejder Somateria mollissima och andra fåglar förorsakad av Pasteurella multocida? - Bläcku 23: 31- 32. (In Swedish).

Appendix I

Bag size, number of hunters and number of eiders bagged per hunter for separate years and counties. County abbreviations: Kbh: København; Frb: Frederiksborg; Ros: Roskilde; Vsj: Vestsjælland; Str: Storstrøm; Bor: Bornholm; Fyn: Fyn; Soj: Sønderjylland; Rib: Ribe; Vej: Vejle; Rin: Ringkøbing; Arh: Århus; Vib: Viborg; Noj: Nordjylland (see Figure 1 for location of county).

Bag size

		County												
Year	Total	Kbh	Frb	Ros	Vsj	Str	Bor	Fyn	Soj	Rib	Vej	Rin	Arh	Vib	Noj
1980	144,585	3,150	6,361	10,217	20,288	14,618	1,978	44,503	7,264	5,639	7,667	1,002	14,878	514	6,506
1981	146,241	5,739	7,810	8,398	19,398	9,861	1,349	42,769	5,265	3,296	7,688	674	18,482	223	15,289
1982	183,726	4,766	7,607	7,872	25,136	15,007	1,861	60,866	9,530	4,783	10,433	939	22,622	425	11,879
1983	152,384	3,053	8,779	7,756	20,261	16,010	1,154	44,337	6,640	6,451	7,867	557	18,960	384	10,175
1984	143,737	2,346	7,904	10,741	18,164	12,301	1,437	36,518	7,932	6,152	7,918	739	20,644	228	10,713
1985	114,818	2,545	5,205	3,949	13,771	7,987	1,508	33,420	6,236	9,280	7,195	662	15,428	250	7,382
1986	109,097	1,425	3,857	4,568	12,755	6,714	1,598	35,643	5,140	7,418	6,433	460	16,072	274	6,740
1987	111,122	1,026	3,370	3,303	15,756	4,925	637	38,854	6,554	8,760	6,730	685	14,590	174	5,758
1988	132,928	1,164	3,864	5,127	19,000	5,273	2,277	47,311	6,535	9,689	6,953	1,154	15,685	530	8,366
1989	149,487	1,486	5,224	9,444	14,738	4,988	911	55,096	7,431	9,548	7,308	947	20,424	388	11,554
1990	133,876	932	5,058	4,557	13,718	5,982	547	48,051	7,752	9,578	6,792	1,224	17,909	235	11,541
1991	119,419	784	4,918	3,484	13,706	4,492	556	36,607	5,954	13,033	6,263	1,199	17,428	502	10,493
1992	148,237	1,439	7,457	6,768	17,612	7,602	731	44,958	8,494	4,393	8,737	1,370	25,328	503	12,845
1993	101,441	1,260	4,971	3,143	11,041	4,057	442	30,771	4,814	4,910	6,465	731	17,800	406	10,630
1994	102,351	878	5,653	2,447	10,396	4,620	403	32,579	5,740	4,456	6,901	753	16,934	347	10,244
1995	112,512	703	5,389	3,645	10,885	5,547	567	34,542	6,525	5,873	8,032	1,570	20,561	370	8,303
1996	82,462	795	4,334	1,287	7,750	4,538	485	28,395	5,167	4,804	5,230	807	13,195	302	5,373
1997	104,563	978	4,577	3,257	9,586	4,756	397	36,745	7,760	6,868	5,391	1,372	15,774	404	6,698
1998	70,609	568	3,876	2,409	6,468	2,450	210	20,831	3,700	6,239	4,350	9,480	12,147	242	6,171
1999	93,548	705	5,109	3,519	9,518	3,469	662	30,849	7,166	6,312	6,075	1,029	12,592	265	6,278

Number of hunters

Year	Total	Kbh	Frb	Ros	Vsj	Str	Bor	Fyn	Soj	Rib	Vej	Rin	Arh	Vib	Noj
1980	13,915	285	632	915	1,592	1,502	237	2,938	997	726	919	216	1,910	79	966
1981	12,114	442	604	545	1,282	1,159	167	2,445	797	484	834	121	1,844	35	1,353
1982	13,913	445	620	591	1,644	1,437	178	2,991	1,086	635	1,005	156	1,875	58	1,191
1983	13,352	285	694	664	1,475	1,430	175	2,750	907	817	867	111	1,980	70	1,126
1984	12,147	256	661	696	1,314	1,264	164	2,184	960	759	746	125	1,837	39	1,143
1985	11,207	286	499	373	1,207	1,083	172	2,176	835	961	782	101	1,781	47	903
1986	9,313	173	391	432	1,008	813	170	1,979	667	766	595	81	1,495	48	696
1987	9,754	137	368	326	1,168	663	94	2,219	799	983	640	123	1,553	34	646
1988	9,709	133	388	339	1,176	609	182	2,097	716	941	583	183	1,505	65	793
1989	10,130	150	495	419	1,071	577	109	2,203	797	836	680	144	1,749	65	835
1990	9,949	99	455	298	1,074	652	78	2,280	746	813	622	184	1,650	41	957
1991	10,010	92	468	283	1,106	533	90	2,063	700	965	628	204	1,743	74	1,060
1992	10,512	121	495	448	1,180	686	95	2,240	736	469	644	202	2,035	61	1,100
1993	8,169	129	424	254	901	478	73	1,816	543	438	560	65	1,552	48	887
1994	8,218	93	465	204	849	505	68	1,886	615	367	576	92	1,577	51	870
1995	8,587	63	468	313	870	550	95	1,854	632	403	622	161	1,722	52	782
1996	7,840	95	412	145	773	521	63	1,830	664	439	540	119	1,514	50	676
1997	8,240	97	333	262	782	517	63	1,981	759	554	527	174	1,448	64	680
1998	7,044	64	395	193	665	361	36	1,546	598	471	526	171	1,338	39	641
1999	7,359	68	387	238	774	386	77	1,650	737	436	527	132	1,263	43	641

Number of eiders bagged / hunter

Year	Total	Kbh	Frb	Ros	Vsj	Str	Bor	Fyn	Soj	Rib	Vej	Rin	Arh	Vib	Noj
1980	9.1	11.0	10.1	11.2	12.7	9.7	8.4	15.1	7.3	7.8	8.3	4.6	7.8	6.5	6.7
1981	10.5	13.0	12.9	15.4	15.1	8.5	8.1	17.5	6.6	6.8	9.2	5.6	10.0	6.4	11.3
1982	11.1	10.7	12.3	13.3	15.3	10.4	10.4	20.4	8.8	7.5	10.4	6.0	12.1	7.3	10.0
1983	9.7	10.7	12.7	11.7	13.7	11.2	6.6	16.1	7.3	7.9	9.1	5.0	9.6	5.5	9.0
1984	10.4	9.2	12.0	15.4	13.8	9.7	8.8	16.7	8.3	8.1	10.6	5.9	11.2	5.9	9.4
1985	9.1	8.9	10.4	10.6	11.4	7.4	8.8	15.4	7.5	9.7	9.2	6.5	8.7	5.3	8.2
1986	9.8	8.3	9.9	10.6	12.7	8.3	9.4	18.0	7.7	9.7	10.8	5.7	10.7	5.7	9.7
1987	9.2	7.5	9.2	10.1	13.5	7.4	6.8	17.5	8.2	8.9	10.5	5.6	9.4	5.0	8.9
1988	11.5	8.8	10.0	15.1	16.2	8.7	12.5	22.6	9.1	10.3	11.9	6.3	10.4	8.2	10.6
1989	12.0	9.9	10.6	22.5	13.8	8.7	8.3	25.0	9.3	11.4	10.7	6.6	11.7	6.0	13.8
1990	11.0	9.4	11.1	15.3	12.8	9.2	7.0	21.1	10.4	11.8	10.9	6.6	10.9	5.8	12.1
1991	10.0	8.5	10.5	12.3	12.4	8.4	6.2	17.7	8.5	13.5	10.0	5.9	10.0	6.7	9.9
1992	12.1	11.9	15.1	15.1	14.9	11.1	7.7	20.1	11.5	9.4	13.6	6.8	12.4	8.2	11.7
1993	10.9	9.8	11.7	12.4	12.3	8.5	6.1	16.9	8.9	11.2	11.5	11.3	11.5	8.4	12.0
1994	10.7	9.5	12.1	12.0	12.2	9.1	5.9	17.3	9.3	12.2	12.0	8.2	10.7	6.8	11.8
1995	11.3	11.1	11.5	11.7	12.5	10.1	5.9	18.6	10.3	14.6	12.9	9.8	11.9	7.1	10.6
1996	9.1	8.4	10.5	8.9	10.0	8.7	7.7	15.5	7.8	10.9	9.7	6.8	8.7	6.1	7.9
1997	10.7	10.1	13.8	12.4	12.3	9.2	6.3	18.6	10.2	12.4	10.2	7.9	10.9	6.3	9.8
1998	8.9	8.9	9.8	12.5	9.7	6.8	5.8	13.5	6.2	13.2	8.3	5.6	9.1	6.1	9.6
1999	11.2	10.4	13.2	14.8	12.3	9.0	8.6	18.7	9.7	14.5	11.5	7.8	10.0	6.2	9.8