Status of the Danish breeding population of Common Eider 2020

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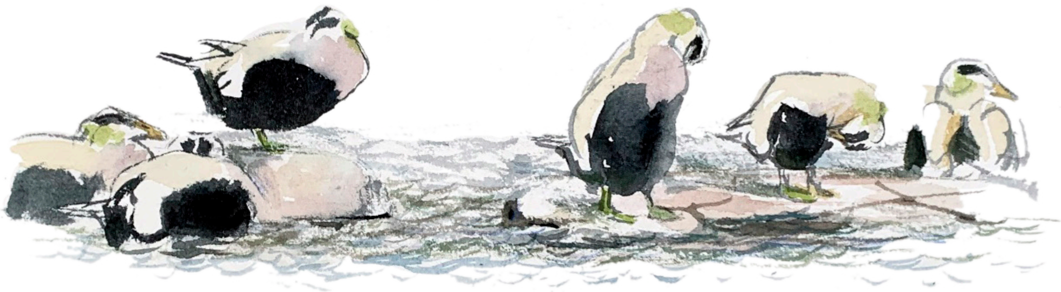


(*Med et dansk resumé: Status over den danske ynglebestand af Ederfugl 2020*)

Abstract The Baltic/Wadden Sea flyway population of Common Eider *Somateria mollissima* has been in decline since the early 1990s yet the numbers breeding in Denmark were stable during 1990-2010. A new breeding survey was conducted during 2018-2022 and the results are reported here. A total of 226 sites were surveyed covering almost all known and potential Danish breeding sites. For 55 of these sites, counts were made only of males staying near the breeding islets. To estimate nests numbers for these sites we multiplied male numbers by 0.55 (based on 53 sites where both male and nest counts had been conducted in the same year). A total of 13 848 nests was thus obtained of which 90.2% originated from nest counts and 9.8% from male counts. Corrected for unrecorded nests, we estimated the breeding population in the 2020 survey to be 17 000 pairs (range: 16 500-17 500 pairs) which is markedly lower than the 24 500-25 500 pairs estimated to have been breeding in 2010. Our result corresponds to a decline of 31.9% (4.6% per year). There was a large geographical variation in the development of nest numbers ranging from growth or stable/slow decline in the north (Limfjorden), west (Vadehavet) and central parts (N Fyn, N Sjælland) of Denmark to the more severe declines that occurred in the southern and eastern regions comprising the Baltic Sea and the belt-areas. Among the larger colonies, the most marked decline was recorded at Saltholm in Øresund where numbers had declined from 4351 nests in 2008 to 1365 nests in 2021, corresponding to 37.5% of the national decline of 8000 pairs over the last decade. There were indications that non-breeding was more frequent in the years of the 2020 survey than in previous surveys. For a number of sites, high numbers of females were recorded on the water near to islands where low numbers of nests were found compared to earlier years. A likely stressor – besides foxes – that may have prevented Eiders from breeding is the White-tailed Eagle *Haliaeetus albicilla*. White-tailed Eagles may stress Eiders during the pre-nesting foraging period, during egg-laying, and during incubation. White-tailed Eagles were observed in or close to several of the surveyed Eider colonies (the maximum recorded was 28 eagles at the largest Eider colony on Saltholm). Female Eider carcasses left by White-tailed Eagles were recorded on nine breeding islets. Disturbance by eagles may also have led to higher predation of Eider eggs by gulls. This recent decline recorded in the size of the Danish Eider breeding population aligns with the decline estimated earlier for the Baltic segment of this flyway population. Emerging pressure from a predator such as the White-tailed Eagle, which directly kills adult females and indirectly affects reproduction, appears to be one of the factors that already have and will continue to affect the development of the Eider breeding population in Denmark.

Introduction

The Danish breeding population of Common Eider *Somateria mollissima* (hereafter Eider) is a segment of the Baltic/Wadden Sea flyway population. Eiders in this flyway occupy breeding colonies in the Baltic Sea, including Denmark, Sweden, Finland and the Baltic states, as well as the Danish, German and Dutch part of the Wadden Sea. During winter, the Danish birds occur in the main wintering area of the flyway, which includes the southern Baltic Sea, the inner Danish waters and the Wadden Sea (Noer 1991, Tjørnløv *et al.* 2020). The flyway population includes an estimated 259 100 breeding pairs most of which breed in Finland (60%) and Sweden (29%; Birdlife International 2021a). The flyway population has shown a marked decline of c. 36-48% during the period 1990-2010 (Desholm *et al.* 2002, Ekroos *et al.* 2012a) and is still classified as declining (Birdlife International 2021b; see also Lehikoinen *et al.* 2022).

Because the Eider is an iconic and highly valued game species throughout most of its distribution area, the observed population decline has been a major point of concern for hunters and conservationists alike. This severe population decline is probably caused by a combination of various factors operating both directly and indirectly (Morelli *et al.* 2021). There is clear evidence for negative effects of a) changes in climate and seawater quality (both affecting food abundance and quality), b) increased predation of incubating females and of ducklings, and some evidence of effects from c) outbreaks of epidemic diseases and d) increased parasite loads. These factors have affected survival (particularly female survival) as well as reproductive output in smaller and larger parts of the population (Christensen *et al.* 1997, Pedersen *et al.* 2003, Hario *et al.* 2009, Tjørnløv *et al.* 2013, 2019, Laursen & Møller 2014).

Hunting, aside from its indirect disturbance effects, has previously represented an additive source of mortality for reproductively active females (Tjørnløv *et al.* 2019). However, from 2004 to 2014 hunting of Eider females became more and more restricted in Denmark, the country with the highest hunting pressure along this flyway. A complete ban on hunting females in Danish waters has been in place since 2014 and has been supplemented by total protection of the species in all relevant offshore SPA's (Natura 2000 sites) since 2022.

With reference to the overall long-term decline in the Baltic part of the Baltic/Wadden Sea population of Eiders, this flyway population recently became classified as 'near threatened' globally, and 'vulnerable' in the EU and in the IUCN red list systems, as well as being uplisted in the African-Eurasian Waterbird Agreement listing (AEWA). The present AEWA classification (as category A4) demands restrictions on hunting and calls for improved protection of the species in all member states, including Denmark.

The marked decline in the total flyway population since the mid-1990s, however, has mainly affected the core breeding area around the Baltic Sea. During the same period, the Danish breeding population remained stable, with estimated numbers ranging between 23 000 and 25 500 breeding pairs based on surveys in 1990 (Lyngs 2000), 2000 (Lyngs 2008) and 2010 (Christensen & Bregnballe 2011).

This paper presents the results of the Danish national breeding Eider survey performed during 2018-2022, here referred to as the 2020 census. The results are evaluated in relation to the previous surveys and to recent development in the flyway population.

Materials and methods

A nationwide survey covering almost all known and potential breeding sites of Eiders was organised by the Department of Ecoscience at Aarhus University. The survey was intended to cover as many of the 250-280 known breeding sites as possible and new potential sites in 2020-2021. For practical reasons and due to the Covid-19 pandemic, some sites were covered in 2018 or in 2019 and some in 2022. One count in 2016 from a distant island (Anholt) was also included. The numbers of sites and breeding pairs (separately given as nest counts and male counts) covered in each of the survey years are given in Tab. 1.

Tab. 1. The number of Eider breeding sites surveyed by nest counts and male counts and the recorded nest numbers covered in each of the years included in the 2020 survey.
Den årlige fordeling af antal optalte ynglelokaliteter for Ederfugle (opdelt på lokaliteter dækket med han-tællinger hhv. redetællinger) og antal reder talt på de lokaliteter og i de år, hvorfra resultater er medtaget i 2020-tællingen

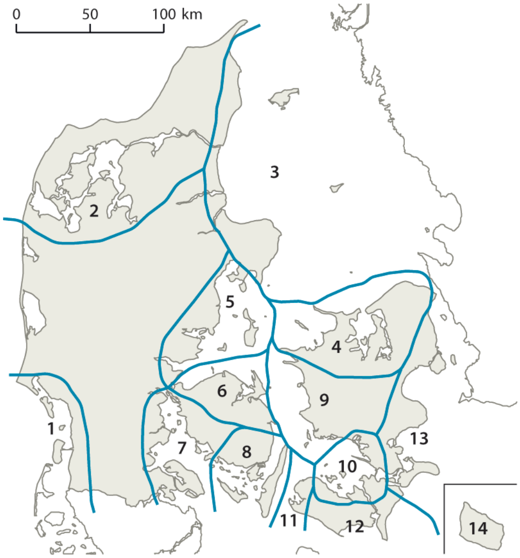
Year	**Number of localities** *Antal lokaliteter*		**Estimated numbers of nests**
År	**Male count** *Hantælling*	**Nest count** *Redetælling*	*Estimerede antal reder*
2016	1	0	31
2018	6	27	2782
2019	0	6	172
2020	67	14	4064
2021	69	80	7364
2022	12	28	2608

In general, nest counts were performed as total counts with a complete coverage at colony level. At a few sites, total nest numbers were estimated by correcting for incomplete coverage of all suitable nesting habitat at the locality. On the 13.5 km^2 large island of Saltholm (Øresund), complete nest counts were performed in eight evenly spaced east-west oriented transects (300 m wide) and covering 33.2% of the total area. The total number of nests was then estimated by extrapolation according to the method applied in the National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environment, NOVANA (Holm 2017).

Following previous surveys, counts of breeding Eiders from specific breeding sites were separated into 14 different regions (see Fig. 1). Counts were generally performed as nest searches. However, the majority of the sites in the Sydfynske Øhav region were covered during bird counts in surveys not specifically targeted at Eiders performed on all the islands in both 2021 and 2022 (Andersen & Bisschop-Larsen 2023). The countrywide survey involved voluntary ornithologists, volunteers from the Danish Hunters Association, private consultants, staff from the Ministry of Environment (see Acknowledgements) as well as staff from Ecoscience, Aarhus University. Some of the data from sites that were not covered were extracted from the observation database, DOFbasen, hosted by BirdLife Denmark (https://dofbasen.dk). Data from DOFbasen were used only if the observations included records of Eider nests or ducklings, and not if birds were merely noted as 'breeding'.

The number of breeding Eider females was estimated for each site based on either nest counts or male counts. Nest counts were performed by visiting known or potential breeding sites during the breeding season. These counts included records of the number of incubating females and nests that were either newly hatched or deserted. Fieldworkers were asked to report site coverage and estimate the minimum and maximum number of breeding Eiders for the entire locality if it had not been surveyed completely. Furthermore, notes had to be taken of signs of predators, e.g., red fox *Vulpes vulpes*, martens *Martes spp.*, American mink *Neovison vison* and brown rats *Rattus norvegicus,* which could affect the number of breeding Eiders negatively.

Compared to previous national Eider surveys, male counts were applied more widely in this survey. These



No.	Region		
1	Vadehavet	8	Sydfynske Øhav
2	Limfjorden	9	Storebælt
3	Kattegat	10	Smålandshavet
4	Nordsjælland	11	Nakskov Fjord
5	Østjylland og Samsø	12	Sydlolland
6	Nordfyn	13	Øresund
7	Lillebælt	14	Bornholm

Fig. 1. The delineation of the 14 geographic regions used in Tab. 2.
Afgrænsningen af de 14 definerede regioner anvendt i Tab. 2.

counts aimed at estimating breeding numbers from the number of adult males observed attending the breeding colonies during the pre-breeding or early incubation period. Male counts facilitated collection of data from sites sensitive to human disturbance, and from sites where access permits could not be obtained, e.g., some privately owned islands. Male counts were made from small boats or from adjacent mainland coasts and included all adult males present within a 200-300 m zone around known or potential breeding sites (islands, islets, peninsulas). In 2020, male counts were also performed from a twin-engine aircraft flying at an altitude of 250 feet to cover some larger archipelago areas in southern Denmark (parts of Sydfynske Øhav and Smålandsfarvandet). During all male counts, immature males and groups of males recorded at larger distances from the breeding sites were also counted separately but were not included in estimates of the breeding numbers. Male counts

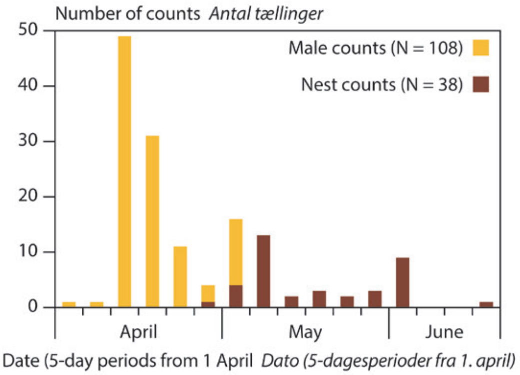


Fig. 2. The temporal distribution of Eider male counts and Eider nest counts for which we know the exact date of the count.
Den tidsmæssige fordeling af ederfuglehan-tællinger og ederfuglerede-tællinger, hvor vi kender datoen for tællingen.

were generally performed in April (or in early May).

A total of 226 sites were surveyed for breeding Eiders. Of these sites, 55 were covered only by male counts, 79 sites were covered only by nest counts, and 92 sites were covered by both nest and male counts. The numbers of breeding Eiders were assessed but not systematically counted by local ornithologists at an additional 36 sites where Eiders were known to breed. Of 146 counts with records made on a specific date, 108 male counts were performed between 1 April and 5 May, with the majority (N = 80) conducted during 11-20 April (Fig. 2), nest counts (N = 38) were performed between 26 April and 9 June, with most (N = 17) collected during the period 1-10 May, while the majority of the remaining undated counts were conducted during April and May. The present survey included 38 sites that had not been covered in the 2010 survey. Of previously surveyed sites, 17 were not included during the 2020 survey. These sites were of low importance and probably did not host any breeding Eiders.

To obtain the most accurate estimate of the number of breeding Eiders we prioritised nest counts over male counts, and we selected the most plausible information when more counts were available from a given site. For sites covered by nest counts more than once in the same year, we used data collected in May, preferentially early May, because nest counts during the first three weeks of May provide the most accurate estimate of the number of breeding Eiders (Meltofte & Preuss 2012). For a few sites, the number of breeding Eiders was assessed from observations obtained from Birdlife Denmark's observation-database (DOFbasen) that included observations of females accompanying young. In each case, we assessed whether the recorded birds could come from other local breeding sites and hence not represent breeding birds from the focal site, and therefore some reported observations were not included in the population estimate. Some sites had not been surveyed with the specific purpose of counting Eider nests (or males on the water) but were targeted at other species of breeding birds and therefore the timing of visits to most of such sites was suboptimal for counting Eider nests or males on the water. Nevertheless, such counts were the best available information from those sites even though they could be considered as 'guestimates' and they were therefore included in the assessment of the size of the breeding population of Eiders in Denmark.

The numbers of males counted around breeding islands were converted to nest numbers by using a correction factor to adjust for an excess of non-paired adult males near breeding sites. The correction factor was obtained from the relationship between the number of males counted and the number of nests counted within the same season (in 2020 or 2021). Initial data inspection of the ratio between male numbers and nest numbers revealed large deviations at some sites. At some places male numbers far exceeded nest numbers, whereas at other sites nest numbers markedly exceeded male numbers. Since nest counts targeted breeding Eiders at sites where both nest counts and male counts were carried out, the number of nests was not corrected for overlooked nests in these locations. At some sites, the deviation in the ratio between the number of males present and the number of nests found could be explained by what appeared to be extensive non-breeding which is relatively common in Eiders (Öst *et al.* 2018). Thus, for a number of sites, observers reported that large numbers of females were present on the water near the breeding sites at a time during the spring season when the majority of adult females were expected to be incubating. At other sites, male numbers were unexpectedly low compared to the recorded numbers of nests, indicating that many males had moved elsewhere at the time of counting. In our attempt to calculate a conversion factor, we used data from 53 sites where the number of males exceeded the number of females counted on nests, with the exception of one extreme outlier location where 599 males and 36 nests had been recorded.

We found a significant linear relationship between male numbers and nest numbers ($F_{1,19}$ = 287.9, $p < 0.0001$, $R^2 = 0.849$) which indicated an average of 0.55 (95% CI: 0.48-0.61) nests per recorded male (Fig. 3). Hence the correction factor for the 2020 survey was lower than the factor calculated for the Eider count in 2010 (0.67) (Christensen & Bregnballe 2011). However, in the overall flyway population the proportion of females had decreased further since 2010 (Berg & Bregnballe 2020) resulting in an increasing surplus of males in the population. The lower estimate of 0.55 nests per male is thus in agreement with the overall development in the population sex ratio.

However, assessing the relationship between male and nest numbers from a linear approach may not provide the best fit because the number of males at the 53 different sites was not normally distributed. To cope with this heterogeneity, we also applied a LOG Link function to describe the relationship between male (x) and nest (y) numbers (also shown in Fig. 3). This approach also revealed a significant relationship between male and nest numbers described by the formula $y = 11.732e^{0.0065x}$ (Wald $\chi^2 = 3492.76$, $P < 0.0001$), with 95% CI for the estimate of the exponential parameter 0.0065 of 0.0063 and 0.0067. In the present estimate of the total Danish breeding population, we use the linear approach for comparison with previous estimates. However, the results of the LOG link approach will be compared to results obtained using the linear approach.

Since available techniques for surveying nests of breeding Eiders tend to underestimate true numbers, recorded nest numbers in previous surveys have been multiplied by a factor of 1.15-1.30 (Lyngs 2000, 2008). Given that counts on several islands (e.g., in the Sydfynske Øhav) were not specifically targeted at breeding Eiders, we therefore used a relatively large correction factor of 1.25. Further justification for using such a large correction factor is that a single count in the season misses the nesting birds that do not have eggs at the time of the count. This is especially pronounced for Eiders, which have a prolonged nesting period so that only about 50-70% of the females are incubating even at the peak of the incubation period (Meltofte & Preuss 2012). This type

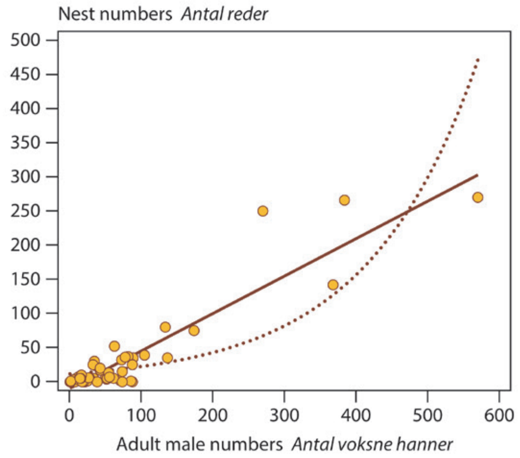


Fig. 3. Relationship between Eider nest numbers and numbers of adult Eider males at 53 breeding sites. Records were made within the same year, either in 2020 or 2021. The linear regression is shown as a line. The exponential relationship based on a LOG Link function is shown as a dotted line.
Forholdet mellem antallet af voksne ederfuglehanner og antallet af ederfuglereder registreret på 53 ynglelokaliteter. Hanner og reder blev talt inden for samme år, enten i 2020 eller 2021. Linjen viser den lineære regression. Den stiplede linje viser den eksponentielle tilpassede relation (LOG Link funktion).

of correction was applied to nest counts only. The fact that several counts were performed rather late in the breeding season (cf. Fig. 2), could induce a bias, but hatched and predated nests were also recorded and included in the colony totals. Predated and hatched nests are, however, more difficult to detect than nests with incubating females.

Based on the actual count results, we calculated the regional annual growth rates for the period 2010 to 2020 by taking into account the actual mean difference in time (years) between the majority of counts in each region. The national growth rate was calculated over a 10-year interval. Annual growth rates in percent were hence calculated as,

$$\left(\left(\frac{N_{2020}}{N_{2010}}\right)^{\frac{1}{Nyears}} - 1\right) * 100$$

where N_{2020} and N_{2010} are the count results in 2020 and 2010, respectively, and N_{years} is the mean number of years between actual counts in separate regions, varying between 8 and 11 years (cf. Tab. 2)

Results

During the 2020 survey, 12 487 nests were found (or estimated to have been present on islands where

Tab. 2. Estimated number of breeding Eiders (nest numbers) in different regions of Denmark in 1990 (counted in 1988-1993), 2000 (2000-2002), 2010 (2007-2010) and 2020 (2018-2022). The table also shows the average number of years between regional counts, and the regional and overall annual growth rates between surveys. The regions are defined in Fig. 1.
Det estimerede antal ynglende Ederfugle (antal reder) i forskellige regioner af Danmark i 1990 (baseret på tællinger udført i 1988-93), 2000 (2000-02), 2010 (2007-10) og 2020 (2018-22). Desuden vises det gennemsnitlige antal år mellem optællingerne og den årlige tilvækst (%). Afgrænsningen af regionerne fremgår af Fig. 1.

	No. of nests *Antal reder*				**No. of years** *Antal år*			**Growth rate (%)** *Væsktrate (%)*		
Region	**1990**	**2000**	**2010**	**2020**	**1990-2000**	**2000-2010**	**2010-2020**	**1990-2000**	**2000-2010**	**2010-2020**
Vadehavet	457	644	244	184	10	9	10	3.5	-10.2	-2.8
Limfjorden	2	25	113	695	11	9	11	25.8	-18.2	17.9
Kattegat	1 274	1 098	1 001	704	12	9	12	-1.2	-1.0	-2.9
Nordsjælland	925	1 615	1 700	2 448	9	10	8	6.4	0.5	4.7
Østjylland	4 412	2 220	2 461	1 708	11	8	9	-6.1	1.3	-4.0
Nordfyn	1 588	3 266	1 765	1 886	11	10	10	6.8	-6.0	0.7
Lillebælt	244	466	974	107	9	10	11	7.5	7.7	-18.2
Sydfynske Øhav	113	1 690	3 098	2 156	11	8	10	27.9	7.9	-3.6
Storebælt	2 321	1 936	1 997	851	10	9	9	-1.8	0.3	-9.0
Smålandshavet	1 092	931	767	309	11	9	11	-1.4	-2.1	-8.0
Nakskov Fjord	118	600	767	137	12	10	11	14.5	2.5	-14.5
Sydlolland	487	774	661	69	9	10	10	5.3	-1.6	-20.2
Øresund	7 160	4 770	4 787	1 479	10	8	11	-3.9	0.0	-10.1
Bornholm	3 000	2 503	1 850	1 115	8	10	11	-2.2	-3.0	-4.5
Total	23 193	22 538	22 185	13 848	10	10	10	-0.3	-0.2	-4.6

results from nest counts were used). For the sites where male counts were used to estimate numbers of breeding females, we estimated nest numbers to be 1361 (95% CI: 1188; 1509). This resulted in a total estimate of 13 848 nests of which 90.2% originated from nest counts and 9.8% from male counts. Nest counts were used for 65.3% of the 226 surveyed sites and male counts were used for another 21.0% of the sites. Numbers of nests present on the remaining 13.7% of the sites were assessed from other types of counts or estimates (e.g., during surveys targeting other species of breeding birds).

On a national scale, there were markedly fewer nests in 2020 than in 1990, 2000 and 2010 (Tab. 2). Overall, this decline corresponds to an annual decline in nest numbers of 4.6% during the last 10-year period calculated from the counted numbers. This rate of decline was markedly higher than during the period 1990-2000 (0.3% decline per year) and 2000-2010 (0.2% decline per year; Tab. 2). According to the survey, nest numbers declined in almost all parts of Denmark during the last decade. There was, however, large geographical variation in the estimated rate of change in nest numbers, which ranged from positive growth rates in two regions (Limfjorden and North Funen), to weak decline (annual growth rates from -2.8% to -4.5%) in five regions, and substantial declines (annual growth rates from -8.0 to -20.2%) in seven regions (Tab. 2). An overall pattern seems to be that positive growth or stable/slow declines took place in the north (Limfjorden), west (Vadehavet) and central parts (N Fyn, N Sjælland) of Denmark, while the most severe declines occurred in southern and eastern regions comprising the Baltic Sea (Smålandsfarvandet, Nakskov Fjord and Sydlolland) and the belt-areas (Lillebælt, Storebælt and Øresund).

The geographical distribution of counted and estimated nest numbers at the 226 sites covered in the 2020 survey is shown in Fig. 4. Development in nest numbers at the individual breeding sites is given in Appendix 1 covering the four surveys conducted since 1990. Among the larger colonies, the most marked decline occurred on Saltholm in Øresund, where the estimated number of nests fell from 4351 in 2008 to 1365 in 2021, i.e., a decline of almost 3000 breeding pairs since 2008 corresponding to a decline

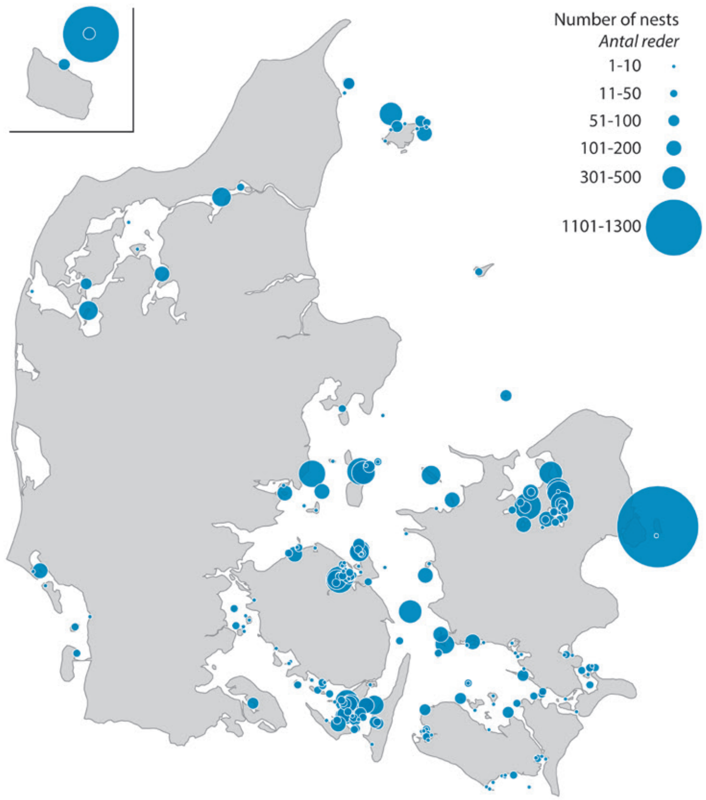


Fig. 4. Distribution of breeding Eiders in Denmark around 2020. The circle size is proportional to the number of counted or estimated nests, but not all circle sizes are shown in the legend.
Geografisk udbredelse af ynglende Ederfugl i Danmark omkring 2020. Cirklernes størrelse er proportionale til det estimerede eller talte antal reder, men antallet er ikke angivet for alle størrelser af cirkler anvendt på kortet.

of 8.5% per year. Saltholm still has the largest Danish Eider colony, but the recorded decline in this one colony corresponds to 37.5% of the national decline of 8000 pairs over the last decade.

By correcting for presumed overlooked nests and late breeders (by multiplying by the factor 1.25), the total number of breeding Eiders in Denmark in 2020 was estimated at 17 021 pairs (see further in the Discussion). When the statistical uncertainty of male counts is included, the confidence intervals of this figure range between 16 848 and 17 169. Thus, we estimate that the total Danish breeding population of Eiders in 2020 lies between 16 500 and 17 500 pairs (Tab. 3). This is markedly lower than the 24 500-25 500 pairs estimated in 2010 (Tab. 3). The decline in the overall breeding population of Eiders between 2010 and 2020 (here defined as estimated nest numbers) corresponds to a decline of 31.9% (4.6% per year).

Discussion

The 2020 survey of breeding Eiders on the basis of both nest and male counts revealed a total of 13 848 breeding pairs recorded throughout the coastal areas in Denmark. With a conservative correction for unrecorded nests, this number increased to an estimate of 17 000 pairs (range: 16 500-17 500 pairs). Compared to the relatively stable population of c. 23 000-25 500 breeding pairs estimated in previous national surveys in 1990, 2000 and 2010, the population has declined by c. 32% over the past decade.

In our estimate of the total breeding population of Eiders, we used a factor of 1.25 to correct for overlooked nests during the survey and to adjust for late breeders that had not initiated egg-laying at the time of the surveys. The value of 1.25 is a conservative approach that most probably underestimates that actual number of females that laid eggs. It was found in an earlier long-term study at three important Danish breeding islets that only about 60% of all the clutches initiated within a season were recorded

Year *År*	**Population size** *Bestandsstørrelse*	**Annual growth rate (%)** *Årlig tilvækst (%)*	**Source** *Kilde*
1935	1 200-1 500		Spärk (1936), Joensen (1973)
1960	3 000-3 500	3.5-3.7	Paludan (1962), Joensen (1973)
1970	7 500	7.9-9.6	Joensen (1973)
1980	19 000-20 000	9.7-10.3	Franzmann (1989)
1990	23 000-25 000	2.3-2.8	Lyngs (2000)
2000	23 000-25 000	-0.3	Lyngs (2008)
2010	24 500-25 500	-0.2	Christensen & Bregnballe (2011)
2020	16 500-17 500	-4.6	This study

Tab. 3. Population size of breeding Eiders (nests) and annual growth rates in Denmark 1935-2020. *Bestandsstørrelse af Ederfugl i Danmark 1935-2020 (ynglende hunner) samt den årlige tilvækst.*

when colonies were visited only once around the time when most females were actively incubating eggs (Meltofte & Preuss 2012). To ensure comparability with earlier national surveys in terms of relative change in population size (cf. Christensen & Bregnballe 2011), we decided to use the conversion factor of 1.25, although, the total number of initiated clutches is very likely to have been higher. As stated in the methods section, estimates of nests numbers from male counts are based on a linear relationship between male numbers and nest numbers, which may not fit the data as appropriately as a LOG Link function. For the 53 sites where nest numbers were calculated from male counts, the linear correction revealed a total of 1361 nests, while the LOG Link correction gave 933 nests. Thus, using this difference of c. 400 nests, the LOG Link correction resulted in a total number of counted nests of 13 420 and an estimated total population size of 16 593 (range: 16 578-16 628), indicating that the linear correction slightly overestimated population size. However, though the LOG Link correction is probably a better predictor of the relationship between male numbers and nest numbers, and should be used in coming surveys, the magnitude of difference between the two methods most probably lies within the limits of uncertainty expected in this kind of survey.

Given that we have conducted instantaneous censuses of breeding numbers in individual colonies at 10-year intervals, confidence in assessing real long-term changes can be subtle, in particular if a count takes place in a year with an abnormally high frequency of intermittent breeding (cf. Coulson 2010, Öst *et al.* 2018). In this survey we are not able to judge whether individual breeding sites were covered in abnormal or normal years. However, the number of Eiders recorded breeding at sites from where annual or almost annual census information is available does not indicate that the year(s) included in the present survey were abnormal. For some sites, however, we certainly did observe an unexpectedly large number of females on the water off the coast of the area where females were nesting (for further discussion of this observation, see below).

In the 2020 survey, male counts were used more frequently (53 sites) than in 2000 (six sites in the Wadden Sea; Lyngs 2008) and 2010 (49 sites; Christensen & Bregnballe 2011). Increased coverage through the use of male counts may potentially lead to an overestimation of actual nest numbers because males may be attending females that are abstaining from breeding due to inadequate body condition or presence of mammalian predators on the breeding islands. Hence, breeding numbers estimated from male counts are less sensitive to the occurrence of the potential non-breeding among females. Years of extensive non-breeding among Eiders have been recorded in Great Britain (Coulson 1984) as well as in Denmark (about 20% of the females at the Saltholm colony did not breed in 1994; Noer & Christensen 1994) and probably occurs regularly on an individual basis without having marked consequences for the development of the population given the longevity of Eiders. The male counts conducted in the 2020 survey were used for estimating nest numbers for 21.0% of the sites covered and contributed 9.8% to the overall estimate of nests in the country. Consequently, the uncertainty linked to the use of male counts cannot have had a large impact on the estimated total number of active nests.

There were indications as mentioned above that non-breeding was more frequent in the 2020 survey than in the previous surveys. For a number of sites, high numbers of females were recorded on the water near to islands where low numbers of nests were found compared to earlier years. These females were often in groups with males. One obvious explanation for the occurrence of non-breeding may relate to predators. As already mentioned, presence of predators on a preferred nesting island can induce females to postpone the onset of breeding, to move to other breeding islets, or even to skip breeding (Mehlum 1991, Bregnballe *et al.* 2002, Meltofte & Preuss 2012, Öst *et al.* 2018). In Denmark, the red fox is the main mammalian predator affecting the attractiveness of breeding islands to Eiders, and there are many examples of low nest numbers on attractive nesting islands in years where foxes had settled, e.g., following a winter with extensive ice cover (Bregnballe 1993, Meltofte & Preuss 2012). For example, on the island of Rønø in Isefjord nest numbers declined from 279 in 2007 to 93 in 2010 after foxes reached the island (Christensen & Bregnballe 2011). Eiders experiencing the presence of one or more foxes on their preferred breeding island will normally attempt to breed on a nearby island (Mehlum 1991, Meltofte & Preuss 2012), but some are also likely to skip breeding if no obvious alternative fox-free breeding sites nearby are available (Öst *et al.* 2018). For the islands used by breeding Eiders in Denmark, it is often very difficult for observers to detect if a fox (or other mammalian predator) has been present earlier in the spring or is present in the area on the day of the count because mammalian predators as well as signs of their presence can easily be overlooked. Therefore it was not a surprise that fairly few observers were able to confidently assess presence or absence of foxes and/or mustelid predators. However, in several breeding colonies brown rats were observed to be present (see Appendix 1). Records of rats during the previous Eider surveys were relatively infrequent and local. However, in the 2020 survey the proportion of islands with rats had markedly increased, and at several of these sites, rats were present in high numbers. The impact of rats on breeding Eiders is poorly documented, but rats in high numbers may stress Eider females during nest establishment and during incubation, and the rodents may potentially be a predator of eggs and females (Jones *et al.* 2008).

Another potential stressor and predator that could prevent Eiders from breeding is the White-tailed Eagle *Haliaeetus albicilla*. The White-tailed Eagle has increased considerably in numbers during the last decades, both in Denmark (Skelmose & Larsen 2023) and in all of the Baltic area (Stjernberg *et al.* 2015). White-tailed Eagles may stress Eiders during the pre-nesting foraging period, during egg-laying and during incubation, potentially resulting in breeding abstention (Öst *et al.* 2018). In the Baltic Sea area, reports of predation by White-tailed Eagles on incubating female Eiders and on both eggs and newly hatched ducklings have increased in recent years (Kilpi & Öst 2002, Öst *et al.* 2018). Indirectly, the presence of eagles may likewise lead to a higher predation by gulls on Eider eggs which may be left exposed when Eiders are scared away by eagle predation attempts. Consequently, the White-tailed Eagle is presently considered to be a significant factor in relation to the continuing population decline in the Baltic population of Eiders (Ekroos *et al.* 2012b, Öst *et al.* 2018, Morelli *et al.* 2021). During the years of the present survey, White-tailed Eagles were observed in or close to several of the surveyed Eider colonies. The highest number of eagles observed was 28 at Saltholm in Øresund. During the survey on this island, which had 1365 nests, several Eider carcasses were found with marks in the breastbone typical for an avian raptor, indicating that White-tailed Eagles were successfully predating nesting Eiders. During the nest count on Egholm island in Storebælt, we observed how one of the locally breeding White-tailed Eagles flew low over the nesting area of the Eiders and caught an incubating Eider female (such predation was a daily occurrence according to the landowner, H. Madsen pers. comm.). We have records of eagle-predated carcasses of female Eiders from nine of the islands visited during the survey.

A general increase in the presence of predators such as rats and White-tailed Eagles may explain some of the potential non-breeding among female Eiders observed in the 2020 survey. However, Eiders may also abstain from breeding if they are unable to attain an adequate body condition for producing eggs and sustaining the 26-day long incubation period during which Eider females do not normally feed (Ma *et al.* 2020, Tertitski *et al.* 2021). Ongoing studies indicate that the nutritional quality of their main prey, the blue mussel *Mytilus spp.*, has declined in Danish waters compared to the 1970's and 1980's (apparently due to improved water quality and higher water temperatures (cf. Waldeck & Larsson 2013), which has limited the ability of females to

Den danske ynglebestand af Ederfugle er faldet med omkring en tredjedel i løbet af 2010erne, hvilket formentlig skyldes en kombination af dårligere fødekvalitet (muslinger), sygdomsudbrud (fuglekolera), lavere ynglesucces, øget forstyrrelse og prædation af især rugende hunner og ællinger fra bl.a. Havørne. Foto: Peter Lyngs.

build up the body resources required for successful breeding (Laursen & Møller 2014). We find it likely that poor foraging conditions have significantly contributed to what appears to have been widespread non-breeding during the recent survey.

If our assessment is correct that the frequency of intermittent breeding has increased (possibly due to increased occurrence of predators and declining foraging conditions during pre-laying), the number of adult female Eiders in the population that potentially could have nested is higher than the 17 000 females estimated to have initiated a nest and laid eggs. By primarily using the results from the count of nests rather than counts of males, we did not include females that either skipped breeding or postponed their onset of egg-laying until late in the breeding season (i.e., until after we and the other observers had conducted the search for nests). Therefore, a potentially increased segment of non-breeding females in the Danish Eider population remains unrecorded in this study. However, a continuously high frequency of intermittent breeding would result in lower reproductive output over time and thus contribute to continued population decline (cf. Öst *et al.* 2018). At present we find it unlikely that the observed indications of extensive non-breeding during the years of the 2020 survey can explain all of the recorded decline in nest numbers. The lower number of breeders in 2020 is probably to a large extent linked to low female survival in preceding years combined with a decline in recruitment of young female breeders. There is little doubt that the mortality of adult females has increased in some colonies due to increased predation by White-tailed Eagles, but we do not find it very likely that the mortality of adult females has increased due to declining accessibility or quality of food. However, poor condition of some females is likely to have contributed to reduced fecundity, i.e., lower production of young per adult female in the Danish Eider population. Although clutch size data were not collected systematically, it was noted that clutch sizes were small in many colonies. Thus, more systematic records of the annual magnitude of non-breeding as well as of clutch sizes and hatching success would be highly valuable in order to monitor indices of the breeding condition and fecundity of nesting Eider females.

Historically, the Danish breeding population increased considerably during the 20th century before reaching a level of c. 25 000 breeding pairs during the period 1990-2010 (cf. Tab. 3). The stability of breeding numbers in Denmark between 1990 and 2010 contrasts with the overall trend observed in the Baltic/Wadden Sea flyway population, where numbers declined by about 36-48% between the mid-1990s and 2010 (Desholm *et al.* 2002, Ekroos *et al.* 2012a). However, the recent decline recorded in the current Danish study indicates that development in the Danish population segment now is comparable to the negative development in the overall flyway population.

The long-term population decline in the overall flyway is generally considered to have a multifactorial explanation that may include outbreaks of avian cholera, overfishing of mussels, lower food quality, hunting and increased predation as well as increased parasite burden, incidences of viral infections and contamination with varying pollutants, which directly and indirectly may affect reproductive output and adult female survival (Hollmén *et al.* 2002, Tjørnløv *et al.* 2013, 2020, Laursen & Møller 2014, Lam *et al.* 2020, Sonne *et al.* 2020). Hence, in understanding the reasons for the general population decline, future focus should target identification of the causes behind a) non-breeding, b) reduced female survival during the breeding period, and c) low reproductive success. Furthermore, we find it relevant to study the direct and indirect effects of Eider predators in the breeding areas.

In the Baltic/Wadden Sea flyway population of Eiders, hunting at a larger scale mainly takes place in Denmark and Finland (Hirschfeld & Heyd 2005). Hence, Eider female hunting mortality should be considered in relation to population development because hunting mortality currently is additive to natural mortality. However, with reference to the population decline, hunting has been adjusted by closing the open season for female Eiders in Denmark (since 2014) and in Finland (since 2019). Consequently, the direct effect of hunting in recent years has only affected males, and as the ratio of males to females has increased since the 1990s from 60:40 to 75:25 (Lehikoinen *et al.* 2008, Berg & Bregnballe 2020), hunters have harvested from a surplus of males in the population. Christensen & Hounisen (2014) showed that the gradual introduction of a hunting ban on females in Denmark theoretically would result in a positive population development. In their analysis, the level of natural mortality was considered stable, but Tjørnløv *et al.* (2019) argued on the basis of a more detailed flyway-based analysis that the Eider population despite the ban on hunting females would most likely continue to decline as a result of increased natural mortality in recent years. It has been shown that hunting can displace Eiders from attractive foraging grounds (Laursen & Frikke 2008) but also that Eiders may change group size to mitigate the disturbance caused by hunting (Laursen *et al*. 2016). Likewise, it has been argued that hunting disturbance potentially may impact Eider mortality as well as the reproductive success of females. In an acknowledgement of the need for disturbance free areas, hunting of Eiders has been banned in relevant SPA's (Natura 2000 sites) in Denmark since 2022. However, the consequences of hunting of Eiders, such as displacement and general disturbance of the population in terms of distress and ultimate effects on demographic parameters, remain to be investigated in detail.

The overall long term population decline has led to classification of Eiders in the Baltic/Wadden Sea flyway as 'near threatened' under the African-Eurasian Migratory Waterfowl Agreement (AEWA). Continued hunting is therefore contingent on the adoption of a Single Species Action Plan (ISSAP) that implements the principles of adaptive harvest management. In September 2022, an ISSAP for the Common Eider was adopted at the 8th Meeting of the Parties to AEWA (Lehikoinen *et al.* 2022). A technical group will now discuss and finalize an adaptive harvest management programme (AHMP) aimed at balancing hunting exploitation with a viable flyway population size for the period 2023-2032.

In conclusion, the 2020 census of the Danish breeding population of Eiders indicates a marked decline of 32% over the past decade. This development now is similar to the decline estimated for the Baltic segment of this flyway population as recorded over the last 20-25 years. Development of Eider populations is very sensitive to changes in mortality among adult females. The emerging pressure from a predator such as the White-tailed Eagle, which directly kills adult females and indirectly affects reproduction, may possibly be the single most important factor that already has affected and will continue to affect the development of the breeding population of Eiders in

Denmark and in many other parts of the Baltic area in the years to come.

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Resumé

Status over den danske ynglebestand af Ederfugl 2020

Denne artikel beskriver resultaterne af den landsdækkende optælling af ynglende Ederfugle i 2020. Af praktiske grunde og pga. Covd19-udbruddet indgår der optællinger fra 2016 (en lokalitet) og 2018-22 (Tab. 1). Som i den landsdækkende tælling i 2010 blev der anvendt både optællinger af reder og optællinger af hanner ved yngleøerne. Optællingen refererer til 14 regionale områder (Fig. 1). Af de i alt 226 lokaliteter, som blev dækket, blev 171 lokaliteter (omfattende 90,2 % af de optalte ynglepar) dækket ved optælling af reder og rugende hunner, mens 55 lokaliteter (9,8 % af de optalte ynglepar) blev dækket ved tælling af voksne hanner nær ynglekolonierne. På 92 af de 171 optalte lokaliteter blev der gennemført tællinger af både reder og hanner. Den tidsmæssige fordeling af 146 daterede optællinger opdelt på rede- og han-tællinger er vist i Fig. 2.

For de lokaliteter, hvor der alene blev gennemført en tælling af hanner, blev antallet af reder estimeret ud fra antallet af hanner, der opholdt sig på vandet nær yngleøen. Omregningen fra hanner til reder blev baseret på en korrelation mellem antal reder og antal hanner på 53 lokaliteter, hvor der blev optalt både reder og hanner i det samme år (Fig. 3). Ud fra disse tællinger blev det beregnet, at der var 0,55 rede pr. han. Denne konverteringsfaktor er lavere end den tilsvarende faktor på 0,67 reder pr. han beregnet i 2010. Relevansen af at omregne til et lavere antal reder pr. han bekræftes af den generelle demografiske udvikling i bestanden, hvor en kraftigere tilbagegang i bestanden af hunner har medført et stigende overskud af hanner (se fx Berg & Bregnballe 2020).

Baseres beregningen af konverteringsfaktoren på en poisson-baseret model (LOG Link funktion, se Fig. 3), som reelt bedre beskriver data, falder det estimerede antal reder for de 53 lokaliteter, hvor der kun er udført han-tællinger, fra 1361 til 933. Den simple omregning, som er anvendt i denne og i tidligere bestandsopgørelser, overestimerer derfor sandsynligvis den samlede bestandsstørrelse. Det vurderes dog, at en forskel på ca. 400 individer ligger indenfor den usikkerhed, der kan forventes med de aktuelle data.

Resultaterne fra tællingerne i de enkelte kolonier er givet i Appendiks 1. Den geografiske fordeling af de ynglende Ederfugle er vist i Fig. 4. Det samlede antal reder (ynglende hunner) blev opgjort til 13 848 (Tab. 2). Efter korrektion for usikkerheder forbundet med de anvendte metoder og utilstrækkelig dækning af visse lokaliteter anslår vi ynglebestanden i Danmark til 16 500-17 500 rugende hunner i 2020. Ved en mangeårig undersøgelse på Rågø i Smålandsfarvandet viste det sig imidlertid, at kun omkring 50-70 % af alle de ægkuld, der blev påbegyndt inden for en sæson, blev registreret ved enkeltbesøg i kolonien, selv når besøget fandt sted omkring det tidspunkt, hvor de fleste hunner rugede (Meltofte & Preuss 2012). Så sandsynligvis har det reelle antal ynglende hunner i Danmark omkring 2020 været en del højere.

I perioden fra 1990 til 2010 lå den samlede ynglebestand i Danmark på et stabilt niveau med en estimeret bestand på 23 000-25 500 rugende hunner (Tab. 3). Ifølge nærværende opgørelse er bestanden faldet med 32 % over de seneste 10 år, svarende til en årlig tilbagegang på 3,8 %. Tilbagegangen ses mest markant i det sydlige Danmark ved Østersøen og i Bælterne (Det Sydfynske Øhav, Smålandsfarvandet, Sydlolland, Nakskov Fjord, Lillebælt, Storebælt og Øresund), mens der kun ses mindre frem- og tilbagegange eller stabile tal i områder i Vadehavet og Kattegat (Nordfyn, Nordsjælland, Vadehavet; Tab. 2). I Limfjorden steg antallet fra 113 par i 2010 til ca. 700 par i 2020. Trods en stor tilbagegang fra 4351 reder i 2008 til 1365 reder i 2021 er Saltholm stadig Danmarks største ederfuglekoloni.

Ved optællingen i 2020 blev der på flere lokaliteter registreret færre reder end forventet, samtidig med at der på vandet ud for yngleøerne kunne registreres mange hunner, ofte i selskab med hanner. Disse observationer indikerer, at en betydelig del af bestandens ellers yngledygtige hunner

undlod at yngle. Det er kendt, at ederfuglehunner kan springe en ynglesæson over, hvis de er i for dårlig kondition til at gennemføre et yngleforsøg (Coulson 1984), eller der er ræv på den ø, hvor de plejer at yngle, og der ikke findes en egnet alternativ ø i nærheden. Efter vores vurdering kan de observerede forekomster af ikke-ynglende Ederfugle under 2020-tællingen imidlertid ikke alene forklare den betydelige nedgang i antallet af fundne reder.

De danske ynglefugle tilhører den flywaybestand af Ederfugle, der omfatter yngleområderne omkring Østersøen, de indre danske farvande, Vestsverige, Sydnorge samt hele vadehavskysten og videre ned til og med kysten af Bretagne (Lehikoinen *et al.* 2022). Den registrerede tilbagegang i de danske yngleområder er nu sammenlignelig med den tilbagegang på ca. 35 %, der siden 1990erne er registreret i den samlede flyway. En række undersøgelser har vist, at der er flere årsager til tilbagegangen, herunder dårligere fødekvalitet (muslinger), sygdomsudbrud (fuglekolera), lavere ynglesucces, øget forstyrrelse og prædation af især rugende hunner og ællinger. Ifølge nyere analyser er det først og fremmest faktorer, der opererer i yngleområderne, som har været bestemmende for den observerede udvikling i flywaybestanden. Vi vurderer, at dette også gælder for den del af bestanden, der yngler herhjemme. Som noget nyt har vi under 2020-moniteringen konstateret, at det nu flere steder i landet forekommer, at Havørne præderer hunner, der ligger på rede. Omfattende prædation af rugende ederfuglehunner har fundet sted gennem flere år i bl.a. Finland.

Den direkte effekt af jagt har formentlig nu en marginal betydning for udviklingen i den danske ederfuglebestand og i flywaybestanden. I Danmark har det således ikke været tilladt at jage hunner af Ederfugl siden 2014/15, og et tilsvarende forbud har været gældende i Finland siden 2019 (i disse to lande er det fortsat tilladt at udøve jagt på ederfuglehanner). Selvom omfanget af motorbådsjagt i danske farvande har været for nedadgående gennem en længere årrække (I. H. Sørensen pers. medd.), kan det ikke udelukkes, at motorbådsjagt visse steder fortsat forårsager forstyrrelser, som påvirker hunnernes muligheder for at nå en optimal kondition inden æglægning. Jagt på Ederfugl har siden efteråret 2022 været forbudt i de Natura 2000-områder, hvor arten er på udpegningsgrundlaget.

Ederfuglen er nu globalt kategoriseret som Nær Truet og som Sårbar i EU- og i IUCN-rødlisterne. Under vandfugleaftalen (AEWA) er den flyway af Ederfugle, som vores ynglefugle tilhører, listet som A4, hvilket betyder, at den jagtligt ikke bør udnyttes før der foreligger en international forvaltningsplan, som er baseret på adaptive forvaltningsprincipper. I september 2022 blev en international forvaltningsplan, gældende for perioden 2023-32, ratificeret på AEWA's 8th Meeting of the Parties, og arbejdet med en plan for adaptiv jagtforvaltning er nu påbegyndt. Forvaltningen af Ederfugl i de kommende år skal på baggrund af disse planer sikre, at en eventuel jagtlig udnyttelse af arten ikke bidrager til yderligere tilbagegang i bestanden.

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Appendix 1: https://pub.dof.dk/link/2024/1.appendix1

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