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Status of the Baltic/Wadden Sea population of the Common Eider *Somateria m. mollissima*

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A dramatic decline in the number of wintering Common Eiders from c. 800,000 to c. 370,000 occurred in Danish waters between 1990 and 2000. Denmark represents the second most important wintering area for Eiders from the Baltic/Wadden Sea flyway, and mid-winter counts suggest the total population could have fallen from c.1.2 million individuals in 1991 to c. 760,000 in 2000, implying major (c.36%) overall declines. However, although declines of similar magnitude have been detected in breeding numbers at some sites (eg Saltholm in Denmark), such a dramatic reduction is not generally evident amongst breeding numbers monitored throughout the flyway. Five hypotheses are offered to explain this discrepancy, two of which are considered likely to contribute to the differences. These relate to shortcomings in our ability to monitor adequately breeding and wintering numbers in both time and space, as well as to an unknown buffering effect of non-breeders (which are counted on the winter quarters, but which do not appear amongst assessments of breeding abundance). Parameters known to contribute to declines in population size include low duckling survival caused by viral infections, mass adult mortality due to Avian Cholera, and reduced adult annual survival rates due to mass mortality events on the wintering grounds. The population continues to be a quarry species in Denmark, Sweden, Norway and Finland. It is strongly recommended that the national monitoring schemes should be standardised and synchronised, in order to establish future population abundance and change. It is further recommended that population modelling is undertaken to understand the relationships between the numbers of Common Eiders in the Baltic/Wadden Sea flyway population and the different factors affecting their abundance.

Key Words: Conservation, hunting, Avian Cholera, duckling viral infection, mass-starvation, monitoring

The Baltic/Wadden Sea flyway population of Common Eider *Somateria m. mollissima* comprises breeding populations from Finland, Estonia, Sweden, Denmark, southern Norway, Germany and The Netherlands. Birds nesting in Denmark, Germany, western Sweden and The Netherlands are resident or partly migratory whereas those in southern Norway, eastern Sweden, Finland and the Baltic countries are completely migratory (Cramp & Simmons 1977). Eiders of eastern provenance mix on the wintering areas in the western Baltic Sea, Kattegat, inner Danish waters, and in the Wadden Sea from Denmark to The Netherlands (Swennen 1990; Noer 1991; Fransson & Petterson 2001). The Common Eider has been widespread and common throughout its range in the Baltic and Wadden Sea countries for most of the 20th Century (Cramp & Simmons 1977). Numbers have fluctuated throughout the 20th Century, but increased continuously between the late 1940s and the 1990s (Almkvist *et al*. 1974; Hario & Selin 1988; Camphuysen 1996).

The Baltic/Wadden Sea flyway population was estimated to comprise 1.35-1.70 million birds in 1991 (based on extrapolation from midwinter counts), and was considered to be stable at that time (Rose & Scott 1997). However, since the late 1980s, reports have documented marked declines in specific breeding populations within the Baltic/Wadden Sea flyway (Hario & Selin 2002; Hollmén 2002; Christensen & Noer 2001). To obtain better information about the Baltic/Wadden Sea Eider population, the Seaduck Specialist Group of Wetlands International arranged a workshop in Estonia during 17-21 April 2002 to compile information on the status and distribution of Eiders from all range states along the flyway. This paper (a) summarises the outcome of the workshop, (b) reviews the present status and most recent changes in the Baltic/Wadden Sea Common Eider flyway population based on data on breeding, migrating, moulting and wintering numbers in the range states, and (c) briefly summarises the causes of mortality reported in recent years.

Methods

Different methods have been used to count Eiders at different stages in the annual cycle, and the sources of data considered in the paper are presented and assessed below.

Denmark

In Denmark, breeding pairs have been surveyed at least once every decade since the 1960s (Paludan 1962; Joensen 1973; Franzmann 1989; Lyngs 2000; Lyngs in prep.). Generally, most breeding sites were visited once during early May, and the numbers of nests/nesting females were counted. In some areas, colony size was estimated from the numbers of males present around breeding islands during the pre-breeding period. No long-term systematic counts of migrating birds at specific Eider locations have taken place in Denmark, but aerial surveys of moulting Eiders in Danish waters took place in August 1987, 1988 and 1989. These covered coastal waters and offshore shoals/reefs to 10m depth (Laursen *et al*. 1997). Since the 1970s, seven extensive aerial surveys have been conducted to estimate the total mid-winter population (Joensen 1974; Laursen *et al.* 1997; Pihl *et al.* 1992, Pihl *et al.* 2001). Each survey was conducted between January 5 and March 11, covering all Danish coastal waters and Kattegat with water shallower than 10 m (Joensen 1974; Laursen *et al*. 1997; Pihl *et al.* 1992; Pihl *et al.* 2001). In the latest national survey (winter 1999/2000) the offshore part of Kattegat was covered by transect surveys. Only birds observed on transect lines were included from these flights, since the methods for density estimation are still in development. See Laursen *et al*. (1997) and Pihl *et al.* (2001) for more detailed descriptions and comparisons of the aerial survey methods. In 1996 and 2001, outbreaks of Avian Cholera epidemics caused mass mortality amongst breeding females at several breeding colonies (Christensen *et al.* 1997, NERI unpublished data). Eiders are hunted in Danish waters from 1 October to 28 February. The number of Eiders shot by hunters has been monitored by the Danish Bag Record Scheme since 1958 (Strandgaard & Asferg 1980; Asferg 2001), while sex/age composition of the bag has been recorded through the Danish wing survey since 1982 (Clausager 2002 and references herein). Based on these data, specific analyses of factors affecting the Danish Eider bag have been undertaken (Noer *et al.* 1995, Christensen *et al*. in prep.). A detailed population study of breeding Eiders on the island of Saltholm (55°39'N, 12°46'E) was carried out during 1993-2000 (Noer *et al.* 1993; Christensen & Noer 2001). Based on parameters collected at Saltholm and other Danish colonies, a demographic model using Leslie matrices was developed to compare the observed changes in population size on Saltholm with that predicted based upon selected breeding parameters (Christensen & Noer 2001).

The Netherlands

Common Eiders first nested in The Netherlands in 1906. Early breeding population censuses were estimates based on incidental sightings of breeding females. Until the early 1940s, Common Eiders only nested on Vlieland (53°15'N, 04°55'E), after initial breeding attempts on Terschelling in 1906. With most breeding Common Eiders in nature reserves, estimates of breeding numbers in the 1940s, 1950s and 1960s were usually from reserve wardens, often without indications of census methods. In the late 1950s, when the breeding population had increased to several thousands of breeding pairs, the 'differentiated count' became established, notably on Vlieland (Hoogerheide 1950; Swennen 1976). The differentiated count involved a census of Common Eiders roosting near the colony, after adult females had gone ashore to incubate eggs. Differentiating between adult males (Am), immature males (Im) and birds in female plumage (F; adults and immatures combined), and assuming a 1:1 sex ratio, the breeding stock (B in pairs) was estimated as:

$$B = Am - (F - Im)$$

This method was developed to avoid disturbance in colonies, but it was deemed inadequate for large colonies (Hoogerheide & Hooogeheide 1958). The differentiated method was employed on Vlieland between 1962 and 1988 and occasionally on Schiermonnikoog (53°30'N, 06°10'E). Reserve wardens monitored all other colonies, who produced annual estimates, usually based on restricted nest searches and extrapolations. In the late 1980s and early 1990s, the monitoring programme on Vlieland was discontinued. On some small, easily covered islands, complete nest counts were conducted (Oosterhuis & van Dijk 2002). Since 1991, breeding Eider numbers have been monitored annually by counting nesting females in selected sampling areas in the Wadden Sea area, covering c. 20% of the Dutch breeding population (Dijksen & Klemann 1992). However, the methods employed probably preclude reliable population trend analyses. On the Dutch North Sea coast, observers make systematic observations of migrating seabirds. The numbers counted along the North Sea coast reflect wintering numbers in the North Sea, but cannot be used to estimate the total number wintering in The Netherlands. The first Wadden Sea aerial survey took place during severe winters in 1956 and 1963 and covered ice-free areas in the western Wadden Sea (Over & Mörzer Bruijns 1956; Verwey 1956; Zweeres 1963). Subsequent surveys made by Swennen and co-workers between 1966 and 1991 concentrated on traditional Common Eider wintering grounds in the Wadden Sea (Swennen 1976, 1991). Since 1993, a systematic aerial survey of Eiders in Dutch coastal waters has been undertaken, covering the Wadden Sea and the North Sea coastal zone during midwinter (Koffijberg *et al.* 2001). In 2000, 2001 and 2002 three aerial surveys per winter were conducted, attempting complete coverage by flying along transects at high tide.

Beached bird surveys have been carried out along the entire Dutch coast, in 19 sub-areas, on a systematic basis since 1977 (Camphuysen *et al.* 2002), with a small number of less systematic surveys before this. Census areas are searched monthly for all dead birds. Based on numbers found per one kilometre coastline searched, the total numbers of beached birds in The Netherlands have been estimated (Camphuysen *et al.* 2002). A number of detailed studies of Eider population size and structure, dispersion, wintering numbers, foraging, reproductive success, adult and juvenile mortality, diseases, and physiology have been undertaken (Everaarts *et al.* 1983; Hoogerheide 1950; Hoogerheide & Hoogerheide 1958; Swennen 1976, 1983, 1990; Swennen & Smit 1991).

Germany

The numbers of breeding Common Eider throughout Germany were estimated for the period 1982-1999 by various methods, depending on size and accessibility of the areas involved (Hälterlein *et al.* 1995; Wilkens 1999). The breeding data allows discrimination between the northern and western parts of the German Wadden Sea. For several smaller areas longer time series are available, but they do not enable the compilation of a national estimate or trend (Behm-Berkelmann & Heckenroth 1991; Berndt *et al.* 1993). Eider migration has not been studied systematically in Germany, but the moulting concentrations during the post-breeding period (July/August) in the German part of the Wadden Sea have been monitored by aerial survey at low tide (when Eiders concentrate in large flocks along tidal gullies) since 1987. Surveys of wintering Eiders have also been conducted annually since 1987 in the German Wadden Sea. In the Baltic, some aerial counts, combined with ground based counts, have taken place in most years (Nehls & Struwe-Juhl 1998). Estimates of the numbers of dead Eiders along a selection of German North Sea beaches can be made for the period 1992/93 to 2001/02 (Fleet 2001; Fleet & Reineking 2000, 2001). Since 1992/93, beaches have been surveyed between October 1 and March 31, with the same search effort and using the same methods, and can be used for the calculation of the number of dead birds found per kilometre.

Sweden

The total Swedish breeding population was estimated in 1973 (Almkvist *et al.* 1974), and 1983-1984 (Andersson 1985; Svensson *et al.* 1999). Aerial post-breeding censuses were carried out when males aggregate at traditional areas, prior to southward moult migration. The sex ratio was estimated during spring migration and on the breeding grounds, and was used to transform these male counts into breeding numbers. No national estimates of Eider breeding numbers exist for the last 18 years. Regionally, trends in breeding numbers have been monitored at several sites along Swedish coasts. Boat based surveys of pre-breeding males have been carried out in the Stockholm archipelago (59°30'N, 19°00'E) in late April since 1985, when pairs are close to their breeding island. Each year, several groups of islands in the northern and the southern parts of the outer Stockholm archipelago have been surveyed (Skärgårdsstiftelsen 2002). In the Bullerö archipelago (59°10'N, 18°52'E), systematic nest counts have been made six times since 1971. In the Lygne archipelago (59°32'N, 19°28'E), Eider nests have been counted regularly by a private landowner and his heirs continuously since 1910. In the Baltic Småland archipelago (57°45'N, 16°40'E) the breeding numbers of Common Eiders were surveyed between 1990 and 2000 (Johansson & Larsson 2001). On Lilla Karlsö (57°19'N, 18°04'E) and Stora Karlsö (57°17'N, 17°58'E), Gotland, numbers of breeding pairs have been counted since 1990. In southern Sweden, land based counts of Eiders have been carried out annually in mid-

September since 1976. At Kåseberga (55°25'N, 14°05'E) in southern Sweden, spring migration counts of Eiders have been made annually between 1992 and 2000. Assuming the percentage of the Baltic-breeding Eiders which pass Kåseberga in spring each year is constant, these counts provide a representative measure of the annual total numbers. Volunteers in Sweden have conducted countrywide land-based winter surveys since 1991 covering the southern part of both the east coast and west coast. In the Stockholm archipelago an experimental study of the effect of the non-native American Mink *Mustela vison* on the Eider population has been carried out between 1995-2001 at Bullerö-Långviksskär. Counts of males, nests and habitat preferences on Mink-inhabited and on Mink-free control islands have been carried out annually.

Finland

The size and extent of the Finnish archipelago makes complete breeding censuses impossible. Eider populations are monitored in sample areas within the framework of the national Archipelago Birds Censuses. These comprise six core areas where regular counts have been conducted for more than 50 years. Since 1984, an additional 27 areas (comprising 1550 islands) have also been counted. From these counts, indices are produced to describe the population trends (Koskimies & Väisänen 1991). The Hanko bird station (59°50'N, 23°00'E) at the southernmost tip of the mainland has generated long-term count data of migrating Eiders (from 1979 onwards), which are currently the subject of analysis. During 1968-92, systematic winter counts have been conducted on four open-sea routes in the Åland Sea (Hario *et al.* 1993). Detailed studies of breeding Eiders have been carried out in the Söderskär bird sanctuary (60°07'N, 25°25'E) in the Gulf of Finland since the 1950s. Data on breeding numbers, clutch size, timing of breeding, hatching success, female body weight and adult and duckling survival have been collected (Hario & Selin 1988). Similar data have been collected at four other Eider nesting areas on the southern coast. Studies to develop methods for the evaluation of effects of diseases, food limitation, and contaminants have been conducted at all these locations since the mid-1990s (Hollmén 2002, Franson *et al*. 2000).

Other countries

The Norwegian Skagerrak winter population was estimated using land-based surveys in the late 1980s (Nygård *et al.* 1988) and in 2002. The breeding numbers for this region have been estimated on the basis of aerial surveys of pre-/post-breeding males. Breeding and wintering numbers are monitored annually (Lorentsen 2001; Lorentsen & Nygård 2001). Estonian breeding surveys have been conducted annually using springtime nest searches within nature reserves supporting 60-70% of the national total (Onno 1970; Renno

1993; Kuresoo *et al.* 1998). The total national breeding numbers are based upon aerial and boat surveys of males in spring performed at a few colonies outside of the nature reserves. In 1990-2002, annual winter ground counts of Estonian Eiders have been made, with an aerial winter survey covering the whole coast in 1993. In Latvia sporadic observations in possible breeding areas have been made. The Latvian coast is counted every winter, and observations of migrating sea birds are made annually during spring and autumn. For Poland, wintering numbers used in this paper are those submitted to the Seaduck Specialist Group Database.

Statistical analysis

Statistical analyses were carried out using SAS for Windows. Spearman Rank Correlation Coefficients were calculated. Trends in the Finnish and Norwegian breeding populations and Norwegian wintering populations are analysed using TRIM software (Trends and Indices for Monitoring data), with stepwise models being used to identify significant changes in index trends (Pannekoek & van Strien 2001; Hario & Rintala 2002; Lorentsen 2001; Lorentsen & Nygård 2001).

Results

Denmark

The Danish breeding population of Common Eiders increased from c. 1,200 pairs in 1935 (Spärck 1936) to a maximum of c.25,000 pairs in 1990 (Lyngs 2000). In 2000, the population comprised c.24,000 breeding pairs (**Figure 1**, Lyngs in prep.). The similarity in numbers of breeding Eiders in 1990 and 2000 does not reflect a stable situation between or within colonies. During this period, a few old, large colonies have experienced marked decreases, while increases have occurred in a number of small and newly established colonies (Lyngs in prep.). Danish breeding Eiders are resident or partly migratory (Lyngs & Christensen, in prep). Females are highly philopatric as documented by ringing data (Lyngs & Christensen, in prep.) and a DNA-study (Tiedemann & Noer 1998), but males show high natal dispersal. Marked declines in numbers of breeding Eiders have been recorded at several Danish colonies during the 1990s. The most obvious declines were related to outbreaks of Avian Cholera in 1996 and most recently in 2001. Avian Cholera, caused by the bacteria *Pasteurella multocida*, was recorded in Eiders from several colonies in south-west Kattegat (Stavns Fjord (55°54'N, 10°39'E), Hov Røn (55°54'N, 10°17'E), Svanegrund (55°50'N, 10°21'E), Alrø Polder (55°52'N, 10°07'E), Mågeøerne (55°35'N, 10°07'E), Søby Rev (55°53'N, 10°14'E)) in both 1996 and 2001, but was also recorded in one colony in eastern Denmark in 2001. The number of Eiders affected by the Avian Cholera epizootics in 1996 and 2001, was estimated to total 3,500-4,000 females and c.400 males (Christensen *et al.* 1997,

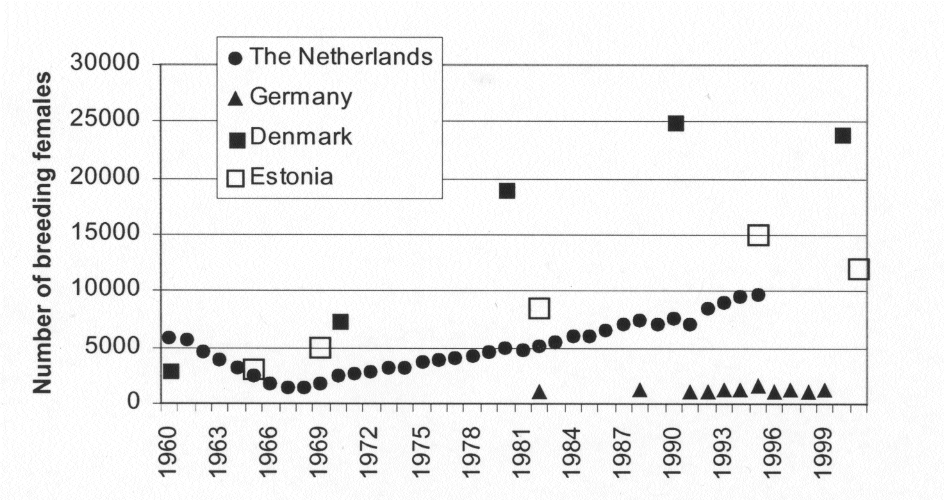

Figure 1. National annual total numbers of breeding Eider females in The Netherlands, Germany, Denmark and Estonia for 1960-2001 (see Methods section for description of data collection techniques and constraints on interpretation). Each year is identified by the January of each count, hence "1986" refers to the winter 1985/1986 etc.

NERI unpublished data). At individual colonies, the proportion of females dying ranged from 30% and 90%. On a national scale, the epizootics were estimated to have reduced the total breeding population in 1996 and 2001 by c.8-10%. In eastern Denmark, the Saltholm colony has decreased by 38% during 1993-2000 (**Figure 2**, Christensen & Noer 2001) without being affected by Avian Cholera. For this colony, modelling showed that observed changes in breeding parameters during the study period could only account for a 3% decline in breeding female numbers. Given this result, the population model was used to assess the effect of potential changes in first time breeding distribution (age at first breeding), and changes in adult survival. Multiple model runs showed that only a reduction in adult survival could result in a match between the observed and expected population decline, corresponding to a change in mean annual survival rate from 0.87 to 0.81 (Christensen & Noer 2001).

Counts of moulting Eiders in Danish waters during August in 1987-89 found total numbers between 70,000 and 135,000 individuals. The major moulting grounds were located in Kattegat, the Belts and in the Wadden Sea, and showed a similar distribution in all years (Laursen *et al.* 1997). Eiders wintering in Danish waters comprise birds from Sweden, Finland, other Baltic countries and local Danish breeders (Noer 1991). Based on aerial mid winter surveys, the number of Eiders wintering in Danish waters was estimated in 1970/71 at 300,000-500,000 (Joensen

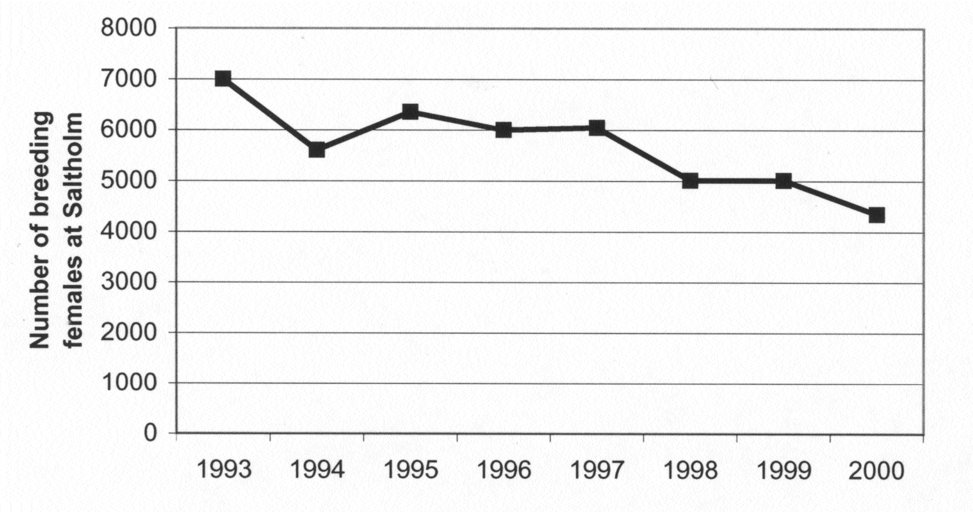

Figure 2. Annual numbers of female Eiders breeding at the Saltholm colony, in Øresund, southeast Denmark, during 1993-2000. Estimates are based on extrapolation of sampled nest-search transects carried out using identical methods each year.

1974), increasing to c.800,000 in the late 1980s and the early 1990s (Laursen *et al* 1997). In 2000, the winter population was estimated to comprise c.370,000 individuals (**Figure 3**, **Table 1**, Pihl *et al*. 2001), suggesting a dramatic decline in mid-winter numbers during the 1990s. Comparison of regional numbers shows that declines in wintering numbers have occurred most markedly in Kattegat (91%) and Great Belt (71%), while five other regions contributed a combined decrease of 30% (see Pihl *et al*. 2001). The overall decrease of c.50% between 1990 and 2000 corresponds to an annual decrease of c.5% over the last ten years.

Studies of the occurrence of intestinal acanthocephalan parasites in Eiders shot by Danish hunters during 2000-2002 found high infestation rates (80-95%), with a mean of c.170 parasites per bird (25 parasites per bird in adult males). Preliminary analyses showed no indication that body condition was affected by parasite infection in either adults or juveniles (NERI unpubl. data).

Denmark has a traditional sea duck hunt during autumn and winter. Eider numbers bagged by hunters increased during 1958-1970 from c.100,000 to c.140,000 per season. During the 1970s and 1980s, the size of the bag was relatively stable, but it has declined during the 1990s to the present level of c.80,000 individuals (**Figure 4**, Noer *et al*. 1995; Asferg 2001). Recent analyses from the period 1983-1999 showed that the annual Eider bag is mainly affected by the number of hunters, since varia-

Table 1. Summary table showing available national estimates of winter (individuals) and summer (pairs) numbers of Eiders in the Baltic/Wadden Sea flyway population for 1991 and 2000. *= extrapolated figure since no firm data exists for the given time period.

	Winter		Summer	
	1991	2000	1991	2000
The Netherlands	103,299	97,657	7,621	?
Germany	236,451	248,663	971	1,166
Denmark	797,000	370,000	25,000	24,000
Sweden	20,000	20,000	?	?
Norway	?	10,000	?	30,000
Finland	30	200	150-180,000	170,000
Poland	24,000	10,000	?	?
Estonia	100	100	12,000*	12,000*
Total flyway	1,180,850	756,620	215,592	237,166

tion in this parameter explains 78% of the variation in bag size. Reproductive success of Danish breeding Eiders (the ratio of juvenile birds per adult female bagged in October), and the number of days with hunting (affected by weather conditions), were found to explain an additional 8.1% and 5.0% of the variation, respectively (Christensen *et al.* in prep). Thus, a decline in the number of hunters reporting shot Eiders from c.14,000 in the early 1980s to c.7,000 in 1999 seems to be the main reason for the decline in Eiders shot in Denmark.

The Netherlands

The number of breeding Eiders in The Netherlands increased markedly from c.10 pairs in 1930 to c.6,000 in the 1960s. In the mid-1960s the population declined due to pesticide discharges in the river Rhine (Swennen 1972; Koeman *et al.* 1969). The population subsequently recovered during the 1970s and 1980s (**Figure 1**). In the late 1990s and early 2000s, local population declines have been documented while the breeding population as a whole numbered probably between 5,000 and 10,000 breeding pairs. The breeding population is sedentary staying generally within the Wadden Sea (cf. Swennen 1990), so its size cannot be determined using migration observations. Females are highly philopatric, but males show high natal dispersal. The majority of Eiders wintering in The Netherlands originate from Baltic breeding areas, which mix with local breeders (Swennen 1991). The total number of wintering Eiders has

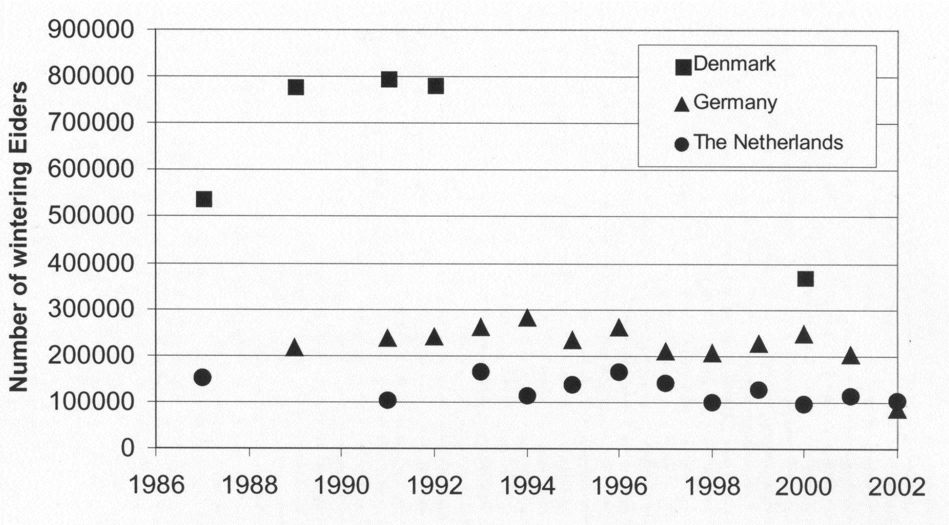

Figure 3. Annual mid-winter counts of Eiders in The Netherlands, Germany and Denmark from 1987-2002. Note that 'Germany' includes only data from the former West Germany, thus excluding Mecklenburg-Vorpommern. Each year is identified by the January of each count, hence "1987" refers to the winter 1986/1987 etc.

Figure 4. Estimated size of the annual Danish Eider bag during 1980-1999. Each year is identified by the January of each count, hence "1986" refers to the winter 1985/1986 etc.

increased markedly from c.10,000 during the 1950s to a peak of c.170,000 in the early 1970s. Since then, numbers have varied between c.100,000 and 170,000. Despite large year to year variation, counts suggest a decline during the late 1990s (**Figure 3, Table 1**). During the 1970s and 1980s, wintering Eiders were mainly confined to the Wadden Sea with few recorded in North Sea coastal waters. In the early 1990s, the distribution of Eiders changed markedly, with a higher proportion of birds recorded along the North Sea coast, especially during the winters 1992-93 and in 2000-2002.

Normally c.3000 beached dead Eiders are found each winter in beached bird surveys, but extremely high numbers occurred during the three most recent winters, 1999/2000, 2000/2001 and 2001/2002, with a peak of c.22,000 during 1999/2000 (Camphuysen 2001; Camphuysen *et al.* 2002, **Figure 5**). Compared to the long-term average, relatively large numbers of beached Eiders were also recorded during the winters 1990/91 and 1991/92 (**Figure 5**). Given the areas in which dead Eiders were found and recoveries of ringed birds (Camphuysen unpublished), it seems that a large proportion of the birds that died belonged to the Dutch breeding population. Recoveries of dead birds ringed in Denmark and Finland showed that these were mainly juveniles and immatures (Lyngs in prep.). Thus, despite the fact that migrants out-number local birds during winter, the migratory adult Eiders apparently avoided the massive die-offs in Dutch waters. Examination of dead birds collected during the winter 1999/2000 and 2001/2002 showed that all were emaciated and carried large numbers of intestinal acanthocephalan parasites (Kuiken 2001; Borgstede 2001; Smaal *et al.* 2001, van den Berk *et al.* 2001). However, as heavy parasite infestation has also been found in 'healthy' Eiders shot by hunters in Denmark, it seems that a general shortage of food (specifically bivalves) in the Wadden Sea is the most obvious explanation for the observed mass mortality. Documented over-exploitation of the shellfish stock (blue mussel and cockles) in the Dutch Wadden Sea occurred in the early 1990s. At this time Eiders began to occur in large numbers on *Spisula* banks in the North Sea, indicating a general food shortage in the Wadden Sea (Camphuysen *et al.* 2002). In the North Sea, however, *Spisula* is being increasingly exploited by humans (Smaal *et al.* 2001; Piersma & Camphuysen 2001), resulting in years when Eiders have difficulties in obtaining adequate alternative food resources. In the winter of 1999/2000 very few large *Spisula* occurred along the entire Dutch North Sea coast.

Germany

The German Wadden Sea breeding population has been stable at 1000-1300 pairs since 1982 (**Figure 1**), although there have been shifts from northern to western areas in recent years (Hälterlein *et al.* 2000). At most,

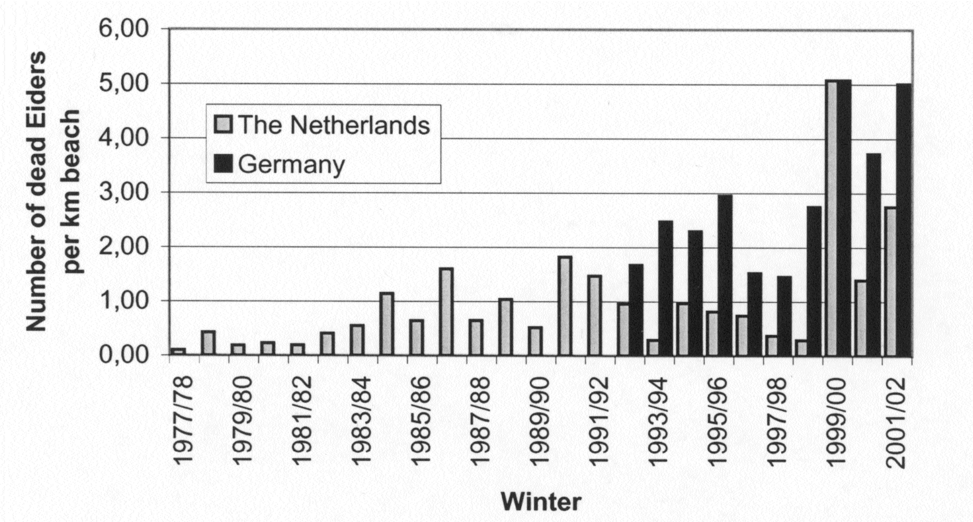

Figure 5. Total number of dead Eiders found in winter per km beach searched during the beached bird surveys in The Netherlands, 1978-2002 and in Germany, 1993-2002.

19 breeding pairs have been recorded in the German part of the Baltic Sea, so the contribution from these birds is negligible in a flyway perspective. The moult concentrations in the German Wadden Sea have shown a significant decrease from 258,000 in 1989 to 160,000 in 2001 (r_S=-0.891, *P*=0.001, n=10). Excluding winter 2001/2002, the German winter population has been stable over the last 15 years, showing no long-term trends in any region (**Figure 3**, **Table 1**, Bräger & Nehls 1987; Bräger *et al*. 1995; Nehls 1989; Scheiffarth *et al*. 2001). In winter 2001/2002, Eider numbers were the lowest seen since the start of regular aerial counts throughout all former West German coastal waters in 1987 (more than 100,000 less than the former minimum numbers). Systematic aerial winter counts along the coast of Mecklenburg-Vorpommern (54°12'N, 12°05'E) started in the early 1990s (Nehls 1994; Nehls & Struwe-Juhl 1998), but have not been conducted on a yearly basis. Wintering numbers were constant around 70,000 Common Eiders during 1997/1998-2000/2001. However, no counts are available for the winter 2001/2002.

The numbers of dead Eiders registered along German North Sea beaches in winter increased tenfold from an average of 433 birds in the period 1991/92 to 1994/95 to 4265 birds in 2001/02. The increase began in 1997/98, two years after the extremely cold winter 1995/96, when 783 were found. Numbers in 2000/01 were lower than in both the previous and the following winter, due to prevailing southeasterly winds that winter, which prevented birds being beached in the German Bight. Because awareness of the recent dramatic increase in Eider mortality could inflate the detection rate of this species, the numbers of dead Eiders registered in winter on only a selection of German North Sea beaches have been compared in this analysis. These are sites using the same methods and effort since 1992/93. Numbers reported from these sites increased from 1.4 birds/km in 1992/93 to 4.6 birds/km in 2001/02 (**Figure 5**). The increase was greater in Niedersachsen (0.9 birds/km 1992/93; 7.6 birds/km 2001/02) than in Schleswig-Holstein (1.7 birds/km 1992/93; 3.2 birds/km 2002/01).

Sweden

The total Swedish breeding population was estimated at 170,000 pairs in 1973 and 270,000 pairs in 1983-1984, an annual increase of c.6%. The Swedish population is mainly migratory, wintering in Danish waters and the Wadden Sea (Fransson & Petterson 2001). In 1973, the Stockholm archipelago was estimated to support c. 50% of the Swedish breeding population. Breeding numbers in the northern Stockholm archipelago have increased (r_S=0.78, P=0.0002, n=17), but decreased in the south between 1985 and 2001 (r_S=-0.53, P=0.03, n=17) (**Figure 6**). Nest counts at Bullerö showed an increase from 1971 to 1989, followed by a decrease in the years from 1989 to the most recent count in 2001 (**Figure 7**). The Lygne Islands in the Stockholm archipelago showed an increase from 1948 to 1979. During the last ten years (1992-2001) the breeding numbers at Lygne have decreased by c. 25% from 1,320 to 980 pairs (**Figure 7**). There was no significant trend in the Eider breeding numbers on the Småland archipelago between 1990-2000, although there were negative trends amongst 10 out of 39 other breeding avian species (Johansson & Larsson 2001). No significant trends in breeding numbers were found from the two islands near Gotland (P>0.05). From the Swedish west coast, September counts of Eiders showed no significant trends between 1992-2001 (r_S=-0.62, P=0.05, n=10). Between 1992 and 2000, there was no overall significant trend in the time series of migration data from Kåseberga (**Figure 8**; r_S=0.067, P=0.86, n=9), although reported numbers have been lower in more recent years. Since 1991, the peak in winter numbers along the southern coasts was c.16,000 in 2000 (**Figure 9**, **Table 1**), with no significant trend over the whole period (**Figure 9**).

In most areas of the Stockholm archipelago where the Mink have been present in high densities for 10-30 years, there has been a substantial decrease in numbers of breeding Eider ducks. The choice of nesting habitats has also changed dramatically since the arrival of the Mink. Eiders have abandoned bushy and wooded islands, and moved to gull colonies or joined solitarily nesting gulls on small open

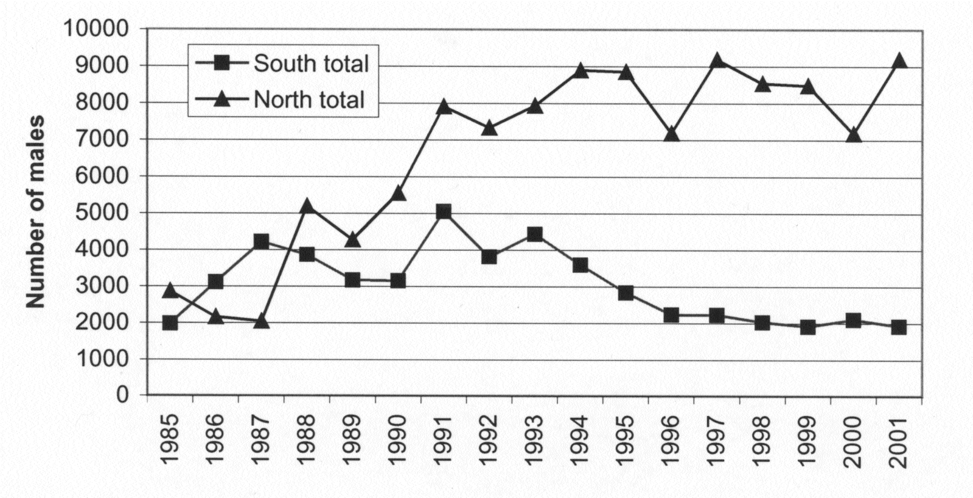

Figure 6. Trends in numbers of breeding Eiders in the northern and southern parts of the Stockholm archipelago, Sweden, as estimated from ship-based male surveys undertaken in late April. Five island areas were not surveyed in some single years and where this occurred, the average of the year before and immediately after were substituted.

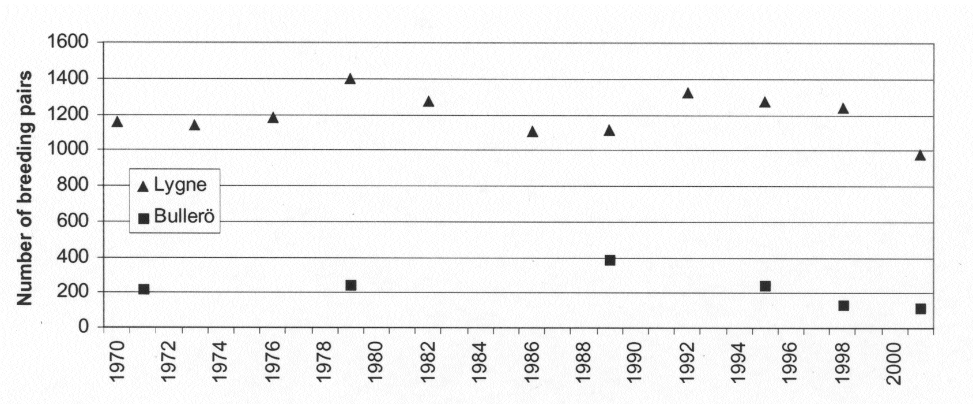

Figure 7. Eider nest counts at Bullerö and Lygne in the archipelago of Stockholm, Sweden, 1970-2001.

islets. In areas more recently colonised by Mink, Eider populations have shown stable or even increasing trends, whilst areas without Mink show consistent increases in numbers of breeding Eiders. The Swedish annual hunting bag amounts to 3-5,000 Eiders.

Finland

In 2001, the total Finnish breeding population was estimated to be 150,000-180,000 pairs. Approximately 150,000 breed in the southwest archipelago, while c.10,000-20,000 breed in the Gulf of Finland, and less than 10,000 breed in the Bay of Bothnia. The population is entirely migratory. The index of breeding Eiders in Finland increased from the 1970s to the late 1990s. The increase was most rapid during the 1970s and 1980s, averaging 7% to 10% per year. No further increases occurred in the late 1980s and 1990s, and the population is estimated to be declining at a rate of 8-16% per year (**Figure 10**). Decreases in numbers of nests were first reported from the Gulf of Finland in the late 1980s, whereas marked declines in nest abundance in the southwest archipelago

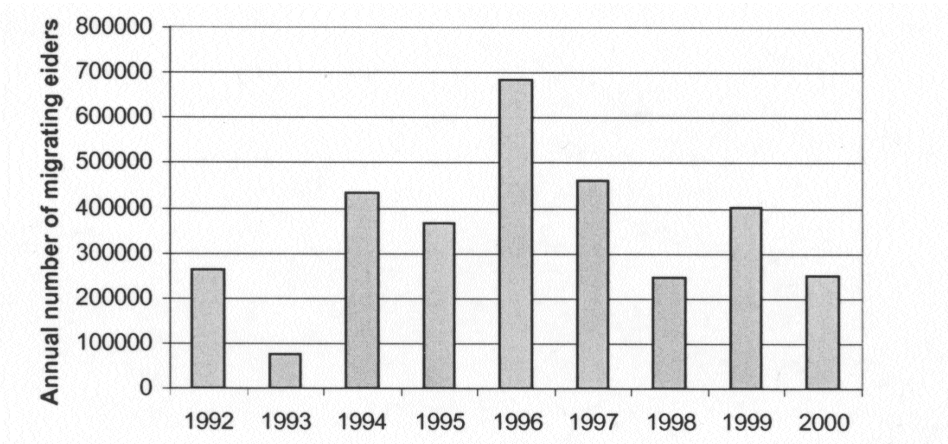

Figure 8. Number of spring migrating Eiders counted at Kåseberga on the southern coast of Sweden, 1992-2000.

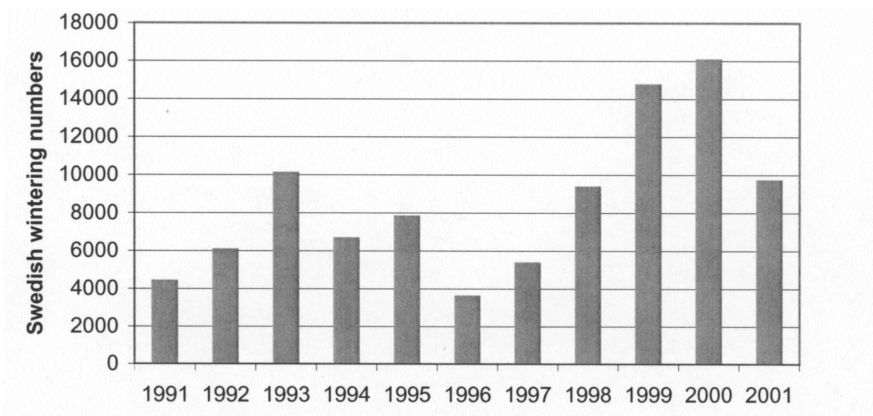

Figure 9. The number of wintering Eiders along the west cost and southern part of the east coast of Sweden, 1991-2000.

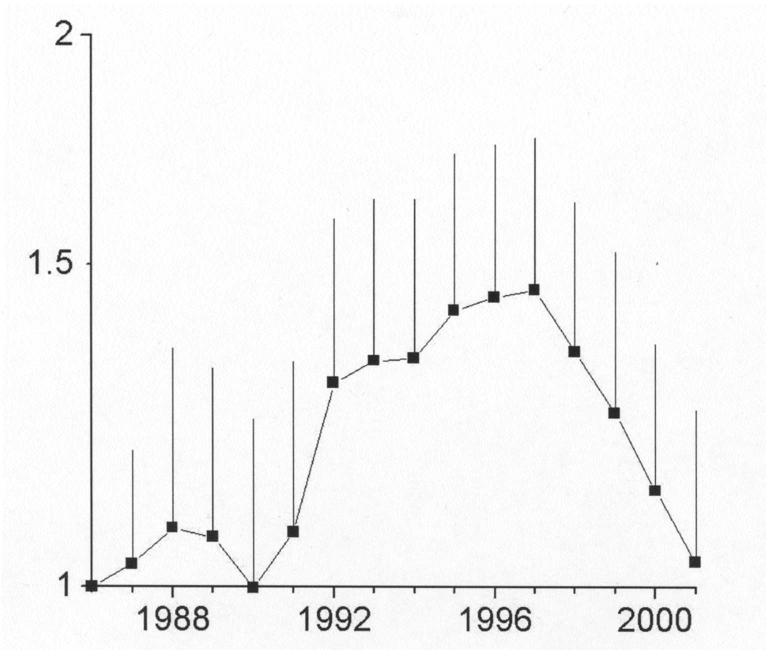

Figure 10. Indices of Eider population trends in Finland according to nest-count data, 1986-2001. Vertical lines show upper 95% confidence limits of the indices (from Hario & Rintala 2002).

only started during the mid 1990s (Hario & Rintala 2002). Regular winter counts from the Åland Islands have shown that only 20-200 Eiders remain in ice-free areas, depending on the severity of the winter (**Table 1**).

Studies at the Söderskär bird sanctuary have documented poor fledging success during the period of population decrease, although adult mortality has remained stable (Hario & Selin, in press). Low duckling production has been related to viral infections in 1996 and 1999, causing mass mortality within the first weeks after hatch (Hollmén 2002). Intestinal infection with acanthocephalan parasites has been found in both adult female Eiders and ducklings in Finland, but the role of parasites as a mortality factor seems to be associated with other predisposing factors, such as impaired feeding ability or immunosuppressive viruses (Hario *et al.* 1995, Hollmén *et al.* 1999, 2000). A decrease in clutch size during the period of population decline cannot explain the population trajectory (Hario & Selin, in press), nor is it associated with the effects of gull predation on ducklings (Hario & Selin 1991). Predation by feral Mink has had only limited effect on the density of incubating females (Niemimaa & Pokki 1990; Nordström *et al.* 2002). However, the recovery of the

White-tailed Eagle *Haliaeetus albicilla* population may be an important factor (Kilpi & Öst 2002).

Common Eiders are legal quarry in Finland in both spring and autumn. Spring hunting is strictly licensed and is only permitted on males. Hunting practices differ between mainland Finland and the Åland Islands, due to differing legislation. On mainland Finland, c. 7,000 males were formerly bagged in spring, but the current annual quota has been reduced to 2,000 males. Another 10-12,000 Eiders are taken in autumn, of which c. 25% is male. On the Åland Islands, spring hunts take 7,500-9,000 males, but there is no open season for females and yearlings. The total Eider bag amounts to 25,000-27,000 birds of which c. 18,000 (70%) are males. Contrary to the situation in Denmark, the Finnish bag size shows a strong correlation with the size of the breeding population (Hario & Selin 1987).

Other countries

The Norwegian Skagerrak population of breeding Eiders is estimated at 20-30,000 pairs based on male counts. The number of breeding pairs has shown an overall significant increase since 1988 (Lorentsen 2001), although breeding numbers since the mid 1990s have stabilised. The wintering numbers have been stable at c.10,000 Eiders (**Table 1**), with minor increases in some sub-areas. In Norway, a mean of 9,108 individuals were bagged annually in the Skagerrak region between 1998 and 2001 (J.A. Rundtorn pers. comm.). The Estonian breeding population increased from c.3,000 pairs in 1965 to c.15,000 in 1995 (Leibak *et al*. 1994), and subsequently decreased to c. 12,000 pairs in 2001 (Eve Mägi and Arvo Kullapere pers. comm.). Between 1990 and 2002, ground counts have shown that Estonia supported fewer than 100 wintering individuals annually (**Table 1**); winter aerial survey of the entire coast in early 1993 found only 75 Eiders. Common Eiders have never been recorded breeding in Lithuania, due to lack of suitable nesting habitat. This species does not regularly winter there, although a few have occasionally occurred in recent years. The species is a little more frequent during spring and autumn migration, but numbers are low, with no regular staging sites (R. Zydelis, in litt.). Common Eiders have never been observed breeding in Latvia (Viksne 1983). The maximum count of wintering Eiders was 14 in 2001, with autumn and spring maxima of 5 and 50 respectively counted along the Latvian coast (A. Stipniece pers. comm.). According to the Polish rarities committee, Eiders have bred only very sporadically in Poland. The Polish coast offers little wintering habitat for this species, which usually numbers fewer than 1,000 (W. Meissner pers. comm.).

Assessing the overall size of the Baltic/Wadden Sea Flyway Population

For 1991 and 2000, reliable breeding estimates exist for Germany, Denmark, Estonia and Finland. For the numerous

Swedish population, there are no nationwide surveys from these two time periods and a reliable breeding estimate for The Netherlands is available only for 1991 (**Table 1**). Summing the breeding figures excluding Sweden, Norway and Poland, results in c.215,000 pairs for both periods. Comprehensive winter surveys have been conducted in Denmark, The Netherlands, Germany and Norway. In 1991 the total number of wintering Eiders amounted to c.1,200,000 birds and during the following 10-year period a decrease to c.750,000 birds has taken place (**Table 1**). This decline is apparently due entirely to changes in the size of the Danish wintering population.

Discussion

Status of population and evaluation of methods

Although the Baltic/Wadden Sea Common Eider population increased steadily in numbers from the 1970s onwards, this review suggests that the situation has begun to change during the last ten years. The total flyway estimate of the wintering population has decreased by c.36% between 1991 and 2000 (**Table 1**), although most national breeding trends show no equivalent marked decrease since the mid-1990s. Unfortunately, the lack of national breeding estimates, precludes an overall assessment of changes in the total flyway breeding population between 1991 and 2000. There are no Swedish national breeding population estimates since the mid-1980s, a country known to host approximately one-third of the Baltic breeding population (Almkvist *et al.* 1974), and trends in breeding numbers at a few local areas may not be representative of those in the total population as a whole. Given that better count coverage is achieved in winter, we consider that the c.36% decline in total numbers offers the best assessment of population change available and therefore gives some cause for concern. In trying to answer the question of why there is an apparent mismatch between the reductions in wintering numbers and apparent stability in local breeding numbers, it is suggested that the discrepancy could be explained by one or more of the following five (not necessarily competing) hypotheses:

Hypothesis A: *declines in breeding numbers at nesting sites are buffered by the availability of substantial numbers of young non-breeding birds.*

These normally non-breeding Eiders are able to recruit into the breeding population during periods of reduced competition for pre-nesting feeding habitat or breeding habitat (eg as a result of increased adult female mortality). This would sustain (at least in the short term), stable local breeding numbers (eg by a simple decrease in age of first breeding) despite an overall decrease in total population number. Alerstam & Högstedt (1982) were the first to propose that the relative extent of breeding habitat to those habitats used to survive between breeding seasons, shaped the migratory and reproductive strategies of different bird species. They characterised the Common Eider as a species that exploits a highly limited breeding habitat, but a surplus of abundant and widespread non-breeding survival habitat (a classic 'S-species' of Alerstam & Högstedt 1982). Strong competition for breeding habitats results in deferred breeding and high annual survival. This 'buffer' element of the population can constitute at least 20-30% of the total population (Almkvist *et al.* 1974; Alerstam *et al.* 1974; Coulson 1984). The buffering effect was evident after the Danish outbreaks of Avian Cholera, which killed 90% of all breeding females in two colonies. In the years following the outbreaks, breeding numbers fell by 75% and 65% at Stavns Fjord and Rønø, respectively (NERI unpublished data), ie less than would have been expected if there was no pool of non-breeders awaiting the opportunity to attempt to nest. These non-breeders contribute in number to the winter counts, but are not detected during normal breeding surveys. In this way, winter surveys would detect a general flyway population decline before this was apparent from counts of breeding birds. In addition to competition for suitable nesting sites, competition for food prior to breeding may have an even greater impact upon the success of a breeding attempt by first-year or experienced breeders. Common Eiders are capital breeders (Meijer & Drent 1999) and females store large energy reserves (up to 20% of body mass) for egg formation, egg laying, and for fasting during incubation. Prior to breeding, females need to feed intensively in order to reach the minimal body mass for a successful breeding attempt. If this weight is not attained, females may decide not to breed, or to breed and risk abandonment of the clutch. Local food supply and the level of competition may therefore affect the pre-nesting increase in body mass. The observed increase of first-breeding females in the year after the die-off of adult females could also indicate less competition and more available food for inexperienced and less competitive first-year breeders.

Hypothesis B: *declines in flyway wintering numbers are caused by a significant (but currently undetected) decline in the Swedish breeding population*.

Since no national breeding estimates exist from Sweden for the last ten years, this population could have decreased significantly without the trend being detected. Three out of four studies of local Eider breeding ecology in the Stockholm archipelago have shown negative population trajectories, whereas a fourth from the northern part of the archipelago showed stable numbers. The results from these local breeding studies, and the fact that the archipelago of Stockholm was formerly known to host c.50% of the Swedish breeding population of 270,000 Eider pairs, indicate that Hypothesis B could contribute to the observed differences in trends between breeding and wintering numbers.

Hypothesis C: *recent winter surveys in Denmark have not counted all Eiders, either because of difference in coverage or problems with the counting procedures.*

The geographical coverage of midwinter Eider counts has not been changed between the surveys. The switch from systematic total coverage to a transect survey in the Kattegat offshore area in 1999/2000 cannot explain the magnitude of the decline in Danish wintering numbers between 1991/1992 and 1999/2000. Additionally, all other areas in Danish waters outside Kattegat showed significant declines. In general, the aerial survey method used for the Danish winter counts is considered to be reasonably robust, as suggested by the low variability between the three survey totals from 1989, 1991 and 1992, when total Danish Eider numbers ranged between 779,000 (in 1989) and 797,000 (1991, **Figure 3**). It is therefore considered that factors relating to survey technique are highly unlikely to have contributed significantly to the dramatic decline in Danish wintering numbers of Common Eiders that was found in 1999/2000.

Hypothesis D: *previous breeding counts have missed a large proportion of the breeding pairs detected in more recent years.*

No major changes in survey methods or extent have occurred or been reported for the breeding counts during the period, and hence, we consider that all figures from the ten year period are reasonably comparable. Hypothesis D is therefore considered unlikely to contribute to the explanation for the observed patterns.

Hypothesis E: *changes in winter distribution of Eiders have involved expansion into previously non-surveyed areas.*

Since most wintering areas are surveyed regularly and because Eiders winter relatively close to coastlines easily covered from either land or aircraft, any significant changes in winter distribution should have been detected. Food supply and the energetic constraints of feeding in deeper water restrict the opportunities for large numbers of Eiders to winter offshore or elsewhere in the range. Although large numbers formerly wintering in the Wadden Sea have moved out into the North Sea in recent years, the probability of this occurring undetected elsewhere in the winter range remains small. Hypothesis E is therefore unlikely to explain the observed patterns. However, the relative low number of wintering Common Eiders in the German Wadden Sea in winter 2001/2002 coincided with a lack of midwinter survey in the Mecklenburg-Vorpommern region. This involved c.100,000 Eiders which underlines the need for a greater degree of co-ordination of winter counts throughout the flyway.

It seems probable that Hypotheses A and B are the most likely explanations for the differences in trends between the wintering and breeding figures. Whatever the true explanation, it is clear that it is possible to count birds effectively on the wintering grounds, and that this is likely to be the best point in the annual cycle at which to measure and detect major changes in overall flyway population number. Birds on the wintering grounds are aggregated, so if the problems of adopting common count techniques and co-ordinating international census effort can be overcome, this represents the most important monitoring goal for the future. If Hypothesis A is correct, it might be expected that, once the pool of non-breeders is exhausted, declines will also be detected on the breeding grounds. At that stage, the Baltic/Wadden Sea Eider population will be even more sensitive to changes in annual adult survival, disease epidemics and winter and pre-breeding food shortage. For this reason, it is recommended that there is continued vigilance on the breeding areas, and that common standards for conducting breeding surveys are devised and adopted.

Even though no significant decrease in national total breeding numbers has been recorded between 1991 and 2000, several indications strongly suggest declines in local sub-populations. Amongst most countries in the Baltic/Wadden Sea flyway, a common trend in population trajectory is seen: an increase during the 20th century until the early or mid 1990s, followed by either stability, or in most cases, declines, either in breeding or wintering numbers (**Figures 1, 6, 7, 8, 10**). In Finland, the annual breeding index was not significantly different between the two breeding seasons of 1991 and 2000, but in the years between, numbers increased up to 1997, after which a steep decline ensued to 2001. In winter 1999/2000 and 2001/2002, relatively large numbers of dead Eiders from the local breeding population have been recorded in the beached bird surveys in The Netherlands (Camphuysen pers. comm.).

In conclusion, it is considered that the c. 36% decline in winter numbers between 1991 and 2000 reflects a significant population decrease throughout the flyway, not distinguishable at present in the trends of national breeding numbers due to the buffering effects of the non-breeding element of the population.

Factors affecting population size

Besides the dramatic decline in the Danish wintering population from 1991-2000, other parts of the wintering range of the Baltic/Wadden Sea population Eiders have also seen substantial declines. For example, declines were observed during 2000-2002 at two large German wintering areas: the Wadden Sea and in the Baltic off Schleswig-Holstein. In the Dutch Wadden Sea, a long-term decline in wintering numbers has occurred. Many local and small-scale population studies along the flyway suggest that the population dynamics of Eiders have been adversely affected by a variety of human induced and natural factors. Modelling has shown that small changes in adult survival have far greater impacts on annual changes in the numbers of Common Eiders (Christensen & Noer 2001) compared to far greater changes in annual reproductive success (Swennen 1983). Nevertheless, a prolonged decrease in recruitment rate due to either persistent low fecundity or low chick survival will eventually result in lower numbers of immature non-breeders, reductions in recruitment and will also finally reduce population size (Hario & Selin, in press).

In the breeding season, both adult survival and recruitment can be adversely affected by different factors, eventually leading to a decline in the population. Intensive predation studies on the American Mink in Sweden have shown significant reductions in local densities of breeding Eiders. To what extent Mink presents a general problem to sustaining the current size of the Baltic/Wadden Sea Eider population and whether the Eiders are able to adapt to this invasion, remains an open question. In Finland, long-term removal of Mink from two archipelago areas (125 km^2 and 72 km^2, respectively), did not alleviate declines in breeding Eider populations, whereas it greatly enhanced re-colonisation by smaller waterfowl species that had been extinct from the areas since the Mink invasion (Nordström *et al.* 2002). Nevertheless, the fact that American Mink have spread to most parts of the Eider breeding range suggests that it is a potential threat to the population and may have contributed to the present decline. Hence, Mink predation represents an important subject for study in coming years. Other ground predators, such as rats *Rattus* spp. and Red Foxes *Vulpes vulpes*, also affect Eider nesting success. In spring 2002, considerable egg-predation by rats was observed at the breeding colony on Vlieland in The Netherlands (R.K.H.Kats unpublished data). The presence of Foxes at breeding areas on the mainland is also thought to contribute to declines in nesting density there. The observed shift from nesting in closed habitats to more open areas and to islands with the presence of gulls may improve adult survival, but may increase the predation of eggs and ducklings and as a consequence reduce reproductive output.

Diseases can lower both adult survival and recruitment during the breeding season, as reported for Avian Cholera in Denmark (Christensen *et al.* 1997), for intestinal occlusion in males in Finland (Grenquist *et al.* 1972), and the outbreaks of duckling virus in Finland (Hollmén 2002). Since little is known about diseases and their effects on the Eider population dynamics, we need to monitor disease in Eiders as a part of an international flyway-monitoring programme. As a first step, a study of the causes of death and an assessment of how many colonies are infected, when and where should be made an immediate priority. Studies found high levels of acanthocephalan parasite infestation in healthy wintering Danish birds, with no relationship between parasite numbers and individual body condition, suggesting that high parasite loads were not responsible for mass mortality events in the Wadden Sea. Amongst potential contaminants, lead exposure needs to be monitored over the entire range. Among nesting females in the Gulf of Finland, highest exposure rates were documented in areas of population declines. Severe or sub-clinical lead poisoning was diagnosed in 23% of females that died of emaciation after incubation (Franson *et al.* 2000, 2002, Hollmén 2002).

The Baltic/Wadden Sea population of Common Eider remains legal quarry in Denmark, Norway, Sweden and Finland, amounting to an annual total flyway kill of c.115,000 individuals. Whether or not this level of hunting pressure is sustainable, is at present unknown. Analysis of the Danish bag statistics indicates that the bag size is more related to the number of active hunters than to the size of the Eider population (Christensen *et al.* in prep.). This apparent lack of relationship between bag size and population size can be explained by the hunting method predominantly used in Danish waters, where hunters approaching a flock of Eiders in motor boats are bagging one or two individuals from each flock when they flush. In this way, the bag size will not change even though the flock sizes are changing, since a maximum of one to two Eiders are normally bagged independent of flock size. The fact that the kill used to be far greater in Denmark at a time when the population still increased dramatically, suggests that the Danish hunting activities were sustainable, at least at that time. Indeed, there was no relationship between the Danish bag size and the size of the Söderskär Eider population during the years of the steep population increase (1973-84). Thus, there is no indication that the Danish hunting pressure responded to the Finnish population growth (despite responding significantly to annual changes in recruitment rate at Söderskär, Hario & Selin 1987; Noer *et al.* 1995).

Other human activities could potentially increase the mortality of full-grown Eiders unintentionally; eg by-catch in gill nets and collisions with high-speed vessels (which are travelling increasingly fast in inshore waters) and with offshore structures such as bridges and wind turbines. These potential sources of mortality have increased in European offshore areas in recent years, but nothing is known about the magnitude of such mortality and its individual and cumulative effects on migratory bird populations such as Eiders.

The Common Eider in the Wadden Sea is at its southern limit of winter distribution where it is almost wholly dependent upon shellfish stocks for its food supply. The staple food items are the Blue Mussel *Mytilus edulis* and the Cockle *Cerastoderma edule*, as well as *Spisula* in some areas (Leopold *et al.* 2001). However, food quality is crucial for these birds, in particular the relation between shell mass and flesh mass (Nehls 1995, 2001). Flesh mass is highly dependent upon winter temperatures and shows large fluctuations between years (Beukema *et al.* 1993; Zwarts 1991; Zwarts & Wanink 1993). Therefore sufficient stocks of alternative prey are important for long-term survival, as has been shown for the Oystercatcher *Haematopus ostralegus*, (Zwarts *et al*. 1996). Since only a small fraction of the total shellfish stock is available for exploitation by Eiders (Nehls 1995), they are sensitive to large scale destruction of mussel and cockle beds as has occurred in several parts of the Wadden Sea in recent years (Piersma & Koolhaas 1997; Piersma & Camphuysen 2001). In combination with a series of mild winters with low food quality and poor shellfish recruitment in the subsequent summer, this human impact on food stocks can have substantial adverse effects on the Eider population. In addition to direct adult mortality caused by lack of food, studies have shown that the reproductive output may also be adversely affected by reductions in food resources (e.g. through delayed nesting, increased desertion rate and reduced hatchability, Oosterhuis & van Dijk 2002).

Among the strictly migratory Finnish Eider population, food-related parameters such as female body weight at the start of incubation, clutch size and egg size did not change during the extended period of population increase followed by recent decrease (based on data from individual females breeding both in 1982-85 and 1986-1991, Hario & Selin in press). This is likely to result from Eiders being capital breeders (Meijer & Drent 1999), determinant egg-layers (Swennen *et al.* 1993), and that egg size varies with age and clutch size (Swennen & van der Meer 1992). This may suggest that the blue mussel stocks exploited in winter in Denmark have not changed in quality or size, as Finnish Eiders rely heavily on stored (subcutaneous) fat transported from Denmark to the northern breeding sites in spring. By contrast, food intake on the breeding grounds, during the relatively unpredictable period between the ice break-up and laying, is mainly invested in female self-maintenance (Hario & Öst 2002). Further evidence for the importance of the Danish mussel stock to northern Baltic Eiders comes from the fact that the strong salinity-induced west-east decline in mussel abundance in the Gulf of Finland (Öst & Kilpi 1997; Westerbom *et al*. 2002) is not reflected in parallel trends in Eider breeding parameters along the Gulf. Since Eiders from the central Gulf of Finland (with poor mussel stocks) fare equally as well as those in the western Gulf (with ample mussel stocks), during the early breeding season, this suggests that both these Eider 'sub-populations' exploit the same winter food resources (ie those in Denmark) which are adequate at the present time. On the other hand, Finnish breeding numbers have declined, suggesting that fewer females are able to feed and store sufficient nutrients in Denmark to fly to Finland and breed. If this is the case, where are the females that failed to acquire sufficient stored nutrients to breed? Perhaps this suggests that the food supply in Denmark has declined in quality or extent, and fewer females return to the colonies to breed (although those that do so, especially the experienced older birds, continue to return in good condition).

Despite the fact that several studies have shown that different local factors are having adverse effects on the breeding population, their relative importance is unknown. For this reason it is important that future research proposals include a modelling approach, which will enable a better understanding of the relative importance of, and potential sensitivity to, the different factors affecting the population size and hence enable a prioritisation of future conservation actions.

Recommendations for monitoring

During the compilation of this review it became clear that national and local monitoring programmes are performed in many areas along the flyway. The usefulness of the compiled data would, however, be greatly enhanced if the methods used by different schemes were harmonised and better co-ordinated. We would particularly urge, for example, those countries, which survey the winter population every second or third year, to synchronise their counting years and increase the number of years in which the whole Baltic/Wadden Sea Eider population is surveyed simultaneously. A monitoring programme of winter numbers on the flyway-scale is of the highest priority, if the further future decline is to be adequately tracked and quantified. The possible alternative options for future monitoring programmes to assess changes in abundance and distribution could include migration counts, breeding surveys or a combination of these two approaches. In general, surveys of sea ducks such as the Baltic/Wadden Sea Common Eider population are difficult to achieve comprehensively, due to the wide and often scattered distribution throughout the annual cycle. During winter, Eiders aggregate in coastal and near offshore waters, making assessment of numbers easier, if not particularly easy logistically. However, in summer they nest on thousands of islands scattered over vast areas, making complete surveys impossible. Designing census protocols that optimise coverage in both time and space to minimise the extent of unsurveyed habitat and avoid double counting due to poor coverage and/or redistributing individuals between counts will be difficult, but not impossible.

Monitoring the overall population trajectory through any form of direct breeding counts is unlikely to be feasible, for the reasons discussed above. If the breeding areas are to be the subject of a future monitoring scheme, the combination of post breeding aerial surveys of male numbers and sex ratio estimates, as performed in the Baltic in the 1970s, seems to be the best potential option. Searching for nests in a systematic or sampled fashion is both time consuming, disruptive and potentially suffers from many pitfalls, although a properly designed stratified sampling programme could be used to generate an index of relative breeding abundance and hence trends over time.

Another possibility, rather than attempting to count birds extensively on the breeding grounds, would be to focus count attention intensively in areas where a representative number pass through on migration. If counts of migrating Eiders could be used to monitor the size of the Baltic breeding stock, spring represents the best period because the spatial and temporal distribution is relatively limited. Such a migration monitoring approach is only feasible for the truly migratory populations breeding in Finland and Sweden, and fails to account for changes in the numbers of resident Eiders in The Netherlands or the partial migrants in Denmark. The study by Alerstam *et al.* (1974) could form the methodological basis for developing such a migration monitoring scheme. An historical perspective is potentially available in the form of a radar dataset from the east coast of Sweden which is known to be available for the study period of this review (per L. Nilsson).

The Baltic/Wadden Sea Eider population is a classic meta-population system with widely differing migratory and life-history strategies depending on breeding provenance. It is therefore unlikely, that the population processes of sedentary Dutch-breeding birds reflect those of the long-distance migratory Finnish birds. Local studies of the breeding biology of the Eider throughout the flyway cannot contribute directly to the monitoring of overall changes in population size. However, they are vital to understand and interpret the reasons for the observed changes in numbers and distribution. Local studies invariably include some assessment of local and relative abundance that can represent important time series for tracking local change in relation to flyway population changes. Although the wing ratios in the hunting bag from Denmark offer an index of annual reproductive success, there is no regular measure of breeding output in the population, so even simple measures of reproductive success would represent a major conservation contribution. Annual ringing of even relatively small numbers of females on nests, and their subsequent recapture histories can now be used to generate robust estimates of annual adult female survival (and other parameters, such as site fidelity, annual breeding probability). Systematic ringing of ducklings also enables an assessment of long-term changes in age of first breeding, a vital parameter in understanding the dynamics of the recruitment, discussed above. However, in practice, this requires massive ringing programs due to the very high early mortality of ducklings; and even when recruited, the first-time breeders need to be located with confidence - a demanding task in the field. Measures of annual fluctuations in these local and regional breeding parameters among the different sub-populations are of enormous value in interpreting population change. This is especially true if the studies are spread over larger areas and generate longer time series, and if study methods are standardised between the various different research groups. If conservationists are to understand Baltic/Wadden Sea Eider population dynamics, we need to know a great deal more about the different sub-populations, in order to identify critical processes in the annual life cycle. Nevertheless, it is important to remain cautious and consider pattern and scale, since in the Swedish studies, two adjacent study areas in the Stockholm archipelago showed very different population trends. Care should therefore be taken when extrapolating to a national or international scale from such local or regional studies.

Conclusions

To conclude, the monitoring mechanisms currently used to track changes in abundance of the Baltic/Wadden Sea Common Eider population are uneven and partly inadequate. Adequate monitoring programmes are needed to track winter population trajectories in the future in a way that can verify changes over time. If remedial actions are to be implemented for this species, aimed at restoring the population to favourable conservation status, it is essential that the monitoring programmes can detect these changes. Establishment of such monitoring programmes needs international agreement, co-ordination and adoption of common standards. The available evidence suggests that a number of factors are responsible for observed declines in the Baltic/Wadden Sea Common Eider population, several of which have adversely affected numbers on a local scale. It is known that disease has reduced adult female annual survival and duckling survival in specific areas, but this may have gone undetected elsewhere. Geographical shifts and mass-mortality events probably caused by starvation have been reported from parts of the wintering range, most notably in The Netherlands and the German Wadden Sea. Eiders are still hunted in annual numbers three times as high as the numbers of Eiders known dying in the mass mortalities and it is still unknown whether the current level of hunting is sustainable. Other factors may also be involved which have not been fully considered here (such as the general increase in shipping and shellfish exploitation throughout the range). The multi-factorial explanation for the declines necessitates an appropriate understanding of the relative importance of these different factors if we are to effectively prioritise and target resources to restore favourable conservation status of Common Eiders. Modelling of population processes is needed to fully understand the relationship between the Common Eider population dynamics and the different factors affecting its abundance and distribution.

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