Annual October/November Razorbill aggregations off Northeast Djursland, Denmark

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(Med et dansk resumé: Årlige oktober/november-forekomster af Alke ved Nordøst-Djursland)

Abstract We looked for historical evidence of regular annual aggregations of thousands of Razorbills *Alca torda* along the northeast coast of Djursland, Denmark between mid-October and late December, based on reports submitted to DOFbasen from 1990 to 2021. Annual numbers peaked regularly during 16 October-16 November, although smaller numbers persisted until April after winter 2019/2020. Annual maxima ranged between 1600 (2010) and 110 000 (1990) reported on a single day, with no clear trend in annual maxima over the period. Birds were most abundant (largely reported flying) off Gjerrild Nordstrand and Fornæs mid-morning, likely due to birds relocating due to diurnal changes in food availability or possibly repositioning after drifting away from food resources with the wind or on currents overnight. Dense Razorbill feeding aggregations often attracted large numbers of foraging Northern Gannets *Morus bassanus*, Great Cormorants *Phalacrocorax carbo* and gulls (predominantly Herring Gull *Larus argentatus*), implying a major prey resource available to multiple species. Although lacking direct evidence, we speculate that shoaling sprats *Sprattus sprattus*, known to move to upper warm sea layers and attain their highest lipid content in October, may be responsible for this phenomenon, supported by fishery landings of this species caught in the area at the same time of year. Daily sprat movement into deeper water after sunrise also may explain the diurnal movements seen among Razorbills relocating midmorning. DOFbasen data suggest other such Razorbill concentrations elsewhere in Danish waters in areas also known for dense schools of sprat based on landings of sprats from human fishery exploitation at this time of year. We recommend aerial surveys of Razorbills in late October and November in Danish waters to determine the true abundance and distribution of Razorbills at key sites at this time in relation to available fish stocks to protect the species and to better explain the reasons for such high feeding densities during a relatively short period.

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Introduction

Relatively little is known about the distribution of auks in Danish waters outside of the breeding season (but see Skov *et al.* 1995 and Laursen *et al.* 1997). The eastern North Sea, Skagerrak and Kattegat have been reported as being of considerable wintering importance for up to 300 000 Common Guillemots *Uria aalge* and 400 000 Razorbills *Alca torda* in the past, although contemporary numbers may be somewhat lower (Blake *et al.* 1986, Lyngs 2002, Petersen & Nielsen 2011). The first description of migrating Alcids from Djursland (see Fig. 1) is from the late 1960s (Hove-Jensen 1968), while Danielsen (1970) reported 99.4% of all individuals observed during a special survey in winter 1968-1969 came from Fornæs (although he stressed that this did not mean that the southern part of Kattegat is the location of the largest overwintering numbers in Denmark).

How these birds distribute themselves in autumn and winter and where particular concentrations occur in response to food resources have almost never been studied, yet these areas are potentially of critical importance in the annual life cycle of the birds as 'survival habitats' (*sensu* Alerstam & Högstedt 1982) between breeding seasons, and therefore potentially of great significance for their effective conservation.

Auks are rapid pursuit piscivorous species and therefore any large dense concentrations can only be explained by the presence of large available aggregations of their typically densely schooling fish prey species and a low risk of predation to densely packed foraging birds (Fauchald 2009). In the Baltic and North Seas, Guillemots and Razorbills mainly rely on three fish families for much of their prey: Ammodytidae (sand eel *Ammodytes marinus*), Clupeidae (herring *Clupea harengus*, sprat *Sprattus sprattus*) and Gadidae (cod *Gadus morhua*, haddock *Gadus aeglefinus*, whiting *Merlangius merlangus*, saithe *Pollachius virens* and Norway pout *Trisopterus esmarkii*). Razorbills tend to exploit fish of slightly lower trophic levels than Guillemots (Swennen & Duiven 1977, Blake 1984, Blake *et al.* 1985, Durink *et al.* 1991, Glew *et al.* 2018). However, herrings, sprats and sand eels are especially favoured and figure predominantly in dietary studies of both auk species, being small, schooling fish of high lipid content (i.e. high energy value; Tasker & Furness 1996, Ouwehand *et al.* 2004). Hence, at key points in the annual life cycle, these fish of appropriate age/size class gather in high local abundance and offer attractive aggregations of prey to foraging auks, a feature that contributes to the ecological success of these highly geographically mobile (outside of the breeding season) piscivores.

Studies have shown that the relative diet composition of fish prey among Guillemots and Razorbills reflects their local abundance in time and space, which may vary from year to year at the same locality (e.g. Blake *et al.* 1985, Barrett & Krasnov 1996, Tasker & Furness 1996, Lorentsen & Anker-Nielsen 1999, Rowe *et al.* 2000). Sprats in particular can constitute a major constituent of the diet of young Guillemots at many Atlantic colonies (e.g. Hatchwell *et al.* 1992), to the extent that Guillemot productivity and chick mass at fledging in Baltic colonies was correlated with local annual sprat condition (Lyngs & Durink 1998, Österblom *et al.* 2006, Kadin *et al.* 2012, Hentati-Sundberg *et al.* 2018). Razorbills tend to feed their young more sand eels (e.g. Barrett 2003). Guillemots and Razorbills are obligate central place foragers during the nesting season, bound to the close proximity of a safe nesting site with predictable aggregations of small energy-dense fish in waters close by (Harris & Wanless 1986).

Outside the breeding season, Guillemots and Razorbills are truly pelagic, dispersing far from breeding colony locations (e.g. Harris & Swann 2002, Merne 2002) during which time they are also likely to show aggregative responses to locally abundant sources of food. For instance, both species showed large-scale associations with herring abundance in Skagerrak-Kattegat in February (Skov *et al.* 2000). But just how persistent are locally dense aggregations of auks in the non-breeding season, is their timing consistent across a series of years and what might be the feeding conditions that precipitate these concentrations?

There are relatively few reports of major aggregations of Guillemots and Razorbills in inshore coastal waters not associated with storm wrecks and the stranding of birds locally, resulting from oiling incidents (e.g. Jones *et al.* 1970, Baillie & Mead 1982) or other causes of mass deaths (Blake 1984, Harris & Bailey 1992, Mudge *et al.* 1992). However, Christensen *et al.* (2022) mention a flock of 120 500 Razorbills off Fornæs on the east coast of Djursland on 3 December 1989, an area well-known for large gatherings of birds from October onwards. Likewise, Laursen *et al.* (1997) mapped an area of high Razorbill densities encountered north and north-eastwards from Djursland based on ship-based surveys in October-November of 1987 and 1989.

In this contribution, we use data from a citizen science portal to attempt to better describe the knowledge of local birdwatchers of a regular major aggregation of Razorbills in shallow (< 10 m deep) coastal Kattegat waters off Northeast Djursland in Denmark. Specifically, we seek to use observational data from

DOFbasen (the Danish Ornithological Society's bird record portal https://dofbasen.dk) to show that the species has aggregated annually in the stretch of water between Bønnerup Havn (56°32'N, 10°42'E) and Havknude (south of Grenå, 56°20'N, 10°54'E) in Northeast Djursland from 1990 to the present (see Fig. 1). We also attempt to establish the consistency of the seasonal timing of such gatherings as well as speculating over the potential cause of this phenomenon.

Methods

Based on recent observations of up to 27 600 (October 2020) and 18 840 (October 2021) Razorbills reported to DOFbasen from inshore waters off Northeast Djursland, we extracted raw data from DOFbasen to determine the historical size, extent and timing of such gatherings in previous years. Based on anecdotal information, we restricted our area of search to 17 defined sections of the coastline of Northeast Djursland between Bønnerup Havn and Havknude (Fig. 1 and Tab. 1); these polygons define the borders of contiguous pre-defined reporting sites in the bird recording system of DOFbasen. We extracted all records of observations of more than five individuals of all Alcid species ('alkefugle') from 1 January 1990 until 31 December 2021 inclusive using the normal search functions, which generated 2411 observations of 2 225 608 birds. We then removed all records of Atlantic Puffin *Fratercula arctica* (one record of five individuals), Little Auk *Alle alle* (typically migrating or storm wrecked individuals; 60 observations of 1537 birds) and Black Guillemot *Cephus grylle* (a breeding species in the area, which also winters locally in numbers rarely exceeding 50 individuals; 374 observations of 3442 birds). None of these species contributed in significant numbers to the major auk aggregations late in the calendar year, which consisted predominantly of Razorbills, with occasional reports of Little Auk and Black Guillemot.

We also removed all Guillemot records (194 counts of 2972 birds) because they contributed relatively little to overall numbers but took the arbitrary decision to retain all reports of unidentified Alcinae ('alkefugl sp.'; 67 reports of 133 744 individuals) and reports of unidentified Guillemot/Razorbill ('Lomvie/Alk'; 163 reports of 92 002 individuals). We took this decision on the assumption that these latter two groups comprised reports of large auk aggregations, where observers were unwilling to assign all flock members with confidence to species, but which were, given the timing of the reports (see below), likely predominantly Razorbills (often qualified in the comments section of reports). This left 1783 auk observations of 2 217 652 individuals in the database distributed between the count units listed in Tab. 1, which we have used as the basis for the analyses presented here. Note that there were no records from 1993 and only two and five observations reported from 1994 and 1995, respectively, so these years provide far less detailed information than in other years.

Since DOFbasen only formally went online in 2002 nationally (although local versions had existed previously and earlier records were and are still entered retrospectively to a limited and variable degree by particularly keen observers), the years since that year inevi-

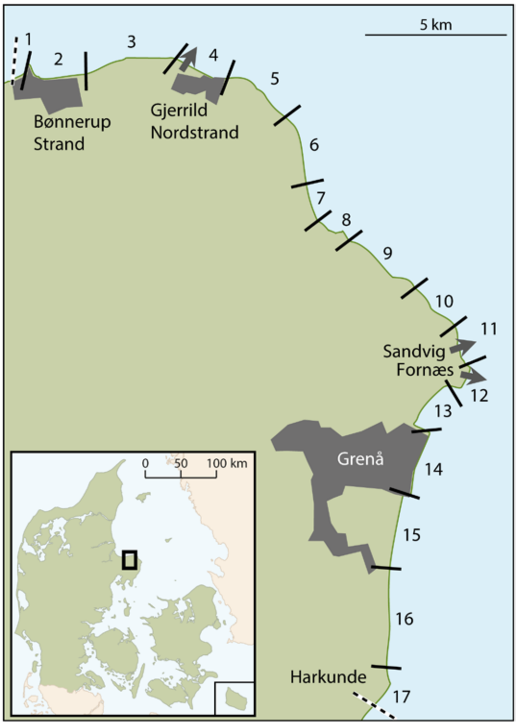

Fig. 1. Map showing location of the north-east Djursland coast study area on map of Denmark (inset) and the numbered stretches of coastline (see Tab. 1 for details) corresponding to the predefined DOFbasen sites used in the study (main map). The pale green areas denote the mainland (on which grey shaded areas represent major urban areas) and the blue areas denote the sea. Arrows and site names indicate sites subject to regular sea-watching counts and/or are sites mentioned in the text.

Placeringen af undersøgelsesområdet udfor det nordøstlige Djursland. De nummererede kyststrækninger henviser til afgrænsningen af de enkelte DOFbaselokaliteter (se Tab. 1 for detaljer). Pile og stednavne angiver lokaliteter, hvor der foretages regelmæssige fugletællinger og/eller steder, som er nævnt i teksten. De grå områder på Djursland viser udbredelsen af større byområder.

Tab. 1. List of predefined DOFbasen sites from which data on all Alcids ('Alkefugle') observations from 1 January 1990 to 31 December 2021 inclusive were downloaded. Site numbers indicate the stretches of coastline identified in Fig. 1. Note the unevenness of coverage in years and numbers of observers, Ålebugt, Grenå Strand and Katholm coast were included for completeness, but did not yield any counts of Razorbills/unidentified auks.
Liste over prædefinerede DOFbaselokaliteter hvorfra alle observationer af alle 'alkefugle' fra perioden 1. januar 1990 til og med 31. december 2021 blev downloadet. Lokalitetsnumre angiver de kyststrækninger, der er identificeret i Fig. 1. Bemærk ujævnheden i dækningen fra år til år og antallet af observatører. Ålebugt, Grenå Strand og Katholms kyst er inkluderet for fuldstændighedens skyld, men bidrog ikke med tællinger af Alke/alkefugle.

Site no. and name *Lokalitets nr. og navn*		**Number of records** *Antal registreringer*	**Number of years** *Antal år med observationer*	**Maximum count** *Maksimum*	**Number of observers** *Antal observatører*
1	Bønnerup Havn	13	5	1 164	9
2	Bønnerup Strand	19	9	1 400	13
3	Stavnshoved Rev	3	2	360	3
4	Gjerrild Nordstrand og Gjerrild, havet øst for	47	15	10 240	18
5	Gjerrild Nordstrand øst, Knudshoved	269	6	18 840	14
6	Gjerrild Klint	13	2	27 600	2
7	Gjerrild, Batterivej	3	2	500	1
8	Karlby Klint	3	1	250	3
9	Sangstrup Klint	14	11	10 000	8
10	Stensmark Strand	5	3	1 562	4
11	Lille & Store Sandvig	33	3	7 810	5
12	Fornæs/Kragenæs	1329	30	110 000	93
13	Ålebugt	0	0	0	0
14	Grenå Havn/Farvandet ud for/Færger	29	11	2 750	14
15	Grenå Strand	0	0	0	0
16	Kysten v. Katholm	0	0	0	0
17	Havknude	10	3	600	1

tably provide more detailed information than previously. Nevertheless, we retained the years back to 1990 to seek evidence for there being an annual occurrence of many Razorbills in this area prior to 2002.

We were particularly interested in the monthly phenology throughout the year, which suggested a major peak in observations during late autumn/early winter. As a result, we analysed the daily cumulative percentage of observations from 1 October to 31 December when the majority observations occurred and compared these graphically to assess consistency between years. To determine if there have been changes in relative abundance over time, we extracted the maximum reported numbers in each year and calculated the annual total numbers reported in each year between 1 October and 31 December. We determined the degree of correspondence between these measures by fitting regression models in Excel (Microsoft Office Professional Plus 2016) and looked for evidence of long-term trends in peak and total numbers during 1990-2021 using the same method.

Results

Based on DOFbasen records in 1990-2021, monthly numbers of Razorbill/auks peaked at Northeast Djursland in late autumn/early winter, with greatest cumulative numbers across years (>100 000 per month) in October, November and December (Fig. 2). Within this period of greatest abundance, the vast majority of records in all years originated from the period between 16 October and 16 November each year, although in some years (notably 1990, 1992, 1995, 1997, 2011 and 2016) peak numbers occurred in November, persisting late into December in the case of 2016 (Fig. 3).

It is important to remember that DOFbasen records were submitted with regularity only after it went online in 2002, so while records in these earlier years may not reflect the true phenology through each season, they do contribute to evidence for Razorbills being most numerous in the area at this time of year back to the 1990s. Reports of large numbers of Razorbills and unidentified auks of any kind off Northeast Djursland were relatively

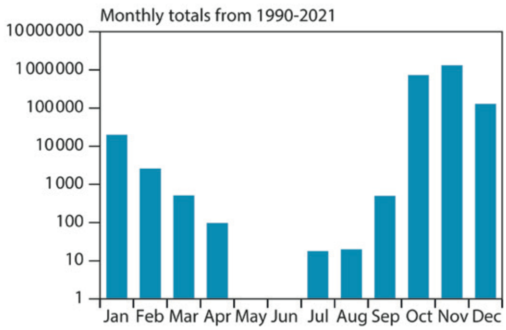

Fig. 2. Total numbers of Razorbill/auks counted off the coast of Northeast Djursland during 1990-2021 reported to DOFbasen from the sites listed in Tab. 1 (note logarithmic scale to y-axis).
Månedlige antal individer af Alke/alkefugle ud for det nordøstlige Djursland 1990-2021 indtastet i DOFbasen fra lokaliteterne anført i Tab. 1 (bemærk logaritmisk skala på y-aksen).

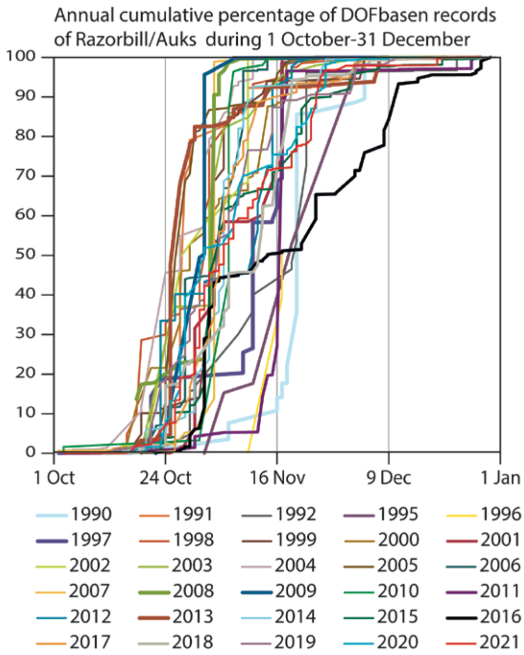

Fig. 3. Daily cumulative percentage of total numbers of Razorbill/auks off the coast of Northeast Djursland in the years 1990-2021 inclusive reported to DOFbasen from the sites listed in Tab. 1.
Daglig kumulativ procentdel af det totale antal individer af Alke/alkefugle ud for det nordøstlige Djursland i årene 1990-2021 indtastet i DOFbasen fra lokaliteterne anført i Tab. 1.

rare after 31 December in all but a few winters, but seem to have become increasingly frequent in recent years (especially in January-April 2020 when numbers persisted into April), although rarely exceeding 100 birds seen at any one time (see Fig. A1 in the electronic appendix).

Based on the maximum and total annual numbers reported to DOFbasen during 1 October-31 December, there is no suggestion of a significant change over time (maximum numbers $r^2 = 0.037$, N = 31, P = 0.30, total numbers $r^2 = 0.024$, P = 0.406; Fig. 4). This was despite major variation between years (maximum numbers were highly correlated with annual mean and total numbers reported, $r^2 = 0.255$, P = 0.004 and $r^2 = 0.684$, $P < 0.001$).

Discussion

DOFbasen data shows there were regular reports of between 1600 and 110 000 Razorbills/auks on a single day in shallow waters off Northeast Djursland, most often during mid-October to mid-November (but occasionally persisting into December) in every year between 1990 and 2021, excepting 1993. Hove-Jensen (1968) reported 35 000 and 20 000 auks counted in 1966/67 and 1967/68, respectively, with a maximum of just over 10 000 birds in a single day. Although we cannot be certain, experience in recent years strongly suggests that the majority of these auks are Razorbills, although Guillemots are often present in numbers less than a few hundred.

The majority (87% of 1504) of these observations was reported as migrating ('trækkende') or flying ('overflyvende') birds at the bird observation points at Gjerrild Nordstrand and Fornæs. However, the comments associated with these, and many other observations made by JSC, AR and other observers at these two sites show that birds generally only appear a few hours after sunrise and are usually most active for a few hours mid-morning, often with no sign of birds present immediately after dawn (although this may occasionally be the case). This regular diurnal pattern is remarkably similar to that described by Hove-Jensen (1968) on their peak day of similar observations in 1966. It seems therefore that the movements witnessed are either large numbers of birds locally relocating well after sunrise, or birds moving around and landing to engage in foraging in the local area. In other words, the vast majority of these large movements are not likely to be classic 'migration' movements in the sense that not all of these are moving in a unidirectional stream past an observer, but mainly relate to local redistribution of very large concentrations of Razorbills in the vicinity. That said, Razorbills have also been observed passing in one direction early in the day and observed to return in the opposite direction later the same day. These patterns of considerable relocation could be in response to local wind or sea currents, local food availability or some other unidentified cause, but require further investigation.

At Gjerrild Nordstrand, daily counts are entered as two separate entries, as the predominant passage direction will most often change during the day. Whether return movements recorded later represent the same birds passing remains unknown but seems likely. Records from observers at other observation points within the area have combined all of their observations passing in both directions when reporting in DOFbasen, which may slightly overinflate their numbers reported relative to those at Gjerrild Nordstrand. These differences in recording should therefore be taken into account when comparing daily counts between different sites, but make no difference to the timing of the movements on a seasonal basis. Observations by JSC, AR and others confirm that it is very rare to see large numbers of Razorbills moving or resting west of Gjerrild Nordstrand or south of Grenå, so the stretch of coast concerned is highly restricted. Hence, it seems very likely that these observations relate to Razorbills remaining in the general area but relocating every morning in relation to local food abundance and/or due to local relocation in response to currents or other factors.

In 2021, when gatherings of up to 10 000 Razorbills were reported, ADF and others witnessed large dense feeding rafts of birds gathered within 1 km of the coast off Sandvig (site 11, Fig. 1) indulging in feeding frenzies, with dense rafts of feeding Razorbills, many of which were flying up and around to presumably relocate in more profitable feeding areas. These included swirling numbers of birds shifting (often at long distances) between feeding sites, which could, likely mistakenly, be interpreted as movement/migration. Once established, these dense feeding aggregations typically attracted large numbers of foraging Northern Gannets *Morus bassanus* (up to 325), Great Cormorants *Phalacrocorax carbo* (up to 220) to join them, as well as large numbers of gulls (predominantly Herring Gull *Larus argentatus*) both admixed but also around the periphery of the larger feeding groups of auks. These multi-species groupings of intensely foraging bird flocks have been consistently witnessed from Gjerrild Nordstrand and Fornæs and implies not just a major prey resource for the Razorbills, but potentially also that larger predatory fish species associated with the Razorbill food resource were also attracted and which in turn attract other feeding sea bird species at the same time.

Lyngs (2002) estimated that 150 000-400 000 Razorbills winter in Danish waters, mainly in Kattegat, Skagerrak and in the North Sea. Ringing recoveries suggested that those occurring in Kattegat and Lillebælt originate from colonies in the Barents, White and Baltic Seas as well as from Britain and Norway (Bønløkke *et al.* 2006). The consistent attraction of large numbers of Razorbills (which typically remain well out to sea and regularly fly maybe 30-40 km to feed) at the same time of year to this relatively restricted stretch of coastline is remarkable over such a span of years and requires some explanation. The aggregative response of such large numbers of birds over some four weeks implies a rich and geographically restricted food resource to support their continuous presence, a phenomenon that is not described from other parts of coastal Denmark (Christensen *et al*. 2022). The diet of Razorbills outside the breeding season is far less described than that of nesting birds, when provisioning adults bring prey to offspring on land, where they can be identified by observation. Results from the few available studies suggest that Razorbills tend to have a more restricted range of prey than Guillemot in winter, with Razorbills predominantly specialising on sprats and herring (Ouwehand *et al.* 2004). Sprats are thought to figure more heavily in the winter diets (e.g.

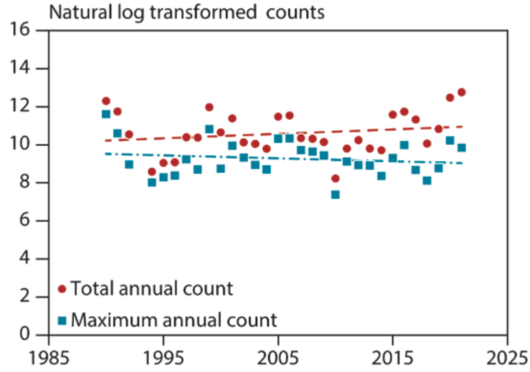

Fig. 4. Annual total number (●) and highest daily maximum count (■) of Razorbill/auks reported to DOFbasen between 1 October and 31 December off the coast of Northeast Djursland 1990-2021 inclusive from the sites listed in Tab. 1. Fitted regression models failed to attain statistical significance for total ($r^2 = 0.037$, N =31, P = 0.30) or maximum counts ($r^2 = 0.024$, N = 31, P = 0.41) suggesting no significant increase or decrease over the period.
Årligt totalantal (●) og største dagsmaksimum (■) af Alke/alkefugle rapporteret til DOFbasen mellem 1. oktober og 31. december ud for det nordøstlige Djursland 1990-2021 fra lokaliteterne anført i Tab. 1. Tilpassede regressionsmodeller opnåede ikke statistisk signifikans for total ($r^2 = 0{,}037$, N =31, P = 0,30) eller maksimumtællinger ($r^2 = 0{,}024$, N =31, P = 0,41), hvilket tyder på ingen signifikant stigning eller fald i perioden.

Sonntag & Hüppop 2005), although other North Sea and Skagerrak studies of dead Razorbills found diets dominated by sand lances/sand eels Ammoidytidae (Blake 1983, 1984, Depooter 2010).

Large concentrations of sprats occur in Danish waters (often close to shore) to the extent that they are commercially harvested in areas where they gather traditionally and therefore predictably occur in large enough concentrations to make it financially worthwhile (Henrik Mosegaard, DTU Aqua pers. comm.). Mapping of registered fishing by Danish vessels during October-November 2015-2019 showed that the highest concentration of fishing for sprat was restricted to eight main areas. These are off North Sea coasts from the German border north to Vedersø, an extensive area around Skagen and east of Læsø, shallow waters northeast and southwest of Anholt, extending to areas off Grenå, in Lillebælt and north of Funen, in Storebælt north of Nyborg and off Sjællands Odde (Henrik Mosegaard, DTU Aqua in litt.). Although not among the most commercially important areas, the fact that sprats were harvested consistently off Grenå, especially in 2015 according to fisheries records, implies potential concentrations of this species there, which could potentially contribute to explaining the aggregations of Razorbills and associated species in this and other years.

Extracted DOFbasen records of sightings of 500 or more Razorbills throughout Denmark between 1 January 1990 and 31 December 2021 yielded 546 records away from Northeast Djursland of which all but 65 (12%, most of which were associated with birds around the breeding site on Christiansø) reports fell in the period 1 October to 31 December. Intriguingly, all these latter records were from North Sea coasts, Skagen, Læsø, areas between Djursland and Anholt, Aarhus Bugt, off North Funen, Sjællands Odde and along the north Zealand coast (Fig. 5). With the exception of the north Zealand coast, which probably represents flocks encountering this coastline as a barrier to moving further south, these are all areas featured in maps as being areas from which sprat were landed by commercial fishermen in October-December of 2015-2019 (Henrik Mosegaard, DTU Aqua in litt.).

Sprats attain their highest lipid content in October, subsequently depleting these fat stores through winter, increasing from June again in the Baltic (Shulman & Lowe 1999, Røjbek *et al.* 2014). In autumn, sprats move from oceanic frontal systems in deep water into the upper warm sea layer (from 10 to 40 m) above the thermocline nearer to the coast (Hoziosky *et al.* 1989, Munk 1993), bringing them close to sea surface, often in great

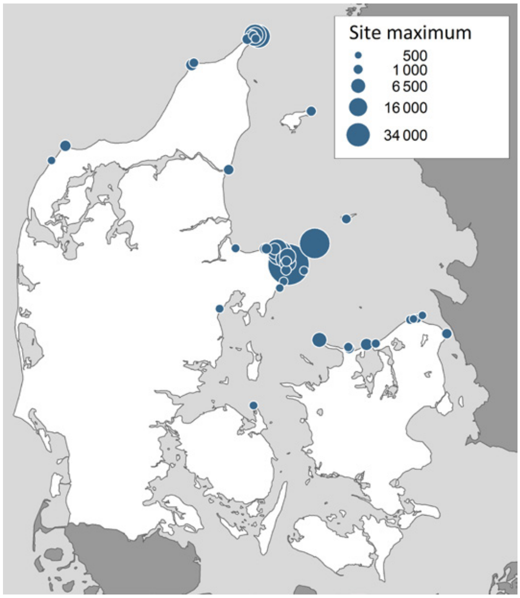

Fig. 5. Maximum daily counts of at least 500 Razorbill reported to DOFbasen between 1 October and 31 December in all Danish count sectors during 1990-2021. The observation between Djursland and Anholt was of 65 000 birds recorded from the ferry between Grenå and Anholt on 2 November 1995. The maximum single count was of 110 000 migrating birds witnessed from Fornæs on 20 November 1990.
Dagsmaksima på mindst 500 Alke indberettet til DOFbasen mellem 1. oktober og 31. december fra alle DOFbaselokaliteter i perioden 1990-2021. Observationen mellem Djursland og Anholt er på 65 000 fugle registreret fra færgen mellem Grenå og Anholt den 2. november 1995. Det maksimale antal var 110 000 trækkende fugle talt fra Fornæs den 20. november 1990.

abundance, when they become accessible to fishery exploitation (and Razorbills). This traditionally occurs in October-November in Kattegat and elsewhere in Danish waters, as well as in the North Sea (Henrik Moesgaard, DTU Aqua in litt.). Sprats are also known to undertake a daily vertical migration through the water column, thought in response to light intensity and/or predation risk and/or food supply remaining deep in winter during daylight but rising higher in the water column by night (Nilsson *et al.* 2003, Voss *et al.* 2007, Andersen *et al.* 2017). Hence, the early morning relocation of Razorbills reported here could be a response to their displacement by currents in relation to the movement and availability of sprat shoals, which perhaps means that the birds relocate after dawn before the fish seek deeper depths during the middle of the day.

Of course, all of the above is wild speculation: we have no proof of any link between the occurrence of large concentrations of sprats in inshore shallow waters close to the sea surface in October-December and the aggregation of Razorbills off Northeastern Djursland between 1990 and 2021, but to us it does seem like a plausible hypothesis. Further support for this hypothesis comes from the fact that similar Razorbill concentrations have been reported from other Danish marine waters associated with areas fished commercially for sprats in the same period in recent years (see above). There appear to be no relationship between these aggregations and the pattern, strength and direction of current in these inshore waters (AR personal observations), but obviously we cannot rule out other explanations, for instance, that the relocation of Razorbills (which are assumed to be primarily daytime feeders) is due to displacement by wind and/or currents during the night.

These dense gatherings of Razorbills likely exceed levels of international importance and their regular and consistent occurrence over what appears from Northeast Djursland to be three decades, suggests they are deserving of some level of site protection. On very flimsy data, the annual maximum numbers of Razorbills reported does not seem to have declined since the 1990s. However, we should be extremely prudent about concluding too much about changes in abundance during the time series and especially about using average and crude cumulative/maximum counts as a true reflection of numbers present, given potential annual variation in observer effort and our inability to observe offshore numbers beyond a certain distance from the shore. We know, for instance, that total numbers in some years were maybe inflated because some sea watch observers entered numbers of Razorbills passing them in both directions (which affected the maximum counts in 2005, 2007, 2008 and 2019), while most other recorders input separate numbers passing in different directions as discrete records. While we cannot know that same-day observations of birds flying in opposite directions relate to the same birds, clearly combining counts in both directions over-inflates numbers present relative to those reported as separate observations, affecting both the maximum and average counts. Accurate assessment of very large rafts of feeding and flying auks extending far offshore in heavy seas and poor visibility also challenge our ability to accurately assess the true numbers present. Although we fear that much more intensive daily observations in the last 10 or so years have failed to find the very large (>30 000) daily numbers of previous years, there is no strong evidence from Fig. 4 to suggest numbers have shown major declines. With regard to the potential prey of these birds, the spawning stock of sprats in the western Baltic were lower in the 2010s than at their peak in the mid-1990s, but still much higher than the low levels of the 1980s (Eero 2012), but otherwise we know little about long term changes in their abundance in this region.

Evidence from DOFbasen data suggests that there are other such concentrations, potentially associated with dense schools of sprat known from human exploitation in Danish waters. For this reason, we recommend carrying out aerial surveys of Razorbills in late October and November in likely areas to determine the abundance and distribution of Razorbills at key sites at this time. Simultaneous sampling of fish stocks in these areas would be valuable to attempt to explain the reasons behind the gathering of such high densities and large numbers of this poorly studied auk species during a relatively short period.

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Resumé

Årlige oktober/november-forekomster af Alke ved Nordøst-Djursland

I denne artikel beskrives forekomsten af tusindvis af Alke *Alca torda* langs den nordøstlige kyst af Djursland (Fig. 1) i perioden mellem midten af oktober og slutningen af december (Fig. 2), baseret på observationer indtastet for 17 lokaliteter i DOFbasen (Fig. 1, Tab. 1, Fig. A1 i det elektroniske appendiks) fra 1990 til 2021 (undtagen 1993-95 begge år inklusiv, måske mere på grund af manglende registreringer end reel mangel på fugle).

Årlige, maksimale antal toppede mellem den 16. oktober og den 16. november (Fig. 3), selvom mindre antal blev observeret indtil april efter vinteren 2019/20. Årlige, daglige maksima toppede med mellem 1600 (2010) og 110 000 (1990) fugle rapporteret uden nogen klar tendens i perioden 1990-2021 (Fig. 4). Der blev observeret flest flyvende fugle ved Gjerrild Nordstrand og Fornæs midt på morgenen, hvilket sandsynligvis drejer sig om fugle, der ændrer position i relation til ændret fødetilgængelighed.

Tætte flokke af fouragerende Alke (på op til adskillige tusinde fugle) blev registreret flere gange ofte ledsaget af fou-

ragerende Suler *Morus bassanus*, Skarver *Phalacrocorax carbo* og måger (de fleste Sølvmåger *Larus argentatus*), hvilket tyder på tilstedeværelsen af en stor føderessource for flere arter af havfugle. En mulig forklaring på dette fænomen kunne være tilstedeværelsen af brislinge-stimer *Sprattus sprattus* i området. Brisling er kendt for, at de i oktober bevæger sig længere op i vandsøjlen, hvor temperaturen er højere. I samme periode landes store mængder brisling fra dette område. Daglige bevægelser af brisling til dybere vand efter solopgang kan også forklare de daglige bevægelser, der ses blandt Alkene midt på formiddagen.

Data fra DOFbasen tyder på, at lignende alkekoncentrationer forekommer i andre områder i danske farvande (Fig. 5), der også er kendt for fiskeri efter brisling. Vi anbefaler, at der fremover gennemføres optællinger af alkefugle fra fly i slutningen af oktober og i november i områder med kendte forekomster af alkefugle for mere præcist at kunne beskrive arternes udbredelse og antal. En sådan monitering kunne fokusere på områder med kendte koncentrationer af brisling. En bedre viden omkring udbredelsen af Alk i en periode, hvor arten tilsyneladende forekommer i store antal i et forholdsvist begrænset, kystnært område, vil højne mulighederne for mere effektivt at kunne beskytte arten. Simultan sampling af områdets fiskebestand og udbredelsen heraf vil desuden kunne hjælpe til med at fastlægge årsagerne til de høje, årligt tilbagevendende koncentrationer af arten indenfor en begrænset periode af året.

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Appendix 1: https://pub.dof.dk/link/2023/4.appendiks1

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Tens of thousands of Razorbills can be seen off Djursland on the east coast of Jutland between mid-October and late December, when they probably feed on shoaling sprats. Photo: Kis Boel Gildmann.
Titusinder af Alke kan ses udfor Djursland fra midt i oktober til sidst i december, hvor de sandsynligvis fouragerer på stimer af brislinger.