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Continued cover page 3

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Med et dansk resumé:
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i Danmark 1958-1990

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Abstract

Noer, H., Clausager, I. and Asferg, T. 1995: The bag of Eider *Somateria mollissima* in Denmark 1958-1990. - Dan. Rev. Game Biol. **14**(5).

Eider hunting in Denmark 1958-1991 was analysed on the basis of data in the official Danish Bag record, wing surveys and ringing recoveries. Total numbers bagged increased through the investigated period from c. 105,000/season to the present level of c. 140,000/season. Bag size only increased in the southernmost parts of the country, resulting in significant changes in geographical distribution of bag. Principal Components Analysis of annual bag sizes in 13 counties indicated a shift towards the southernmost parts 1970-1975 and a further shift towards the southwesternmost parts after 1980. Surveys of wings received from hunters revealed highly significant regional differences. In the southeastern parts of the inner Danish waters, numbers taken peak in October. In contrast, numbers peak in the southwestern parts in February. Corresponding results were found for ringing recoveries. Comparisons between sets of recoveries made before and after 1970 indicated that before 1970 there was no February maximum in the southwestern areas. The age composition of the bag showed seasonal trends with 65-70% of the October bag being first-year individuals, contrasting with c. 15% in February. Based on wings received in the seasons 1986/87-1989/90, 58-59% of the bag is estimated to be males. The c. 40% increase of the total annual bag size is considerably smaller than the increase in overall population sizes. In combination with the geographical shifts, this is taken to suggest that changes in the phenology of different Eider populations wintering in the Danish waters have influenced the observed changes in bag size and composition strongly. Estimates of overall population sizes staging and wintering in Danish waters lead to estimates of 6-10% being taken annually by Danish hunters. Age specific annual harvest rates are 10-15% of a cohort during the first autumn and winter, and c. 5% for older birds. These estimates are discussed in relation to population sizes and trends.

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Contents

INTRODUCTION

The Eider *Somateria mollissima* winters in large numbers in Danish waters. Besides the Danish breeding population of c. 18,000 pairs (Franzmann 1989), most of the Swedish West Coast and Norwegian Skagerrak population winter in the Kattegat, and large sections of the Baltic population occur in all areas (Noer 1991). In countrywide aerial surveys 1987-1991, annual midwinter counts total 800,000 individuals (Laursen et al. in print).

The Eider is also one of the most important quarry species in Denmark. The open season extends from 1 October to 28 (29) February, and the total bag varies between 110,000 and 190,000 individuals (Joensen 1974a, b, and 1978, Strandgaard and Asferg 1980, Asferg unpublished). Based on examination of Eiders from game dealers in the hunting seasons 1967/68-1975/76, Joensen (1978) found that 40% of the bag was taken in October, decreasing to 9% in December, and thereafter increasing to 17% in February. Percent first year individuals was highly variable between years, but with a seasonal trend from 30-90% in October to 10-40% in February (Joensen 1974a and 1978). Males made up 55-60% of the bag.

Most European Eider populations have grown for more than 100 years (e.g. Joensen 1973, Swennen 1991). Between 1960 and 1985, growth rates were particularly high (Hario and Selin 1988, Franzmann 1989), and many populations increased by up to 10% annually (Pehrsson 1978, Stjernberg 1982, Coulson 1984, Hario and Selin 1988, Franzmann 1989, Swennen 1991). This increase caused changes in both bag size and other aspects of shooting utilisation in Denmark. The purpose of the present paper is:

- to analyse the information on bag size and document changes,
- to update the information on spatial and temporal distribution of the bag,
- to update information on age and sex composition of the bag, and
- to use these results in a discussion of factors affecting the Danish Eider bag size and the harvesting of the species in Denmark in relation to the present knowledge of size and trends of Eider populations.

ACKNOWLEDGEMENTS

Through funding of analyses of the Eider's ecology in Denmark, The Nordic Council for Wildlife Research sponsored the work of H. Noer in this study. Dr.s Åke Andersson, Anders Holm Joensen and Anthony D. Fox provided critical reviews and comments on earlier drafts. Ebbe Bøgebjerg Hansen and Stefan Pihl provided valuable information on Eider hunting and numbers of Eiders in the Danish waters.

MATERIAL

Three different materials compiled by the National Environmental Research Institute, comprising the official Danish Bag Record, annual wing surveys and ringed Eiders recovered as shot, were analysed.

The official Danish Bag Record results from questionnaries sent annually to all persons having held a hunting license in the preceding season (ca. 170,000). This questionnaire prompts information on size and species composition of the bag. Answering is mandatory. A detailed account of the collection of these data, including an assessment of reliability, was given by Strandgaard and Asferg (1980). The present study includes numbers of Eiders bagged in each of 14 counties in the 33 seasons 1958/59 - 1990/91.

Wing surveys have been carried out since 1982. These surveys are based on hunters sending wings of bagged birds to the Department of Wildlife Ecology on a voluntary basis. The annual number of 9,000-17,000 duck wings thus collected are determined to species, aged and sexed (Clausager

1991). For the Eider, age classes of more than one year (only discernible for males) are pooled in this paper, and the term 'juvenile' is used for first year individuals throughout. Statistics on wings of Eiders received during the seasons 1985/86-1989/90 were included in the analyses.

Ringing of Eiders has been carried out in many countries during the past 40 years. From the Danish waters, 2,100 recoveries of Eiders ringed outside Denmark were available (Noer 1991), together with a further 3,500 recoveries of birds ringed in Denmark (Noer unpublished). This study includes birds reported as shot, i.e. some 80% of the recoveries (Noer 1991).

METHODS

Subareas

The official Bag Record is compiled on a basis of counties *(Fig. 1)*. The administrative division of Denmark was changed in 1970, when a former 22 counties were reduced to 14 by amalgamation. By combining bag numbers from some counties pre-1970 it is possible to extract continuous data series for all new counties throughout the investigated period, except for the counties of København and Roskilde. Accordingly, data from these two counties were pooled.

The wing survey results have been computerised on a basis of a 25x25 km² grid as well as on counties (Clausager 1991). Thus, this part of the material can be subdivided in several ways.

Ringing recoveries have been computerised with position given as geographical coordinates, i.e. this material can be subdivided as convenient. Recent analyses of ring recoveries from Denmark (Noer 1991) used the subdivision of Danish waters proposed by Joensen (1974a) for analysing aerial counts, with borders between subareas straightened in order to facilitate computer programming *(Fig. 2)*.

Since several counties are heterogeneous with respect to the spatial and temporal distribution of Eiders, the subdivison presented in Fig. 2 was chosen as the most convenient basis of the calculations of age and sex composition of the bag. Wing surveys and ringing recoveries could readily be summed over subareas, but a recalculation of the bag record was required. In this recalculation, splitting of total numbers bagged in counties was obtained from the geographi-

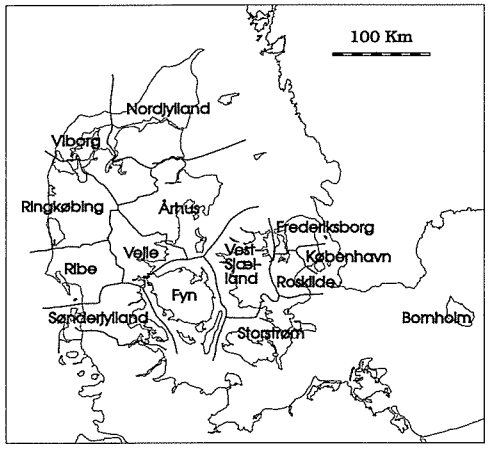

Fig. 1. The 14 Danish counties making up the basis of the official bag record.

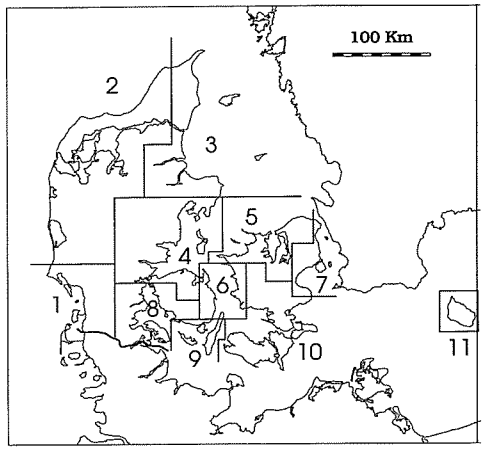

Fig. 2. The subdivision of the Danish waters used for analysing distributions of wings from wing surveys and ringing recoveries.

cal distribution of wings by means of the formula:

$$N_a = \sum_{c=1}^{13} \frac{w_{ac}}{w_c} \cdot N_c$$

where N_a is the number bagged in an area (a = 1,2,..,11), N_c is county bag (c = 1,2,..,13), w_c is number of wings received from a county and w_{ac} is number of wings from county c that were taken in area a. Following this, numbers taken in any month of a hunting season (N_j) were calculated as

$$N_j = \sum_{a=1}^{11} \frac{w_{aj}}{w_a} \cdot N_a$$

where w_{aj} is the number of wings from area a taken in month j and w_a is the total numbers of wings from area a.

Age and sex compositions were calculated straightforward by multiplying N_a for each area with frequencies of age and sex classes obtained from the wing survey material.

Statistical analysis

Variation in temporal and geographical distribution of the bag was analysed by means of Principal Components Analysis (e.g. Maxwell 1977). In the present case, the analyses were based on the correlation matrix between annual numbers bagged in the 13 counties. This standardisation of data means that all counties were allocated equal weight in the analysis. In comparison with unstandardised data, which will place the emphasis of the analysis on counties with a large bag, this standardisation emphasises geographical variation in the bag.

RESULTS

Long-term changes in numbers bagged

Total numbers

Bag size increased from an annual mean of c. 105,000 in the seasons 1958/59-1964/65 to c. 140,000 in the seasons 1988/89-1990/91 *(Fig. 3)*. This increase took place in the first half of the investigated period, up to the mid 1970's. After that, the bag size has shown no obvious trends. In spite of this variation, the correlation between total annual bag size and time is highly significant *(Table 1)*.

Geographical distribution

Plots of bag size against time for single counties are given in *Fig. 4*. Correlations between numbers bagged and time were sig-

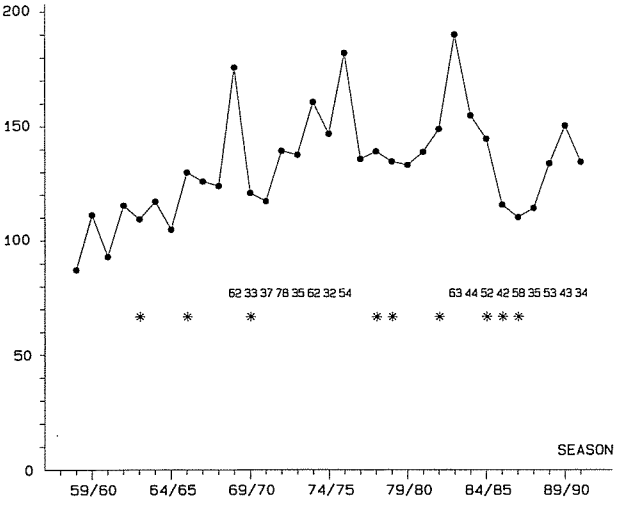

Fig. 3. The total bag of Eiders in Denmark in the hunting seasons 1958/59 to 1990/91. Percent juveniles (first year) in the bag is shown for the years with available data. Seasons closed in January-February due to severe winter weather are indicated by asterisks. Details on these seasons are given in Appendix I.

*Table 1. Simple correlations between time and annual numbers bagged in separate counties. Significance levels are given as NS = not significant, * = 2.5% < P < 5.0%, ** = 1% < P < 2.5% and *** = P < 1%.*

COUNTY	r	P
København/Roskilde	0.1108	NS
Frederiksborg	-0.2352	NS
Vestsjælland	-0.3090	NS
Storstrøm	0.1575	NS
Bornholm	0.3126	NS
Fyn	0.7170	***
Sønderjylland	0.8237	***
Ribe	0.7021	***
Vejle	-0.2763	NS
Ringkøbing	-0.0055	NS
Århus	0.2392	NS
Viborg	-0.3294	NS
Nordjylland	-0.2372	NS
Total Bag	0.4314	**

nificant for three counties only and six counties even showed negative (though insignificant) correlations with time *(Table 1)*. This heterogeneity between counties implies that even if total annual numbers of Eiders bagged in Denmark increased between 1958 and 1990, this increase was unevenly distributed over counties.

In order to obtain an objective analysis a Principal Components Analysis was carried out on the distribution of the annual bag over seasons and counties. Almost all correlation coefficients between counties were positive. This is reflected in the Principal Components, as all counties have positive loadings on the first PC *(Table 2)*. Accordingly, PC 1 expresses annual variation in numbers bagged, counties showing parallel variation in annual hunting success.

For the second Principal Component, loadings of the counties of Frederiksborg, Vestsjælland, Vejle, Viborg and Nordjylland were negative, while those for København/Roskilde, Storstrøm, Bornholm, Fyn, Sønderjylland and Ribe were positive *(Table 2)*. The counties of Århus and Ringkøbing had small loadings on this component. Thus, PC 2 is a contrast between the Northern and Southern parts of the Danish waters, and hence expresses the relative distribution of the bag along a North-South axis *(Table 2)*.

The third PC has relatively high positive loadings on the counties of Fyn, Sønderjylland, Ribe, Vejle and Nordjylland and high negative loadings for the counties of København/Roskilde, Storstrøm and Bornholm *(Table 2)*. Thus, PC 3 can be interpreted to express the relative distribution of the bag over the southernmost parts of the Danish waters. Together, the first three Principal

Table 2. Loadings of the first three Principal Components of annual variation in numbers bagged on a county basis. The scaling of PCs has been chosen in a way that individual loadings represent correlation coefficients between the bag of the county and the different PC's.

COUNTY	PC 1	PC 2	PC 3
København/Roskilde	0.7698	-0.2451	-0.4664
Frederiksborg	0.7636	0.4255	-0.0413
Vestsjælland	0.6723	0.3892	0.0228
Storstrøm	0.7810	-0.2519	-0.4130
Bornholm	0.5371	-0.4219	-0.3739
Fyn	0.5164	-0.5440	0.5657
Sønderjylland	0.5381	-0.7059	0.3394
Ribe	0.1088	-0.7522	0.3385
Vejle	0.5899	0.5300	0.4027
Ringkøbing	0.6141	0.0266	-0.1888
Århus	0.6558	0.0634	0.1852
Viborg	0.5542	0.5244	0.0651
Nordjylland	0.3523	0.6323	0.3063
Eigenvalue	4.6806	2.9545	1.4101
% Variation	36.0000	22.7300	10.8500

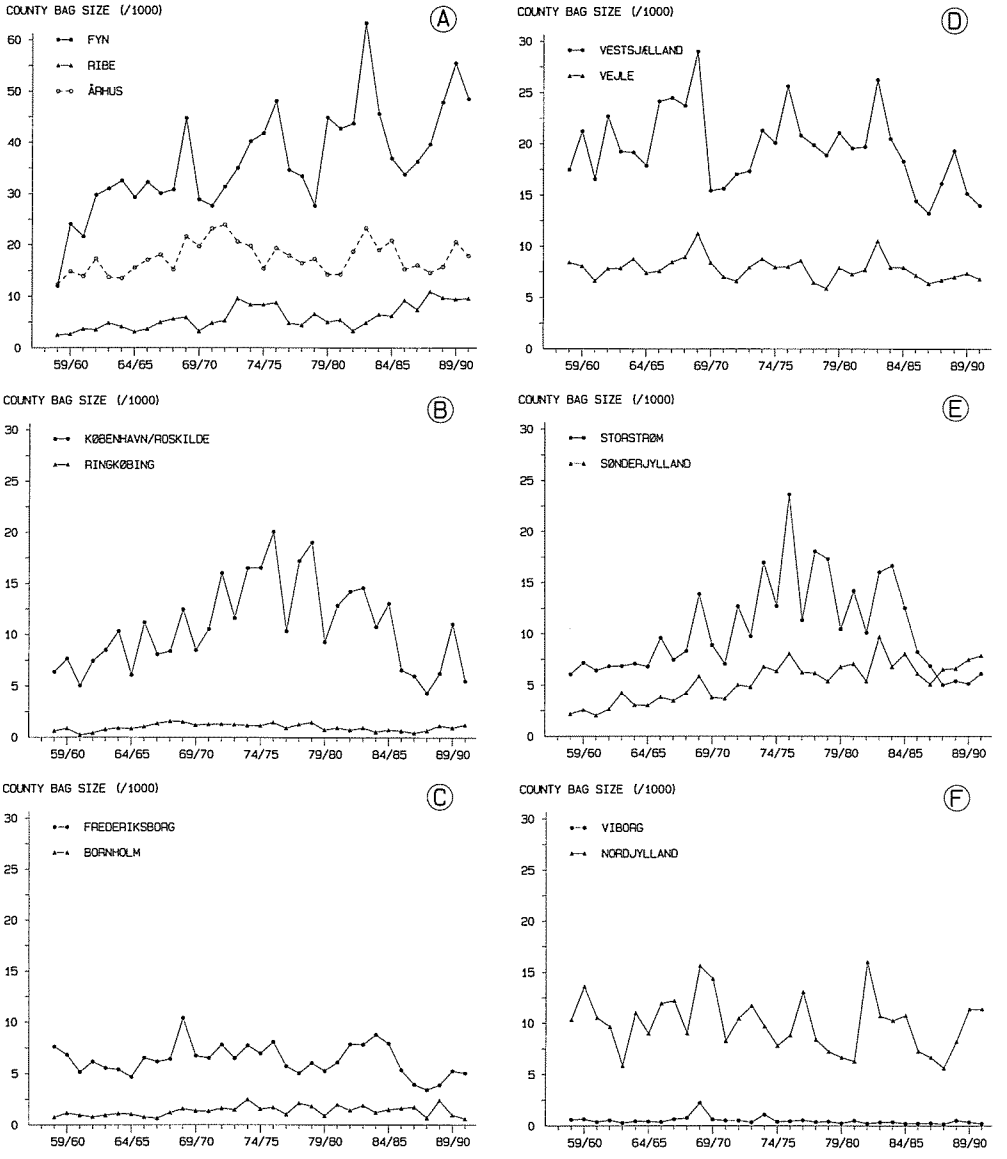

Fig. 4. The total bag of Eiders in each of the 13 counties investigated (the counties of København and Roskilde were pooled).

Components represent 69.58% of the total variation between years and counties over the investigated periods.

Scores of the 33 seasons on PC 1 and PC 2 *(Fig. 5)* reveal a temporal trend towards a larger part of the total bag being taken in the southern parts of the Danish waters. Moreover, there was a marked shift in the distribution of the bag over counties from the 1960's to the 1970's.

Scores on PC 2 and PC 3 *(Fig. 6)* reveal that further changes took place after 1980, and that for the following decade the relative size of the bag in the southwestern parts has been much larger than the size in the southeastern parts.

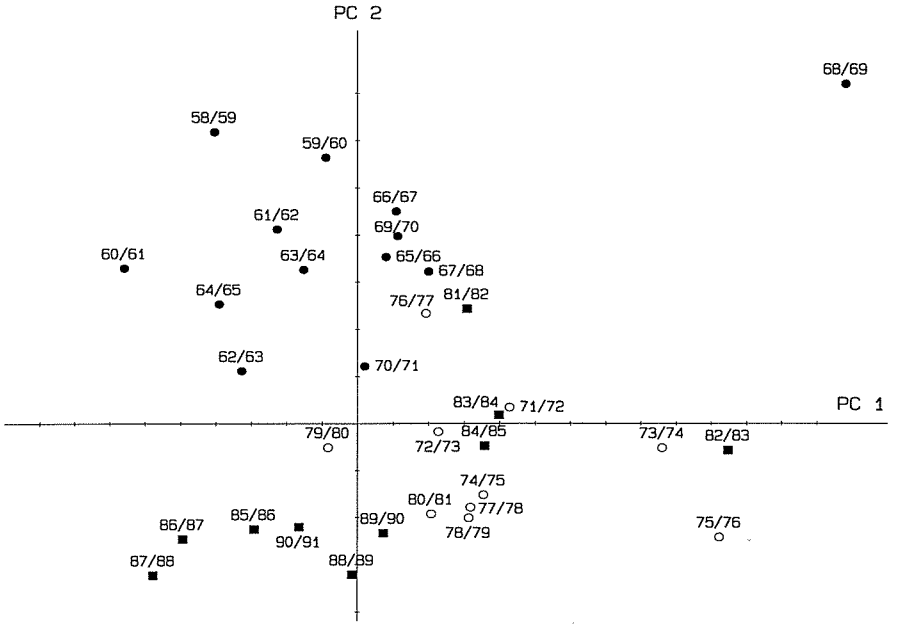

Fig. 5. The 33 investigated hunting seasons plotted according to their scores on first and second Principal Component (PC 1 and PC 2, respectively, see Table 2 for loadings). Scores for each season are calculated by multiplying (standardised) numbers shot in each county by the corresponding loading and summing the results.

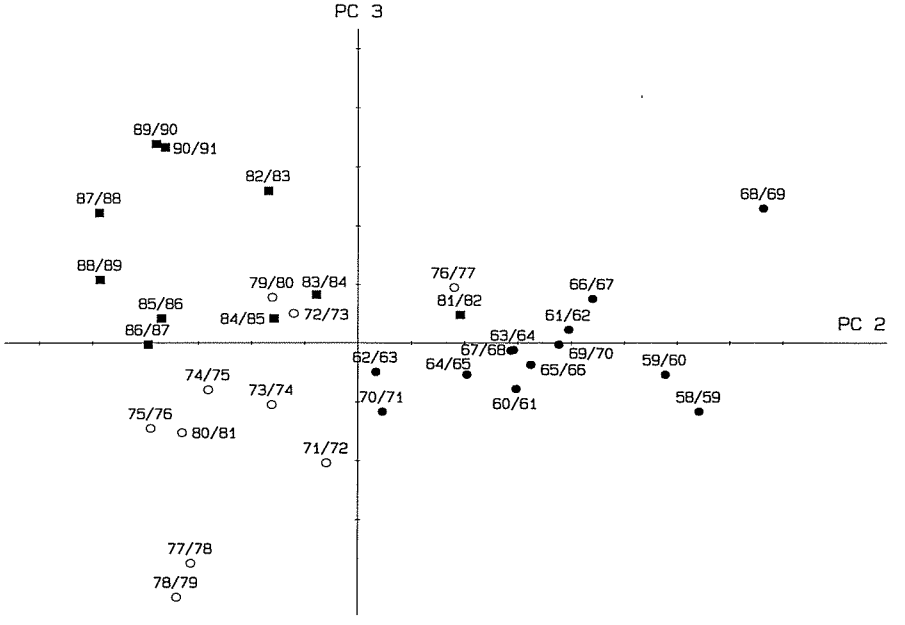

Fig. 6. The 33 investigated hunting seasons plotted according to their scores on second and third Principal Components (PC 2 and PC 3, respectively, see Table 2 for loadings).

Thus, the most important sources of variation can be summarised as

- year to year variation in bag size *(Fig. 3)*. This variation derived partly from four seasons with very high bag size (1968/69, 1973/74, 1975/76 and 1982/83) and partly from an increasing bag in the 1960's in many counties *(Fig. 4)*,
- changes in relative distribution of the bag over counties, a much larger part of the bag being taken in the southern parts of the Danish waters after 1970, and
- further changes in the distribution of the bag within the southern parts of the Danish waters, with the southwestern parts contributing a larger part of the bag after 1980.

This analysis thus confirms that bag size has developed differently in three regions. The Kattegat region had a relatively stable bag size over the 33 seasons, the southwest parts of the Danish waters (counties of Fyn, Sønderjylland and Ribe) had increasing bag sizes throughout the period, and the southeastern parts (counties of København/Roskilde and Storstrøm) had a bag size that increased until the mid 1970's and then decreased from the beginning of the 1980's *(Fig. 4)*. In Bornholm county bag size increased until the 1988/89 season, followed by two seasons of low bag sizes *(Fig. 4)*.

Seasonal variation in numbers bagged

The wing survey material

For each of the five investigated seasons, distributions of wings over months and subareas *(see Fig. 2)* were compared by means of χ^2-tests. In all cases, significant differences were found *(Table 3)*. Accordingly, it is concluded that subareas are different with respect to time of hunting, and thus cannot be pooled.

Within subareas, significant differences between the five investigated seasons existed in temporal distributions of wings. These differences reflected annual variation in weather conditions, as periods of unfavourable weather (e.g. strong winds) occurred in all years. In spite of these differences the gross annual patterns were similar within all subareas. Therefore, the five investigated seasons were pooled. For each subarea, the pooled distribution is assumed to be more representative of the general hunting pattern than any single season.

Table 3. Geographical and temporal distribution of wings from the wing surveys. χ^2-comparisons of ten count areas (Fig. 2, area 2 is omitted because of small sample sizes) for each of the five investigated seasons.

SEASON	χ^2	df	P
1985/86	587.85	36	<< 1%
1986/87	1004.20	36	<< 1%
1987/88	774.70	36	<< 1%
1988/89	1372.05	36	<< 1%
1989/90	1059.52	36	<< 1%

Age distributions of the total bag were estimated from age distributions in subareas, multiplied by estimated numbers taken. Numbers taken were estimated from the recalculation of county bag sizes described above. The splitting of county bag sizes into subareas was averaged over seasons and is given in *Table 4*.

At the west coast of Jutland, in south Kattegat and in Øresund, Smålandshavet and at Bornholm (Subareas 1, 2, 4, 5, 7, 10 and 11 in *Fig. 2)* hunting of Eiders has a more or less clear October maximum *(Fig. 7)*. In contrast, hunting of Eiders in Storebælt, Lillebælt and Sydfynske Øhav (subareas 6, 8

Table 4. The splitting of bag sizes of different counties used for the recalculation of numbers bagged in each count area.

Area	Counties included
1	Ribe
2	Ringkøbing + Viborg
3	Nordjylland + 10% of Århus
4	Vejle + 90% of Århus + 15% of Fyn
5	Frederiksborg + 50% of Vestsjælland
6	50% of Vestsjælland + 17% of Fyn
7	København + Roskilde
8	Sønderjylland + 34% of Fyn
9	34% of Fyn
10	Storstrøm
11	Bornholm

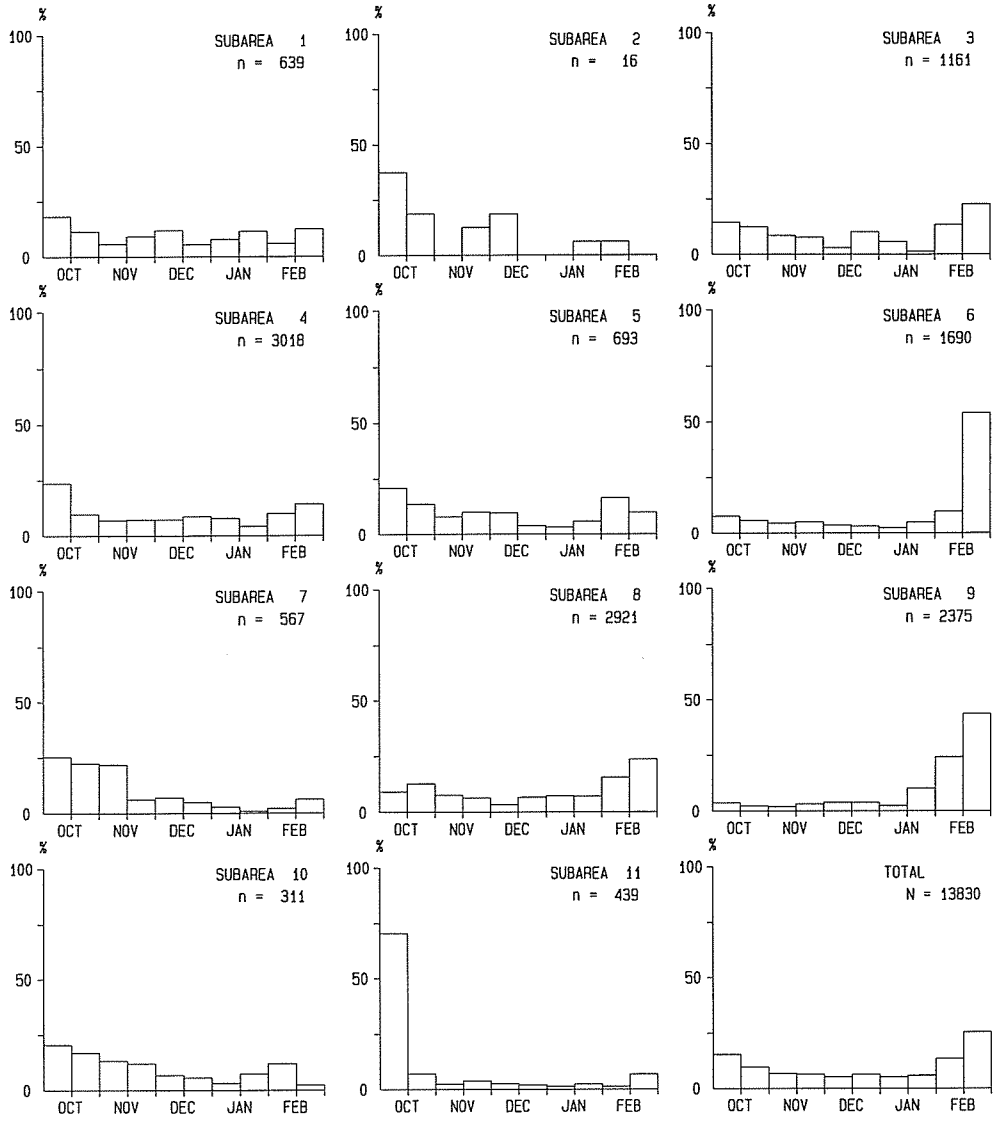

Fig. 7. Temporal distribution of wings received from each of the 11 subareas (Fig. 2) in the five seasons (pooled).

and 9) has a clear maximum in late February. In the northern part of Kattegat (Subarea 3) the temporal distribution likewise has a February maximum.

For each investigated season the estimated distribution of the total bag over the five months of the open season is given in *Table 5.* Joensen's (1978) average estimates for the seasons 1968-1976 are included for comparison. From the table it is evident that a major shift in the distribution of the bag over the season has taken place since 1970-1975.

Ringing recoveries

The February maximum in Storebælt, Lillebælt and Sydfynske Øhav (Subareas 6, 8 and 9) is also found for ringing recoveries (Noer 1991). Comparisons with older recoveries, however, revealed that this was not

Season	OCT.	NOV.	DEC.	JAN.	FEB.	TOT.
1968-76	65,000	36,000	15,000	20,000	28,000	164,000 †
1985/86	47,178	26,826	17,139	9,271	15,231	115,645
1986/87	25,075	15,761	28,751	10,729	29,818	110,134
1987/88	27,374	17,755	10,042	24,140	34,835	114,146
1988/89	45,198	17,795	9,560	11,783	49,375	133,711
1989/90	34,500	18,290	10,966	15,646	70,813	150,215
1968-76	39.5%	22.0%	9.2%	12.2%	17.1%	100.0% †
1985-89	28.7%	15.5%	12.2%	11.5%	32.1%	100.0%
Juv. %:						
1968-73	61.8%	69.2%	45.2%	30.6%	21.2%	51.8% ‡
1985-89	65.1%	69.7%	50.1%	35.1%	14.5%	44.0%

Table 5. The estimated distributions of bagged Eiders over months in the five investigated seasons. Results for the seasons 1968/69-1975/76 are given for comparison: † After Joensen (1978); ‡ After Joensen (1974a).

the case before 1970 *(Fig. 8)*. For Storebælt (Subarea 6), differences between periods were not significant ($\chi^2 = 10.84$, df = 8 , P = 21.08%), while they were for Lillebælt (Subarea 8, $\chi^2 = 26.43$, df = 8, P = 0.09%) and Sydfynske Øhav (Subarea 9, $\chi^2 = 22.97$, df = 8, P = 0.34%). The northern Kattegat (Subarea 3) could not be investigated due to sparse data. Other areas showed no such differences, and the recent distribution of ring recoveries over months are similar to that resulting from the wing surveys (Noer 1991). The shift in distributions after 1970 was rather abrupt and is consistent with the shift observed in the geographical distribution of the bag *(Fig.s 5 and 6)*.

Age and sex composition of bag

Age composition

Age composition of the bag is known to vary highly significantly between years, in accordance with the reproductive success of the preceding breeding season (Joensen 1974a and b, and 1978). This was also the case for the five seasons of wing surveys, 1986/87, 1988/89 and 1989/1990 having 9-11 juveniles per adult female in November, while 1985/86 and 1987/88 had ratios of 3-4 juveniles per adult female in November (Clausager 1991).

Since years of good and poor reproductive success tend to alternate (see discussion below) the five analysed seasons were assumed to be representative with respect to variation in reproductive success over longer periods. Accordingly, they were pooled *(Fig. 9)*. Although for all areas there is a general tendency for the juv./ad. ratio to decrease through the season, a slight increase in the percentage of juveniles from October to November was seen in most areas. Undoubtedly, this increase reflects the later arrival of juveniles from the Baltic populations (Noer 1991). Notable differences between regions are that subareas 7, 10 and 11 in general have high ratios of juveniles to adults, while subareas 1 and 9 have very low ones. The remainder of the areas are intermediate in this respect.

Overall percentage of juveniles in the bag decreased from 52% in 1968-1976 (Joensen 1978) to 44% in 1985-1990 *(Table 5)*. Percentages of juveniles in October-December, however, were similar between the two periods *(Table 5)*. Therefore, the main reason for the lower percentage of juveniles in the bag 1985-1990 is the increased percentage taken in February, when the bag contains more older birds. In particular, the February hunting in Subareas 3, 6, 8 and 9 has caused this change *(Fig.s 7 and 9)*.

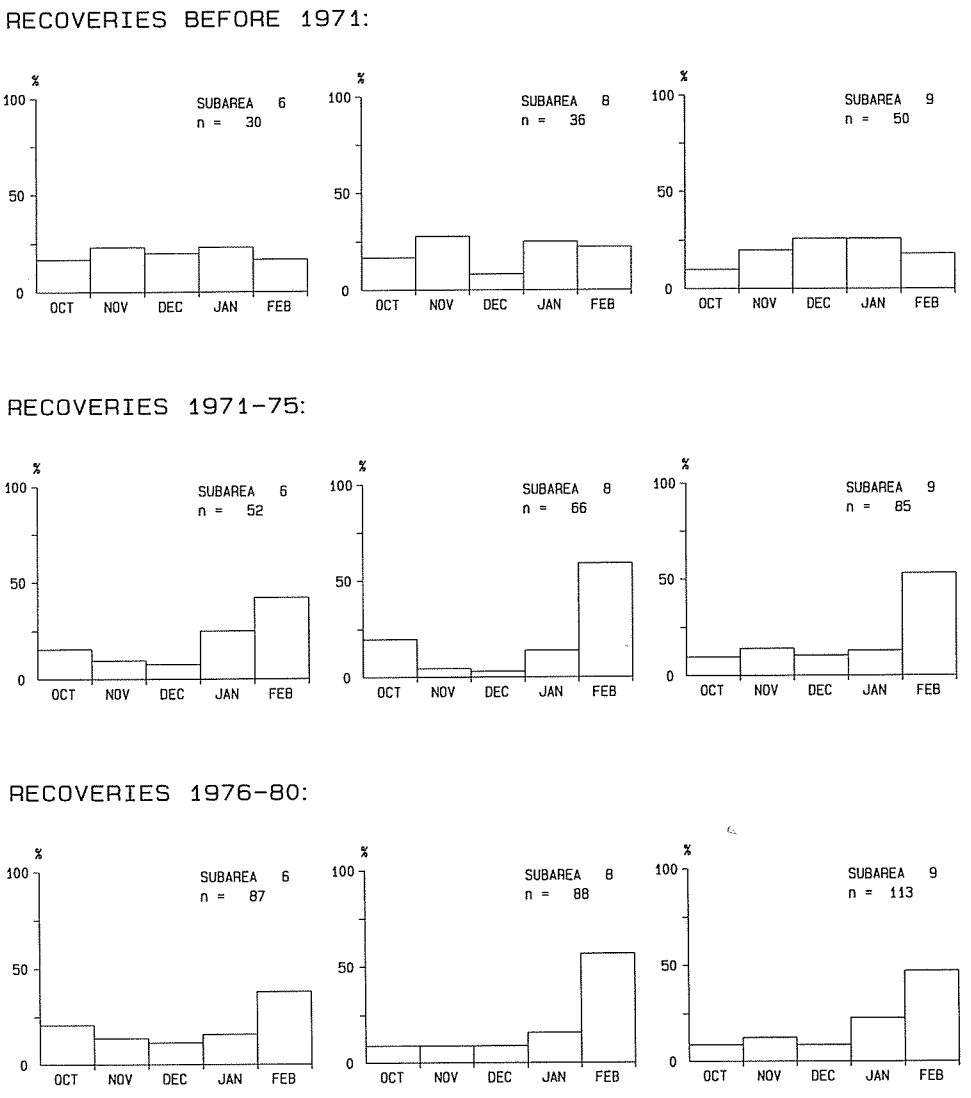

Fig. 8. The distribution over months of recoveries of Eiders shot in Storebælt, Lillebælt and Sydfynske Øhav (Subareas 6, 8 and 9 in Fig. 2), in three separate periods.

Sex composition

For each of the five investigated seasons, the overall sex composition of the bag was calculated by extrapolation from the sex composition of the wing survey material, using the same computational procedure as for the age composition *(Table 6)*. Pooling of seasons leads to an estimated 61.3% of the adult individuals in the bag being males (38.7% females), while 54.5% of the juvenile (first year) individuals were males (45.5% females). Compared to the percentage of juveniles, sex composition was relatively constant between seasons, with males contributing 58-64% (Clausager 1991, and Table 6).

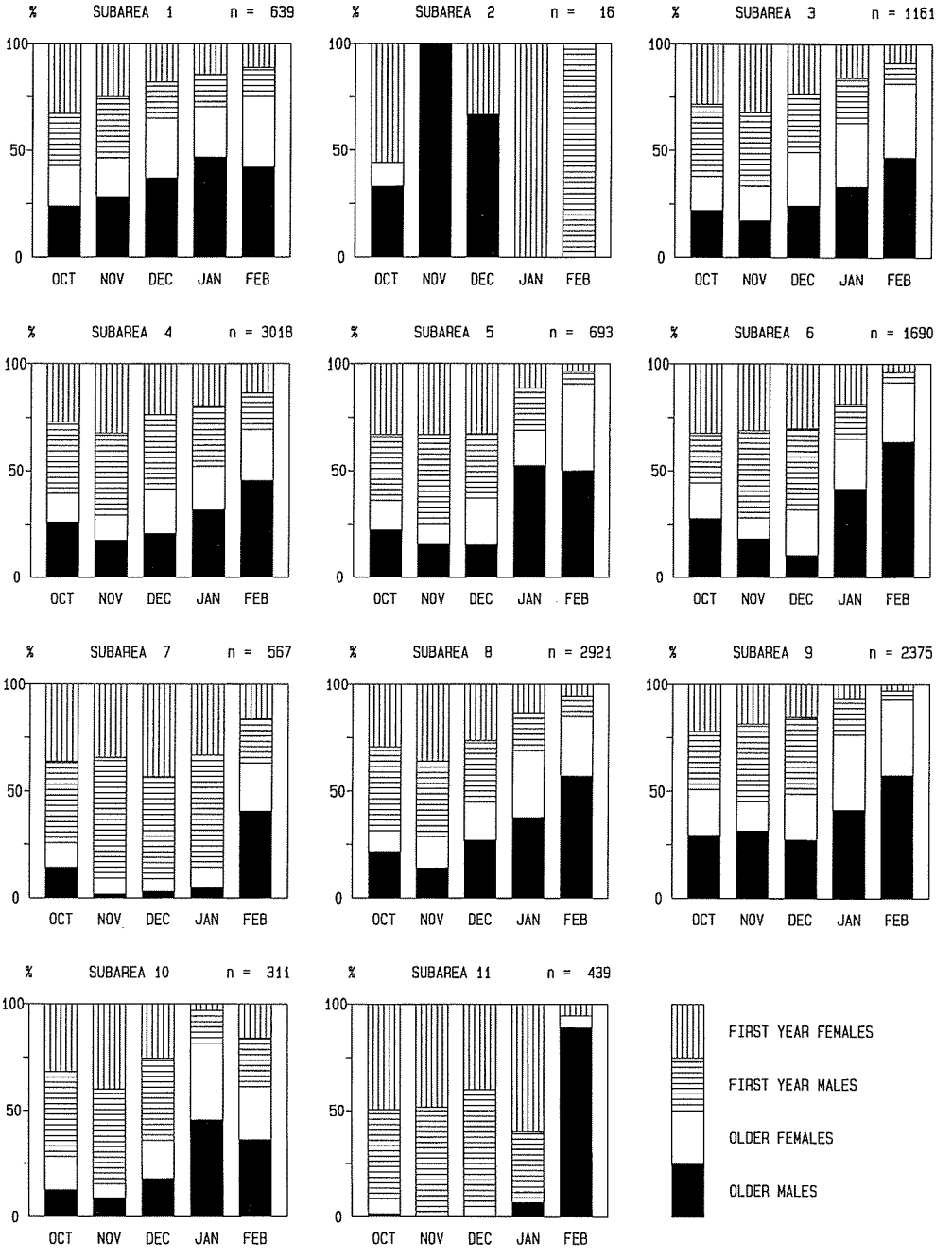

Fig. 9. Age and sex composition of wings from the wing survey over the five months of the open season for each of the 11 subareas (see Fig. 2). The five investigated seasons were pooled.

SEASON	MALES		FEMALES		TOTAL
	Juv.	ad.	Juv.	ad.	
1985/86	27,011	38,997	21,949	27,688	115,645
1986/87	34,688	26,549	29,423	19,473	110,133
1987/88	20,374	47,562	19,503	26,706	114,145
1988/89	39,419	39,277	31,508	23,506	133,710
1989/90	32,379	57,041	25,934	34,861	150,215
TOTAL	153,871	209,426	128,317	132,234	623,848
%	24.6	33.7	20.6	21.1	100.0

Table 6. The estimated sex and age composition of the bag in the five investigated seasons.

DISCUSSION

Representability of material

The estimates of overall temporal, spatial and age- and sex distributions all rest on extrapolations of the wing survey material. Lack of representativeness in this material would therefore lead to biased overall estimates. Because of the very large sample sizes involved, statistical uncertainties are minor compared to this potential source of error. For this reason, we chose not to present standard errors and confidence limits of estimates since these might be misleadingly small.

Checks of the representability of the wing survey material were done partly by means of comparisons between geographical distributions of received wings and bagged numbers of counties, and partly by comparisons between spatial and temporal patterns in respectively wings and ringing recoveries. In four of five investigated seasons, highly significant correlations (correlation coefficients between +0.87 and +0.89, $t_{11} > 5.8$, $p < 0.0005$) were found between wing numbers (summed over counties) and county bag sizes. For the 1986/87 season, numbers of wings and county bag sizes were slightly weaker correlated ($r = +0.79$, $t_{11} = 4.27$, $p < 0.001$). This close correspondence between the distributions over counties of collected wings and bagged Eiders verifies that on the geographical scale used in the estimates, the spatial patterns of collected wings are representative. With respect to temporal distributions, the distributions of wings over months correspond in a similar way to distributions of ring recovery numbers (Noer 1991).

For some subareas, wing survey sample sizes are rather small when subdivided after season, area and month (down to less than 30, cp. *Fig.s 7 and 9).* However, for areas with small sample sizes bag sizes are likewise small, and the relative contribution to total distributions is negligible. Computer runs confirmed that the composition of the total bag changed very little with changes in these areas, and the presented estimates are considered robust to random fluctuations. Simulations did also confirm that the estimates were robust to the assumptions made in subdividing the bag into subareas *(Table 4).*

Factors affecting bag size and distribution

Potentially, the size of the annual bag is influenced by 1) population size, 2) weather conditions, 3) phenology and 4) number and performance of hunters. The possible influence of these factors and their changes over the 33 investigated seasons will be discussed in the following.

Population size

Two aspects of population size are expected to influence bag size. First, long-term trends may cause trends in overall bag size, and second, annual fluctuations in reproductive

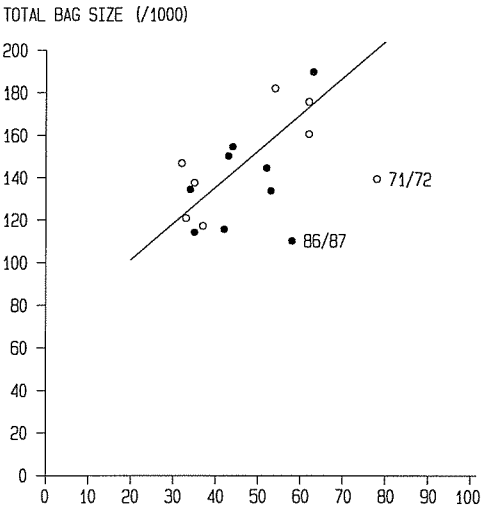

Fig. 10. Regression of annual total bag size on percent juveniles in bag in the seasons 1968/69 to 1975/76 (open circles) and 1982/83 to 1990/91 (filled circles). The regression line shown results from exclusion of the two 'outlier' seasons 1971/72 and 1986/87 (y = 1.7147x + 66,821, r = 0.77, t13 = 4.30, p < 0.01). See text for a discussion of the exclusion of these seasons.

success may lead to considerable variation in number of young Eiders alive by 1 October, which in turn influence hunting success.

With respect to the first of these aspects, the growth in the Danish bag size since 1960 is undoubtedly explained - at least to some degree - by the general population growth described above. This will be commented more fully below.

With respect to the second aspect, annual reproductive success in Eiders is highly fluctuating (e.g. Mendenhall and Milne 1985, Swennen 1989). This is reflected in the annual percentage of juveniles in the Danish bag (Fig. 3), and since juveniles are more easily shot than adults, variation in reproductive success explains much of the year to year variation in bag size *(Fig. 10)*. The correlation between total annual bag size and per cent first year individuals is not significant ($r = 0.47$, $t_{15} = 2.05$, $0.10 > p > 0.05$). However, exclusion of the two 'outlier' seasons 1971/72 and 1986/87 (for reasons given below) yields a highly significant correlation for the remaining 15 seasons ($r = 0.77$, $t_{13} = 4.30$, $p < 0.0005$). Thus, up to 60% ($r^2 = 0.59$) of the variation between 'normal' years in bag size can be explained in terms of fluctuations in per cent juveniles.

Four of the investigated seasons had particularly high bag sizes (Fig. 3). However, this was not reflected in all counties. Generally, the southernmost counties (Vestsjælland, Storstrøm, Fyn, Sønderjylland and Vejle) had large bag sizes in these seasons, while this tendency was much less pronounced in the counties of the southern Kattegat region (København/Roskilde, Frederiksborg and Århus), and no such tendency was found for the northern and western counties (Ribe, Ringkøbing, Viborg and Nordjylland) (Fig. 4). As the Eiders occurring in counties showing well-defined maxima in peak seasons are almost exclusively from the Baltic population (Noer 1991), the four seasons with a very high overall bag size mainly reflect seasons with high reproductive success in the Baltic.

Weather conditions

Seaduck hunting in Denmark requires favourable weather conditions. The two most important factors are wind force and temperature. Eider hunting is difficult when wind forces are above 3-4 Beaufort (Joensen 1974a), while severe winter weather - often occurring in January and February - in most cases affects hunting opportunities negatively. In almost all severe winters since 1960, the season has been closed by government order (Fig. 3 and Appendix I). The two 'outlier' years in Fig. 10, where bag size was much lower than expected from per cent juveniles, probably resulted from adverse weather conditions in winter. Very few Eiders (less than 25% of the season's total) were bagged December 1971-February 1972 (Joensen 1974b), and this would tend to give both a low total bag and a high percentage of juveniles. For the 1986/87 season, very severe winter conditions occurred in January 1987, and the numbers of wings collected during this period was unusually low. The presented regression analysis

should therefore be considered tentative, subject to further improvement if the monthly distribution of the bag is modelled, too.

Phenology

Within counties there is a good agreement between hunting and phenology of Eiders. The regions of Øresund and Smålandsfarvandet (Subareas 7 and 10) are important staging areas in autumn, while concentrations during the winter are low (Joensen 1974b, Noer 1991). This explains the October maximum of numbers shot (Fig. 7). Moreover, the high percentage of juveniles taken in this region (Fig. 9) explains why the bag size shows a very high level of variation between years (Fig. 4 b and e). The February maximum of numbers shot in Storebælt, Lillebælt and Sydfynske Øhav (Subareas 6, 8 and 9) correspond to the relatively low numbers during the autumn and the large concentrations occurring during January and February (Noer 1991). The Baltic population generally bypass Bornholm (Subarea 11) on migration, and most of the Eiders taken in this area originate from the local colony at Ertholmene. The only area apparently having an inconsistency between known phenology and hunting is the north Kattegat, where Eiders tend to appear early in autumn and leave in early winter (Noer 1991).

Numbers and performance of hunters

Analysis of the influence of numbers and performance of hunters is complicated because Eider hunters do not necessarily take their bag in their home county. This information is included in the bag record since hunters have to detail their bag to counties. Statistics on numbers of Eider hunters in separate counties could, however, be misleading if hunters that only visited a county occasionally and bagged a few birds were included. The influence of numbers of hunters and mean numbers of Eiders bagged per hunter is therefore discussed on the basis of statistics on hunters that live in a county rather than on those taking their bag there. Therefore, the statistics given in the following are not strictly comparable to the bag statistics for counties given above.

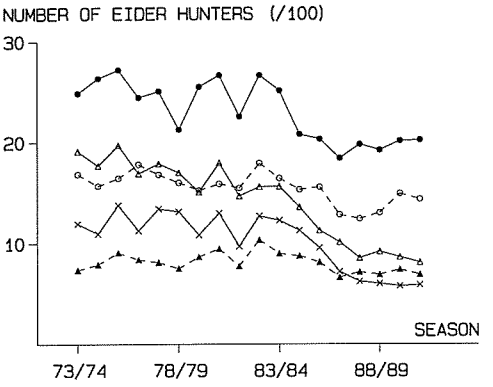

Fig. 11. Numbers of hunters reporting to have shot Eiders in the seasons 1973/74 to 1990/91 in five selected counties: København/Roskilde (open triangles, solid line), Storstrøm (x-signature, solid line), Fyn (filled circles, solid line), Sønderjylland (solid triangles, stippled line) and Århus (open circles, stippled line).

Moreover, the bag record of seasons before 1973/74 is not computerised, and information for the crucial seasons in the 1960's and 1970's when the increase in bag size took place is only available on a countrywide basis (Appendix II).

From the available data, five counties were selected for closer inspection, viz. København/Roskilde, Storstrøm, Fyn, Sønderjylland and Århus. For all five counties, numbers of hunters shooting Eiders were almost constant in the seasons 1973/74 to 1983/84 *(Fig. 11)*. After the 1983/84 season a marked decrease in numbers of hunters reporting to have shot Eiders took place over the next five years. This decrease was general (Appendix II) and could have been caused by a number of factors:

- Statistics collection procedure. Until 1983, official bag record questionnaires were sent separately to every license holder, to be completed and returned before renewal of the license. From 1983 onwards, bag record information has been prompted on payment requests, which means that payment and renewal take place also if no information is returned. Following this change, the return

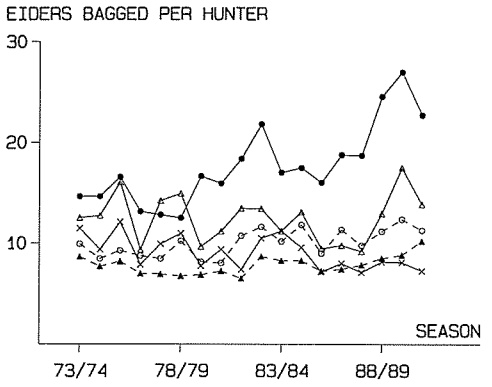

Fig. 12. Numbers of Eiders per hunter reporting to have shot Eiders in the seasons 1973/74 to 1990/91 in five selected counties: København/Roskilde (open triangles, solid line), Storstrøm (x-signature, solid line), Fyn (filled circles, solid line), Sønderjylland (solid triangles, stippled line) and Århus (open circles, stippled line).

rate of answers decreased from 95-96% to about 80%. The results presented above have been corrected for this decreased percentage, assuming that there is no overrepresentation of Eider hunters among the 20% not returning information on their bag.

- Severe winters 1984/85 to 1986/87 may have decreased the number of active Eider hunters. However, this is not likely to have affected the numbers of hunters in København/Roskilde and Storstrøm counties since most Eiders bagged in these areas are taken during the autumn (Fig. 7).
- A controversial public debate leading to prohibition of motor boat hunting in most fiords in 1987. Though undoubtly this ban has had little effect on Eider hunting opportunities, the preceding debate could have influenced reporting rates.

Numbers of Eiders bagged per hunter were relatively constant throughout the period, except for the county of Fyn which showed a marked increase *(Fig. 12)*. Hence, the increase in bag size in the county of Fyn is associated with an increase in hunting success, while the decrease in southeastern Denmark is associated with a decrease in number of hunters reporting to have shot Eiders.

Causes of changes

The documented changes in bag size and distribution could be explained either by changes in population size and/or phenology, or by changes in numbers, distribution and performance of hunters. The latter explanation, however, fits the observed changes poorly. At least during the 1970's numbers of hunters and Eiders/hunter were relatively stable (Fig.s 11 and 12, Appendix II), and though the relative number of hunters in the county of Fyn increased during the 1980's (Fig. 11), this was also the case for Århus county where no increase in Eiders/hunter was observed (Fig. 12). Hence, it is not likely that the shift in numbers bagged towards the southern parts of the country after 1970 happened because of changes in hunting patterns. The further change in bag distribution towards southwest during the 1980's may be partly explained by a decrease in Eider hunting in southeast Denmark (Fig. 11), but this can not be the full explanation since the number of Eiders/hunter in the county of Fyn increased throughout the 1980's (Fig. 12). This leaves changes in population size and/or phenology as a much more likely cause.

Hario and Selin (1987) compared the size of the Finnish Eider population with the total Danish bag size and found no correlation. This is in full accordance with the results presented in this paper, since the 30% increase in total bag between 1960 and 1990 is much less than the overall population increase. The Danish breeding population, for example, increased from 3,500 pairs by 1960 (Paludan 1962) to 7,500 by 1970 (Joensen 1973) and 18,000 by 1980 (Franzmann 1989). Hence, though the increase in total bag size is correlated with overall population increase, the present size of the bag is not determined by overall population size. This contrasts to the Eider hunting in Finland, where a strong correlation exists between numbers bagged and population size (Hario and Selin 1987).

The countrywide aerial midwinter surveys 1968-1973 gave annual totals of about

500,000 Eiders (Joensen 1974b), while total numbers were c. 800,000 in the 1987-1991 counts (Laursen et al. in print). Of the two series of counts, the 1987-1991 counts were more intensive, and larger areas were covered. The increase in numbers counted by mid-winter in Denmark is thus 60% at most, strongly suggesting that as populations have grown the percentage wintering in the inner Danish waters has decreased.

This possibility is consistent with the growing bag size in the southern parts of the Danish waters. Autumn migration of Baltic populations follow the south coast of Sweden (e.g. Alerstam et al. 1972), and birds destined for the Wadden Sea or the western parts of the Baltic are thus likely to bypass all but the southernmost parts of Denmark. Moreover, recent aerial counts have demonstrated that more than 300,000 Eiders concentrate annually during February and March in Lillebælt, Storebælt and Sydfynske Øhav (Subareas 6, 8 and 9). Thus, 160,000 Eiders were counted in Subareas 8 and 9 in January 1991, while in late February this number had increased to 400,000 (S. Pihl, pers.comm.). These birds probably come from the Wadden Sea and western Baltic, moving to Lillebælt and Sydfynske Øhav prior to the spring migration in late March (Noer 1991). The increasing numbers taken in February in these areas after 1970 are thus consistent with a larger part of the overall population wintering in other areas, and moving to Danish waters during that month.

Though this hypothesis can explain most of the observed changes in the Danish bag record, little evidence has been published so far that can support it. For the Baltic colony at Ertholmene (Subarea 11), however, Franzmann (1983) showed that a significant shift in wintering areas took place after 1970, from the inner Danish waters to the German parts of the Wadden Sea.

The Danish bag and population size

The Eiders staging and wintering in Danish waters comprise the Finnish, Swedish, Estonian, Norwegian (south coast) and Danish breeding populations (Noer 1991). The Finnish and Swedish populations were estimated to be c. 150,000 and 250,000 pairs respectively by 1990 (Koskimies 1993). Assuming c. 15,000 pairs to breed on the Norwegian south coast, c. 20,000 in Estonia and 20,000 in Denmark, the total population size at present amounts to c. 450,000 pairs. Most Eiders do not breed until three or four years old (Franzmann 1980, Noer and Hansen in print), and since adult survival is c. 90% (Coulson 1984, Noer and Hansen in print) 22-25% immature individuals (second and third year) are required to maintain a stable breeding population. Breeding success and clutch size are well documented (Franzmann 1980 and 1983, Coulson 1984, Hario and Selin 1988, Noer and Hansen in print), averaging 88% successful nests and c. 4.40 ducklings/clutch. Assuming a 50:50 sex ratio of ducklings (Swennen et al. 1979), and a c. 25% survival of ducklings until the start of the hunting season (Noer and Hansen in print) the population in the recruitment areas of the Danish waters is estimated to contain c. 220,000 first year females, c. 100,000 second and third year females, and c. 450,000 adult females - adding up to c. 770,000 females - by 1 October, at the start of the Danish hunting season.

Males are known to be more numerous than females, probably due to a higher survival (Swennen et al. 1979, Baillie and Milne 1989). No exact estimates exist, but the ratio in the Danish bag is c. 60:40 (Table 6). It is notable that the sex ratio is more skewed for adults (Table 6), which is consistent with the hypothesis that the sex ratio is explained by higher female mortality. Similar sex ratios have been observed in samples of birds collected from oil spills (Joensen 1972), counted from aerial photographs (Swennen et al. 1979), and drowned in fishing nets (Noer unpublished). Thus, it is assumed that a sex ratio of 60:40 exists in adults, leading to an estimated c. 220,000 first year males, c. 100,000 second and third

year males and c. 650,000 adults males, i.e. 970,000 males by 1 October, adding up to a total population size between 1.5 and 2.0 million birds.

These figures are crude, and undoubtedly they can be improved in the future. However, they are in reasonable agreement with present midwinter estimates for the involved populations, where aerial counts sum up to 1.3 mill. individuals (Pihl et al. in print). As aerial surveys of a seaduck species would not be expected to record the complete population, the discrepancy between the two figures does not appear unrealistic.

The 130,000-140,000 birds taken annually in Denmark presently (Fig. 3) are thus estimated to comprise 6.5-9.5% of the total population involved. Given the age distribution of the Danish bag (Tables 5 and 6), it is estimated that 10-15% of a cohort are taken during the first year, while c. 5-6% of older birds are taken annually. These figures appear consistent with the fact that the involved Eider populations have been able to grow over a prolonged period while being hunted in Denmark and that the growth rates of hunted and protected populations have shown no marked deviations (cp. Coulson 1984, Hario and Selin 1987 and Swennen 1991). The Eider thus represents an example of a bird species that has been able to multiply in spite of hunting exploitation.

Obviously, however, the growth of Eider populations must cease eventually. This will happen either through decreased reproductive success, through decreasing survival rates, or through a combination of these factors. The evaluations given above do not extend to such a scenario. For example, species having a very high annual survival rate will be highly sensitive to even small changes in this parameter, and the documented shift towards February hunting has caused a slightly increased adult mortality in the involved populations. On this background, an updated evaluation of the impact of harvesting on Eider populations will be necessary when stabilisation of the populations has been documented eventually.

DANSK RESUME

Jagtudbytte af Ederfugl *Somateria mollissima* i Danmark 1958-1990

Ederfuglen er en af Danmarks vigtigste vildtarter. Jagtsæsonen strækker sig fra 1. oktober til 28. (29.) februar, og det gennemsnitlige årlige udbytte er 130.000-140.000 individer. Udbyttets geografiske og tidsmæssige fordeling i perioden 1968 til 1973 blev analyseret af Joensen (1974a og b, samt 1978), der ligeledes behandlede udbyttets køns- og alderssammensætning.

Siden da har de skandinaviske ederfuglebestande mere end fordoblet deres størrelse, og det årlige udbytte er vokset. Formålet med denne artikel er derfor at analysere geografisk og tidsmæssig fordeling samt køns- og aldersfordeling af udbyttet. Data fra vildtudbyttestatistikken (jagtsæsonerne 1958/59 - 1990/91), DMU's vingeindsamlinger (jagtsæsonerne 1985/86 - 1989/1990) og genmeldinger af ringmærkede fugle blev inddraget i disse analyser.

Udbyttet af ederfugle voksede indtil midten af 1970'erne, med en efterfølgende stabilisering (Fig. 3). Denne fremgang viser sig at være resultatet af en meget forskellig udvikling i udbyttet i de enkelte amter (Fig. 4). Tre amter (Ribe, Sønderjylland og Fyn) tegner sig for hele stigningen. Tre andre amter (Storstrøms, København og Roskilde, - de to sidstnævnte er behandlet under eet) havde stigende udbytte i 1960'erne og 1970'erne, men aftagende udbytte efter 1980. De øvrige amter har haft et næsten konstant udbytte gennem de 33 undersøgte jagtsæsoner. Den geografiske fordeling af udbyttet har altså forskudt sig væsentligt gennem den undersøgte periode.

En nærmere analyse af variationen i udbyttet mellem år og amter blev gennemført v.hj.a. en såkaldt Principal Components Analysis (Tabel 2). Resultaterne viste, at den vigtigste komponent er år til år variation i udbyttets størrelse, - fælles for hele landet. Denne variation fremkommer dels gennem en meget variabel ynglesucces (Fig. 10), dels gennem variation i vejret, hvor først og fremmest vindforholdene i den enkelte jagtsæson er afgørende. Den næstvigtigste komponent viste sig at være en forskydning i den geografiske fordeling af udbyttet, således at den sydlige del af landet har haft et relativt større udbytte efter 1970. Den tredje komponent afspejler en yderligere geografisk forskydning efter 1980, hvor udbyttet i Fyns, Sønderjyllands og Ribe amter er fortsat med at vokse, mens det er gået tilbage i København/Roskilde og Storstrøms amter. De tre vigtigste komponenter i variationen er derfor netop de ovenfor fremhævede, og tilsammen kan de beskrive ca. 68% af variationen i udbyttet. Resultaterne af analysen viste samtidig, at der tilsyneladende skete en ret hurtig forskydning af udbyttets geografiske fordeling i begyndelsen af 1970'erne (Fig. 5).

DMU's vingeindsamlinger viste, at der er forskel mellem de enkelte landsdele i de tidspunkter hvor jagten kulminerer. I Storebælt, Lillebælt og Sydfynske Øhav er der sket en forskydning, så de fleste ederfugle i dag nedlægges i februar, mens resten af landet har en uændret fordeling af udbyttet over jagtsæsonens fem måneder, med flest nedlagt i oktober (Fig. 7). Denne forskel afspejler sig også i fordelingen af genmeldte fugle (Fig. 8). Forskydningen får samtidig konsekvenser for udbyttets alderssammensætning, fordi der i februar nedlægges en større procentdel kønsmodne fugle. I oktober og november skydes flest ungfugle, hvorefter ungfugleprocenten i udbyttet falder til ca. 15 i februar (Tabel 5 og Fig. 9). En ændring af jagten fra oktober til februar vil altså betyde at andelen af gamle fugle i udbyttet øges (Tabel 5). I en sæson med gennemsnitligt udbytte (ca. 140.000) vil dette betyde, at der i dag nedlægges ca. 10.000 flere gamle fugle end tidligere.

Disse ændringer diskuteres i forhold til de kendte bestandsændringer. Over 30 år er udbyttet steget med ca. 35%, mens bestandene i mellemtiden er mere end fordoblet i størrelse. I denne sammenligning skal det også inddrages, at antallet af jægere der ned-

lagde ederfugle har været ret konstant i perioden 1968-1985. Udbyttet viser altså ingen simpel sammenhæng med bestandstørrelsen, men har snarest udgjort en aftagende procentdel af bestanden. Der er heller ingen simpel sammenhæng mellem forskydningen mod flest nedlagt i februar og udbyttets vækst. Af de amter, der viser den samme procentuelle stigning i udbyttet er det kun Fyns Amt der viser en ændring mod jagt i februar.

I de enkelte amter er der derimod en god overensstemmelse mellem artens forekomst og jagttidspunkterne. Netop i Storebælt, Lillebælt og Sydfynske Øhav koncentreres store mængder af ederfugle i februar, formodentlig p.gr.a. tiltræk fra Vadehavet og Kielerbugten. F.eks. viste DMU's tællinger fra fly 160.000 ederfugle i Lillebælt i januar 1991. I februar var dette tal steget til 400.000. Det store udbytte i farvandene omkring Fyn i februar skal givetvis ses på baggrund af disse forekomster.

Det markante fald efter 1983 i antallet af jægere, der oplyser at de har nedlagt Ederfugle, kan delvist forklare den fundne forskydning i fordelingen af udbyttet gennem 1980'erne. Men derudover kan der ikke dokumenteres nogen langtidsændringer, hverken i antallet af ederfuglejægere eller i størrelsen af udbyttet pr. jæger, der på overbevisende måde kan forklare disse resultater. I stedet må det formodes, at de fundne ændringer i udbyttets geografiske og tidsmæssige fordeling afspejler ændringer i artens trækmønstre.

Sammenligninger af landsdækkende flytællinger i perioderne 1968-1973 og 1987-1991 viser, at der i den førstnævnte periode blev talt ca. 500.000 fugle i de danske farvande i januar, mens der i den sidstnævnte blev talt op til 800.000. Ved midvintertællingerne er antallet af fugle altså steget noget mindre end den samlede bestandsstørrelse, hvilket tyder på at efterhånden som bestanden er vokset har en aftagende andel overvintret i danske farvande. At 300.000-400.000 fugle sidst på vinteren dukker op i de sydlige farvande kan også forklares på denne måde.

De seneste vurderinger af bestandsstørrelsen (omkring 1990) i de områder, hvis ederfuglebestande enten passerer de danske farvande på trækket eller direkte overvintrer her (den norske Skagerrakkyst, hele de svenske, finske og estiske bestande, og den danske ynglebestand), er på ca. 450.000 ynglepar. Ud fra kendskab til artens ynglesuccess er det beregnet, at dette svarer til en total bestandsstørrelse på 1.5-2.0 millioner individer pr. 1. oktober. Denne bestand vil i gennemsnit bestå af c. 440.000 førsteårs fugle, ca. 200.000 andet- og tredjeårs fugle, ca. 450.000 voksne hunner og ca. 650.000 hanner. På dette grundlag vurderes det, at der i Danmark afskydes 6.5-9.5% af bestanden årligt, og at dette udbytte består af ca. 10-15% af førsteårsfuglene og 5-6% af de ældre fugle. Denne udnyttelsesrate er formodentlig forklaringen på, at væksten i jagede ederfuglebestande (Sverige, Finland, Estland og Danmark) ikke har adskilt sig fra væksten i fredede bestande (England, Holland, Tyskland, og Norge). Ederfuglen er således et eksempel på en fugleart, der har kunnet opformere sig selv om den er blevet jagtligt udnyttet.

Det må midlertid ikke overses, at væksten i ederfuglebestandene vil ophøre før eller senere. Dette vil ske enten gennem en reduceret ynglesuccess, eller gennem en reduceret overlevelse, eller gennem en kombination af disse faktorer. De vurderinger, der er givet i det foregående, kan ikke uden videre udstrækkes til en sådan situation, og det vil derfor være nødvendigt at vurdere betydningen af den danske ederfuglejagt påny, når bestandsvæksten er ophørt. Arter med så høj en årlig voksenoverlevelse som ederfuglen - op mod 90% - er meget følsomme overfor selv ganske små ændringer i antallet af skudte voksne fugle, og forskydningen af udbyttet hen imod større antal taget i februar har lagt et voksende jagttryk på netop disse aldersklasser. Ikke mindst dette aspekt af ederfuglejagten i Danmark bør derfor følges i de kommende år, med henblik på en løbende sikring af, at bestanden fortsat påvirkes minimalt.

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APPENDICES

APPENDIX I. Seasons closed due to severe winter weather.

Season	Closing
1962/63	12 January to 28 February. All waterfowl species countrywide, excepting the county of Bornholm.
1965/66	12 February to 28 February. All waterfowl species countrywide in areas within 500 m of coasts.
1969/70	5 February to 28 February. All waterfowl species countrywide, excepting the county of Bornholm.
1977/78	22 February to 28 February. All waterfowl species countrywide.
1978/79	12 January to 28 February. All waterfowl species countrywide.
1981/82	25 December to 28 February. All waterfowl species countrywide, except the Eider and other seaduck species.
1984/85	13 January to 28 February. All waterfowl species countrywide, except the Eider and other seaduck species.
1985/86	19 February to 28 February. All waterfowl species countrywide, except the Eider and other seaduck species.
1986/87	12 January to 28 February. All waterfowl species countrywide, except the Eider and other seaduck species.

APPENDIX II. Total (countrywide) numbers of hunters reporting to have shot Eiders in the seasons 1968/69 to 1973/74. Three later seasons are included for comparison.

Season	Eider hunters	Eiders	Eiders/hunter
1968/69	14,253	175,761	12.33
1969/70	11,848	120,810	10.13
1970/71	11,883	117,167	9.85
1971/72	11,747	139,390	11.87
1972/73	11,620	137,621	11.84
1973/74	13,784	160,609	11.46
1978/79	12,783	134,714	10.54
1983/84	13,367	154,678	11.57
1988/89	9,753	133,711	13.71

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