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KATTEGAT

OFFSHORE SURVEYS OF BIRDS, BATS AND MARINE MAMMALS FOR OFFSHORE WIND FARMS IN DANISH WATERS.

TECHNICAL REPORT BIRDS


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INDHOLD

Abbreviation	Explanation
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency of Germany)
CSR	Conservation status report
DHI	Dansk Hydraulisk Institut (Danish Hydraulic Institute)
EEA	European Environment Agency
GLS	Global location sensor
GPS	Global positioning system
GW	gigawatts
HELCOM	Baltic Marine Environment Protection Commission (Helsinki Commission)
HIDEF	HiDef Aerial Survey Ltd.
IUCN	International Union for Conservation of Nature
MTR	Mean traffic rate
OWF	Offshore wind farm
SPA	Special Protected Area

1 SUMMARY

1.1 INTRODUCTION

In order to accelerate the expansion of Danish offshore wind production, it was decided with the agreement on the Finance Act for 2022 to offer an additional 2 GW of offshore wind for establishment before the end of 2030. In addition, the parties behind the Climate Agreement on Green Power and Heat 2022 of 25 June 2022 (hereinafter Climate Agreement 2022) decided), that areas that can accommodate an additional 4 GW of offshore wind must be offered for establishment before the end of 2030. Most recently, a political agreement was concluded on 30 May 2023, which establishes the framework for the Climate Agreement 2022 with the development of 9 GW of offshore wind, which potentially can be increased to 14 GW or more if the concession winners – i.e. the tenderers who will set up the offshore wind turbines – use the freedom included in the agreement to establish capacity in addition to the tendered minimum capacity of 1 GW per tendered area.

In order to enable the realization of the political agreements on significantly more energy production from offshore wind before the end of 2030, the Danish Energy Agency has drawn up a plan for the establishment of offshore wind farms in three areas in the North Sea, the Kattegat and the Baltic Sea respectively.

The area for Kattegat Offshore Wind Farm (OWF) is located in Kattegat, approximately 20 kilometer east of Djursland and approximately 30 kilometers north of Zealand. The area for the OWF is approximately 122 km^2. The Kattegat OWF will be connected to land via subsea cables making landfall close to Grenaa.

Because of these political decisions, a series of biological and scientific investigations for three well-defined pre-investigation areas in the Kattegat and western Baltic was initiated as part of the baseline mapping. This also includes a baseline investigation of birds, comprising resting and migrating birds in the pre-investigation areas, which is presented in this technical report.

This report presents the results of the 1st year of bird surveys undertaken in the pre-investigation area for the planned Kattegat OWF. The surveys were undertaken between February 2023 and January 2024. Since the area is close to the plannnes Hesselø OWF area, the pre-investigation area for bird and marine mammal surveys covers both sites.

1.2 OBJECTIVES AND METHODOLOGIES

<u>Resting birds:</u>

We define resting birds in this report as all birds regularly staying the pre-investigation area either for resting, feeding or regular stop-over during their movements between breeding and winter areas or between different feeding areas. The pre-investigation area for this study covers an area in which both of the planned offshore wind farms (Hesselø and Kattegat) are located. To determine the abundances, densities, and spatial distribution of resting birds in the pre-investigation area it is important to use a method, which is able to cover huge areas within a short time period with a high spatial resolution. For this aim, digital aerial surveys are the best available method so far. We undertook four digital aerial surveys specifically planned to record resting birds, in the 1st survey-year of the project. Additionally, two digital aerial surveys were conducted to specifically determine the presence of marine mammals. Since the transect lines and the methodology to record birds and marine mammals are the same, data from all six surveys could be used for both protected assets. This first draft of the report contains data from all six surveys. The digital aerial surveys were conducted in March, April, June, August, November and December 2023 using digital video technology developed by the company HiDef (https://www.hidefsurveying.co.uk). A plane equipped with four digital video cameras flew over 18 transects at an altitude of 550 m covering a total area of 4,121 km² while taking video footage (10 pictures/minute) that was later processed and analysed to detect and identify any resting bird (and marine mammal) present in the images.

Migrating birds:

Migrating birds are all birds which fly across the pre-investigation areas regularly on their movements between wintering and breeding grounds. Bird migration was investigated by means of vessel-based investigations in the pre-investigation area by visual observations during daylight, acoustic observations during nights, and standardised simultaneously recordings of bird echoes by vertical and horizontal radar devices. As there are no indications that there are significant differences in species composition as well as in migration intensity between the proposed OWF areas Kattegat and Hesselø, it was decided to collect data at only one position for both areas but use two different anchoring positions in spring and autumn. The distance between both anchoring points is approximately 30 km. The vessel was centrally anchored in spring within the proposed OWF area of Kattegat for 15 24-hour days divided into one to two surveys per month between March and May 2023 (spring migration). In autumn the vessel was centrally anchored within the proposed OWF area of Hesselø for 20 days again divided into one to two surveys per month between August and November 2023 (autumn migration). In spring data were collected at the anchoring point in the Kattegat area, since this is closer to the mainland where the migration movement will seasonally originate from. Likewise, in autumn, the anchoring position further east within the Hesselø area was used. The data of the respective anchor point can be used in any case to describe the intensity and flight height distribution of birds at both sites. Through the analysis of all the collected data, information on migration intensity, flight altitude and distribution, temporal patterns and species composition during day and nocturnal migration could be investigated.

1.3 RESULTS

Resting birds:

A total of 7,956 resting birds belonging to 23 species were registered during the six digital aerial surveys covering the pre-investigation area Kattegat/Hesselø/. Auks represented over half of all resting birds seen during the whole survey period (53.6%) and were largely dominated by common guillemots (*Uria aalge*), which represented alone 38.5% of all resting birds. Razorbills (*Alca torda*) and black guillemots (*Cephus grylle*) represented respectively 4.4% and 1.1% of all resting birds in the survey area. Sea ducks were the second most common species group (19.9%) with common scoter (*Melanitta nigra*, 13.6%) and common eider (*Somateria mollisima*, 6.0%) being the most common species. Gulls were the third most common species group (15.3%). Lastly, divers, mainly red-throated divers comprised the fourth most common species group in the area (6.7%). The absolute density of divers was higher than expected from existing data.

Spatially, common guillemots and divers occurred throughout the whole pre-investigation area, also within the proposed OFW area but were more densely seen at offshore regions. Sea ducks were concentrated at only few spots close to land, especially at the tip of Sjællands Odde. In autumn, many birds concentrated in the northeastern part of the pre-investigation area. High density grid cells were also seen within the limits of the planned OWF.

Migrating birds:

Spring

A total of 9,177 birds identified to 67 species, were registered during the 14 analysable days (out of 15) of diurnal observations in spring 2023 at the anchoring point in the centre of the proposed OWF Kattegat.

Of the total number of migrating birds observed, 71.6% were geese, most of them being barnacle goose (67.9%). The second most abundant group of migrating birds observed during the survey period were ducks (13.2%) and these were mainly composed of common scoters (10.7%). A large number of migrating passerine species make up the third most abundant migrating group of birds in spring 2023 (songbirds, 6.1%) whereas cormorants, gulls and waders represented each less than 3% of all migrating birds in the area during spring 2023.
Mean migration intensity across all bird groups was 86.3 (± 52.6) ind./h with the maximum peak occurring on May 9th (768 ind./h) and was mainly due to a migration event of barnacle geese (*Branta leucopsis*).
Most observed migrating birds were flying at very low altitudes (0 – 5 m), but about a third of all birds (34%) were observed at altitudes between 20 m and 200 m. The flying direction of most birds (>75%) was the NE.

A total of 179 calls belonging to 15 species were heard during night during the survey period. Most of the birds heard during night belonged to songbirds: 49.7% were thrushes (*Turdus* spp, among which redwings were most abundant) and 38.5% belonged to other songbird species (e.g. European robins, common chiffchaffs, etc.). Other groups worth mentioning were geese (barnacle goose, 6.7%) and waders (3.4%) .

No nocturnal flight calls were registered during the first two nights of surveys (4-5.03.2023). Overall, the mean nocturnal migration intensity reached 5.7 ± 3.3 ind./h in spring 2023 and the maximum value occurred on the night of 23rd of March 2023 (30.2 calls/h).

Data from vertical radar confirmed higher migration intensity during nights compared with daylight phases with 22.3 MTR (migration traffic rate, here defined as the number radar signals (= birds) crossing 1 km vertical line in the course of 1 hour within 1000 m of altitude) on average during day and 174.2 MTR on average during night. Flight height distribution showed significant high migration intensity in the lowest level (0-100 m) during day and a more even distribution during night with somewhat lower intensity in the highest level (900-1,000 m). This pattern during night was mainly characterised by the 5 nights with the highest migration and on all other nights the lowest altitude class was used significantly more than the higher altitude classes. The phenology of bird migration in the course of a 24-day showed a constantly high flux of birds during night with clearly decreasing numbers towards sunrise. During day very low MTR values were reached with no clear pattern except already significant high bird migration in the last hour before sunset.

Autumn

In autumn, a total of 3,105 diurnally migrating birds identified to 75 species were registered during the analysable 18 days (out of 20) of diurnal observations in autumn 2023 at the anchoring point at the centre of the proposed OWF Hesselø.

Of the total number of migrating birds observed, half of them were ducks, most of them were common scoters (28.6%) and Eurasian wigeons (10.9%). The second most abundant group of migrating birds observed during the survey period were geese (14.2%) of which barnacle goose were the most abundant species (11.6%). After these, gulls (8.1%), songbirds (8.0%) and auks (6.4%) followed in terms of abundance. In both seasons, birds of prey were observed only sporadically and very rarely.

Mean migration intensity across all bird groups was 31.9 (± 7.5) ind./h with two dates in October when similar high migration peaks were reached (on the 3rd of October, 103 ind./h and on the 24th of October, 104.2 ind./h).

Almost half of all migrating birds were observed flying at very low altitudes (0 – 5 m) while a quarter of all birds (25%) were observed at altitudes between 20 and 200 m. Almost 30% of the birds flew to the SW, however about 25% flew to the west, whereas 15% flew to the NW and other 15% to the S.
A total of 3,132 bird calls belonging to 18 species were registered during nights. Most bird calls belonged to songbirds, of which the great majority were thrushes: 87.5% (*Turdus* spp, song thrush was the most abundant) and only 6.8% belonged to other songbird species (e.g. European robins, etc.). The only other group that was relatively common was waders (5.1%).

Nocturnal migration intensity was very variable during the whole survey period. The mean nocturnal migration intensity reached 33.2 ± 28 calls/h in autumn 2023 and the maximum value occurred on the night of 5th of October 2023 (478.3 calls/h).

Data from vertical radar confirmed again higher migration intensity during nights compared with daylight phases with mean MTR values of 22.9 during day light, which is very similar to spring. During night 109.7 MTR on average was measured which is clearly lower compared to spring. Flight height distribution showed significant high migration intensity in the lowest level (0-100 m) for both phases, day and night with a more pronounced difference between the lowest class and the higher classes at day. The pattern during the 5 nights with the highest migration intensity and on all other nights was not different, neither days nor nights. The phenology of bird migration in the course of a 24-day showed an increasing flux of birds from sunset to 23:00 and a decreasing flux of birds from 1:00 till sunrise. During day lowest bird migration was during noon.

1.4 CONCLUSIONS

The results from the first of a two-year baseline study represented in this report reveals first valuable information on the presence and distribution of resting and migrating birds in the pre-investigation area for the proposed OWF Kattegat. Results show for the resting birds that in line with existing data auks, especially the common guillemot were the most abundant species in the pre-investigation area with highest concentrations either in the north (winter) or in the northwest and southeast (autumn) of the pre-investigation area but also common in the proposed OWF area Kattegat.

Also, divers (primarily red-throated diver) occurred widely distributed over the whole pre-investigation area but in higher numbers than expected. Sea ducks (common scoter and eider) were observed in high number very local close to the coast, e.g. at the tip of Sjællands Odde.

Data from the second year will provide information if seasonal and spatial patterns will be consistent over time.

For migrating birds, the results show that the pre-investigation area is crossed by migrating birds in quite high numbers compared to areas in the North Sea and the western Baltic Sea. The area is part of the coastal diurnal migration with geese (barnacle goose) and ducks (common scoter and European wigeon) as the most dominant species occurring in high numbers at certain days with good migration conditions. Whereas ducks mostly fly below 20 m geese were frequently observed at altitudes above 50 m. Flying directions of common scoters suggest that they were heading towards main resting areas either in the north (Alborg Bugt) or in the south of the pre-investigating area, closer to the coast of Hesselø Bugt. Songbirds as part of the diurnal migration crossed the area regularly but also at night the results from the bird calls suggest that the pre-investigation area is part of the broad band nocturnal migration route for passerines. Some crane migration (56 individuals) was registered in spring at the pre-investigation area. Though not a very large number, cranes are large birds that may be subject to collisions with offshore wind turbines. Surprisingly, few observations were made of birds of prey. Here, a second year will give more information if this is a more common pattern or only the result of the specific year.

Bird migration intensity measured with the vertical radar confirms a high nocturnal migration flow through the area with higher values in spring than in autumn. While the nocturnal bird migration is relatively evenly distributed across all altitude classes up to 1,000 m, especially in spring, the birds clearly favour the lowest altitude class of 0-100 m during the day.

2 INTRODUCTION

In order to accelerate the expansion of Danish offshore wind production, it was decided with the agreement on the Finance Act for 2022 to offer an additional 2 GW of offshore wind for establishment before the end of 2030. In addition, the parties behind the Climate Agreement on Green Power and Heat 2022 of 25 June 2022 (hereinafter Climate Agreement 2022) decided), that areas that can accommodate an additional 4 GW of offshore wind must be offered for establishment before the end of 2030. Most recently, a political agreement was concluded on 30 May 2023, which establishes the framework for the Climate Agreement 2022 with the development of 9 GW of offshore wind, which potentially can be increased to 14 GW or more if the concession winners – i.e. the tenderers who will set up the offshore wind turbines – use the freedom included in the agreement to establish capacity in addition to the tendered minimum capacity of 1 GW per tendered area.

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Because of these political decisions, a series of biological and scientific investigations for three well-defined pre-investigation areas in the Kattegat and western Baltic was initiated as part of the baseline mapping. This also includes a baseline investigation of birds, including resting and migrating birds in the pre-investigation areas, which is presented in this technical report.

This report presents the results for the proposed wind farm area Kattegat from the first year between February 2023 and January 2024 (Figure 2-1). Since the area is close to the proposed wind farm area Hesselø the pre-investigation area for birds and marine mammals covers both sites.

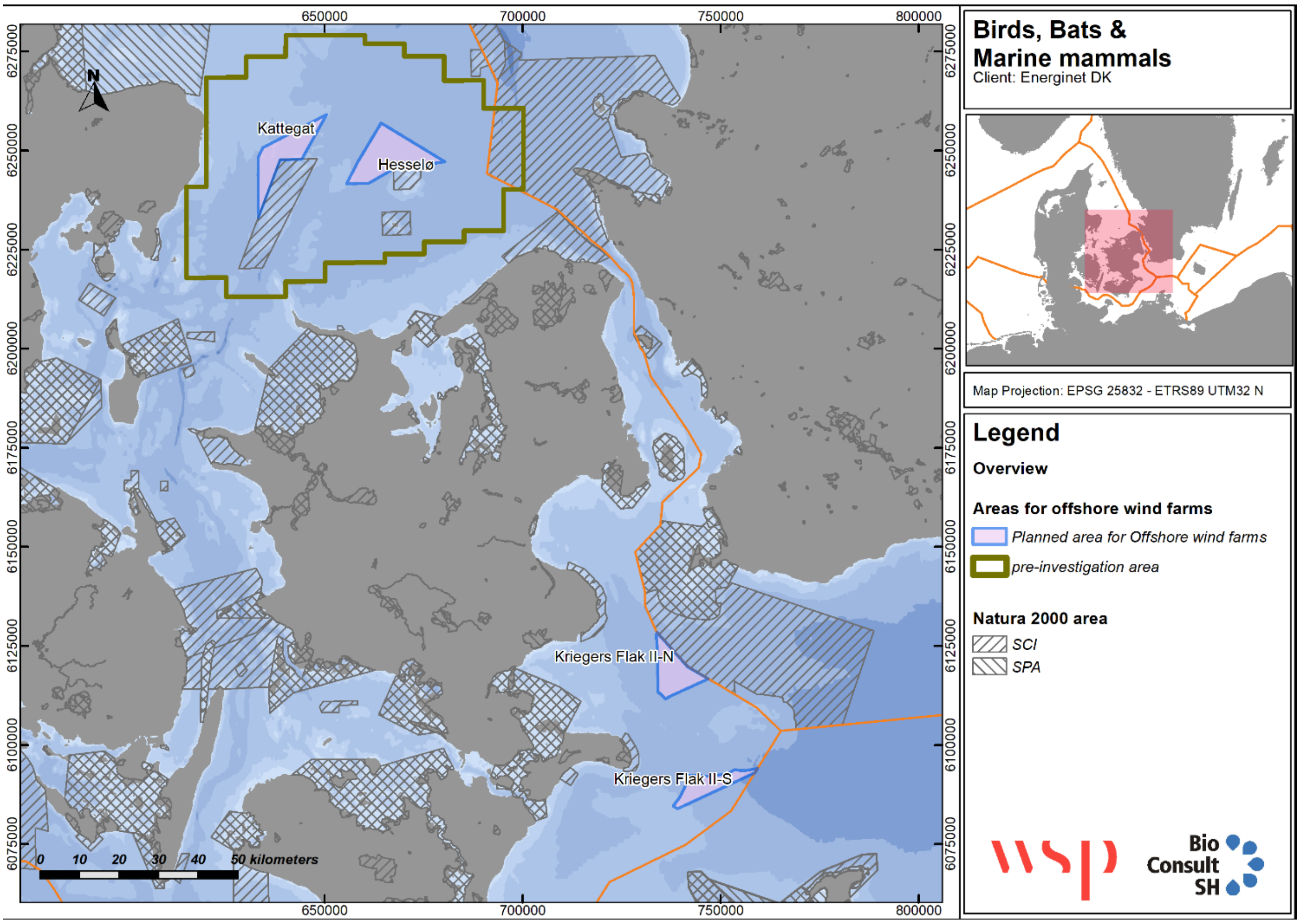


Figure 2-1. Map showing the location of the parallel investigated wind farm areas Kattegat, Hesselø and Kriegers Flak. The present report focuses on Kattegat.

The present report analyses the occurrence of birds in the pre-investigation area and is divided into one part focussing on resting birds and a second part focussing on migrating birds. Resting birds include seabirds resting and foraging in the pre-investigation area as well as assessing the suitability of the habitat at least during periods throughout the year. Migrating birds are bird species migrating through the pre-investigation area often twice a year on their seasonal movements between breeding and wintering grounds. For many of the terrestrial species, the sea is a biologically hostile habitat that needs to be crossed as quickly as possible in order to reach their breeding or wintering grounds. However, since many seabirds and other waterfowl are also migratory birds, the grouping is fluid and some of these species staying in the area but also crossing the pre investigation area will occur in both parts of this report.

The report is structured in such a way, that for both parts (resting and as well as migrating birds), a compilation of data based on already available publications is given firstly, followed by a description of the methodological approach applied in order to attain the new data. Finally, the new data are brought into context based on the existing knowledge.

3 EXISTING DATA

A review of relevant literature including peer-reviewed journals as well as publicly available “grey literature” has been done. The considered publications included information on the general distribution and biology, as well as the abundance in the pre-investigation area of resting and migratory bird species. Species were selected as relevant, because they either commonly occur in and around the pre-investigation area or have a special conservation status. A detailed description of available information for the most relevant species groups of resting and migratory birds potentially present in the pre-investigation area is given.

Birds potentially utilising the pre-investigation area can be roughly divided into two groups: (i) resting birds, which are typically found within an area for long time periods, and (ii) migrating birds, which alternate between different distant regions such as breeding and wintering grounds and may therefore only cross an area temporarily. Migrating birds can be found among many different orders, such as songbirds, birds of prey or seabirds. Seabirds include a variety of species specifically adapted to marine environments. They generally breed in coastal regions or on islands and forage at sea (DIERSCHKE & GARTHE 2006). Nevertheless, this grouping is fluid as several resting bird species are also migratory. The chapter on resting birds therefore considers all seabird species, which use the investigation area over longer periods of time for foraging, moulting, wintering, or stopping over during migration. The chapter on migrating birds partly considers the same seabird species which are already described in the resting bird chapter, when the species (or species group) also occurs during migration. Besides, all other species, which were regularly observed are presented in the migratory bird chapter. Since radars cannot distinguish between different species, results of this methodology present migration intensity (Mean traffic Rate, MTR), flight height distribution (vertical radar) and flight direction (horizontal radar) for all birds crossing the area within a few hundred metres around the anchoring vessel.

3.1 RESTING BIRDS

Resting birds include seabirds and other waterfowl species that remain in a non-breeding area during certain periods of the year. They are dependent on the local resources in these areas for moulting, overwintering, foraging etc. They typically tend to be very long-lived and have several adaptations allowing them to exploit resources even during harsh weather conditions.

Two Natura 2000 sites are located close to the investigation area. The “Aalborg Bugt, østlige del” (code DK00VA344) with a size 1,774 km^2 is located north-west of the study site and is also specified as a Bird Directive Sites or SPAs (Special Protected Areas). It is designated specifically for the common scoter (*Melanitta nigra*), the common eider (*Somateria mollissima*) and the brent goose (*Branta bernicla*). In the western parts of the investigation area lies the site “Schultz og Hastens Grund samt Briseis Flak” (code DK00VA303) covering 207 km^2. This Natura 2000 site is characterised by shallow sandbanks, which are slightly covered by water all the time, as well as reefs. The site “Lysegrund” (code DK00VA299) is located in the east of the investigation area, north of Anholt. It covers 32 km^2 and includes sandbanks as well as reefs. Anholt itself is part of the site “Hesselø med omliggende stenrev” (code DK003X202), which covers 42 km^2 and is characterised by several different habitat types. Most important for resting (and migrating) birds are sandbanks, coastal lagoons and reefs.
In the following paragraphs, the resting bird species or species groups, which were identified as most relevant for the investigation area, will be described in more detail.

3.1.1 DIVERS (RED-THROATED DIVER AND BLACK-THROATED DIVER)

Divers, also called loons, include four species of fish-eating birds strongly linked to aquatic environments that inhabit the taiga and tundra regions of the Holarctic. All divers are migratory, breeding in freshwater lakes mainly in Scandinavia and in Russia and spending the winter season at sea (DURINCK ET AL. 1994; DORSCH ET AL. 2019; HEMMER 2020). Two diver species are commonly found in the Baltic Sea, the red-throated diver (*Gavia stellata*) and the black-throated diver (*Gavia arctica*).

Both species use the Baltic Sea almost exclusively as wintering and staging grounds and as a migration corridor to wintering areas further south and west, such as the North Sea or Atlantic coastal waters. These are predominantly divers breeding in northern Russia (MENDEL ET AL. 2008; DORSCH ET AL. 2019) which will arrive in or cross the area from October to January, and leave until June. BELLEBAUM and colleagues (2010a) report higher numbers of migrating red-throated divers near the coast as opposed to areas further offshore, assuming a more southward concentration of spring migration along the German coast and an autumn migration further north, with counts of 4,000 individuals in total passing between the Swedish Skåne coast and Bornholm. GPS tracks of about 20 tagged red-throated divers (DORSCH ET AL. 2019) suggest that individuals are rather evenly spread across the area and did not confirm these patterns.

Flight heights of both diver species are generally estimated to be low (JOHNSTON et al. 2014b) . Especially during headwind situations divers tend to fly closely above the water surface. They will usually not be observed flying higher than 50 m and often just up to 10 metres (KRÜGER & GARTHE 2001; BELLEBAUM ET AL. 2010b; BIOCONSULT SH ET AL. 2020).

During wintering, divers forage on a broad range of fish species (KLEINSCHMIDT ET AL. 2019). For the Baltic Sea, the diet of red-throated divers has been investigated in the Pomeranian Bay, which is one of their main wintering areas probably due to the suitability of the area as spawning, nursery and feeding ground for many fish species. In this area, zander (*Sander lucioperca*) and herring (*Clupea harengus*) constituted the majority of the consumed biomass of red-throated divers in winter and spring respectively (GUSE ET AL. 2009).

Both species are widely distributed in the Baltic Sea. Most individuals occur in the Gulf of Riga at waters less than 30 m depth (DURINCK ET AL. 1993). Other important areas are located off the coast of Lithuania and the Pomeranian Bay (DURINCK ET AL. 1994). According to both studies, most divers winter offshore at waters with depth ranging between 5 and 30 m. They arrive in the Baltic Sea in September with increasing numbers during the winter peaking in February and March in the Kattegat (SKOV ET AL. 2011). They start leaving the areas in April and May to migrate to their breeding grounds and are thus expected to be present in the investigation area from September to June. During the rest of the year, they are expected to appear sporadically only. In a report by DHI (DHI 2019) for the nearby Hesselø site, low densities were found in general during winter and spring, but medium to high densities in coastal area with water depth < 20m. PETERSEN AND NIELSEN (2011) reported high densities of both diver species during the winter particularly in the areas between Læsø and Anholt with 0.81 – 2.3 ind./km^2 with birds preferring water depths between 10 and 22m. Similar high densities were observed on the northern coasts of Sjælland as well as close to the coast of Falster. While SKOV ET AL. (2011) reported that the most important wintering area for black and red-throated divers in the Baltic Sea is located along the coast north of Rügen in Germany, they also identified the areas in the north west and south Kattegat as important wintering sites in Danish waters.

Estimates conducted almost two decades ago suggested overall wintering numbers of 150,000 – 450,000 red-throated divers and 250,000 – 500,000 black-throated divers for the population inhabiting northwest Europe

(MENDEL ET AL. 2008; SKOV ET AL. 2011). More recent evaluations estimate 210,000 – 340,000 wintering red-throated diver individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 10.04.2024). It is still unclear whether populations of both species are in decline in the North Sea (VILELA ET AL. 2021; GARTHE ET AL. 2023). The population of black-throated divers inhabiting northern and western Europe and Siberia is estimated at 390,000 – 590,000 individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 23.02.2022).

Since their populations may have decreased and since they are among the seabird species most vulnerable to many anthropogenic factors, they are included in the Annex I of European Union (EU) Birds Directive (Council Directive 2009/147/EC on the conservation of wild birds, EUROPEAN UNION 2010) and in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA, UNEP/AEWA SECRETARIAT 2019). Moreover, their wintering populations are considered critically endangered (CR) by HELCOM (2013). The IUCN categories but the recent Birdlife International Red List for Europe (BIRDLIFE INTERNATIONAL 2021) considered them as species of least concern.

Oil spills, habitat degradation and being bycaught in fishing nets are the most common threats for divers (MENDEL ET AL. 2008). Additionally, contamination in lakes for example by mercury pollution may affect their reproduction (e.g., ERIKSSON 2015). Ship traffic and offshore wind farms have been shown to have detrimental effects on divers. They display strong avoidance behaviour towards OWFs (DIERSCHKE ET AL. 2016; WELCKER & NEHLS 2016; HEINÄNEN ET AL. 2020), which can be noticeable up to a distance of 16 km away from OWF (MENDEL ET AL. 2019; VILELA ET AL. 2021; GARTHE ET AL. 2023).

3.1.2 GREBES

Grebes occur in coastal areas with shallow waters. The most important species of grebes which may be found in the pre-investigation area are red-necked grebes (*Podiceps grisegena*), great-crested grebes (*Podiceps cristatus*), and slavonian grebes (*Podiceps auritus*). Durinck et al (1994) reported that the main wintering area for all three species was found in the Pommeranian Bay. In the Danish Baltic Sea, they found a small concentration of wintering great-crested grebes in the north-west Kattegat along the coast northeast of Aalborg (mean density of 0.3 ind./km^2). For red-necked grebes, they reported high densities of up to 2.4 ind./km^2 particularly in the Aalborg Bight. These high densities were also confirmed in a recent report by DHI (DHI 2019).

An estimated total of 3,500-4,000 pairs of great-crested grebes breeds in Denmark. Many of these concentrate in lakes and coastal waters during July-September (MELTOFTE 1996). Based on the IUCN categories and the recent Birdlife International Red List for Europe, the European populations of Slavonian grebes are considered near threatened, those of red-necked grebes are categorised as vulnerable and those of great-crested grebes are considered to be of least concern (BIRDLIFE INTERNATIONAL 2021).

3.1.3 GREAT CORMORANT

Two of the six subspecies of the great cormorant (*Phalacrocorax carbo*) may occur in north Europe: *P. carbo carbo* and *P. carbo sinensis*, the latter is the subspecies that may occur in the pre-investigation area. Cormorants are diving birds that mainly feed on herring, perch, eelpout, cyprinids and sprat among other species found in the Baltic Sea (e.g. (BOSTRÖM ET AL. 2012a; b; LARSSON 2017).

According to population estimates by Birdlife, 828,000 – 1,030,000 great cormorant individuals are found across Europe (BIRDLIFE INTERNATIONAL 2021). In the Baltic Sea, they occur during the whole year but mainly associated to coastal habitats. Largest concentrations can be generally found in the Mecklenburg region of Germany, the southern part of Bohuslän and Gdansk Bay and the Sound, as well as in Danish waters (SKOV ET AL. 2011). In Danish waters high concentrations of wintering great cormorants were mainly found along the coast of Sjælland and Fyn, as well as in the Aalborg Bight with densities varying between 100 and 5000 ind./km^2.

During the 19th century, the species went almost extinct. After protection measures established in the mid-20th century, the population has increased in the Baltic with a total of 190,000 – 210,000 breeding pairs occurring in the entire region, and between 2014 and 2022 30,000 - 33,000 pairs occurred in Denmark (STERUP & BREGNBALLE 2022). Recent IUCN assessments consider them as least concerned (BIRDLIFE INTERNATIONAL 2021). Besides the common threats affecting most sea birds like oil spills, habitat degradation and fishing nets, great cormorants may suffer from conflicts with the fishing industry. Since their diet includes fish also utilised by humans, they have been blamed for potentially reducing fish stocks. Although a reduction of perch was associated to the colony size of cormorants, no significant results were observed for other species (ÖSTMAN ET AL. 2012). Most probably, the relationship between cormorants and fish is more complex and further research is needed (OVEGÅRD ET AL. 2021).

Great cormorants can be attracted to OWFs and other man-made structures, as these provide them with resting sites, thus allowing them to expand their foraging grounds further offshore (DIERSCHKE ET AL. 2016).

3.1.4 SEA DUCKS

Sea ducks spend their non-breeding season in marine environments feeding mainly on bivalves (MADSEN 1954; NEHLS 1989, 2001; MEISSNER & BRÄGER 1990; MENDEL ET AL. 2008). The Baltic Sea offers important moulting and wintering sites for sea ducks with individuals mainly located in coastal waters and shallow offshore banks, where they can easily dive to obtain their food (e.g., BRÄGER et al. 1995). Among the most common and abundant sea ducks that may occur in the pre-investigation area are long-tailed ducks, common eiders, common scoters and velvet scoters. In general, all sea duck populations have suffered from declines in recent years (e.g., DURINCK ET AL. 1993; MENDEL ET AL. 2008; BELLEBAUM ET AL. 2012; NILSSON & HAAS 2016). They are subject to many anthropogenic threats including oil pollution, being bycaught in fishing nets and habitat degradation (MENDEL ET AL. 2008; BELLEBAUM ET AL. 2012; NILSSON 2016). In addition, breeding populations may suffer predation from gulls and other raptor species (BELLEBAUM ET AL. 2012). Some sea duck species such as common scoters are strongly disturbed by ship traffic showing long escape distances, while others may be less disturbed (FLIESSBACH et al. 2019). The same applies to the disturbance caused by OWFs, as the reaction differs among species as well (PETERSEN & FOX 2007; PETERSEN ET AL. 2014; DIERSCHKE ET AL. 2016).

LONG-TAILED DUCK

Long-tailed ducks (*Clangula hyemalis*) have a circumpolar distribution range and migrate between arctic breeding grounds and temperate wintering areas. They mainly breed in freshwater habitats located in the arctic tundra areas, or in areas that provide similar conditions – e.g., the alpine areas of the Norwegian west coast (GLUTZ VON BLOTZHEIM & BAUER 1992). During the breeding season long-tailed ducks forage on a variety of organisms including insect larvae, fish spawn, crustaceans, and molluscs (GLUTZ VON BLOTZHEIM & BAUER 1992).

During the non-breeding season, long-tailed ducks are gregarious, and often seen in flocks at temperate marine coastal areas and offshore banks, where they mainly feed on bivalves supplemented by polychaeta worms, echinoderms, and fish spawn (Madsen 1954; Kirchhoff 1979; Stempniewicz 1995; Evert 2004; Žydelis & Ruskyte 2005).

Long-tailed Ducks wintering in the pre-investigation area are part of the Fennoscandian-West Siberian population. They arrive from the breeding grounds from October to moult in the Baltic Sea, are most numerous during winter (January-February) and leave until April to migrate to their breeding grounds (Mendel et al. 2008). Observations of long-tailed ducks in the pre-investigation area during summer are thus unlikely except for sporadically appearing young non-breeding individuals. The most important areas in the Baltic Sea with highest observed densities are in the Pomeranian Bay, the Gulf of Riga, and the Midsjö banks south of Gotland (Skov et al. 2011). In Danish waters, highest densities were mainly observed on Rønne Banke. The Danish Center for Environment and Energy (DCE) has regularly conducted aerial surveys of the region and has estimated a total of 18.000-30.000 wintering individuals at Rønne Banke (Petersen et al. 2016).Other areas such as Kriegers Flak, Køge Bugt, Præstø Bugt and the waters south of Falster, Lolland, Langeland and Ærø showed higher concentrations as well with up to 21.05 ind./km^2 (Petersen & Nielsen 2011). Lower densities were found in the Aalborg Bight with up to 8.83 ind./km^2. (Petersen & Nielsen 2011).

Based on a coordinated Baltic Sea survey from 2007 to 2009 roughly 1.5 million long-tailed ducks were estimated to winter in the Baltic Sea (Skov et al. 2011). This is a decline of 65 % compared to the census in 1988-1993, where a number of 4.7 million individuals was estimated (Wetlands International 2006).

Long-tailed duck populations have decreased in the last decades due to various anthropogenic factors, especially oil pollution (Skov et al. 2011). Various anthropogenic factors are suspected to have influences this decline (e.g., Skov et al. 2011; Nilsson 2016; Nilsson & Haas 2016). Due to this drastic population decline, they are considered as vulnerable under the IUCN and are listed in Appendix II B of the European Birds Directive (European Union 2010).

COMMON EIDER

The population of common eiders (*Somateria mollissima*) in Denmark has increased during the 20th century (Lyngs 2000). The performed censuses indicate a population of about 23,000 eiders between 1988 and 1993. The last censuses of 2000-2002 reported a similar number of eiders, indicating that the population in Denmark remained stable (Lyngs 2008). Based on Petersen and Nielsen (2011), estimates suggested 503,000 common eiders wintering in Danish waters during 2008. More recent evaluations between 2000 and 2008/09 estimated this population to be stable as well (Ekroos et al. 2012).

During summer, common eiders are mostly located in the coastal areas around Samsø and the north western coasts of Sjælland with up to 252.85 ind./km^2 (Petersen & Nielsen 2011). High concentrations were also found around Læsø and Smålandsfarvandet with up to 66.61 ind./km^2. During winter, their main concentration areas are found in the southern Kattegat, especially around the south western coast of Fyn with up to 419.60 ind./km2 (Petersen & Nielsen 2011). High densities were also observed south of Læsø (up 70 43.85 ind./km^2) and in the coastal regions of Aalborg Bight (up to 27.46 ind./km2; Petersen & Nielsen 2011).

Common eiders are considered as near threatened under the IUCN. In Europe, they are generally considered endangered (BirdLife International 2021). Like other sea duck species, they are also listed in the Annex IIB of the European Birds Directive (European Union 2010). Recent evaluations estimate 560,000 – 920,000 wintering common eider individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 10.04.2024) for the Baltic, North & Celtic Seas population, with a declining trend.

COMMON AND VELVET SCOTER

In winter, most common scoters (*Melanitta nigra*) occur in the western Baltic Sea (DURINCK ET AL. 1993). Besides, the Pomeranian Bight and the Kattegat are important moulting areas from June to September. In the German Baltic Sea, they may be found during the whole year, especially in the Pomeranian Bay and surrounding area (MENDEL ET AL. 2008). In the Baltic Sea, common scoters show a preference for areas with water depths between 5 and 15 m (SKOV ET AL. 2011). In the wintering areas their diet consists largely of marine bivalves, which are harvested on or up to three centimetres below the surface (MADSEN 1954; FOX 2003; KAISER ET AL. 2006). Thereby, common scoters are assumed to choose their diet according to abundance, availability and energetic content of prey items rather than being restricted to certain prey species.

The results of the Baltic coordinated survey in 2007 to 2009 indicate that the winter population of common scoters has declined markedly from 783,310 birds in 1988–1993 to 412,000 birds in 2007–2009, equivalent to a 47% decline over 16 years (HELCOM 2019a). However, recent evaluations for the Northwest European population estimate 678,000 – 815,000 wintering common scoter individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 10.04.2024), with an increasing trend. High densities of wintering common scoters have been found north of the pre-investigation area in Aalborg Bugt and the areas around Læsø and Anholt with up to 303 ind./km^2 (PETERSEN & NIELSEN 2011) and lower densities in the Sejrøbugten with up to 105 ind./km^2. In summer during their moulting period, high common scoter densities were mainly found around Læsø and in Aalborg Bugt with up to 284.78 ind./km^2. Smaller concentrations were also located in the southern parts of Sejrøbugten and Bredegrund with up to 23.17 ind./km^2 (PETERSEN & NIELSEN 2011). Therefore, common scoters are expected to be present in the area year-round.

Velvet scoters (*Melanitta fusca*) breed along the Baltic Sea coast of Sweden, Finland, Russia and Estonia. The species is a regular and common winter and migration visitor in the Baltic Sea area from September to May. An important moulting area is located in the Pomeranian Bay around the Odra Bank (SKOV ET AL. 2011). Thus, velvet scoters can be found in the Baltic Sea throughout the year (DURINCK ET AL. 1994; SONNTAG ET AL. 2006). A study of velvet scoters wintering along the Lithuanian coast demonstrated a preference for marine areas with sandy substrates at depths between 2 and 30 m (ZYDELIS 2000). In the Pomeranian Bay the species occurred in waters with sandy sediments up to 30 m depth but was most frequently found up to 15 m depth (SONNTAG ET AL. 2009). The closest identified key area relative to the pre-investigation area is the Sejerø Bay (SKOV ET AL. 2011)). However, bird densities were rather low as compared to other key sites (e.g. Pomeranian Bay).

While the common scoter is listed as a species of least concern by the IUCN, the velvet scoter is considered vulnerable (BIRDLIFE INTERNATIONAL 2021). Recent evaluations for the Northwest European population estimate 220,000 – 410,000 wintering velvet scoter individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 10.04.2024), with a probably increasing trend.

3.1.5 GULLS

The general term ‘gulls’, groups different species of small and larger gulls (genus *Larus*). The first include two species that may occur frequently in the pre-investigation area: the black-headed gull (*Chroicocephalus* *ridibundus)*, the little gull (*Hydrocoloeus minutus*) and the black-legged kittiwake (*Rissa tridactyla*). All gull species are opportunistic and omnivore feeders. Little and black-headed gulls feed mainly on insects and crustaceans whereas large gulls feed mainly on small or medium-sized fish (MENDEL ET AL. 2008). Except for the great black-backed gull (*Larus marinus*) they tend to be gregarious. While little gulls may be slightly affected by offshore wind farms avoiding these areas, other species are known to be attracted by OWF structures (DIERSCHKE ET AL. 2016).

COMMON GULL

In the Baltic Sea, common gulls (*Larus canus*) breed along the coast mainly in Sweden and Finland. These gulls are mainly migratory, some birds winter in the northeast and southern Baltic Sea, but most overwinter in the North Sea (DURINCK ET AL. 1994). They feed on terrestrial and aquatic invertebrates as well as fish, but also on fish discards and garbage dumps (DURINCK ET AL. 1994). In fact, they are typical ship followers (WALTER & BECKER 1997; KUBETZKI 2002). They are observed in large flocks of up to 100 birds (DURINCK ET AL. 1994).

Common gulls may occur in the area throughout all year but might be more numerous in winter. During winter, low densities are expected in the Kattegat region in general with only a mean density of 0.3 ind./km^2, whereas highest densities were observed west of Bornholm (1-5 ind./km^2, DURINCK ET AL. 1994). Previous surveys indicated they were distributed over most of the Baltic Sea (DURINCK ET AL. 1993). Recent evaluations for the Northwest European population estimate 1,400,000– 2,000,000 common gull individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 10.04.2024). They are considered as a species of least concern based on the recent IUCN Red List (BIRDLIFE INTERNATIONAL 2021).

LESSER BLACK-BACKED GULL

Lesser black-backed gulls are distributed throughout Europe. Three subspecies exist: the eastern variation *Larus fuscus fuscus,* which breeds from Sweden to northern Norway and eastwards to Russia. The western variation *L. f. graelssii* breeding from SW Greenland to Iceland and to Spain and the intermediate form *L. f. intermedius* mainly occurring in the Netherlands and Denmark (MENDEL ET AL. 2008). In Denmark, two of these subspecies may occur (*L. f. fuscus* and *L. f. intermedius*). Breeding lesser black-backed gull individuals can be found on Græsholm (3-5 breeding pairs) and single individuals on Bornholm. In the western areas of the Danish Baltic Sea breeding pairs are reported for Saltholm, but the exact number is unknown (HELCOM 2013a). In the study by Petersen et al. (PETERSEN et al. 2021), lesser black-backed gulls were only recorded in very small number in the pre-investigation area and thus the area is probably of low importance for this species.

Almost two decades ago, estimates suggested a population of 300,000 to 350,000 breeding pairs of lesser black-backed gulls (MENDEL ET AL. 2008). Recent evaluations for the ’intermedius’ population estimate 560,000 – 610,000 lesser black-backed gulls individuals with a stable trend. (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 09.04.2024). They are considered as a species of least concern based on the recent IUCN Red List (BIRDLIFE INTERNATIONAL 2021), but are listed as vulnerable by HELCOM (2013a).

GREAT BLACK-BACKED GULL

The great black-backed gull *(Larus marinus*) occurs in small numbers in the Baltic Sea throughout the year. The highest populations are observed in winter when birds migrate southward from northern breeding sites. In the Kattegat, an important key area has been identified by Durinck et al. (1994), stretching along the Swedish coast. Great black-backed gulls feed mainly on fish and are solitary or observed in small loose flocks (DURINCK ET AL. 1994). They also gather near fishing ships to forage on discard (DURINCK ET AL. 1994; GARTHE & SCHERP 2003;

MENDEL ET AL. 2008). In the pre-investigation area, great black-backed gulls were commonly found with a dispersed pattern which is probably associated to the presence of fishing vessels (DHI 2019). Recent evaluations for the Northwest European population estimate 240,000 – 310,000 great black-backed gull individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 10.04.2024). They are considered as a species of least concern based on the recent IUCN Red List (BIRDLIFE INTERNATIONAL 2021).

HERRING GULL

The numbers of herring gulls (*Larus argentatus*) have increased in Denmark during the last decades. While the first censuses of 1920 estimated a population of around 3000 pairs, more recent counts in 2010 estimated roughly 87,000 pairs. Currently, declining population trends of partially significant magnitude in the Baltic region for example in Finland have been reported (HARIO & RINTALA 2016; WETLANDS INTERNATIONAL 2022, retrieved on 03.03.2022). Most of the growth of the population occurred after the 1960s and parallels the growth observed in north-western Europe, apparently linked to an increase due to protection measures and the availability of additional food resources for example by garbage dumps and fisheries discards (BREGNBALLE & LYNGS 2014).

The development of the population of herring gulls differed between eastern and western Denmark. Before the mid-seventies, most herring gulls (61%) bred in the eastern part of Denmark (BREGNBALLE & LYNGS 2014), with the colony of Ertholmene being the second largest colony in Denmark (LYNGS 1992). Around 1974, the government installed culling programs in the largest colony, which resulted in a decline of the entire breeding population and shifted their centre of distribution towards the western part of the country (BREGNBALLE & LYNGS 2014). Although herring gulls breeding at Ertholmene have reduced from about 20,000 pairs in 1970s (LYNGS 1992) to about 9,000 pairs (BREGNBALLE & LYNGS 2014), the breeding colony is still important. During winter, a high-density area in the Kattegat, Middelgrundene, has been identified (Durinck et al. 1994). Using more recent data, also DHI (2019) showed that herring gulls occurred commonly in the pre-investigation area during winter, with locally high densities that were probably associated with fishing vessels. Recent evaluations for the Northwest European population estimate 860,000 – 1,000,000 herring gull individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 10.04.2024). Herring gulls are considered as a species of least concern based on the recent IUCN Red List (BIRDLIFE INTERNATIONAL 2021), but listed as vulnerable in the HELCOM Red List (2013b).

Herring gulls are regarded as the most common gull species in the offshore sites of the German Baltic Sea. Thus, their occurrence is expected in the pre-investigation area.

BLACK-LEGGED KITTIWAKE

Kittiwakes show a very wide distribution in the North Sea and adjacent waters, especially during the non-breeding season. In the Baltic Sea, the Kattegat is the main wintering area for this species (DURINCK et al. 1994). The black-legged kittiwake breeds only at a few locations in north Jutland (https://dk.birdmigrationatlas.dk; accessed 22.04.2024), the main breeding areas are located in Northwest Europe (e.g. UK, Iceland and Norway). Kittiwakes mainly feed on small shoaling fish like sandeels and clupeidae but also on the pelagic larval states of crustaceans (MENDEL et al. 2008). They are often found following fishing vessels and taking discards (GARTHE & HÜPPOP 1994).

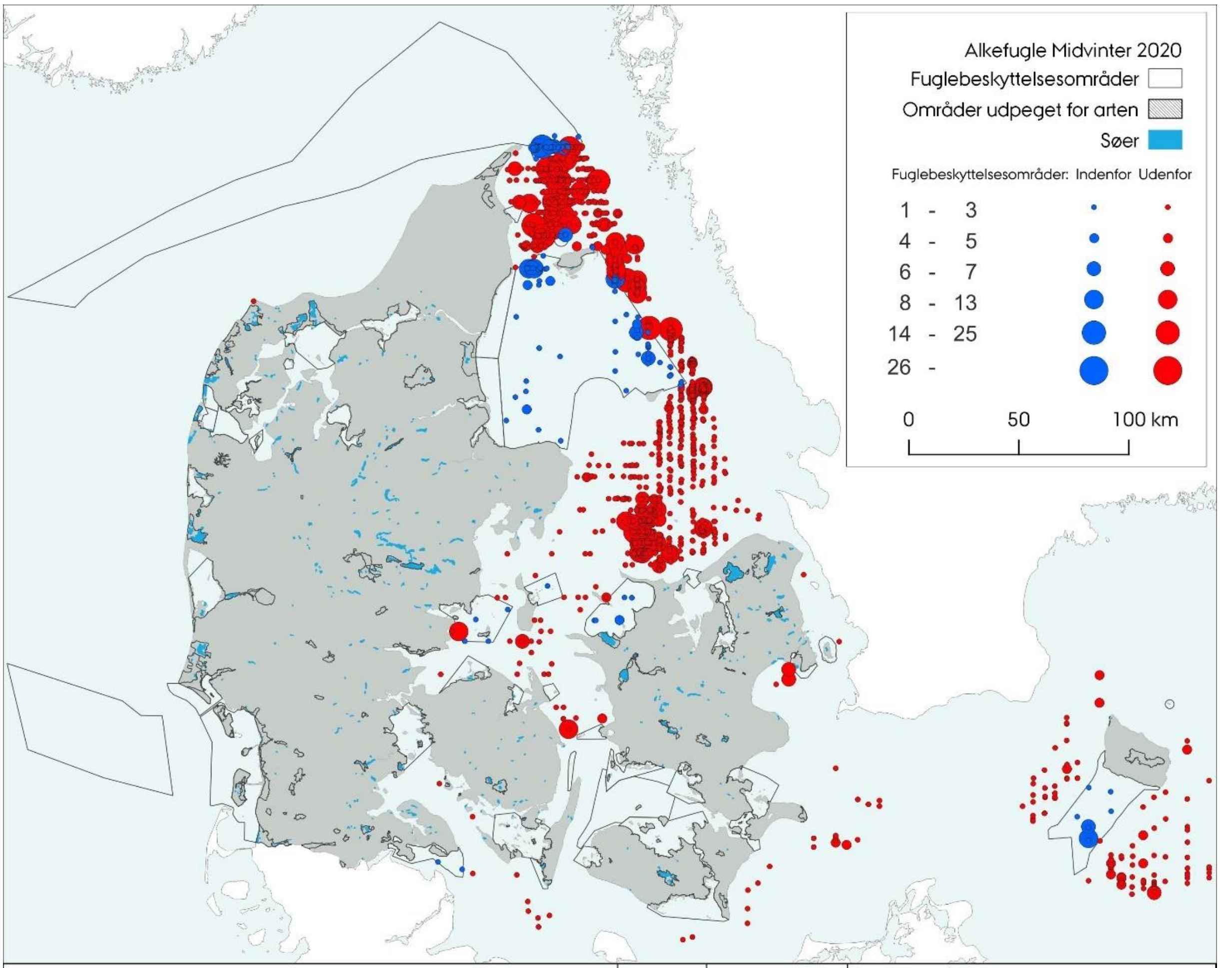
In the Kattegat, black-legged kittiwakes were found in locally high densities in the eastern part of the Kattegat (DURINCK et al. 1994) and this was also confirmed in more recent studies (DHI 2019; PETERSEN et al. 2021). Birds mainly occurred there between November and March.

The Atlantic biogeographical population of the black-legged kittiwake (to which individuals in the study site would mainly belong) was recently estimated to be 6.1 million individuals (AEWA CSR 8, http://wpe.wetlands.org/, accessed 22.04.2024), with a declining trend.

3.1.6 AUKS

Auk species typically found in the Baltic Sea are common guillemots *(Uria aalge)* and razorbills (Alca torda). Occasionally, other auks such as the Atlantic puffin (*Fratercula arctica)* and the black guillemot (*Cepphus grylle)* may appear as well. The black guillemot is one of the species for which Rønne Bank is considered an important bird area (Heath & Evans 2000). Over two thirds of the population of common guillemots and 30% of the populations of razorbills breed on Stora Karlsö (and Lilla Karlsö), two small islands located west of the island of Gotland, which are famous for hosting the largest fish-eating seabird colonies of the Baltic Sea (Olsson & Hentati-Sundberg 2017). Other colonies are located in different areas of the Baltic Sea, but most are relatively small. The second largest colony of common guillemots in the Baltic Sea is found on Graesholmen, a very small island north of the island of Bornholm, which hosts about 2,000-3,000 breeding pairs (Olsson et al. 2000). Lyngs (1992) suggests that there were 2,000 pairs of common guillemot and around 450 pairs of razorbills breeding in Graesholmen in the 1980s. In the early 2000s, the breeding pairs of razorbills had increased to 780 pairs (Lyngs 2001). The archipelago of Ertholmene is one of the Danish important bird areas and the only site in Denmark known to have breeding colonies of both auk species (Heath & Evans 2000).

During winter, surveys in the Inner Danish Waters found razorbills/guillemots almost exclusively in the central Kattegat, between Nordsjælland, Anholt and Læsø. Most birds were found in areas with water depths of 20 - 40 m (Petersen & Nielsen 2011). Durinck et al. (1994) also found key areas in the northern part of the Kattegat with high densities of razorbills in the Middelgrundene and the Djursland coast. This was also confirmed by a more recent study (DHI 2019). Also common guillemot reached the highest densities in the Middelgrundene area (Durinck et al. 1994) and a more recent study also showed a high persistency of occurrence in the central, eastern and northeastern parts of the Middelgrund study area (Petersen et al. 2021). Recent surveys from winter 2020 also showed high numbers further south, towards the coast of Sjællands *Odde* (Figure 3-1; https://novana.au.dk, accessed 22.04.2024). Of black guillemots, only a small population winters in the northern Kattegat (Durinck et al. 1994). Higher densities of this species may occur in the Pomeranian Bay and south of Rønne Bank (Ode Bank, Adlergrund bank, Durinck et al. 1994; Mendel et al. 2008). Compared to the other two auk species, black guillemots prefer shallower waters (depths < 25 m, Durinck et al. 1994).



Fugle talt i alt:	3.144	Procentandel:
Heraf talt i fuglebeskyttelsesområder:	360	11,5%
Heraf talt i fuglebeskyttelsesområder udpeget for arten:	0	0,0%
Fugle talt i fuglebeskyttelses- og habitatområder (Natura 2000)	530	16,9%

Figure 3-1. Spatial distribution of auks in the winter 2020. From https://novana.au.dk.

While the two most common auk species have relatively stable populations or are increasing, other auk species are threatened (HELCOM 2019b). In general, auks are long-lived, but start reproducing only after several years of life. Moreover, these species were heavily hunted by humans, and their populations almost got extinct. Both the common guillemot and the razorbill are listed a species of least concern on the IUCN Red List (BIRDLIFE INTERNATIONAL 2021). For common guillemot, individuals from several subspecies might occur in the Kattegat and the exact proportion of birds from the different breeding areas/flyways/subspecies is not known. Recent evaluations for the Northwest European population estimate 500,000 common guillemot and 830,000 – 2,000,000 razorbill individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 09.04.2024), with an increasing trend. Among the two other species that may rarely occur in the area, the black guillemot is listed as a species of least concern as well, whereas the Atlantic puffin is considered endangered (BIRDLIFE INTERNATIONAL 2021).

3.2 MIGRATING BIRDS

Migrating birds alternate between breeding and non-breeding regions. They can travel over long distances twice a year. Although this is a regular, annually recurring phenomenon, the magnitude of migration can vary strongly from year to year and is subject to great variability. The distance covered during migration varies among species as well, some migrate over long distances of several 100 or 1000 km, others travel short distances with only a few km. Among some species, only parts of the population migrate while the rest resides in their area of distribution (BAIRLEIN ET AL. 2014; CORDES & MAY 2023).

Estimates for the western Baltic Sea (including Belt Sea and Kattegat) suggest that about half a billion birds belonging to approximately 200 different species cross the area during autumn and roughly ~ 250 million birds during spring (BSH 2021; NUSSBAUMER ET AL. 2021). The majority of these are songbirds (> 95%). The rest is composed of seabirds and other waterfowl such as divers, grebes, ducks, geese, waders, gulls, terns and auks (BSH 2021). Especially daily migrants like thermal gliders such as birds of prey and cranes tend to avoid crossing open sea when migrating (ALERSTAM 1978) and thus are frequent migrants in the Belt Sea/Kattegat area with shorter distances across sea areas compared to the western Baltic Sea. Instead, they follow land areas until a crossing is unavoidable and therefore concentrate at peninsulas or other narrow stretches of land in order to reduce the risks and energy expenditures associated with active flight over water (ALERSTAM 1990).

As previously mentioned, bird migration is very variable and thus hard to predict. However, the timing of migration is influenced by weather conditions such as temperature, precipitation, fog, wind speed and direction, as energetic costs necessary for flying itself are related to the presence and magnitude of these parameters (LIECHTI & BRUDERER 1998; LIECHTI 2006; SHAMOUN-BARANES ET AL. 2010; NILSSON ET AL. 2019). Thus, migration mostly takes place during only a few days of the migration period with the most favourable weather conditions (BSH 2021).

For many Scandinavian and Siberian breeding bird species, the Baltic Sea including Belt Sea and Kattegat is part of their annual migration routes (WELCKER & VILELA 2020) (Figure 3-2). Numerous night-migrating songbirds are thought to cross the offshore area in a broad front mainly with a south-western orientation, but local aggregations and deviating directions are also possible. Most day-migrating birds follow landmarks like in spring from the eastern edge of the Djursland peninsula over the island of Anholt to the Swedish mainland in Kattegat or from the Falsterbo peninsula in south Sweden over Danish islands such as Zealand and Lolland and German Fehmarn to the mainland of Europe in autumn, but fractions of those populations also directly cross the open water. Waterfowl like geese, ducks or divers mainly move through the area in an east-west direction (BELLEBAUM ET AL. 2010a).

Concerning especially Kattegat, the area of Gjerrild is considered to be the second most important site after Skagen for landbirds migrating between Jutland and Sweden in spring (DHI 2009). Although the numbers will be lower than at Skagen, the northernmost tip of Jutland, numbers migrating from Gjerrild is still considerable. Raptors are considered the most important species group in the Anholt area, specifically common (*Buteo buteo*) and honey buzzard (*Pernis apivorus*), sparrowhawk (*Accipiter nisus*) and red kite (*Milvus milvus*). Important are also diurnally migrating passerines (e.g. chaffinch/brambling, wagtails, pipits, larks and swallows) as well as swifts and pigeons (wood pigeons *Columba palumbus*). Waterbird counts revealed the importance of the area for sea ducks such as common scoters and eiders as well as gulls.

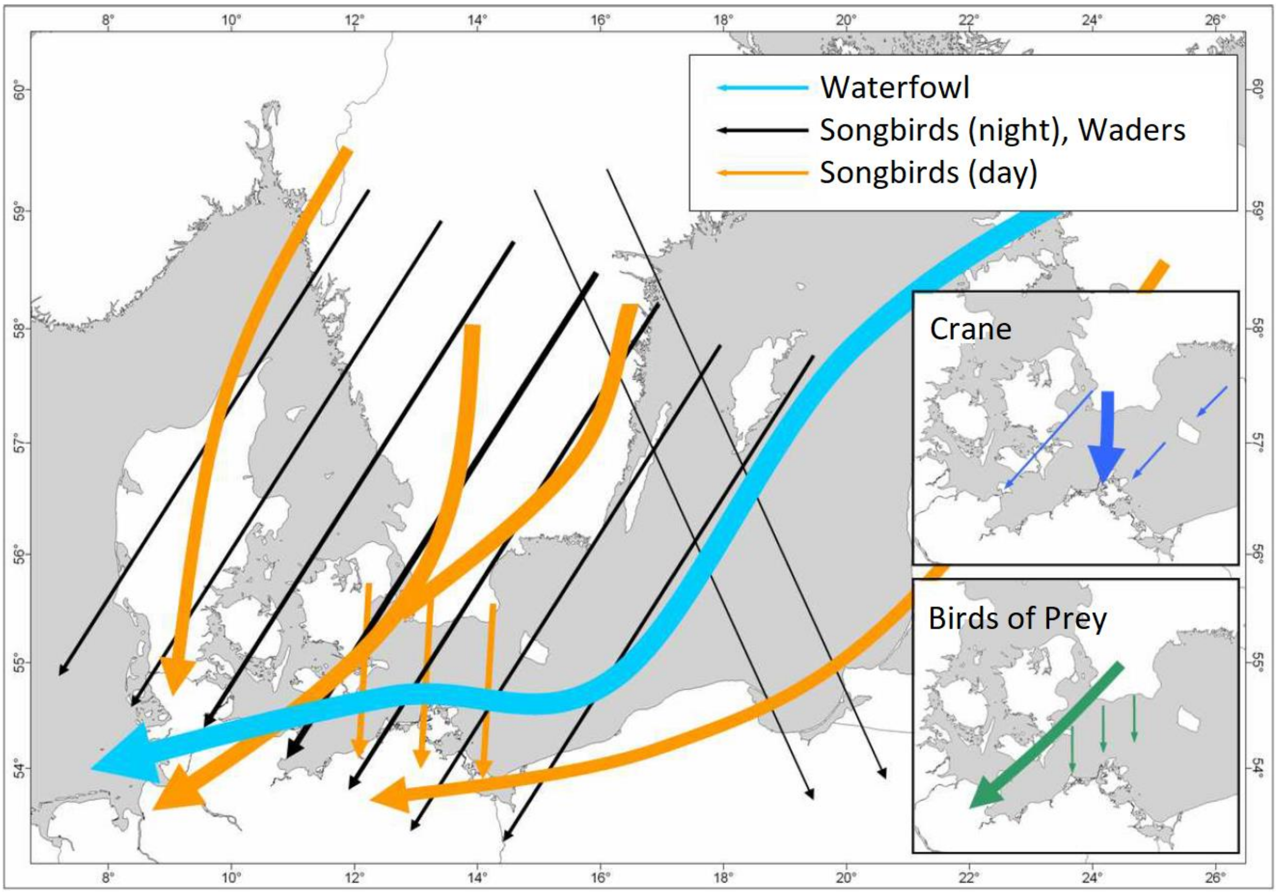


Figure 3-2. Most important migration routes in the Baltic Sea during autumn. From Bellebaum et al. (2010a).

Two Natura 2000 sites are located close to the investigation area. The “Aalborg Bugt, østlige del” (code DK00VA344) with a size 1,774 km^2 is located north-west of the study site and is also specified as a Bird Directive Sites or SPAs (Special Protected Areas). It is designated specifically for the common scoter (*Melanitta nigra*), the common eider (*Somateria mollissima*) and the Brent goose (*Branta bernicla*). In the western parts of the investigation area lies the site “Schultz og Hastens Grund samt Briseis Flak” (code DK00VA303) covering 207 km^2. This Natura 2000 site is characterised by shallow sandbanks, which are slightly covered by water all the time, as well as reefs. The site “Lysegrund” (code DK00VA299) is located in the east of the investigation area, north of the island Anholt. It covers 32 km^2 and includes sandbanks as well as reefs. The island Anholt itself is part of the site “Hesselø med omliggende stenrev” (code DK003X202), which covers 42 km^2 and is characterised by several different habitat types. Most important for resting (and migrating) birds are sandbanks, coastal lagoons and reefs.

In the following paragraphs, those migratory bird species or species groups, which were identified as most relevant for the investigation area, will be described in more detail.

3.2.1 GEESE AND SWANS

At least three goose species of the *Anser* genus, two “black” *Branta* species of barnacle and brent goose, and three species of swans migrate annually through the Belt Sea/Kattegat region. In general, these species are either polytypic (except for *Branta leucopsis* and two of the swan species), or if monotypic, have populations that rarely exchange genetic material. Most geese breed on lakes, pools, rivers and in a variety of wetland habitats and winter on farmland in open country or in swamps, lakes, saltmarshes and coastal lagoons further south than their breeding areas (SCOTT & ROSE 1996). Moreover, the subspecies or populations of geese and swans that may be encountered in the Kattegat area have all increased in size in the last decades partly because of protection of their main wintering and staging sites in northwestern Europe, and also a reduction of hunting pressure on some of these species (for example *Branta leucopsis*).

Whereas the specific biology and requirements of each of the species mentioned here varies, mostly all of them follow the same migration pattern. They start their migration towards the wintering areas (reaching from Denmark to southwest Europe) by September, reaching peak numbers in January and February in their winter quarters and migrate back to their breeding areas from March onwards (SCOTT & ROSE 1996). For example, the whooper swans overwinter in Denmark with numbers of 57,303 in 2020 and 60,612 in 2021 (HOLM et al. 2021).

Only the greylag goose (*Anser anser*) breeds relatively close to the pre-investigation since the greylag goose is a common breeding bird in Denmark, estimated at 18,000 breeding pairs (HOLM et al. 2021) and migrates further south in winter, whereas some of the populations of the barnacle goose (*Branta leucopsis*) have recently established new breeding sites in these regions but in farther distances to the Kattegat area (FEIGE et al. 2008) e.g. 4.500 pairs on Saltholm close to Copenhagen in 2019 (HOLM et al. 2021).

Regarding observed migration altitudes, geese often fly at high altitudes. The barnacle goose for example is known to fly at faster speeds and higher altitudes in spring than in autumn (341 m vs 215 m, GREEN & ALERSTAM 2000).

As already mentioned, the populations of these species have increased in recent years. However, this increase has also resulted in some conflict with humans. *B. b. bernicla* has increasingly turned to new food sources grazing on cultivated crops near the coast, causing a conflict with farmers, for example in Britain (Salmon & Fox 1991). As a result, and a possible solution, studies have been conducted to evaluate whether an increase of the hunting bag for some of these geese species could help to control their populations without representing a threat. Similar conflicts arise with many of the other species, and with the exception of the barnacle goose no other species of these waterbirds is listed under the Annex I of the Birds Directive.

Geese and swans are known to show avoidance behaviour to wind farms. Almost 95% of pink-footed geese (*Anser brachyrhynchus*), a species which is more often encountered in the North Sea, showed strong vertical and horizontal avoidance behaviour as a response to offshore windfarms (PLONCZKIER & SIMMS 2012). Moreover, these authors also showed that during periods of reduced visibility geese tended to fly at lower altitudes (100-150 m) compared to periods of good weather conditions when they flew higher (250-300 m). Nevertheless, they said that in their study most of the migration took place early in the afternoon under favourable conditions, thus possibly reducing the risk of collision (PLONCZKIER & SIMMS 2012).

3.2.2 BIRDS OF PREY

Birds of prey, also known as raptors, are all top predators. About 39 species of breeding diurnal birds of prey are inhabiting Europe (STROUD 2003). More than half of the species known worldwide (at least 62% or 183 species) undertake seasonal migrations with many of them being long-distance migrants undertaking sometimes intercontinental flights (BILDSTEIN 2006). Most birds of prey can soar, meaning they are able to maintain flight without flapping their wings by making use of the rising air currents and thereby reducing energetic costs. Soaring is an efficient form of transport, both during and outside of long-distance migration (BILDSTEIN 2017). Especially long-distant migrants are strongly dependent on soaring flight. However, when crossing large waterbodies such as the Kattegat, which usually lack upwinds, soaring provides quite a challenge. Other species such as ospreys, harriers and most accipiters and falcons migrate with powered flight by flapping their wings. Most raptors are day migrants, but few species such as peregrine falcons, ospreys, and merlins also migrate during nights.

The migration corridors of raptors, which often travel in flocks, are well-known (BILDSTEIN 2006). Their most important flyway in Europe is the western European-western Africa flyway (BILDSTEIN 2017). A comparative study of satellite tracking and ring recoveries for four common raptor species gathered detailed information on the taken routes (STRANDBERG ET AL. 2009).

At Falsterbo in South Sweden, raptor autumn migration has been studied since the early 1940s (KJELLÉN & ROOS 2000), whereas standardized counts of raptors and other migratory birds have been conducted since 1973 (KJELLÉN 2019). Therefore, this spot has often been used to describe the common pattern of migratory birds in the western Baltic Sea region including Kattegat and Belt Sea. An average of 46,000 migrating raptors and falcons are observed annually. The most common species there are the eurasian sparrowhawk (*Accipiter nisus)*, the common buzzard (*Buteo buteo)* and the red kite (*Milvus milvus)* (KJELLÉN 2019). Species with more southerly distribution breeding close to Falsterbo are more commonly observed compared to species with northerly distributions (KJELLÉN 2019). Similarly, thermal migrants tend to be more concentrated than active flyers at Falsterbo. Since raptors tend to fly at lower altitudes in these regions, the censuses at Falsterbo have been particularly important for raptor studies (e.g., KJELLÉN 1997). The numbers of the most common birds of prey have either increased or remained stable within the last decades (cf. KJELLÉN 2019). Three species show negative trends at Falsterbo: the European honey buzzard (*Pernis apivorus),* the rough-legged buzzard (*Buteo lagopus)* and the northern goshawk (*Accipiter gentilis)* (KJELLÉN 2019). In comparison to a previous study on the trends of raptors from 1940s to the late 1990s in the same area, there seems to be a slight recovery of raptors currently migrating through Falsterbo (KJELLÉN & ROOS 2000; KJELLÉN 2019).

The baseline study as well as specific investigations on collision risks for the OWF Anholt in the northern part of the pre-investigation area revealed the area of Gjerrild to be the second most important site after Skagen for landbirds migrating between Jutland and Sweden in spring (DHI 2009: Anholt OWF Baseline 2009). Although the numbers will be lower than at Skagen, the northernmost tip of Jutland, specifically common and honey buzzard, sparrowhawk and red kite are migrating regularly and in high numbers across the Kattegat.

There is, however, a large variation in the number of raptors being observed during the autumn migration every year. This may not only be linked to more birds being counted under favourable weather conditions. When birds fly against the wind, they tend to fly at lower altitudes and may be more easily observed and thus counted. It could also be caused by changes in population numbers due to changes in reproduction. Species like the Eurasian honey buzzard and the rough-legged buzzard are known to produce varying numbers of juveniles depending on the availability of prey such as wasps or rodents during the breeding season (KJELLÉN 2019).

As top predators, most birds of prey are k-selected species with relatively little annual reproduction and their young require many years to mature before breeding (DWYER ET AL. 2018). Thus, they have naturally low densities. The population sizes of raptor species are relatively small compared to other breeding birds. Their life-history traits and their high trophic level make them extremely susceptible to anthropogenic threats such as land use change, direct killing, poisoning and environmental contaminants, electrical injuries causing death and climate change. They are among the most threatened group of birds in the world (MCCLURE ET AL. 2018). In Europe, the most influential impacts affecting the populations of the most vulnerable diurnal raptor species include habitat loss/change, intensification of agricultural habitats, direct persecution (e.g. shooting), pesticide contamination, disturbance of nest sites and many others (STROUD 2003; SERRATOSA ET AL. 2024).

Due to the particular vulnerability of birds of prey and the reduction of their population sizes caused by numerous threats they have already faced by the first half of the last century (BIJLEVELD 1974; BILDSTEIN 2017), they are among the rarest birds in Europe: 46% of European birds with less than 1,000 breeding pairs are birds of prey (STROUD 2003). Thus, many of the species are protected by European legislation and have also been included in other conventions (see Figure 3-2 for the most common species likely crossing through the Baltic Sea including Kattegat).

Since no collision victim search underneath offshore wind turbines is possible, all studies measuring direct mortality are based on onshore studies. Direct mortality from collisions with onshore wind turbines are relatively common in birds of prey. The collision of individuals by wind turbines were already observed with the first large wind farms placed in Altamont Pass in California and have been documented in many other onshore places ever since. In Germany, in March 2013 at least 37% of all reported bird collisions corresponded to birds of prey confirming that they made up a disproportionately large amount of all collisions (HÖTKER 2017). Some species were especially susceptible. Among them were Red Kites, whose breeding populations in Germany have been rapidly declining since 1991 (MAMMEN ET AL. 2017), which is why they are a focal species in relation to potential risks of wind turbines.

Despite the estimates of collision rates being very variable and the difficulty of obtaining reliable data, some overall findings and conclusions have been achieved from a German database (RASRAN & DÜRR 2017). According to this study, most frequently killed birds at onshore wind farms were red kite and common buzzards, but other species such as white-tailed eagles, common kestrels and black kites were also often reported as victims. Most collision victims were adult birds mainly occurring in spring and late summer (RASRAN & DÜRR 2017). The collision risk directly depends on the rotor swept area. Red kites often flew at heights within the rotor swept area of onshore wind turbines. Up to 50% of all recorded red kite flights are at a collision risk height (MAMMEN ET AL. 2017).

Whereas collisions with onshore turbines have been documented for at least 34 species of birds of prey, the effect this may have on population level has been explored for comparatively fewer species. For example, a study modelling the population of red kites in Germany has predicted a further decline due to additional mortality from collisions with wind turbines (BELLEBAUM ET AL. 2013). Indirect effects such as modifying flight altitudes to avoid wind farm collision and displacement and effective habitat loss have also been studied for different species. Golden eagles for example are apparently able to detect and avoid turbines during migration after the construction of wind farms (JOHNSTON ET AL. 2014b). Black kites have been found to reduce the use of areas up to 674 m away from turbines with an estimated loss of 3-14 % of the suitable areas at the migratory bottleneck of the Strait of Gibraltar (MARQUES ET AL. 2019). After the construction of the Anholt wind farm in Kattegat specific investigations were conducted to assess the weather dependent collision risk for raptors passing the OWF during spring migration (JACOBSEN et al. 2019). The study shows, that 73 % of the observed raptors showed avoidance behaviour to the OWF with three quarters of all reacting birds returning back to mainland indicating that an OWF could potentially act as a barrier by forcing some birds to use alternative routes. Accordingly, the authors recommend that important raptor migration routes should be taken into consideration when planning OWF sites. Further examples of study cases of the effects of wind turbines on different birds of prey are reviewed by WATSON and colleagues (2018).

However, since reliable methods for the monitoring of bird collisions with offshore turbines are still under development, all numbers on potential collision victims in offshore areas are based on models with the BAND model the most famous one (BAND 2012).

3.2.3 CRANES

The population of common cranes breeding in Northwest Europe and Scandinavia increased and is estimated to support 350,000 individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, retrieved on 25.02.2022). Especially for cranes inhabiting Finland and Sweden, the Southwestern Baltic Sea is an integral part of their migration route to and from wintering quarters in Southwestern Europe. In Denmark the migration intensity of cranes is decreasing towards northwest and in the Kattegat area cranes are not observed in high numbers (HOLM et al. 2021). The Rügen-Bock region in Germany is an important resting area, hosting temporarily up to 40,000 individuals (BSH 2021). A huge part of these birds crosses the Arkona basin in a 1–2-hour flight. Especially in autumn, a proportion of cranes will also move in a southwestern direction over the area of Bornholm (Figure 3-3). Nonetheless, common cranes migrate also towards the north potentially crossing the pre-investigation area (cf. bird migration atlas, https://migrationatlas.org/).

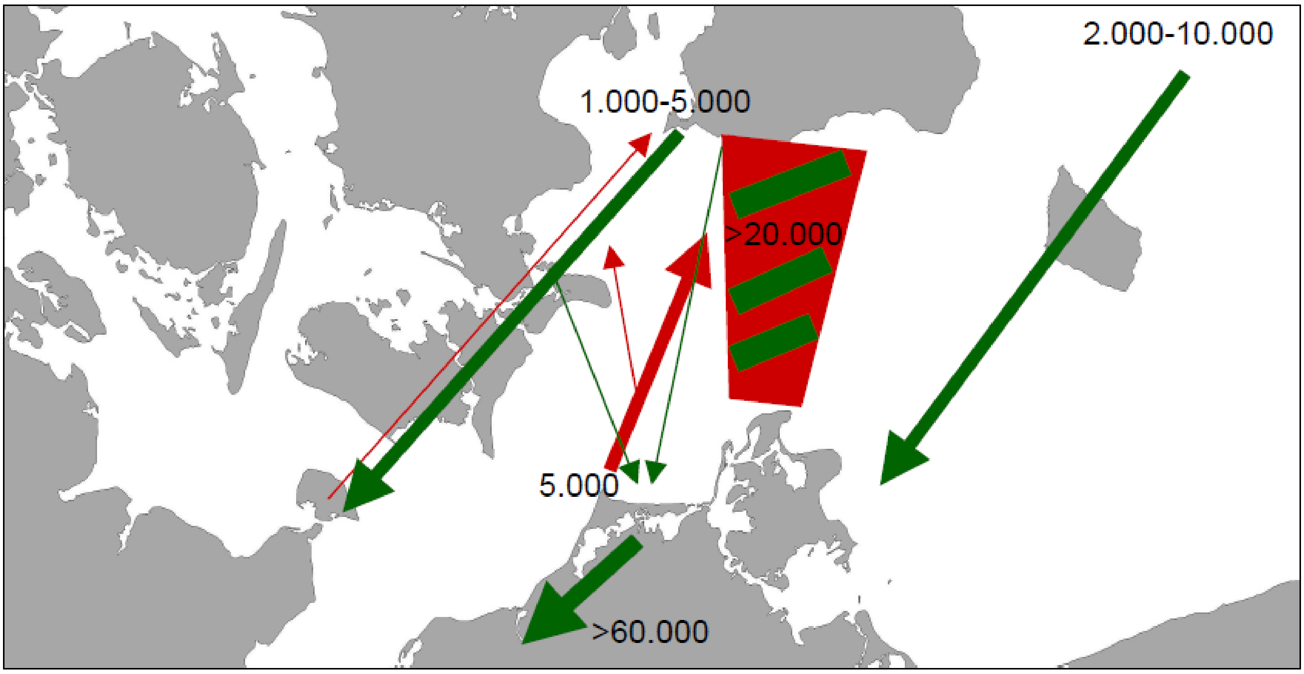


Figure 3-3: Migration routes of common cranes in the southern Baltic area (BSH 2021 based on Falsterbo, Bornholm and other observation data). Estimated numbers may be higher today due to an increasing population trend.

Due to the increasing population, the common crane currently is listed as a species of least concern (BIRDLIFE INTERNATIONAL 2021). However, its susceptibility to increasing offshore wind power generation remains unclear. One important behavioural trait in this regard might be the flight height of cranes crossing the Baltic Sea including Kattegat. They tend to use soaring flight over land, but due to the lack of thermal updrafts over the open water, they have to gain or hold their altitude in powered flight after leaving the coasts (ALERSTAM 1990). Studies of flight altitudes of cranes in the Baltic offshore region so far revealed a certain variety, with cranes observed flying clearly below 200 m height as well as far above (SCHULZ ET AL. 2013; SKOV ET AL. 2015). Even though a study from an onshore wind farm determined avoidance rates for Cranes of 99.93-100% (Drachmann et al. 2022), their flight behaviour and flight height during the crossing of the Baltic Sea leads to the fact that a theoretical risk of collision in the offshore area cannot be ruled out and therefore this species is a significant factor in the discussion about shutdowns in the western Baltic Sea.

3.2.4 TERNS

Terns are in general not very common in Danish waters and thus in the pre-investigation area. Most common species are the Sandwich tern (*Thalasseus sandvicensis*), the Arctic tern (*Sterna paradisea*) and the common tern (*Sterna hirundo*). Sandwich terns were not breeding in the Baltic Sea region at the beginning of the 20th century (HERRMANN ET AL. 2008). The Danish population of Sandwich terns was counted at 5,125 breeding pairs in 2021, but the majority bred in the North Sea region (HOLM et al. 2021).

The arctic tern (2021: ca. 1700 breeding pairs), the common tern (2021 ca. 880 breeding pairs) and the little tern (2021: ca. 630 breeding pairs) may also be observed close to the pre-investigation area, but mainly close to the coast and only in the summer months. None of the tern species are expected to occur abundantly, they are seabirds requiring protection (all species are listed in Annex I of the European Birds Directive and under the AEWA), and at least the sandwich tern seems to react negatively towards OWF (DIERSCHKE ET AL. 2016).

3.2.5 SONGBIRDS

Passerines include more than half of all described bird species in the world and are also referred to as songbirds or perching birds, due to the arrangements of their toes, which facilitates perching.

Since passerines include a very large number of species, it is not surprising that they also comprise most of the bulk of migrating birds. One of the best studied bird migration systems is the one involving the Palearctic-African flyway. The first evaluation of the number of passerine birds migrating between Europe and Africa birds by Moreau in 1972 estimated 4.3 billion (HAHN ET AL. 2009). Newer estimations suggest only half of this number (~ 2.1 billion birds) migrating from Europe to Africa every autumn with almost three quarters of those birds corresponding to the migration of 16 passerine bird species (HAHN et al. 2009). This estimation corresponds to numbers of birds migrating from largest parts of Europe not only crossing the Western Baltic Sea, but it gives an impression of the importance of passerine birds during migration. European passerines show a variety of migration patterns and strategies of which a lot is still unknown (BUSSE 2001). European migrating passerine birds typically travel from their breeding sites often located in the north of Europe to their wintering quarters located in warmer regions in southern Europe or northern Africa. Passerine migration is often occurring in broad fronts instead of corridors (see Figure 3-4 for an example).

Passerine birds can be long-distance migrants with their breeding wintering sites geographically separated by an area which the species is only crossing or using as a stopover site during migration. Other species are short-distance migrants with their wintering grounds being close to or overlapping with their breeding sites. For several species it is known that their populations only partially migrate. For example, there may be different migration patterns between sexes or ages or even populations (e.g., only northern populations of European robins are migratory, southern populations are resident and populations at intermediate distributions are partially migratory). According to the review by BUSSE (2001), at least 63 species of European passerines are long-distance migrants, whereas 69 species can be classified as short-distance migrants (BUSSE 2001).

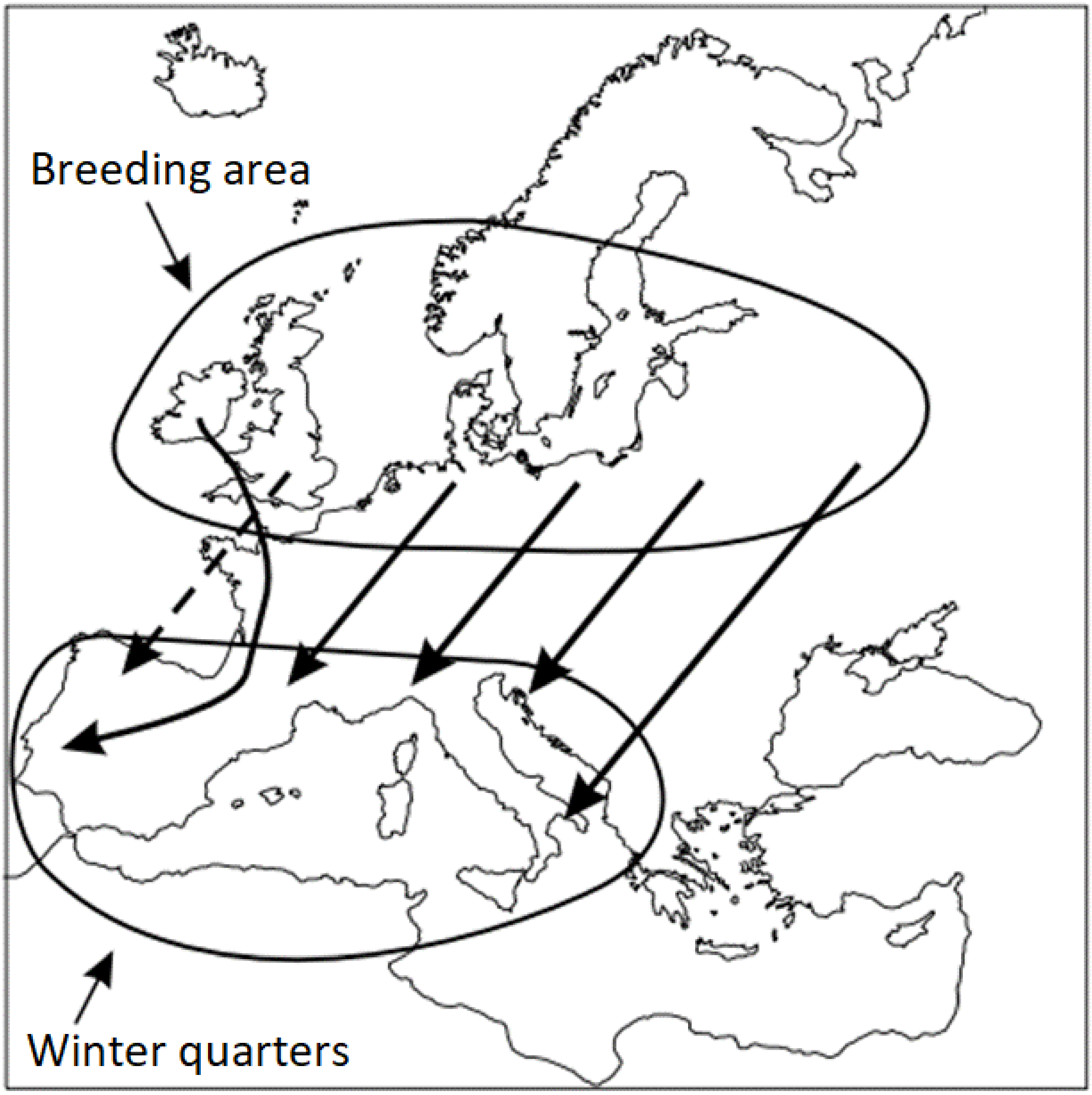


Figure 3-4: Example of broad front migration from the breeding region to the wintering quarter. Taken from Busse (2001, who modified it from Zink, 1973).

Most recent interpretations of migration studies and routes suggest that there might be four main passerine flyways in the Western Palearctic: 1) the Western/Atlantic flyway, 2) the Central/ Apennine flyway, 3) the South-Eastern (Balkan-SE) flyway and 4) the Eastern (Indian) flyway, which are shown in

Figure 3-5 (BUSSE et al. 2014). The different lines shown in

Figure 3-5 connect breeding sites with wintering quarters (as summarized from ringing recovery studies). Most (passerine) birds fly on these routes across broad fronts, but there are some passages with bottlenecks.

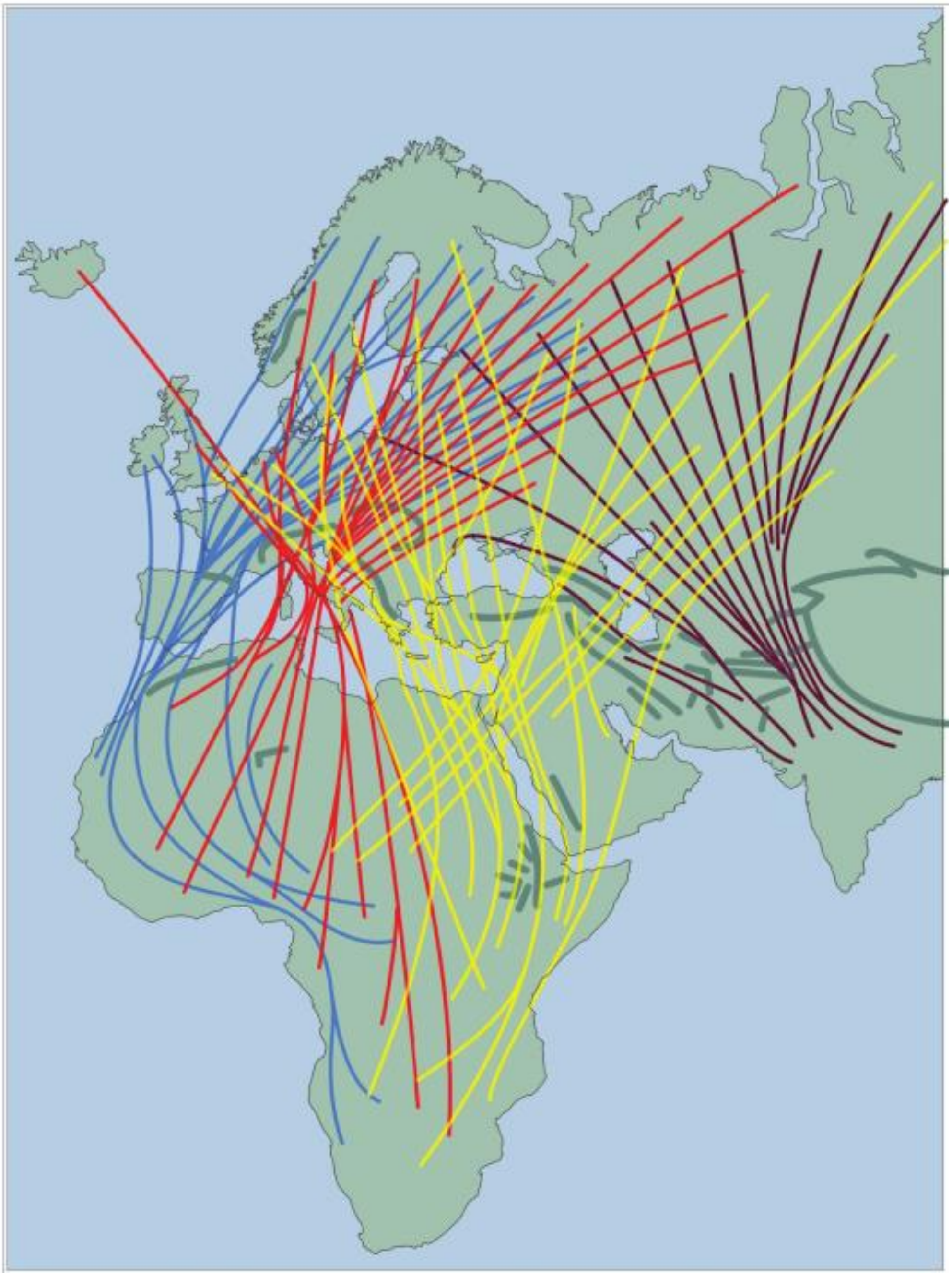


Figure 3-5: The four main fly way routes occurring in the Palearctic: 1) the western/Atlantic (blue), 2) the Central (Apennine, red), 3) South-Eastern (Balkan, yellow) and 4) Eastern (Indian, brown). Taken from Busse et al., 2014.

Migration of passerine birds occurs during day and night with species having adapted to migrate at a particular time of day. Most diurnal migrating species include low and mid-distance migrants, such as finches and wagtails, which are more dependent on visual orientation cues. Birds migrating during night are mid-distance migrants, such as thrushes and robins, as well as long-distance migrants such as warblers.

As seen in Figure 3-2 and Figure 3-5 most common migrating passerine birds cross the Kattegat area fly in a SW direction in autumn (the flyway 1). Nevertheless there are some migrating in a SE direction (BELLEBAUM ET AL. 2010a).

Given the large number of passerine birds potentially crossing the Baltic Sea including the pre-investigation area especially during the autumn migration, they are potentially affected by wind turbines, especially during (mass) migration. Some studies have shown that many species and a large proportion of birds killed by turbines correspond to passerines birds. For example, in South Africa, a fourth of all species and all individuals killed by wind turbines corresponded to Passeriformes. They fell second only in terms of collisions kills only after raptors (PEROLD ET AL. 2020).

In temperate waters and during migration, the proportion of migrating passerines that may be affected by direct collisions with wind turbines may be much larger. HÜPPOP ET AL. (2006) found that over 98% of all carcasses recovered at FINO1, an offshore research platform in the North Sea, belonged to passerine birds. Despite the study by HÜPPOP ET AL. (2006) covering the German North Sea, some of the overall findings may also be expected for the Baltic Sea. Migration intensity concentrates on certain days of the whole migration period (75% of all passerines were observed during 17-33% of the migration days in the study). These results obtained from visual observations were also confirmed from the study of radar echoes. With regards to flight altitudes during migration, it was observed that almost half of the radar echo signals (registered up to an altitude of 1,500 m) corresponded to the first 200 m of altitude (within the range at which wind turbines may be in operation).

4 METHODOLOGY

4.1 RESTING BIRDS

The recording of resting birds was performed using the digital video technology developed by the company HiDef (HIDEF AERIAL SURVEYING LTD 2024, WEISS ET AL. 2016). This method has already been used for several years in various studies also in the western Baltic Sea and Skagerrak area (e.g., ZYDELIS et al. 2019; BIOCONSULT SH et al. 2020). The HiDef system, specifically designed for this type of work, follows a methodology that is widely accepted by the industry and relevant authorities. Since 2014, BioConsult SH has conducted more than 1,000 survey missions in the North Sea and the Baltic Sea, most of them in relation to offshore wind farms, gaining images of several hundred thousand birds and some thousand marine mammals. Digital aerial surveys have been developed and established in the UK and became in 2014 the standard method for offshore wind farm studies in Germany (BSH 2013). The method has proven to be highly suitable for offshore surveys and to consolidate the basis for consenting offshore wind farms.

4.1.1 DESCRIPTION OF THE SURVEY TRANSECTS

To determine abundances, densities, and distribution patterns of resting birds in the pre-investigation area, six aerial surveys were conducted between February 2023 and January 2024. Since both proposed OWF areas (Kattegat and Hesselø) are less than 20 km away from each other one pre-investigation area for both OWF was used and the survey design is adopted to cover the pre-investigation area Kattegat within one survey (see Figure 4-1). For the analysis results from the whole survey is presented for each of the proposed wind farm projects. A total of 18 transects with varying lengths between 20.5 and 66 km in length were covered during the study period, resulting in a total of 889.4 surveyed km (see Figure 4-1, Table 4-1 and Table 4.2) for information regarding single surveys. The transects ran parallel to each other in a north-south direction and were 5 km apart. In total, 4,120.7 km^2 were covered during the surveys.

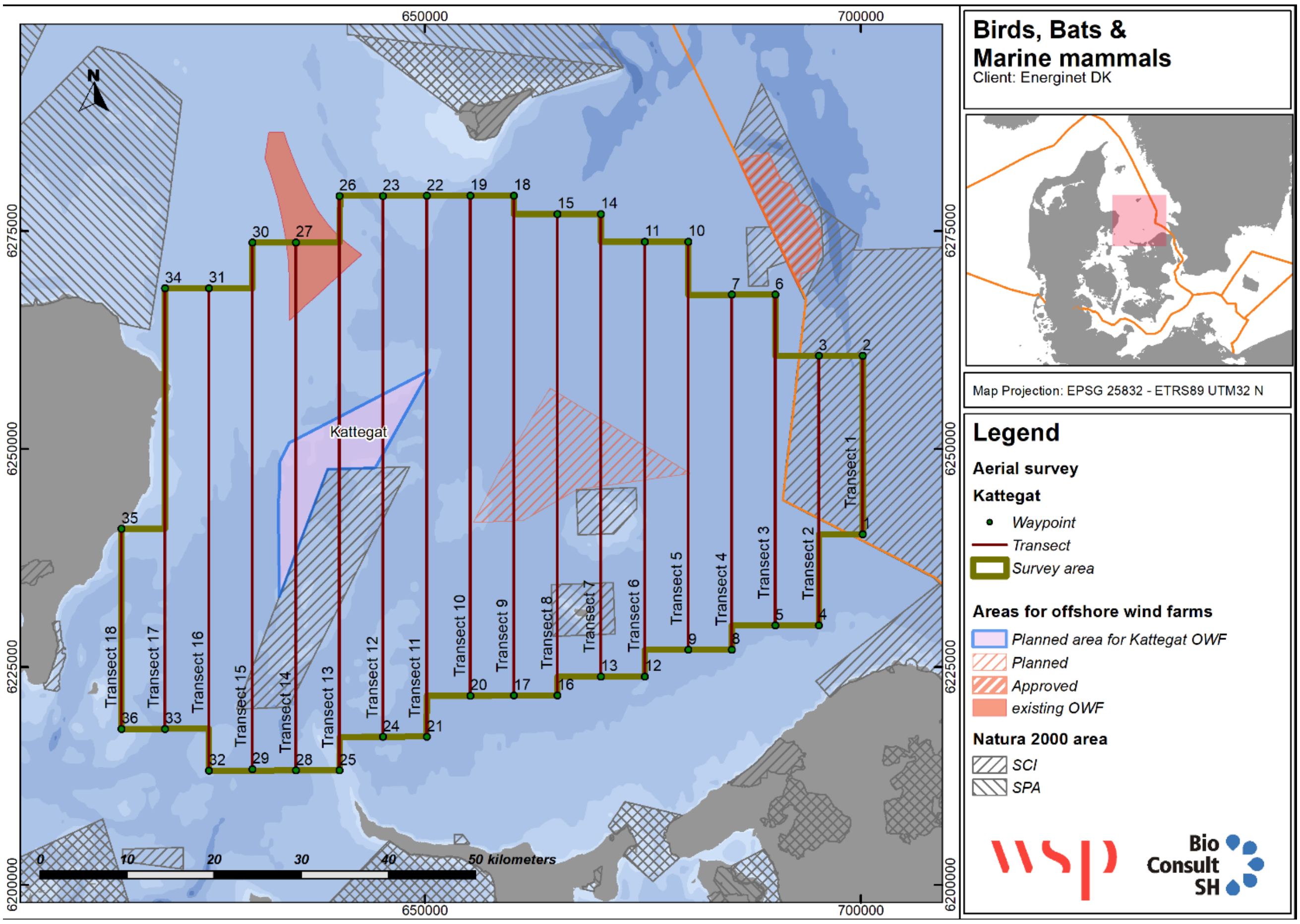


Figure 4-1 Aerial survey transect design for the survey area used during all flights. The figure includes the proposed OWF area (Kattegat, pink) and the Natura 2000 areas (diagonals, crosshatched).

Table 4-1. Overview of the six digital aerial surveys carried out in the survey area between February 2023 and January 2024. Survey dates, distances, and survey effort as well as the covered area are given for every single flight.

Survey no.	Date	Distance (km)	Effort (km²)	Coverage (%)
1	04.03.2023	863	463	11.2
2	08.04.2023	891	483	11.7
3	17.06.2023	892	483	11.7
4	27.08.2023	895	479	11.6
5	18.11.2023	895	485	11.8
6	30.12.2023	-	-	-
		Total: 4,436	**Total: 2,394**	**Average: 11.6**

Table 4.2. Waypoints (WP) showing the start and end transect coordinates and transect lengths during the digital aerial surveys in the pre-investigation area.

Transect	Start Transect	End Transect	Length [km]
1	WP01: 56.26473°N; 12.23245°E	WP02: 56.44831°N; 12.24803°E	20.5
2	WP03: 56.45031°N; 12.16704°E	WP04: 56.17310°N; 12.14416°E	30.9

3	WP05: 56.17503°N; 12.06374°E	WP06: 56.51548°N; 12.09118°E	37.9
4	WP07: 56.51738°N; 12.01003°E	WP08: 56.15204°N; 11.98138°E	40.7
5	WP09: 56.15386°N; 11.90099°E	WP10: 56.57385°N; 11.93309°E	46.8
6	WP11: 56.57565°N; 11.85181°E	WP12: 56.12816°N; 11.81858°E	49.9
7	WP13: 56.12987°N; 11.73823°E	WP14: 56.60606°N; 11.77261°E	53.1
8	WP15: 56.60775°N; 11.69125°E	WP16: 56.11229°N; 11.65655°E	55.2
9	WP17: 56.11389°N; 11.57622°E	WP18: 56.62851°N; 11.61120°E	57.3
10	WP19: 56.63010°N; 11.52977°E	WP20: 56.11545°N; 11.49588°E	57.3
11	WP21: 56.07468°N; 11.41289°E	WP22: 56.63163°N; 11.44834°E	62.0
12	WP23: 56.63312°N; 11.36690°E	WP24: 56.07613°N; 11.33263°E	62.0
13	WP25: 56.04313°N; 11.25036°E	WP26: 56.63455°N; 11.28545°E	65.9
14	WP27: 56.58813°N; 11.20122°E	WP28: 56.04447°N; 11.17015°E	60.6
15	WP29: 56.04719°N; 11.09001°E	WP30: 56.58944°N; 11.11986°E	60.4
16	WP31: 56.54375°N; 11.03597°E	WP32: 56.04700°N; 11.00972°E	55.3
17	WP33: 56.09135°N; 10.93165°E	WP34: 56.54496°N; 10.95470°E	50.5
18	WP35: 56.29859°N; 10.86128°E	WP36: 56.09249°N; 10.85133°E	23.0

4.1.2 DATA COLLECTION

A twin-engine, high-wing propeller-driven aircraft (Partenavia P 68) was used for the acquisition of digital videos, see Figure 4-2. This aircraft is equipped with four high-resolution video camera systems, which take approximately seven images per second and can achieve a resolution of two cm at sea surface. Since the camera system is not directed vertically downwards (depending on the sun position, it can be slightly inclined or even set against the flight direction), interferences arising from solar reflections (glare) can be effectively reduced. The external cameras (indicated by A and D, Figure 4-2) cover a strip of 143 m width while the internal ones cover a width of 129 m each, resulting in 544 m effectively covered. There is however about 20 m distance between each strip to avoid double counting of individuals detected by the cameras. Thus, the total recorded strip of 544 m is distributed over a width of 604 m. By this nearly 11 % of the area was covered by 100%.

The aircraft flew at an average speed of approx. 220 km/h (120 knots) at an altitude of 549 m. A GPS device (Garmin GPSMap 296) recorded the position every second, which permitted to geographically assign a location to the images and the individuals registered on them. The collected data was stored on mobile hard disks for subsequent review and analysis. For further details regarding the method see Weiß et al. (2016).

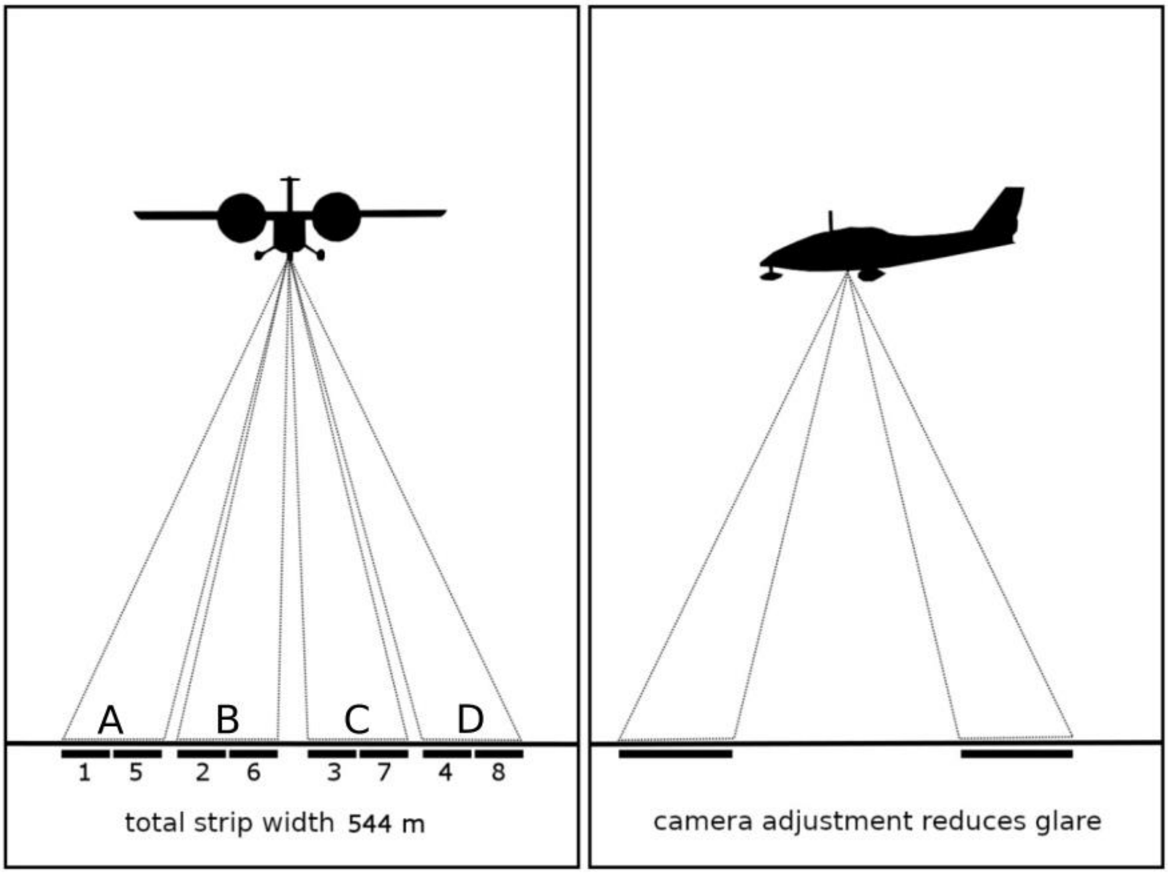


Figure 4-2. The HiDef Camera-System. The four cameras (A to D) cover an effective strip width of 544 m of the sea surface at a flight altitude of 549 m (left: frontal view; right: side view). The numbering indicates the camera images as they are used in the evaluation (the images from each camera are divided into two halves).

4.1.3 DATA PROCESSING

To facilitate the detection of objects, the video sequences taken from each camera were split into two halves, so that each half of the picture fitted the width of a large monitor. The video files were then processed using an image capture and management software (StreamPix). First, the images were examined and all the detected objects (birds, mammals, ships, etc.) were marked and pre-sorted for subsequent identification. To guarantee a consistent high quality, 20% of each film was randomly selected and processed again by another reviewer. If both reviewers reached a consensus of 90% regarding object identification, discrepancies were rechecked, and the film afterwards approved for further analysis. If the consensus was below 90%, the film was reanalysed entirely. Sections of the footage that could not be assessed due to backlight or the presence of clouds were not considered for further analysis.

The next step involved the identification of the previously marked objects (birds). This was done by experienced observers. Often birds can be identified on the images to species level. Due to strong similarities between some species (e.g. common guillemots and razorbills, common and Arctic terns, red-throated and black-throated divers), an identification on species level is not always possible. However, it is usually possible to identify individuals as belonging to a species group formed by two (or few) closely related species. In addition to the identification, other information such as position, age, behaviour (swimming or flying) and flight direction were determined whenever possible. Environmental parameters (air turbidity, sea state, solar reflection, and water turbidity) were recorded for every 500 images (approx. covering 4 km).

To assure quality control, 20% of the objects identified were re-assessed by a second reviewer. All discrepancies between the first and second identification process were checked again by a third expert. If there was a consensus of at least 90%, the data collected was released for further analysis. If the consensus was below 90%, systematic errors (e.g., problems in determining specific species groups) were corrected and all objects were re-identified.

4.1.4 DATA ANALYSIS

All detected resting birds were either identified to species level or assigned to a species group category (see below). Among these, relevant species/species groups were defined based on the frequency of occurrence in the pre-investigation area and the importance of the area as habitat for species according to reference literature.

The individuals not identified to species level in the aerial surveys were initially grouped into a larger taxonomic group of very similar species. Examples of these are common guillemot/razorbill and unidentified divers (red-throated and black-throated diver). These groups consisting of two species include a large proportion of the resting birds not identified to species level. Other resting birds that could not be assigned to any of the previously mentioned or other two-species group, are in most cases identified to family level.

4.1.5 CALCULATION OF DENSITIES

Based on the number of detected individuals for each species or species group, monthly mean densities given as ind./km^2 were calculated. As the survey effort differed among transects (see Table 4-1), densities were corrected by dividing them by the area covered for each transect. As the effect of the aircraft on birds is negligible, no correction factors are applied to the abundances of species (ZYDELIS et al. 2019). Therefore, it is assumed that all individuals present in the study during the time of the survey are captured by the images.

Dependent on the species-specific biology the timing of migration and breeding as well as phenological patterns can differ considerably among species. Therefore, species specific seasons are defined, to allow comparisons of distribution patterns between species (GARTHE et al. 2007). For example, for divers, March and April are considered spring whereas for cormorants, spring starts in February and ends in March (GARTHE et al. 2007). Thus, the spatial distribution was determined for all surveys grouped according to the species-specific seasonal classification by GARTHE et al. (2007). The spatial distribution was displayed using grid density maps. A grid was laid over the pre-investigation area with its grid cells aligned with the EEA grid (EEA 2019).

4.2 MIGRATING BIRDS

Bird migration was studied from an anchored ship using four different methods, each looking at different aspects of bird migration. Observer-based observations (4.2.2) are divided in visual observations during daylight for species composition, flight height distribution (up to a maximum of 200 m), phenology and migration intensity and acoustic observations during night for adding information on migration intensity and species composition crossing the area during night (only for calling species when they are flying in the lower altitudes). Standardised (vertical and horizontal) radar surveys (4.2.3) were applied continuously when the ship was laying for anchor for migration intensity and flight height distribution as well as flight direction. Table 4-3 indicates the type of information that is possible to investigate by each method.

Table 4-3 Survey methods and data output

Data/Method	Species determination possible		No species determination	
	Visual observations	Acoustic observations	Horizontal radar	Vertical radar
Species composition	X	X		
Altitudinal distribution	X			X
Flight direction	X		X	
Migration intensity	X	X		X
Phenology	X	x		X

The surveys were conducted from vessels equipped with radar devices suitable for monitoring bird movements. The vessel was anchored centrally in the proposed OWF Kattegat in spring and in the proposed OWF Hesselø in autumn (Figure 4-3). The anchor positions (56° 22.02’ N, 11° 12.75 E, in spring and 56° 20.34’ N, 11° 41.89’ E, in autumn) were verified upon the arrival and controlled hourly during adverse weather conditions. A survey was only interrupted if adverse weather conditions (e.g. wind speeds above 17 m/s and >2.5 m waves) prevented the bird observations or prevented the vessel from maintaining the anchor position at the survey site. Weather conditions (precipitation, wind speed and direction, temperature, visibility, and wave height) were recorded every full hour. The alignment of the vertical radar antenna was checked every 30 minutes and realigned if necessary to keep the direction of the antenna perpendicular to the main migration direction.

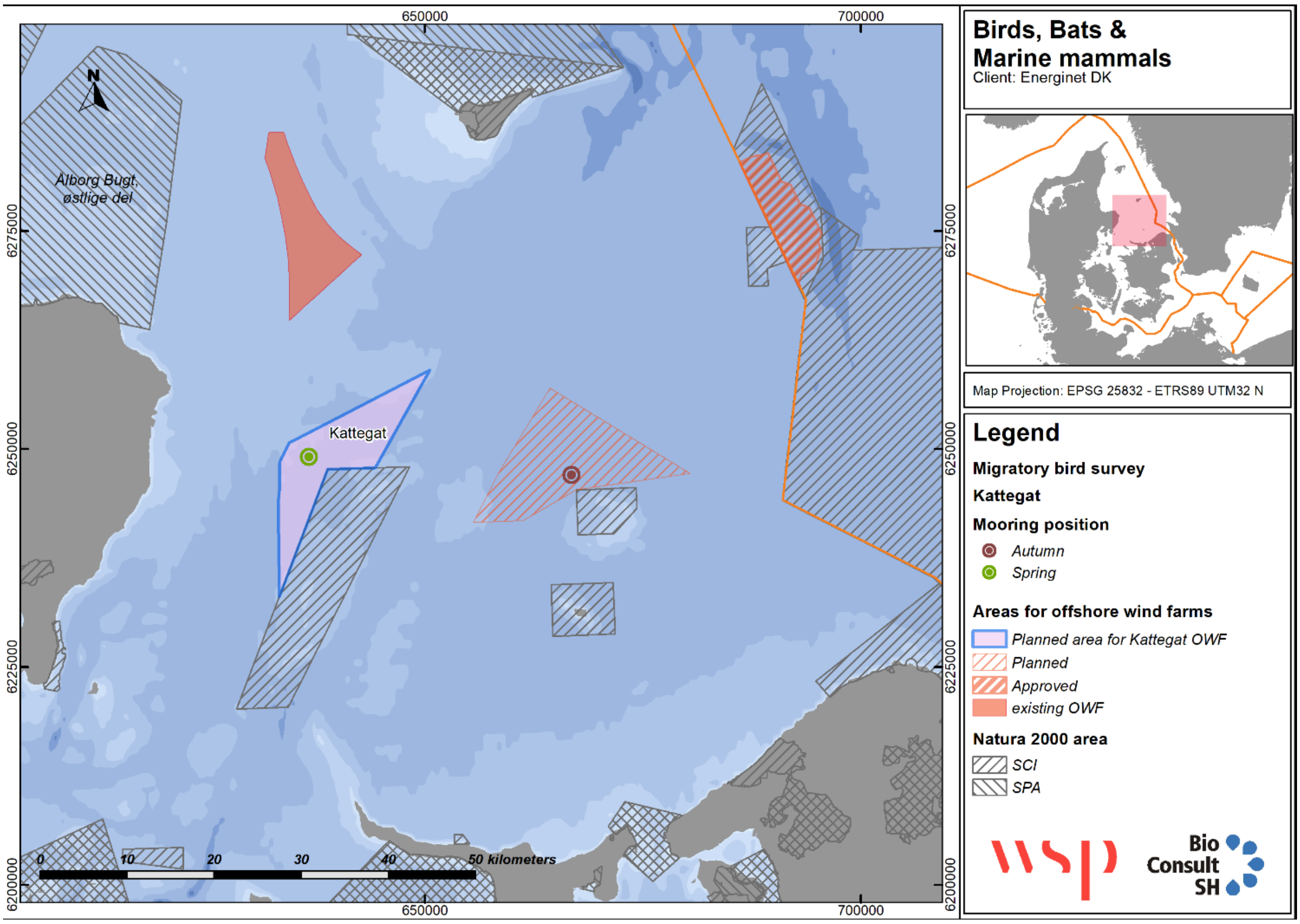


Figure 4-3. Overview of the anchoring points in the middle of the areas of the proposed OWF Kattegat and Hesselø (spring and autumn 2023).

4.2.1 SURVEY EFFORT

All surveys were conducted on board of the ship Skoven. In spring, surveys were conducted between March 4th and May 5th, 2023 (

Table 4-4) while in autumn, the surveys were between August 18th and November 29th, 2023 (Table 4-5). Observations usually began at dawn (at civil morning twilight) or dusk (civil evening twilight) at the given date (see

Table 4-4 and Table 4-5) and then continued for two to five 24 h cycles. Civil twilight is defined as the moment when the sun is 6 degrees below the horizon or when the light is barely enough for reading.

In spring, 15 observation days and 11 nights were completed (see

Table 4-4) whereas in autumn a total of 19 day observations and 18 night observations were achieved (see Table 4-5). However, only data from days or nights during which the observations spanned at least 70% of the respective period were used for data analysis (see below). Radar measurements were conducted simultaneously.

Table 4-4 Survey information. Starting and finishing periods of every survey and number of days/nights, dates for the collection of every type of data in spring 2023 (proposed OWF area Kattegat).

Survey	Survey periods		Number of 24 h cycles	Number of days/nights	
	Start: Date and time	End: Date and time		Visual observations	Nocturnal flight calls
1	04.03.2023, 05:34	06.03.2023, 17:30	2.5	3	2
2	23.03.2023, 23:00	26.03.2023, 04:35	3.5	2	3
3	13.04.2023, 17:00	18.04.2023, 19:00	5	5	2 (0)
4	04.05.2023, 19:30	09.05.2023, 19:00	5	5 (4)	4
Total:				**15 (14)**	**11 (9)**

One date of collection (06.05.2023), was discarded during day observations and two nights (15.04 and 17.04) because they did not cover enough hours of data collection.

Table 4-5 Survey information. Starting and finishing periods of every survey and number of days/nights, dates for the collection of every type of data in autumn 2023 (proposed OWF area Hesselø).

Survey	Survey periods		Number of 24 h cycles	Number of days/nights	
	Start: Date and time	End: Date and time		Visual observations	Nocturnal flight calls
1	18.08.2023, 18:39	22.08.2023, 18:30	4	4	4
2	08.09.2023, 18:11	13.09.2023, 18:00	5	5	5
3	03.10.2023, 05:00	06.10.2023, 15:00	3.5	3 (2)	2
4	22.10.2023, 16:17	24.10.2023, 22:00	2	2	3(2)
5	24.10.2023, 14:30	26.11.2023, 14:30	2	2	2
6	26.11.2023, 20:40	29.11.2023, 14:30	2.5	3	2
Total:				**19 (18)**	**18 (17)**

Due to bad weather the survey was interrupted on October, 04th 2023. In addition, two dates were discarded before the analysis due to not enough hours of collection for the respective day/night: October, 05th 2023 (diurnal migration) and October 24th, 2023 (nocturnal migration).

4.2.2 OBSERVER-BASED DATA

VISUAL OBSERVATIONS (DAY MIGRATION)

Visual observations provide extensive information on diurnal bird migration. Migration intensities, flight altitudes and directions as well as species composition are derived from data collected by observers (Table 4-3).

Visual observations were conducted during the daylight phase, starting with civil morning twilight until civil evening twilight. Every hour, observations took place in two 15-minute intervals, during which two observers scanned the surrounding area for flying birds with bare eyes and binoculars. Each observer covered a 180°area. Species and number of individuals of flying birds or bird flocks were noted, as well as estimations of flight altitude and flight directions (subdivided in eight directions: N, NE, E, SE, S, SW, W, NW). Observers also noted if birds were visibly associated with the observer vessel or other (especially fishing) vessels, as in those cases birds were assumed to be foraging instead of migrating. The observers entered the observation data directly via a tablet, and data was backed up daily to a database to prevent data loss.

DATA ANALYSIS

The evaluation only included observations of flying birds that were not associated with the own vessel. The most commonly occurring species and species groups (higher category taxa, e.g., gulls, auks, etc.) are shown in pie charts that represent their percentage based on the number of total registered individuals per season.

Migration intensity was calculated as birds per hour, extrapolating from 30 minutes of observations per hour. Based on this, both the annual and daily course of migration intensity was presented for all birds combined as well as for single species groups. Only data from days during which the observations spanned through at least 70 % of the daylight period were used. For example, of the 15 dates of analysis in spring 2023, the 6th of May included low effort and was excluded.

To evaluate flight altitude distribution, the recorded migratory altitudes of all individuals of every species were grouped into altitude ranges (0-5 m, 5 - 10 m, 10 - 20 m, 20 - 50 m, 50 - 100 m, 100 – 200 m, > 200m) as proposed by German authorities (BSH 2013) and are shown according to their relative frequency. Observations are also combined for systematic groups. Migratory directions of flight are shown in 45° increments, also according to their relative frequency.

FLIGHT CALLS (NOCTURNAL MIGRATION)

Recording of flight calls provides information on the species composition and the intensity of nocturnal bird migration. The nocturnal flight call observations were carried out by one observer at a time with two observation units of 15 minutes per hour from civil evening twilight to civil morning twilight. Here as well, only data from nights during which the observations spanned through at least 70 % of the night period were used.

For the recording of bird calls, the number of single calls were noted and not the number of (estimated) individuals. Calls which typically consist of a certain number of single elements, as for instance the call of common greenshank, were only counted as one call.

DATA ANALYSIS

The recorded calls were corrected for effort and converted into call rates (calls per hour). To illustrate the temporal pattern of the migratory activity during a night, the call intensity was determined for each hour of the night, beginning with the onset of civil twilight. To determine seasonal patterns, the calling activity was determined for each recorded night. All analyses were carried out separately for all taxonomic groups and in summary for all species.

4.2.3 RADAR MEASUREMENTS

Horizontal and vertical radar devices (Figure 4-4) emit electromagnetic waves which are reflected by objects that can thus be spatially located. Detection depends on the wavelength emitted by the radars, the size of the objects, the distance to the radar and the direction of movement of the objects in relation to the radar. Compared to ships and other objects usually detected by radar, birds are very small and therefore best detected with lower wavelengths. For this reason, devices transmitting with a power of 25 kW in the X-band range (9,410 MHz) were used.

Figure 4-4 Horizontal and vertical radar mounted on a research vessel.

VERTICAL RADAR

Data from the vertical radar provided information on the intensity, temporal pattern, and flight altitude distribution of bird migration during the day and night (Table 4-3). The vertically rotating radar antennae were aligned perpendicular to the assumed main migratory direction by means of manual readjustment every 30 minutes.

DETECTION METHODOLOGY

The detection radius of the radar was set to 1,500 m and the sensitivity (gain) of the radar antenna was set to 70%. Filters for rain and sea clutter were switched off, as these would also filter out an unknown number of bird signals. The afterglow duration of the radar signals was set to 45 seconds. For moving objects, the "radar shadow", i.e. signals of the same object detected during previous revolutions of the antenna, were displayed as a track in addition to the current signal (Figure 4-5). Every four minutes an image of the radar screen was captured and stored.

The recorded radar screenshots were visually scanned for bird signals, which were identified based on size and the trail caused by the time of afterglow. The bird signals were marked, and their image coordinates were converted into flight altitudes and distance to the radar unit. The number of individual birds that correspond to a bird signal cannot be determined. A bird signal thus represents at least one bird. Images were not evaluated if more than 25% of the radar screen was obscured by rain clutter superimposing bird signals. The effort of the vertical radar during spring and autumn is shown in Figure 4-6 and Figure 4-7 (graphs are missing but will be added to the final report).

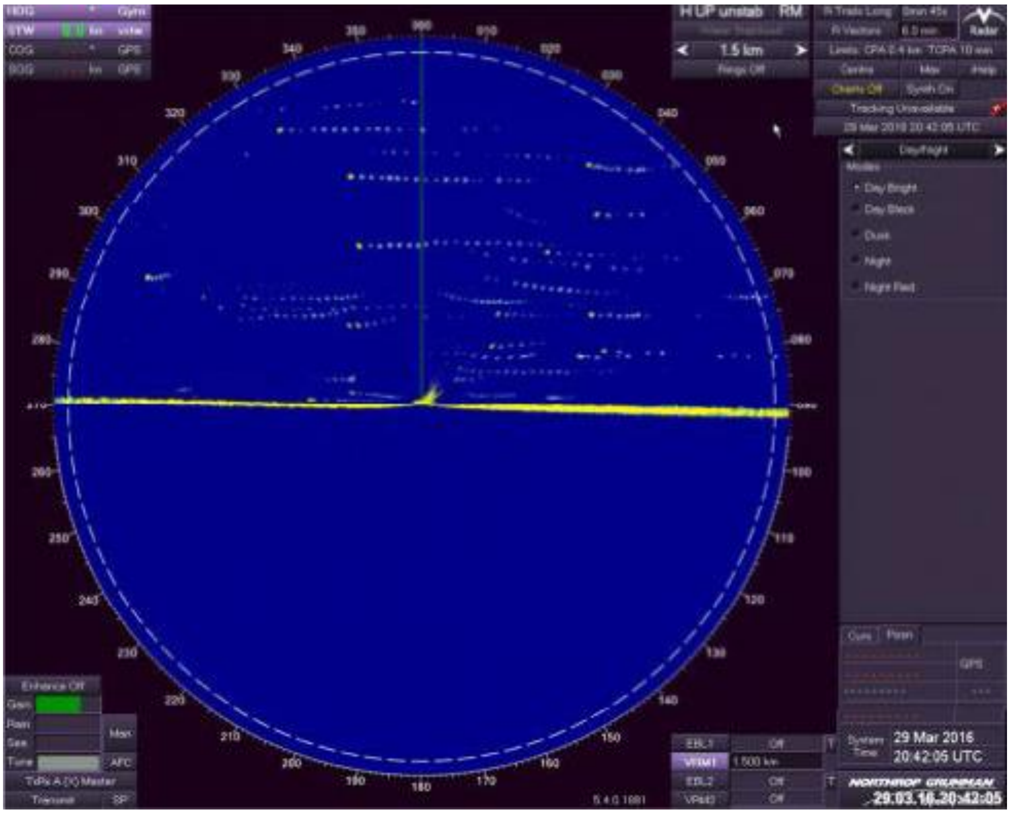


Figure 4-5 Example of a screenshot from vertical radar with characteristic bird signals (the yellow line represents the sea surface, the signals in the upper half of the radar area are bird echoes).

Since not all images obtained from vertical radar were available yet for analysis at the time of writing this report, results from vertical radar will be presented in the final report.

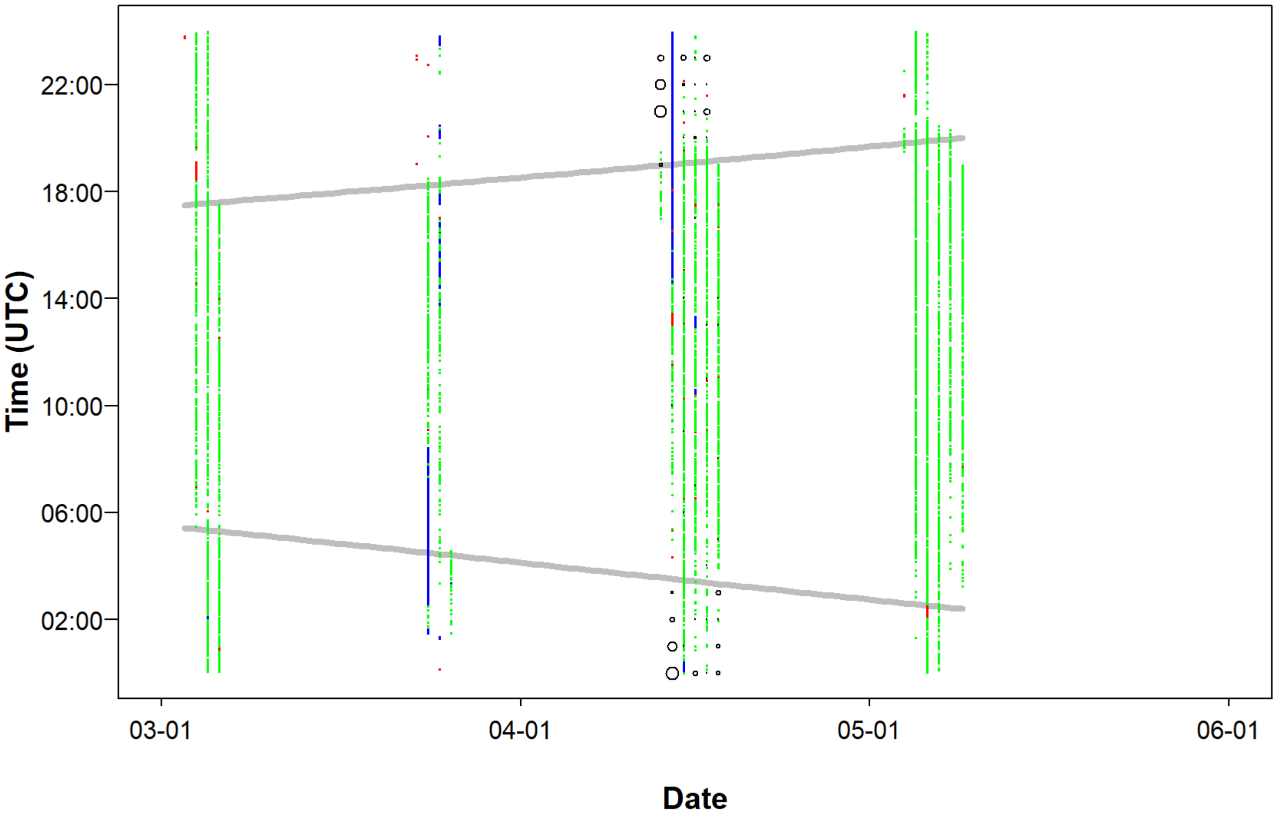


Figure 4-6 Effort of vertical radar (spring 2023). Colours during the time of recording indicate the possibility to analyse the data: green indicate periods with analysable data, blue are periods not evaluable due to precipitation, red are periods not analysable due to other disturbances. Black circles indicate the number of bird signals and grey lines mark the sunrise and sunset in spring 2023.

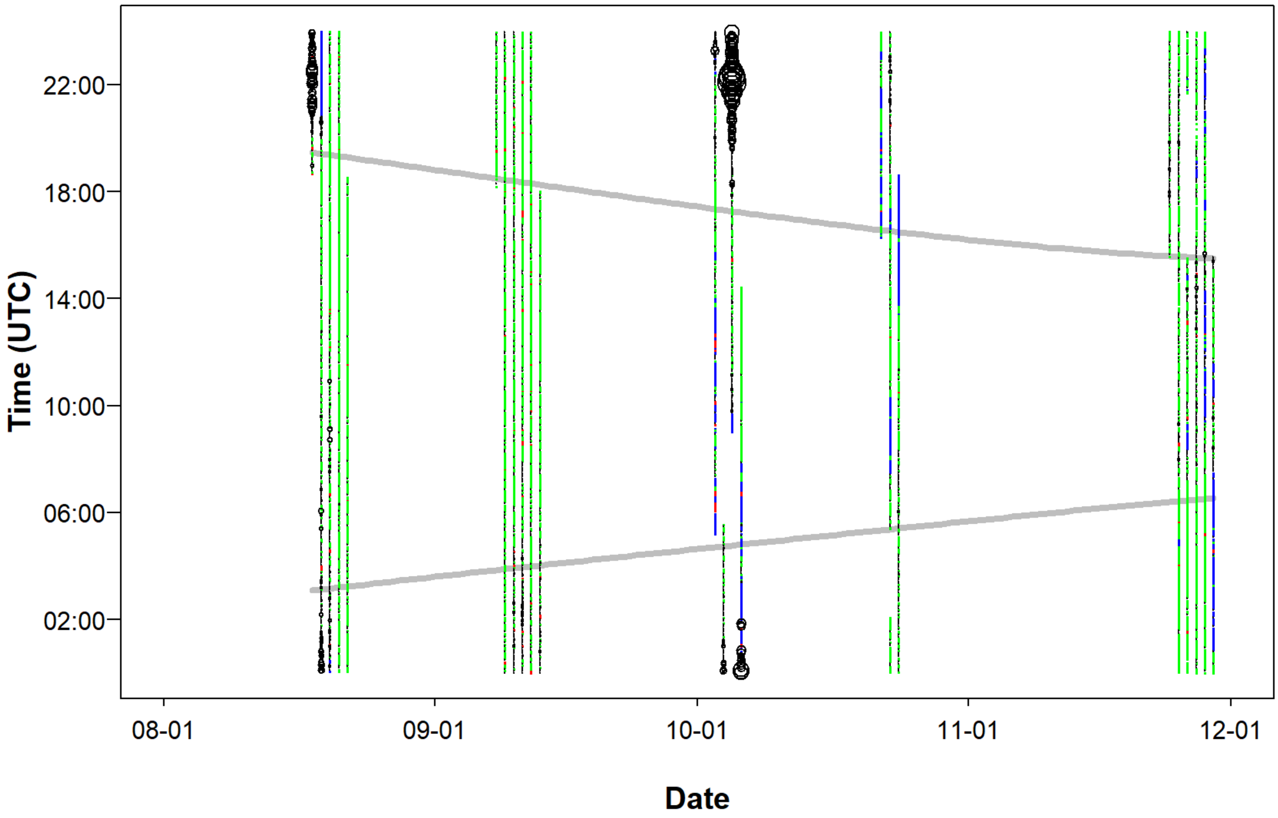


Figure 4-7 Effort of vertical radar (autumn 2023). Colours during the time of recording indicate the possibility to analyse the data: green indicate periods with analysable data, blue are periods not evaluable due to precipitation, red are periods not analysable due to other disturbances. Black circles indicate the number of bird signals and grey lines mark the sunrise and sunset in autumn 2023.

As the detectability of bird signals is highly dependent on the distance to the radar, the raw data obtained as described above had to be distance-corrected before analysis. For this, empirical bird signal data of 50 to 150 m altitude were selected. The distance from the radar unit was determined for all signals in this altitude band and a distance-dependent detection probability was calculated according to BUCKLAND et al. (2001), using "Distance" package (MILLER et al. 2019) and the R software 4.2.2,. "Half normal" and "hazard rate" models up to 5th order were tested, choosing the best-fitting model per radar device based on Akaike information criterion. As in close vicinity of a radar the device generally does not record bird signals, an area of 100 m around the device was not considered for the determination of the correction functions.

Using the distance functions derived from the 50 - 150 m data, individual distance correction factors were calculated for all recorded signals of the whole detection range up to 1 km height, and the number of signals at each given altitude was corrected accordingly.

MIGRATION INTENSITY

The migration intensity was calculated as migration traffic rate (MTR). This is the number of signals that cross a virtual stretch of 1,000 m perpendicular to the migration direction every hour up to an altitude of 1000 m. Migration intensity was calculated for all hours of the recording periods for which at least three valid radar images were available.

For each day and night, the mean migration intensity was determined from the corresponding hourly results. Only days or nights for which hourly migration intensities were available for at least 70 % of the time, were taken into consideration. Like visual and acoustic observation data, results were depicted as an annual phenology as well as its temporal pattern in the course of 24 hours.

FLIGHT ALTITUDE DISTRIBUTION

To represent the flight altitude distribution from vertical radar, the relative proportion of signals was determined for each 100 m height increment up to 1,000 m. The evaluation was carried out separately for diurnal and nocturnal migration and for spring and autumn migration, respectively. In order to show potential differences in altitude distribution between days/nights with high and low migration intensity, this evaluation was additionally conducted separately for the five days/nights with the highest migration intensities compared to the rest of days and nights sampled.

HORIZONTAL RADAR

Flight directions of birds were determined with the horizontal radar (Table 4-3). A similar radar device with a transmission power of 25°KW and 9,410 MHz wavelength was used, but the antenna was aligned horizontally instead of vertically.

DETECTION METHODOLOGY

Filters for rain and waves were turned off as they would also suppress an unknown number of bird signals. The detection radius of the radar was set to 3,000 m and the sensitivity (gain) of the radar antenna to 60 %. The afterglow duration (i.e., echo) was prolonged to 90 seconds in order to record flight paths of birds, which were used to determine the flight direction. The horizontal radar devices were operated in “north up” mode, the radar screen therefore always displayed north to the top independently of the ship’s orientation. Every four minutes, an image of the radar screen was captured and stored.

The recorded radar screenshots were visually scanned for bird signals, which were identified based on their size and the flight paths visible due to the afterglow period. Head (current position of a bird) and tail (end of the visible flight path) of each track were marked using the software “GSA Bird Counter 1.17” and stored as image coordinates, which were then converted into flight directions in relation to north.

Horizontal radar screenshots are very often affected by sea clutter and therefore cannot be analysed. Since only relative information regarding flight directions is to be obtained from the data, quantification is not necessary. Only screenshots with less than 50% of the image area covered by sea clutter were evaluated. The effort of horizontal radar surveys is shown in Figure 4-8.

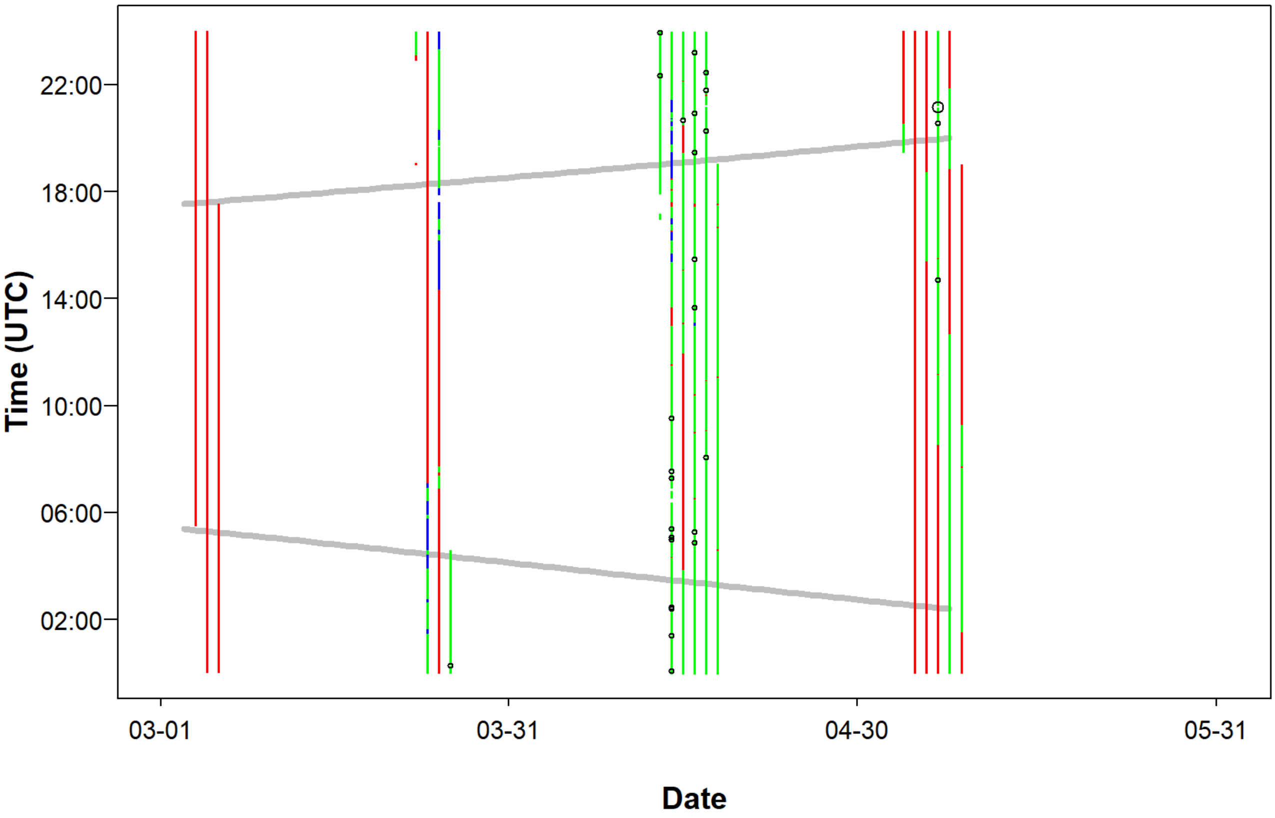


Figure 4-8 Effort of horizontal radar (spring 2023). Colours during the time of recording indicate the possibility to analyse the data: green indicate periods with analysable data, blue are periods not evaluable due to precipitation, red are periods not analysable due to other disturbances (mostly sea state). Black circles indicate the number of bird signals and grey lines mark the sunrise and sunset in spring 2023.

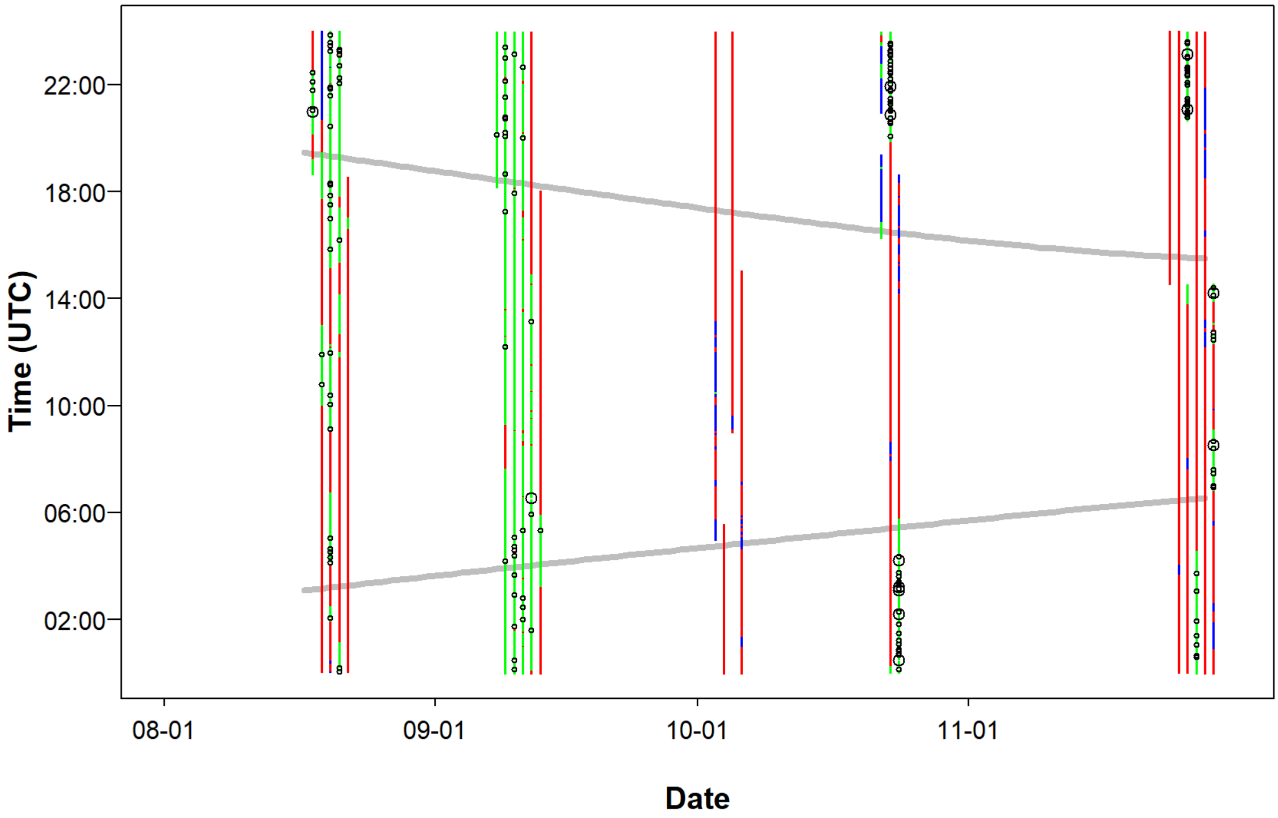


Figure 4-9 Effort of horizontal radar (autumn 2023). Colours during the time of recording indicate the possibility to analyse the data: green indicate periods with analysable data, blue are periods not evaluable due to precipitation, red are periods not analysable due to other disturbances (mostly sea state). Black circles indicate the number of bird signals and grey lines mark the sunrise and sunset in autumn 2023.

FLIGHT DIRECTION

The flight direction distribution was presented per season for both day and night migration. For plotting, flight directions were grouped into 20° increments. Using Rayleigh tests, it was tested whether directional migration could be assumed based on the respective directional distribution. When this was the case, the mean direction of flight was marked with an arrow in the diagrams.

All analysis described in this chapter were conducted using R 4.2.2.

5 DATA AND RESULTS

5.1 RESTING BIRDS

5.1.1 ALL SPECIES

Fehler! Verweisquelle konnte nicht gefunden werden. reports the total number of species observed during the six digital aerial surveys between February 2023 and January 2024. The phenology and spatial distribution of species which represented at least 0.5% of total abundance are described in more details in the next pages.

Table 5-1 Bird counts and percentages of all resting bird species during the six digital aerial surveys between February 2023 and January 2024. Species representing at least 0.5% of total abundance are highlighted.

Species groups	**English name**	**Scientific name**	**All digital surveys**	
			N ind.	**Percentage**
Divers	**Red-throated diver**	***Gavia stellata***	**500**	**6.28**
Divers	Black-throated diver	*Gavia arctica*	17	0.21
Divers	unidentified diver	*Gavia sp.*	18	0.23
Grebes	Great crested grebe	*Podiceps cristatus*	10	0.13
Grebes	unidentified grebe	*Podicipedidae sp.*	5	0.06
Tubenoses	Northern fulmar	*Fulmarus glacialis*	7	0.09
Gannets	Northern gannet	*Morus bassanus*	6	0.08
Cormorants	**Great cormorant**	***Phalacrocorax carbo***	**306**	**3.85**
Ducks	**Common eider**	***Somateria mollissima***	**481**	**6.05**
Ducks	Long-tailed duck	*Clangula hyemalis*	9	0.11
Ducks	**Common scoter**	***Melanitta nigra***	**1,087**	**13.66**
Ducks	Common /velvet scoter	*Melanitta sp.*	3	0.04
Ducks	Velvet scoter	*Melanitta fusca*	7	0.09
Skuas	Arctic skua	*Stercorarius parasiticus*	1	0.01
Gulls	Little gull	*Hydrocoloeus minutus*	1	0.01
Gulls	Black-headed gull	*Chroicocephalus ridibundus*	16	0.20
Gulls	**Common gull**	***Larus canus***	**209**	**2.63**

Gulls	unidentified small gull	*Larus small sp.*	22	0.28
Gulls	**Lesser black-backed gull**	***Larus fuscus***	**176**	**2.21**
Gulls	**Herring gull**	***Larus argentatus***	**422**	**5.30**
Gulls	Common/herring gull	*Larus canus / Larus argentatus*	24	0.30
Gulls	**Great black-backed gull**	***Larus marinus***	**138**	**1.73**
Gulls	unidentified large gull	*Larus (magnus) sp.*	24	0.30
Gulls	Great / lesser black-backed gull	*Larus fuscus/Larus marinus*	11	0.14
Gulls	**Black-legged kittiwake**	***Rissa tridactyla***	**150**	**1.89**
Gulls?	fulmar/gull	*Fulmarus/Larus*	6	0.08
Gulls	unidentified gull	*Laridae sp.*	27	0.34
Terns	Sandwich tern	*Thalasseus sandvicensis*	2	0.03
Terns	Common/Arctic tern	*Sterna hirundo/Sterna paradisaea*	1	0.01
Auks	**Common guillemot**	***Uria aalge***	**3,064**	**38.51**
Auks	Common guillemot/razorbill	*Uria aalge / Alca torda*	642	8.07
Auks	**Razorbill**	***Alca torda***	**349**	**4.39**
Auks	**Black guillemot**	***Cepphus grylle***	**80**	**1.11**
Auks	Atlantic puffin	*Fratercula arctica*	1	0.01
Auks	unidentified auk	Alcidae sp.	126	1.58
Total			**7,956**	**100**

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Table 5-2. Monthly mean densities (ind./km²) of selected species/species groups recorded in the pre-investigation area during digital aerial surveys from February 2023 and January 2024. The maximum value is also indicated. The number 0 means that no individual of this species/species group was found in that month.

Survey Method		**Digital aerial surveys**					
Species/Species-group	**March 2023**	**April 2023**	**June 2023**	**August 2023**	**November 2023**	**Decem-ber 2023**	**Max**
Red-throated diver	**0.373**	0.261	0	0.002	0.066	0.348	**0.373**
Black-throated diver	0.006	**0.014**	0	0	0.004	0.01	**0.014**
Great crested grebe	0.002	0	0	0	0.006	**0.012**	**0.012**
Northern fulmar	0	0	0	0	0.01	0.004	**0.01**
Great cormorant	0.147	0.068	0.023	0.121	0.052	**0.23**	**0.23**
Common eider	**0.412**	0.213	0.06	0.015	0.153	0.159	**0.412**
Long-tailed duck	**0.011**	0	0	0	0	0.008	**0.011**
Common scoter	0.065	**2.129**	0	0.031	0	0.029	**2.129**
Velvet scoter	0.004	0.006	0	0	0	0.004	**0.006**
Little gull	0	0	0	**0.002**	0	0	**0.002**
Black-headed gull	**0.015**	0.008	0	0.01	0	0	**0.015**
Common gull	0.114	0.037	0.014	0	**0.239**	0.031	**0.239**
Lesser black-backed gull	0.039	**0.182**	0.031	0.096	0.019	0	**0.182**
Herring gull	**0.242**	0.101	0.215	0.015	0.188	0.122	**0.242**
Great black-backed gull	0.017	0.056	0.033	0.023	**0.128**	0.029	**0.128**
Black-legged kittiwake	0.002	0	0	0	0.132	**0.176**	**0.1762**
Arctic/common tern	0	0	**0.002**	0	0	0	**0.002**
Sandwich tern	0	0	**0.004**	0	0	0	**0.004**
Common guillemot	0.708	0.089	0.008	1.705	**2.092**	1.777	**2.092**
Razorbill	0.073	0.004	0	0.023	0.26	**0.364**	**0.364**
Black guillemot	0.002	0	0	0.038	0.043	**0.099**	**0.099**
Divers	**0.382**	0.28	0	0.002	0.08	0.379	**0.382**
Sea ducks	0.492	**2.348**	0.060	0.046	0.153	0.201	**2.348**
Gulls	0.455	0.406	0.319	0.165	**0.817**	0.381	**0.817**
Auks	0.831	0.104	0.012	1.805	2.83	**3.297**	**3.297**
No. of surveys	**1**	**1**	**1**	**1**	**1**	**1**	

During the six digital aerial surveys conducted between February 2023 and January 2024 (see Table 4-1), a total of 8,5033birds were observed of which 7,956 were classified as resting birds. Of these, 909 birds could not be identified to species level (11.4% of the total number of resting birds). The total number of birds, together with their scientific names, Danish common names and conservation status are shown in Table A-1 in the appendix. The resting birds identified in this study belonged to 23 species (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

The most common species group was that of auks which represented almost half of all resting birds seen during the whole survey period (53.6%, Figure 5-1). Auks were dominated by common guillemots, which represented alone 38.5% of all resting birds. Razorbills and black guillemots represented respectively 4.3% and 1.1% of all resting birds in the pre-investigation area. Sea ducks were the second most common species group (19.9%). common scoter and common eider were the two most common species of sea ducks, which also represented the second and third most common species of resting birds. These species represented respectively 13.6% and 6.0% of all resting birds. Gulls were the third most common species group. Altogether, gulls made up for 15.3% of all resting birds and five species will be analysed in detail in the next section. These are: herring gull, common gull, lesser and great black-backed gulls, and black-legged kittiwakes. Divers were the fourth most common species group in the area (6.7%) with most of them being red-throated divers. The last species group was formed by one species, the great cormorant which represented 3.8% of all resting birds.

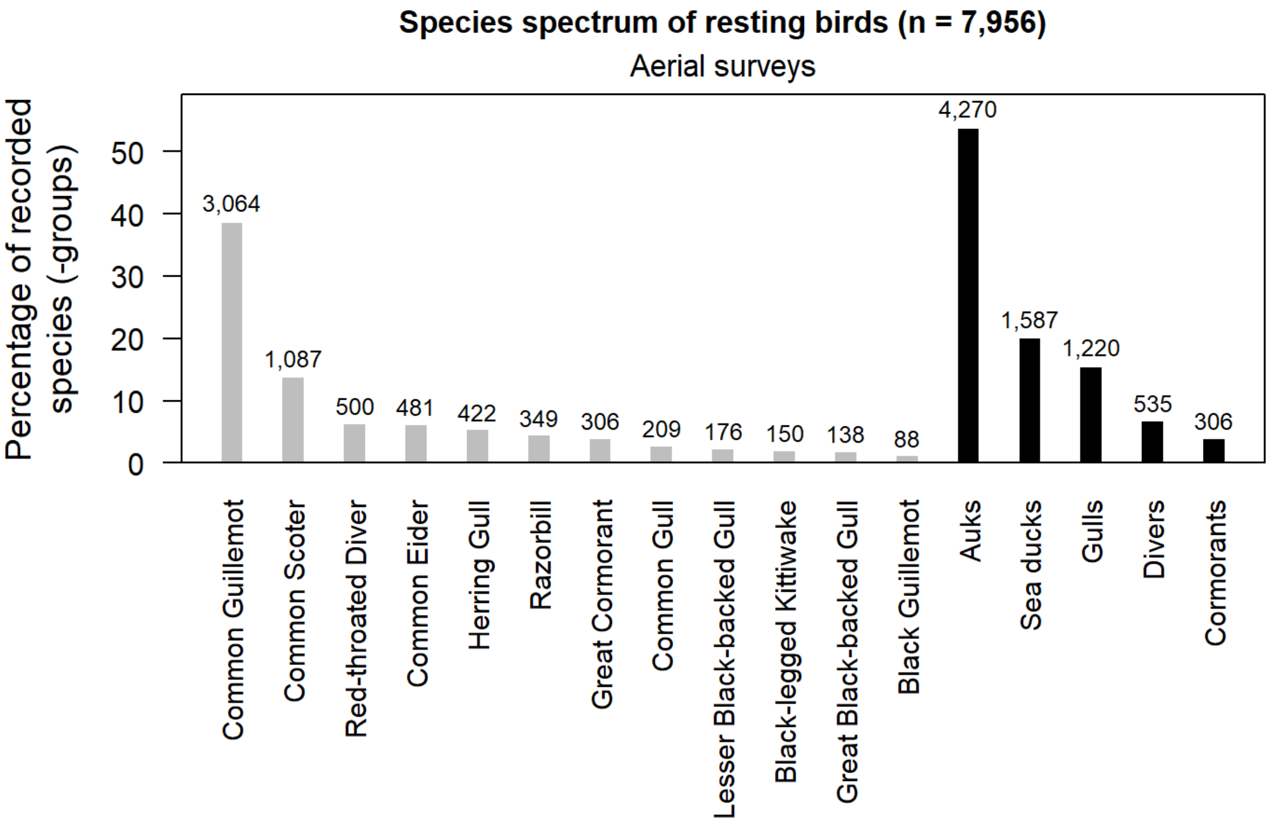


Figure 5-1 Percentage of the most common species or species groups representing at least 0.5% of the total number of resting birds recorded during aerial surveys in the survey area between February and November 2023 (number of individuals shown above each bar). Species are depicted in grey, species groups in black bars.

5.1.2 ABUNDANCE AND DISTRIBUTION OF THE MOST COMMON SPECIES

DIVERS

Two species of divers were seen in the area: Red-throated and black-throated divers. However, red-throated divers (500 individuals) were much more common representing over 94% of all divers seen in the area. Only 12 divers were identified as black-throated divers.

RED-THROATED DIVER

A total of 500 red-throated divers were registered in the pre-investigation area during the six digital surveys. The highest monthly density was observed in March 2023 and reached 0.37 ind./km² (Figure 5-2). Densities decreased towards the warmer season. No diver was seen during the June survey and then numbers increased again in November 2023. The highest seasonal density was seen in spring (the flights of March and April, 0.32 ind./km²) and the lowest seasonal density corresponded to summer (the flights of June and August, 0.002 ind./km²). No flight was conducted during the autumn period of the species.

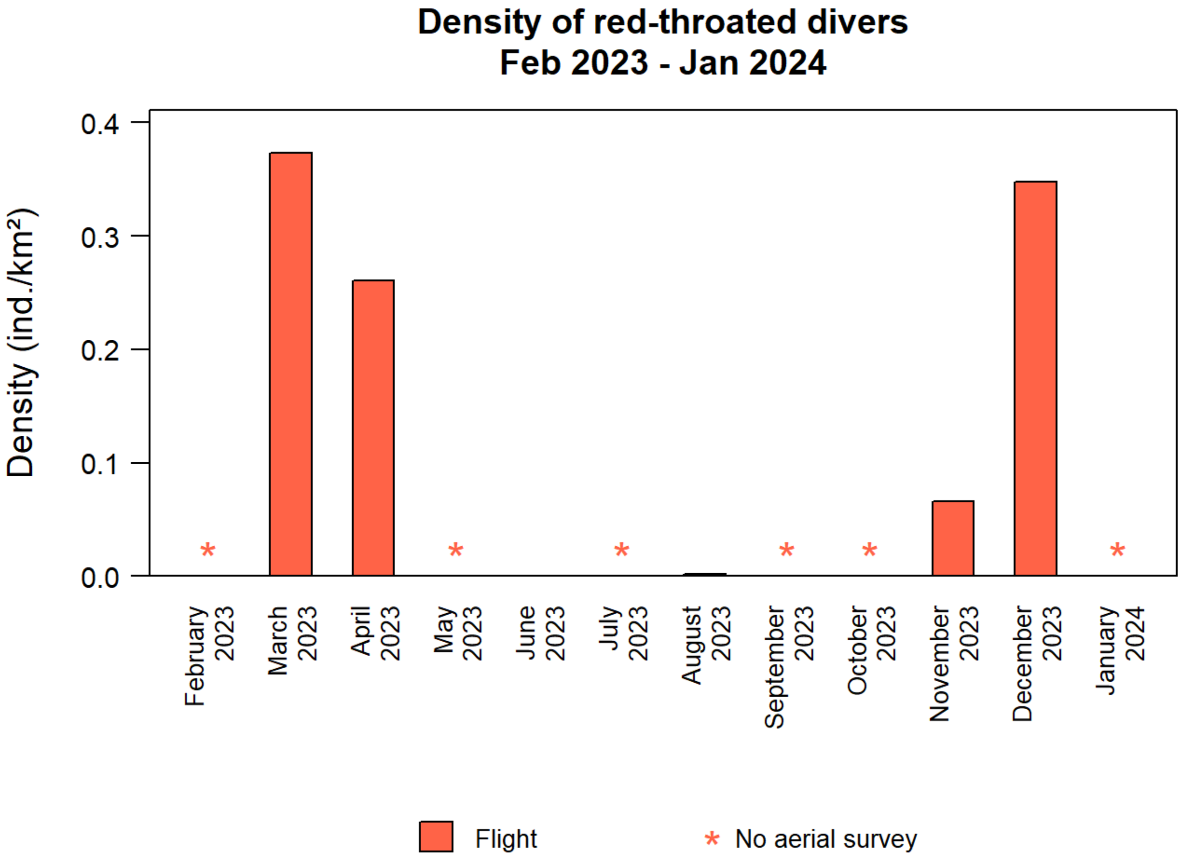


Figure 5-2 Monthly densities of red-throated divers during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Spatially, they were widespread throughout the survey are, especially in spring when densities were larger. In this season they were also observed within the limits of the planned wind farm area (Figure 5-3).

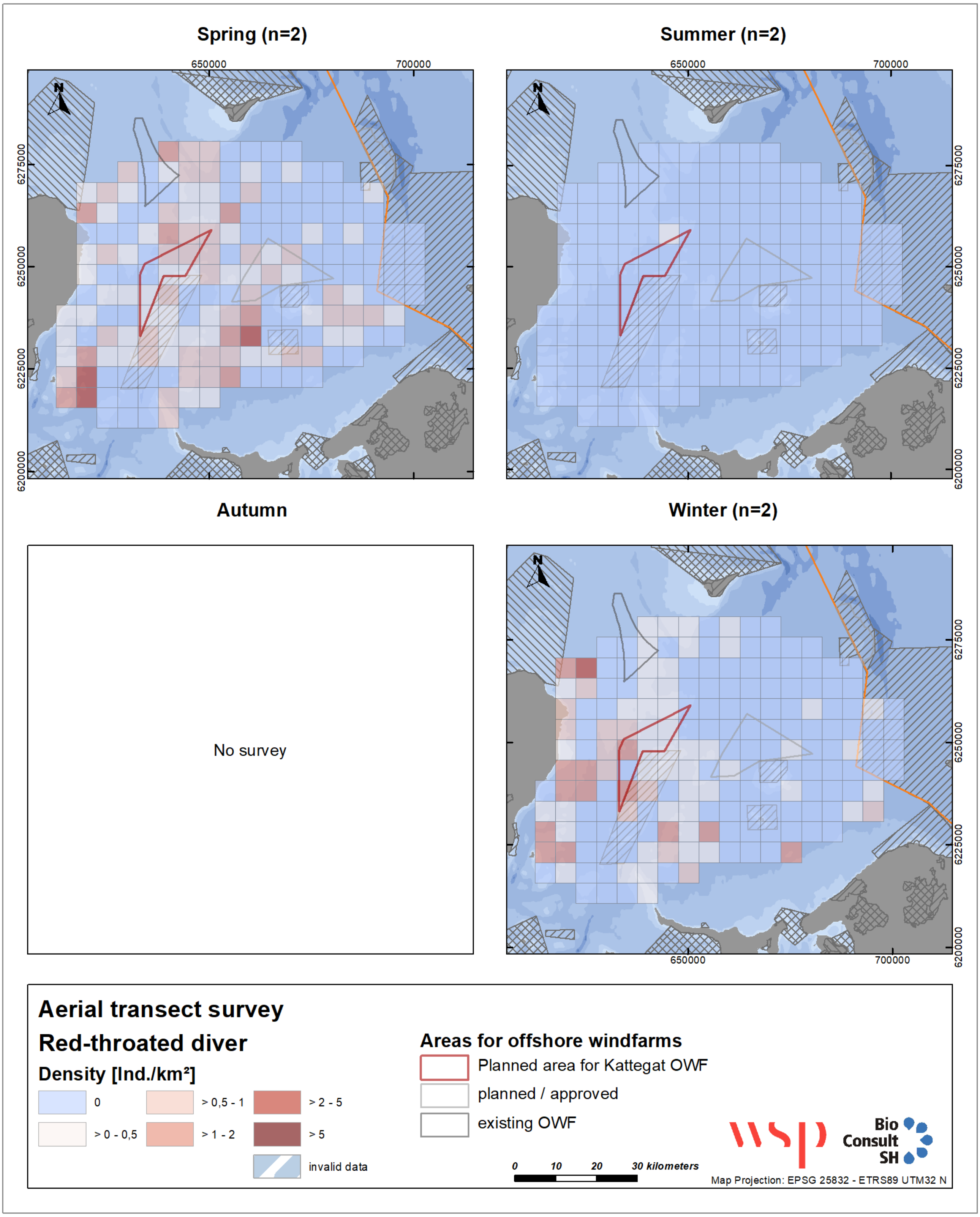


Figure 5-3 Distribution of red-throated divers in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

GREAT CORMORANT

A total of 306 individuals of great cormorants were detected during all the surveys, representing 3.8% of all resting birds in the survey area. The abundance of this species was highest in the month of March (0.15 ind./km²) and lowest in June (0.02 ind./km²), but the species was present during all surveys. The maximum seasonal density was detected in spring (March flight), whereas the seasonal density was lowest in summer (April and June flights, 0.04 ind./km² on average, Figure 5-4).

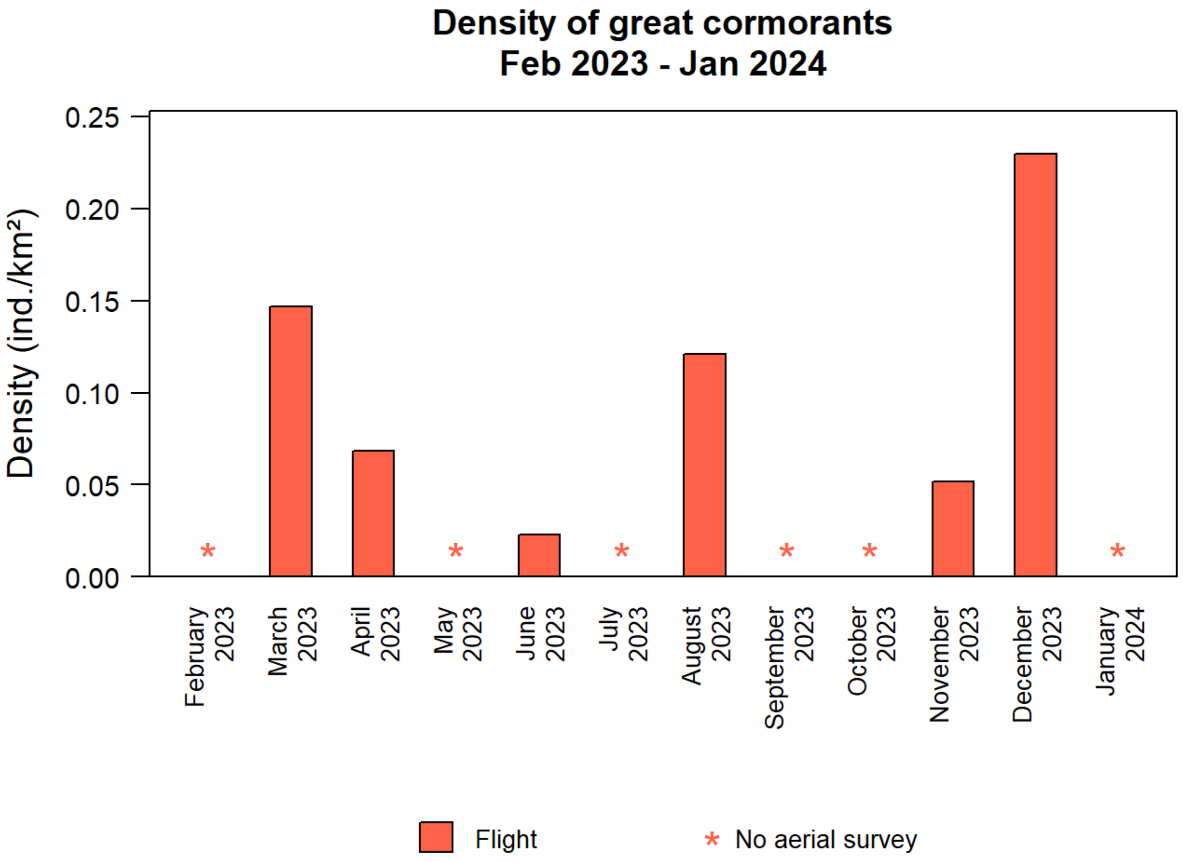


Figure 5-4 Monthly densities of great cormorants during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Spatially, great cormorants were mainly encountered towards the west of the pre-investigation area, closer to the shore and to the west of the planned OWF. Some individuals were also seen in offshore regions, but at low densities, Figure 5-5). In spring, rather higher numbers were found within Anholt OWF. Probably these birds were using the OWF structures for resting.

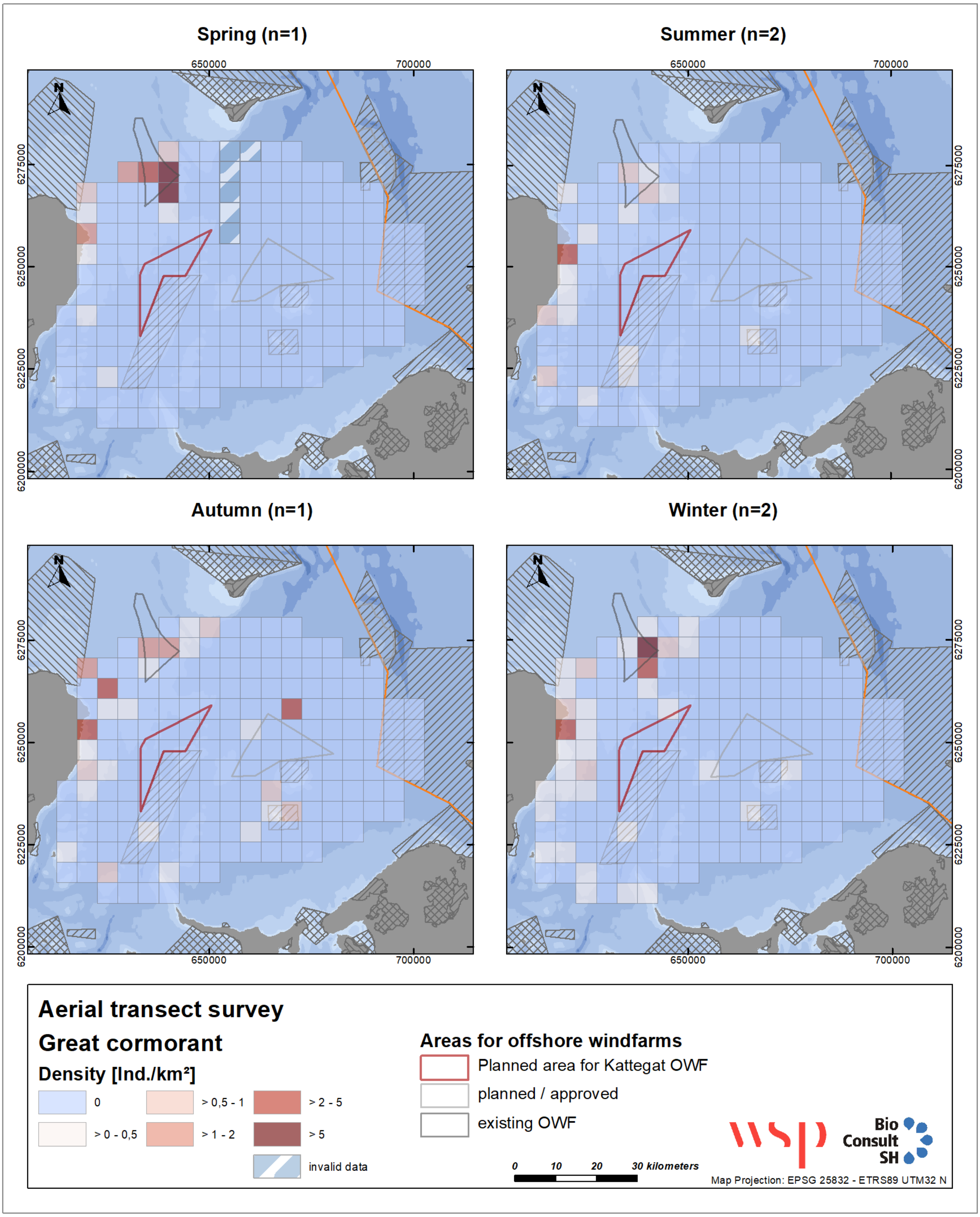


Figure 5-5 Distribution of great cormorants in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

DUCKS

Ducks were the second most common species group and represented 19.9% of the total resting birds. Two species were dominant: common scoters (13.6%) and common eiders (6.0%).

COMMON EIDER

A total of 481 common eiders were registered in the pre-investigation area during the six digital surveys. The highest monthly density occurred during the survey of March and reached 0.41 ind./km² (Figure 5-6) and coincided with the spring season (March and April, 0.31 ind./km²). The lowest density was observed in the survey of August (0.01 ind./km²), which correspond to the summer season of the species (June and August). The summer density was therefore 0.04 ind./km². No flight was conducted in the winter season of the species.

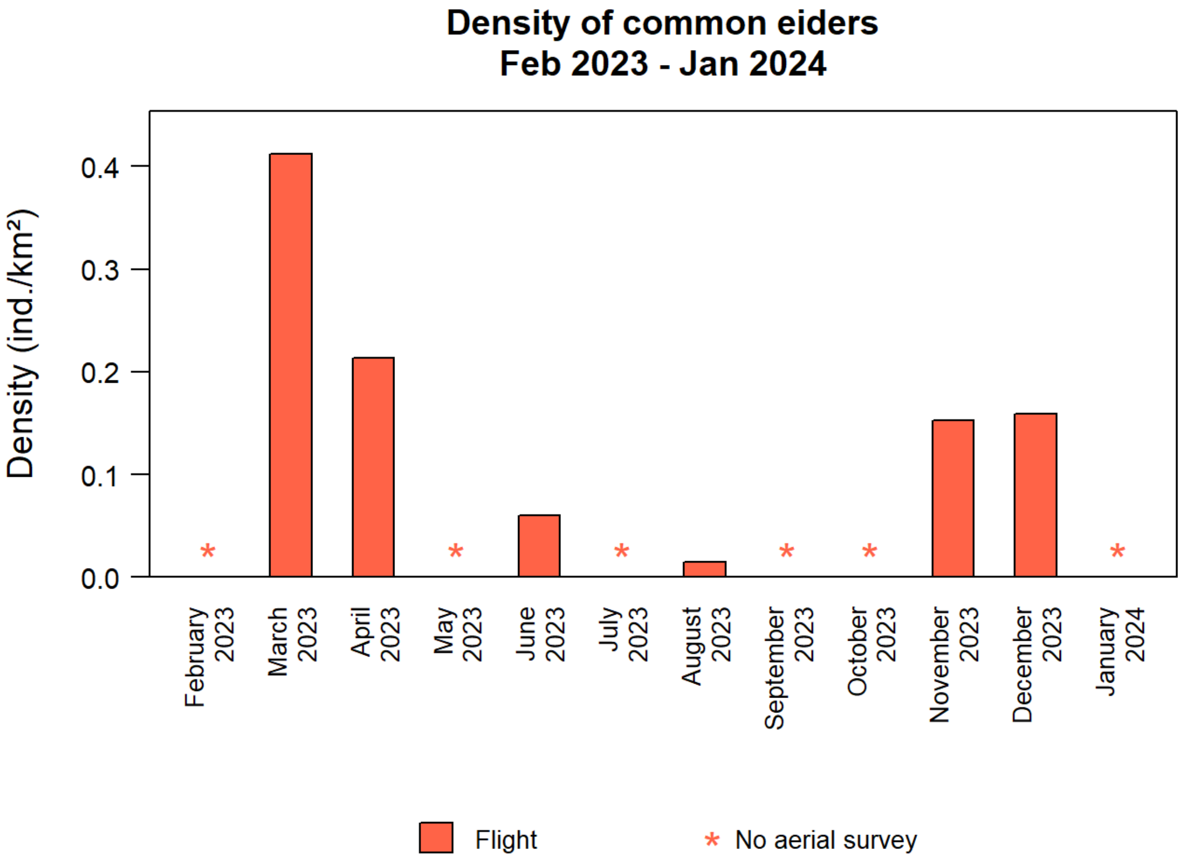


Figure 5-6 Monthly densities of common eiders during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Spatially, the species was more commonly found towards the west of the pre-investigation area, or if present in the middle of the pre-investigation area, then close to protected areas. Also, individuals regularly occurred at the tip of Sjællands Odde. In spring, two individuals were found within the limits of the planned OWF (Figure 5-7).

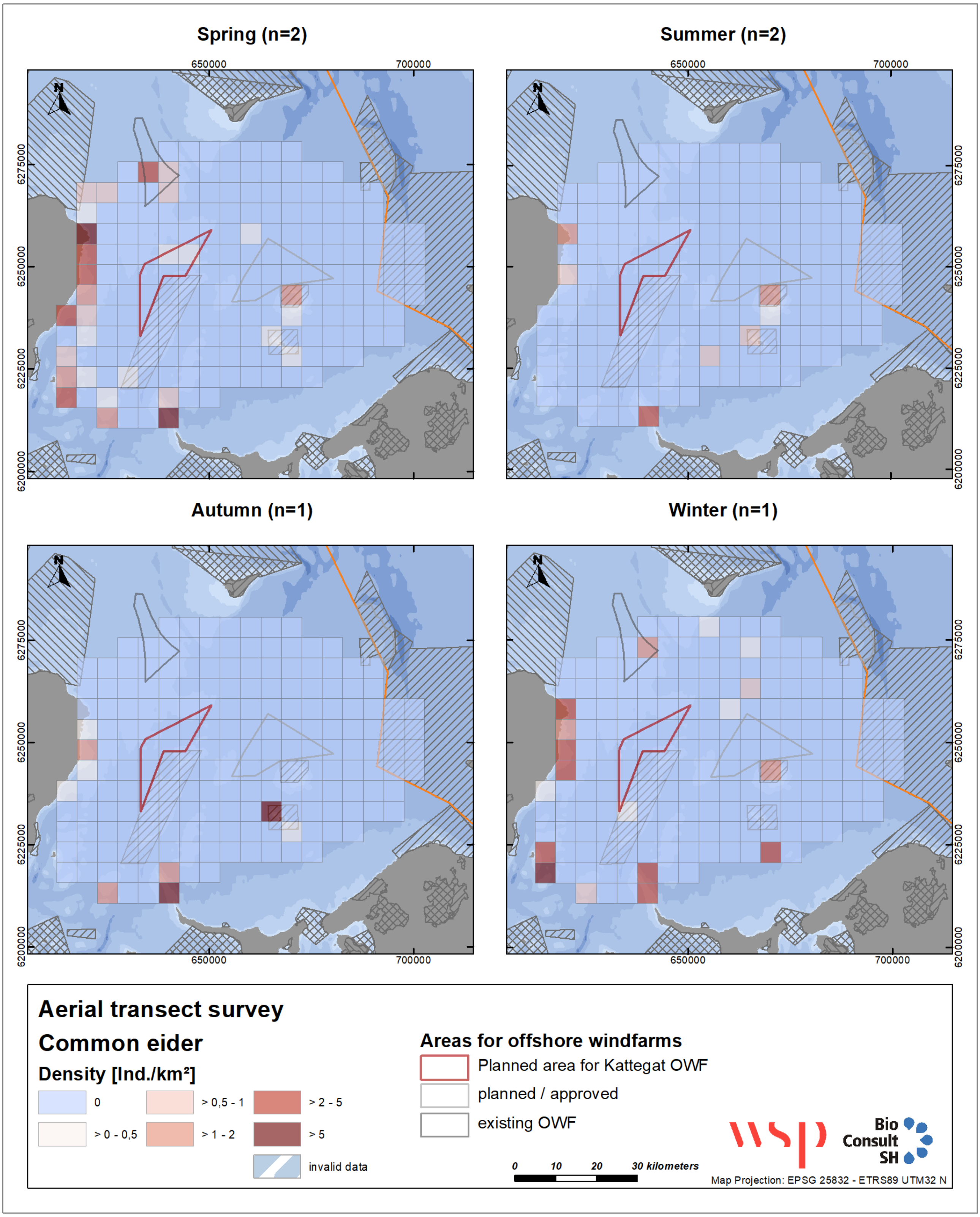


Figure 5-7 Distribution of common eiders in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to Garthe et al. (2007).

COMMON SCOTER

Common scoters were the most common species of ducks in the pre-investigation area and the second most common species of resting birds. A total of 1,087 individuals were observed during the whole survey period. They were seen in three out of the six digital aerial flights. The density of common scoter was highest in April 2023 (2.13 ind./km²) and lower than 0.1 ind./km² in the flights of March and August (Figure 5-8). The seasonal density was highest in spring (March and April, average: 1.1 ind./km²), much higher than in summer or autumn. One flight was conducted during the wintering season of this species, but detected densities were low (0.03 ind./km²).

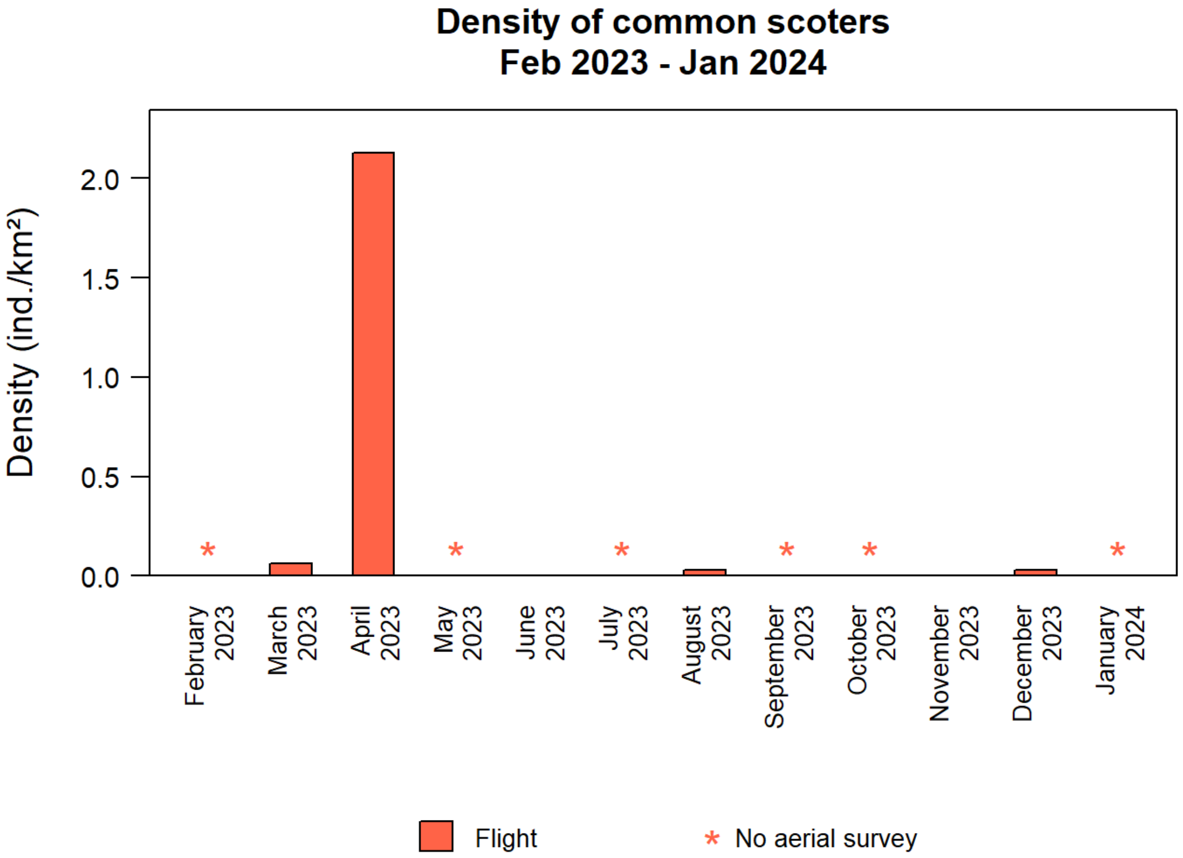


Figure 5-8 Monthly densities of common scoters during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Despite being very abundant in spring, the by far highest numbers were reached in one grid cell at the tip of Sjællands Odde with > 500 individuals. Densities in other locations, e.g. towards the northwest of the pre-investigation area, were much lower (Figure 5-9).

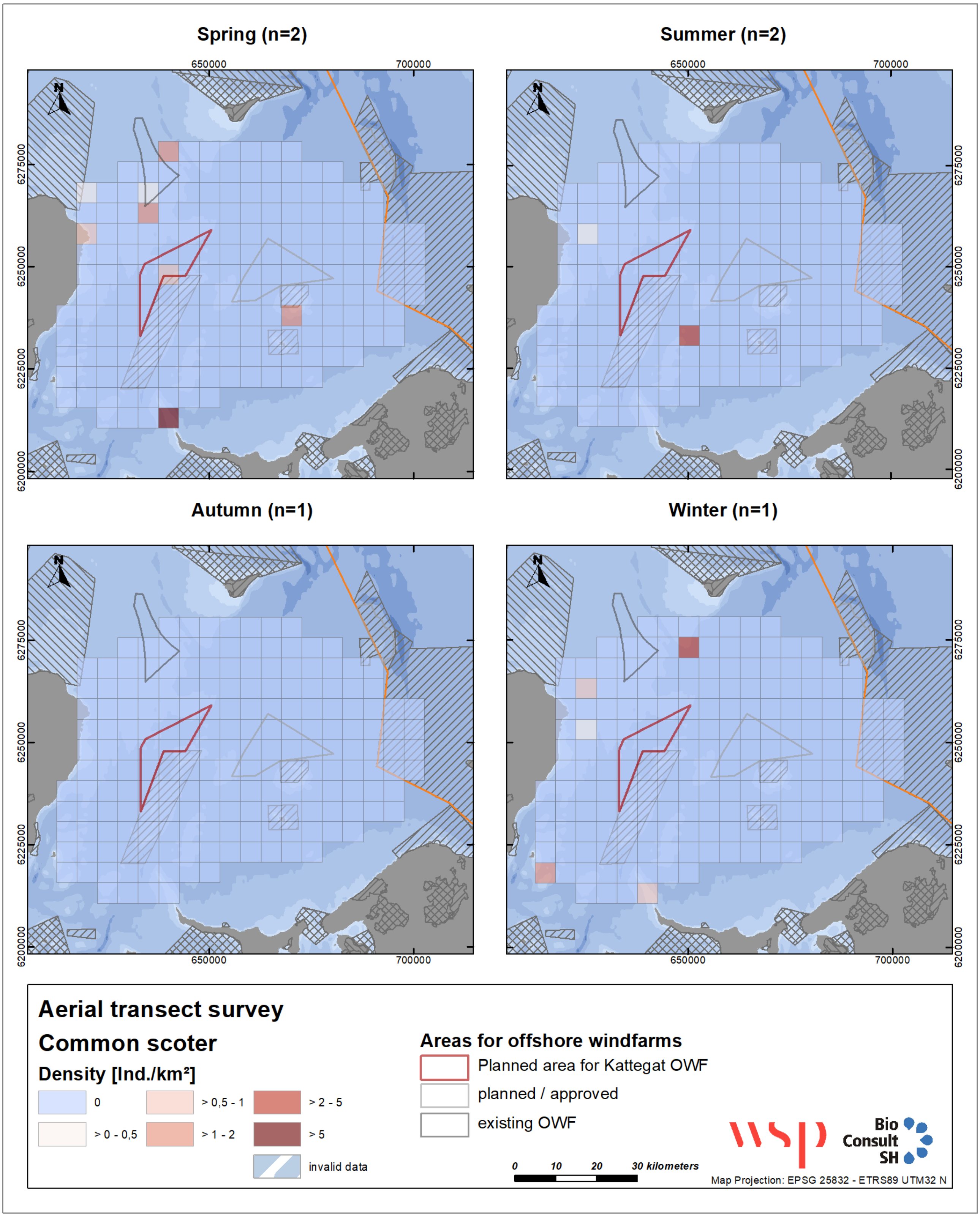


Figure 5-9 Distribution of common scoters in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

GULLS

Seven gull species were observed in the pre-investigation area during the six digital aerial surveys. The most common one was the herring gull whose total abundance represented 5.3% of all resting birds seen in the area. In order of abundance, the following species occurred in the area as well: common gulls (2.6%), lesser black-backed gulls (2.2%), black-legged kittiwakes (1.9%), great black-backed gulls (1.7%), black-headed gulls (0.2%), and only one individual of little gull (0.01%). The abundances of the first named five species are described in the following pages.

COMMON GULL

Common gulls were the second most common species of gulls in the area. A total of 209 individuals were observed in the pre-investigation area during the six digital aerial surveys. Their maximum abundance occurred in the month of November (0.24 ind./km²), which corresponded to the winter season. The smallest numbers were seen during the warmer months. Common gulls were not seen in August (which corresponded to the autumn season). In spring an average density of 0.07 ind./km² was estimated, whereas in summer the density was very low (0.01 ind./km², Figure 5-10).

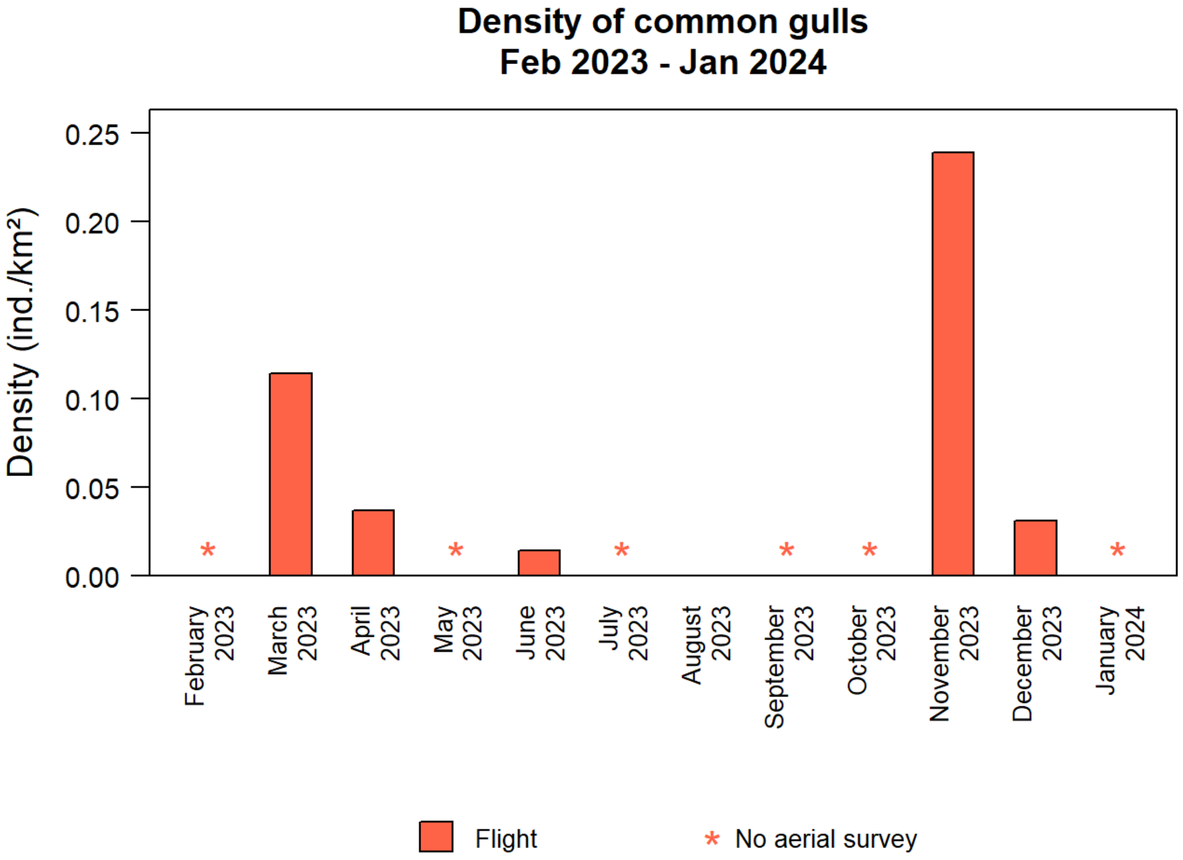


Figure 5-10 Monthly densities of common gulls during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Spatially, common gulls were observed distributed throughout the whole area, but higher densities were observed at locations closer to the coast (northern and western part of the pre-investigation area, Figure 5-11).

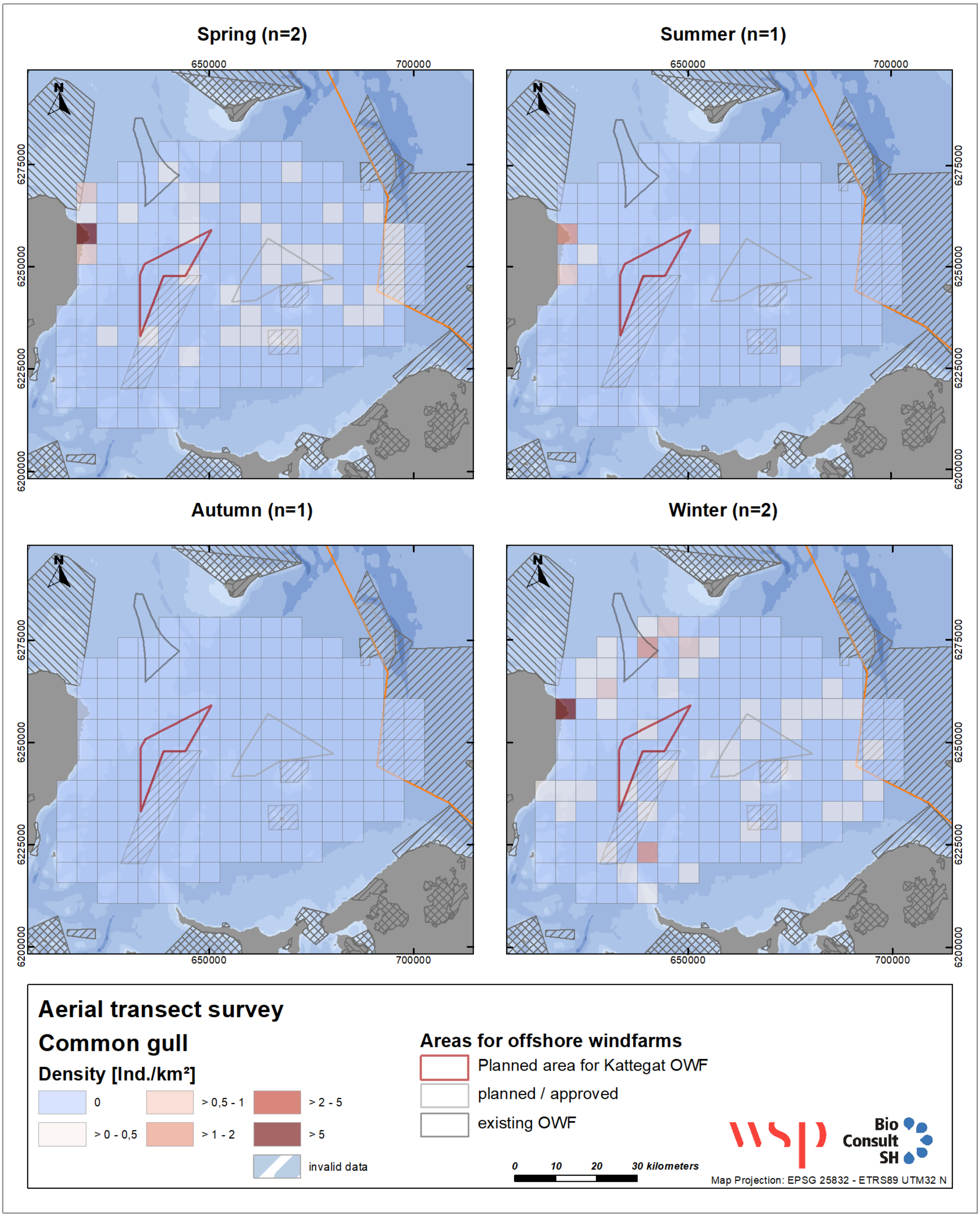


Figure 5-11 Distribution of common gulls in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

LESSER BLACK-BACKED GULL

A total of 176 individuals of lesser black-backed gulls were observed between February 2023 and January 2024. These gulls were found in all surveys including August at middle densities (0.1 ind./km²). The highest density was observed in April (0.18 ind./km²), coinciding with the spring density. In winter the average density was 0.03 ind./km² (averages of March and November densities), similar to the density of summer (June, 0.03 ind./km². Figure 5-12).

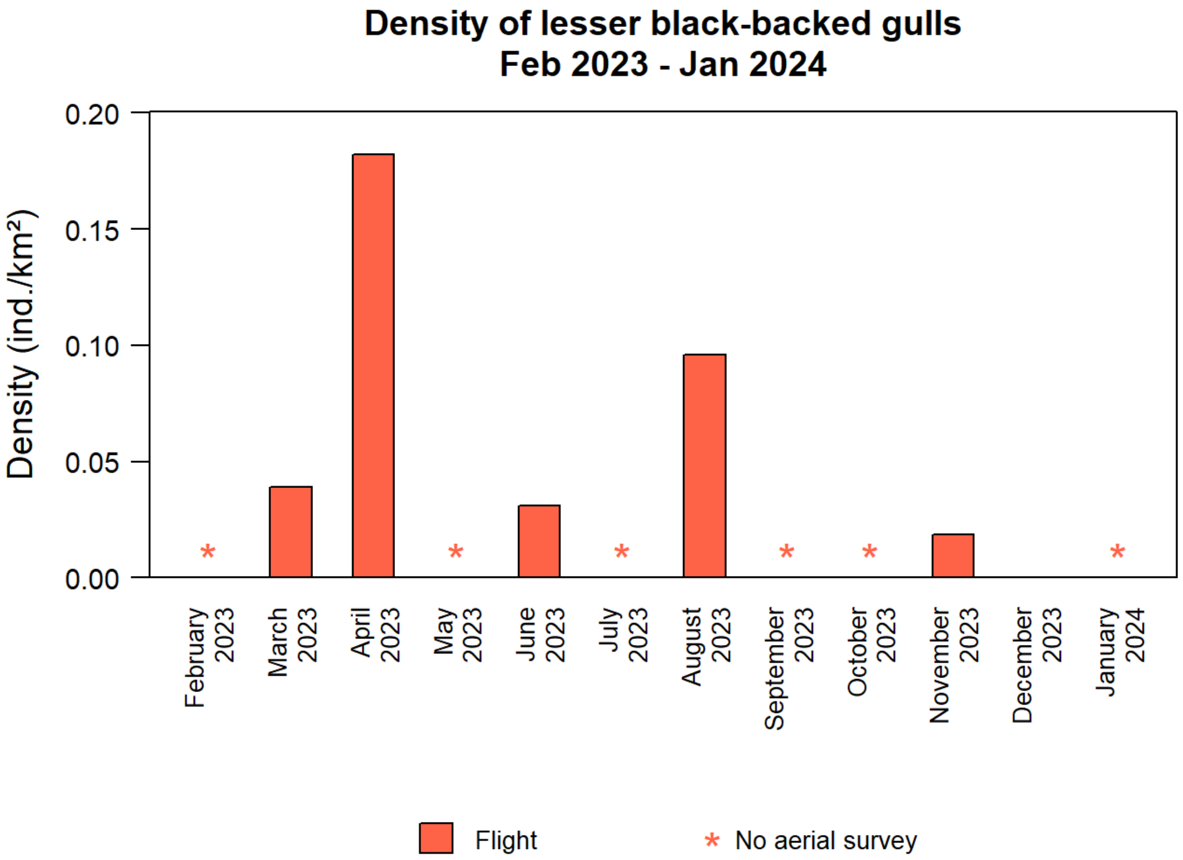


Figure 5-12 Monthly densities of lesser black-backed gulls during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Spatially, lesser black-backed gulls were mainly distributed in the eastern part of the pre-investigation area (especially in spring, when their densities were highest). To the east of the pre-investigation area is the Nordvästra Skånes havsområde Natura 2000 site (code SE0420360) which protects gulls among many other seabirds. In autumn and winter, they were also seen towards the western part closer to the coast (Figure 5-13). In autumn, an aggregation of gulls was found at the tip of Sjællands Odde.

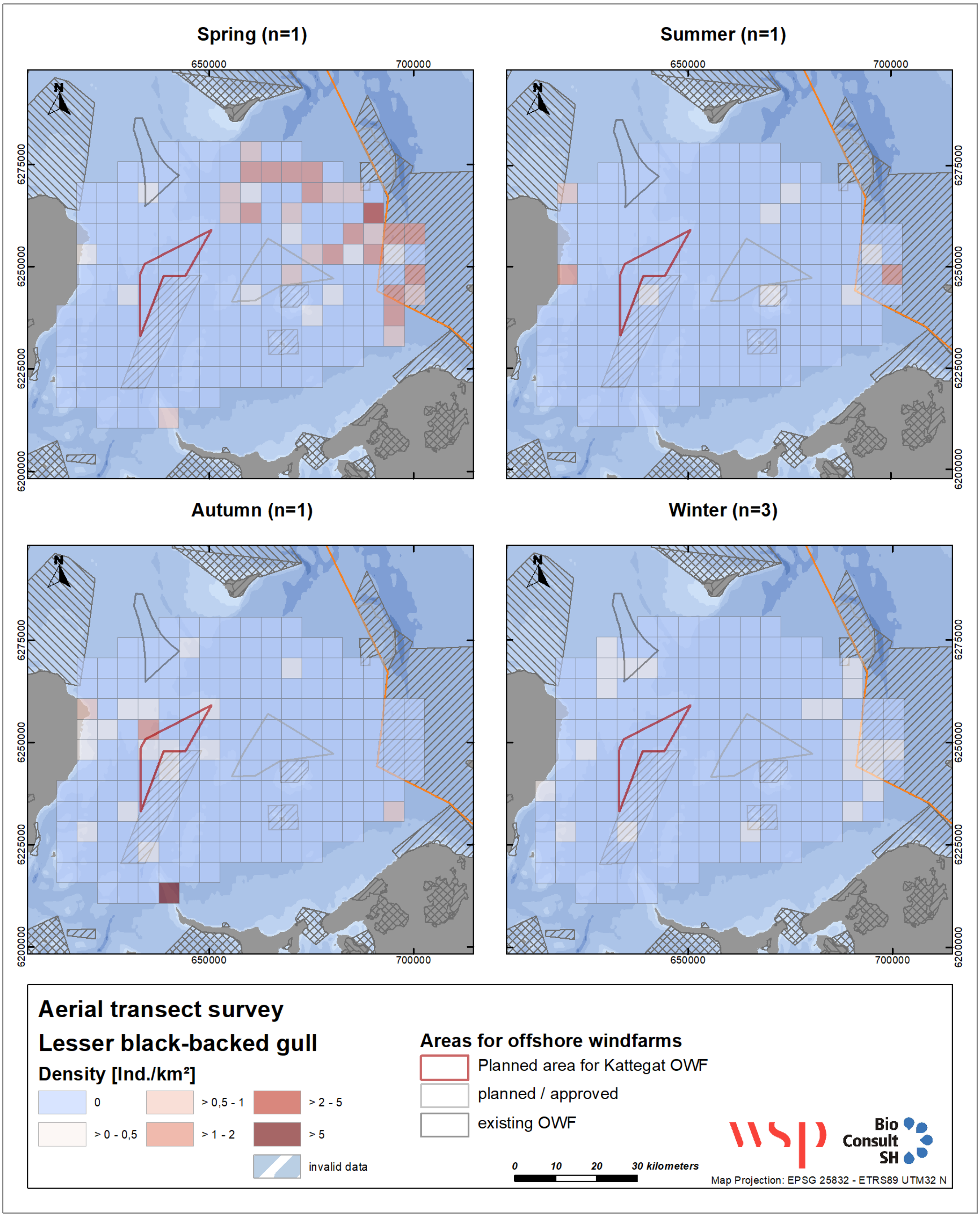


Figure 5-13 Distribution of lesser black-backed gulls in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

HERRING GULL

Herring gulls were the most common species of gulls in the area. A total of 422 individuals were observed which represented 5.3% of all resting birds found in the area. They were present in all flights at relatively similar densities, but their densities were lower in August (0.01 ind./km²). The highest density was in March (0.24 ind./km²). In terms of seasons, they were slightly more abundant in summer (June, 0.22 ind./km²) than in winter (0.18 ind./km²) and spring (0.17 ind./km², average of March and April) with the lowest density in the autumn season of the species (0.01 ind./km², Figure 5-14).

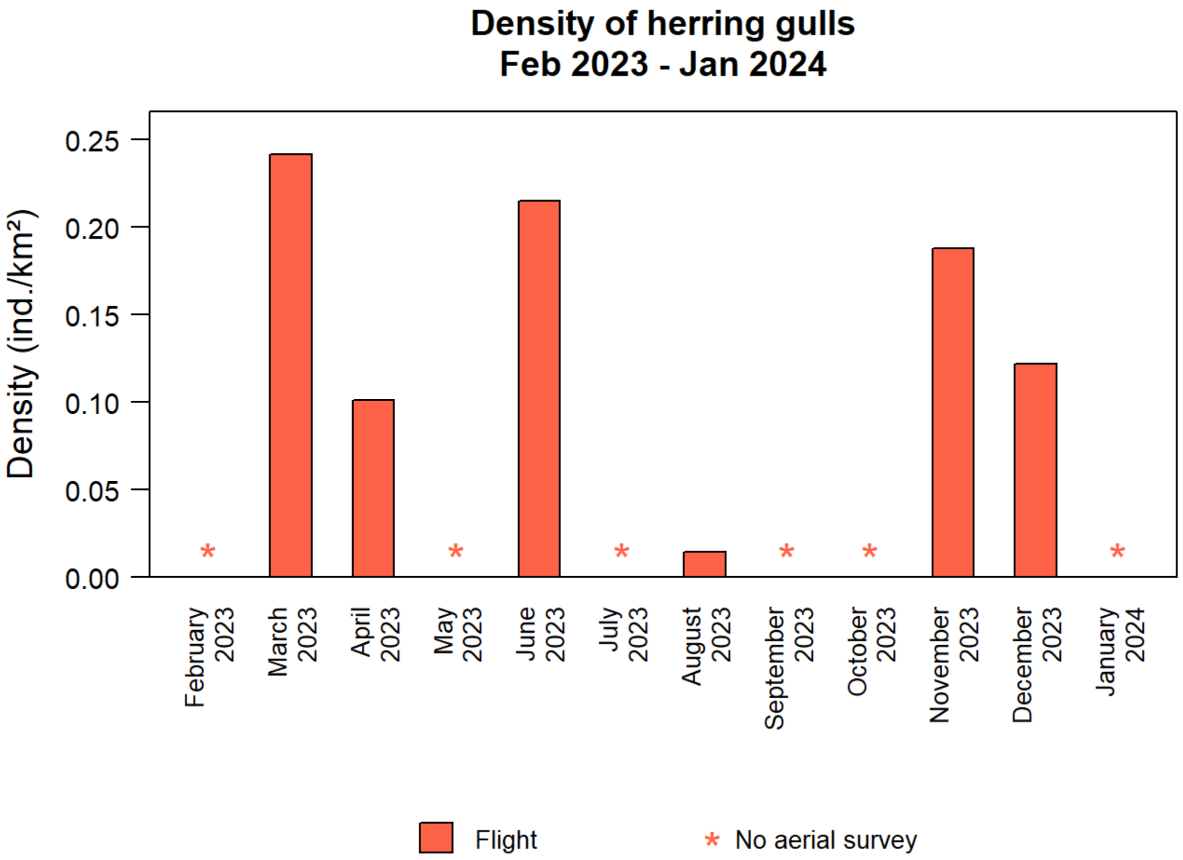


Figure 5-14 Monthly densities of herring gulls during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Herring gulls were distributed all over the pre-investigation area without specific pattern. Higher densities were observed however, either to the west, at the coast of Djursland (e.g., spring and summer) or towards the eastern part of the pre-investigation area, closer to the protected Natura 2000 site “Nordvästra Skånes havsområde” (Figure 5-15).

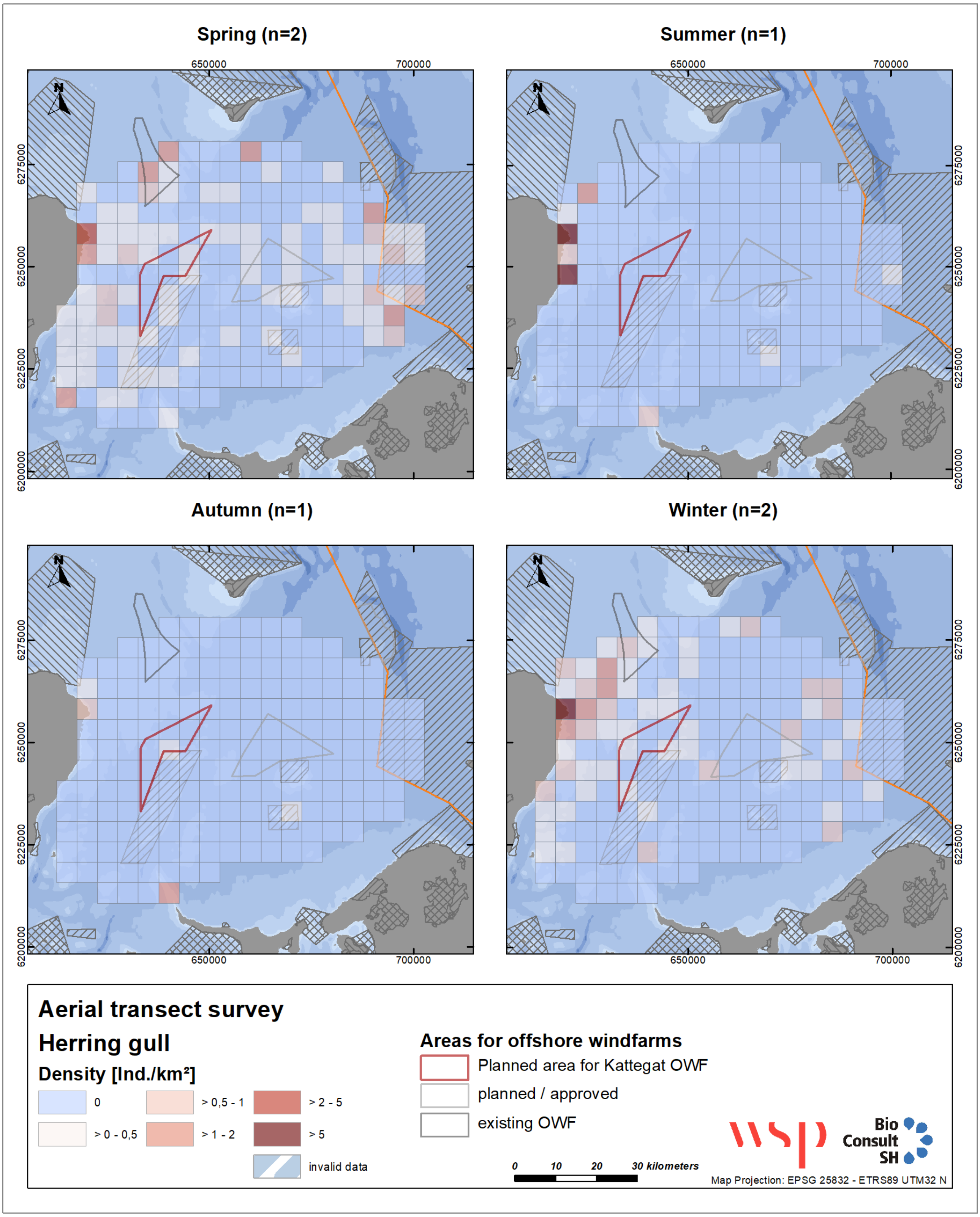


Figure 5-15 Distribution of herring gulls in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

GREAT BLACK-BACKED GULL

With 138 individuals, great black-backed gulls represented 1.7% of all resting birds. They occurred in all flights with varying densities between <0.02 to 0.06 ind./km² between March and August. The highest density was observed however in November when they reached 0.13 ind./km², which coincided with the winter season of the species. All other seasonal densities remained more or less at the same level ranging between 0.02 ind./km² (August and autumn) and 0.04 ind./km² (spring, average of March and April, Figure 5-16).

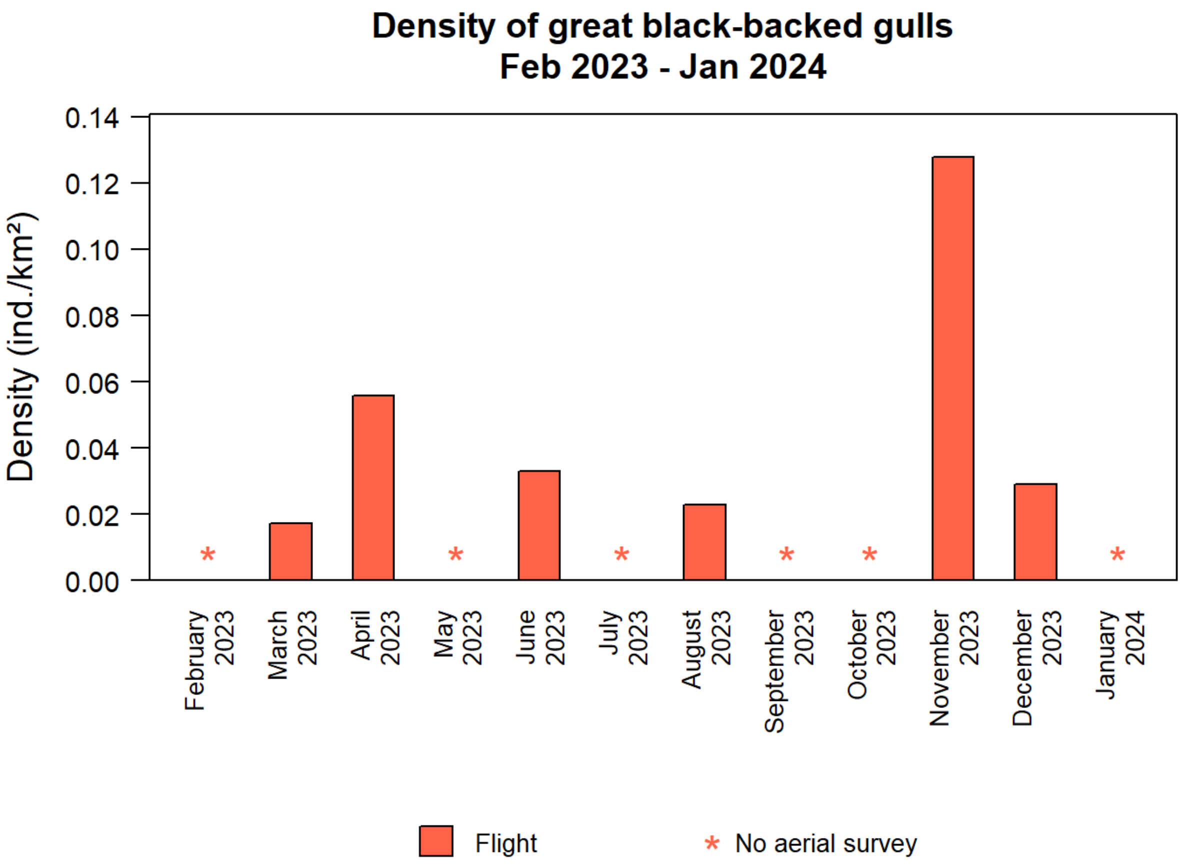


Figure 5-16 Monthly densities of great black-backed gulls during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Spatially, great black-backed gulls were sparsely distributed throughout the whole pre-investigation area but were more common and present at higher densities towards the coast (summer and autumn) but the highest densities were observed in the eastern part of the pre-investigation area close to the Natura 2000 site “Nordvästra Skånes havsområde” (Figure 5-17).

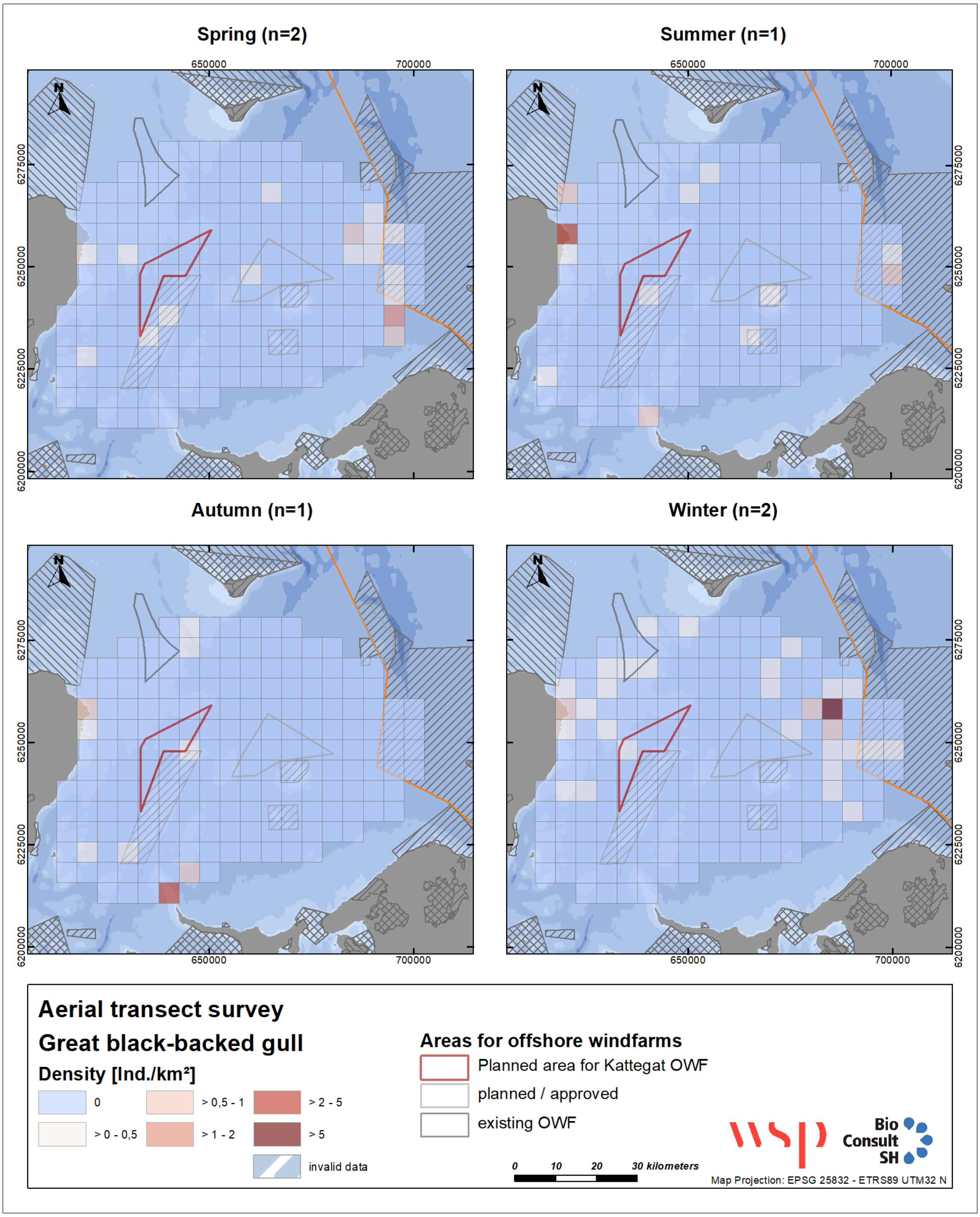


Figure 5-17 Distribution of great black-backed gulls in the pre-investigation area per season during the digital aerial surveys between February 2023 and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

BLACK-LEGGED KITTIWAKE

With a total of 150 observed individuals, black-legged kittiwakes were not frequently occurring in the pre-investigation area, but a large number of individuals was observed in November (64 individuals) and especially in December 2023 (85 individuals) which, together with the single individual spotted in March 2023 accounted for 1.9% of all resting birds in the pre-investigation area. The density of November was 0.13 ind./km² and that of December 0.18 ind./km², both months corresponding to the winter season of the species whose density was much larger than the density of spring (0.15 ind./km², Figure 5-18).

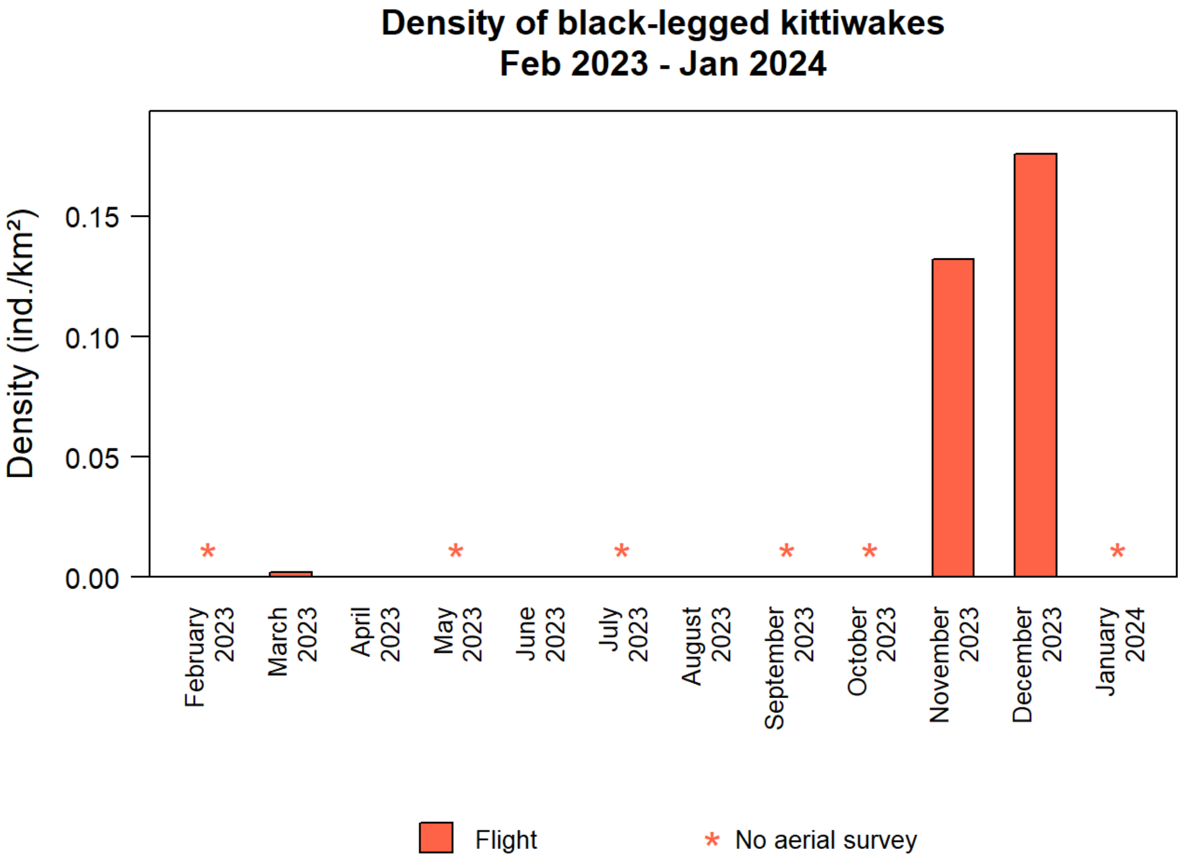


Figure 5-18 Monthly densities of black-legged kittiwakes during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Spatially, black-legged kittiwakes were distributed throughout the whole pre-investigation area (winter), without any specific geographical pattern (both at offshore locations and also towards the coastal parts, Figure 5-17).

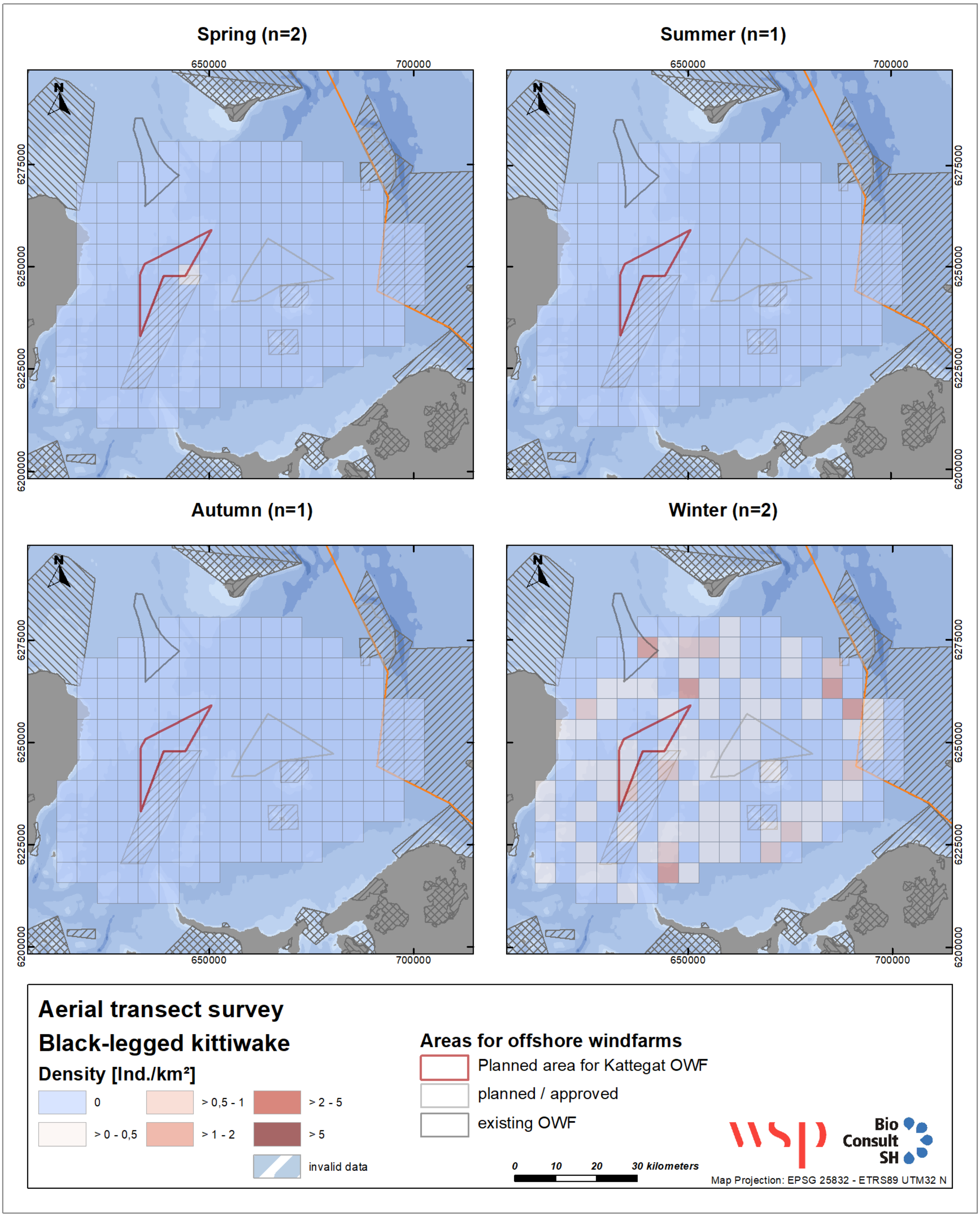


Figure 5-19 Distribution of black-legged kittiwakes in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

AUKS

Auks were the most abundant species group in the pre-investigation area and altogether represented 53.6% of all resting birds detected in the area during the six digital aerial surveys. There were in total four species of auks detected, of which by far the most abundant one was the common guillemot (38.5%). The other species in order of importance were razorbills (4.4%), black guillemots (1.1%) and one individual of Atlantic puffin (0.01%). In addition, there were 642 individuals that could not be properly assigned as being common guillemots or razorbills (8.1%) and 126 individuals of unidentified auks (1.6%).

COMMON GUILLEMOT

A total of 3,064 common guillemots were observed during the observation period but at very different densities. The densities varied between < 0.01 ind./km² (June and summer) to 2.1 ind./km² (November and winter). Two flights belonged to the spring season; thus, the spring density was 0.4 ind./km², Figure 5-20).

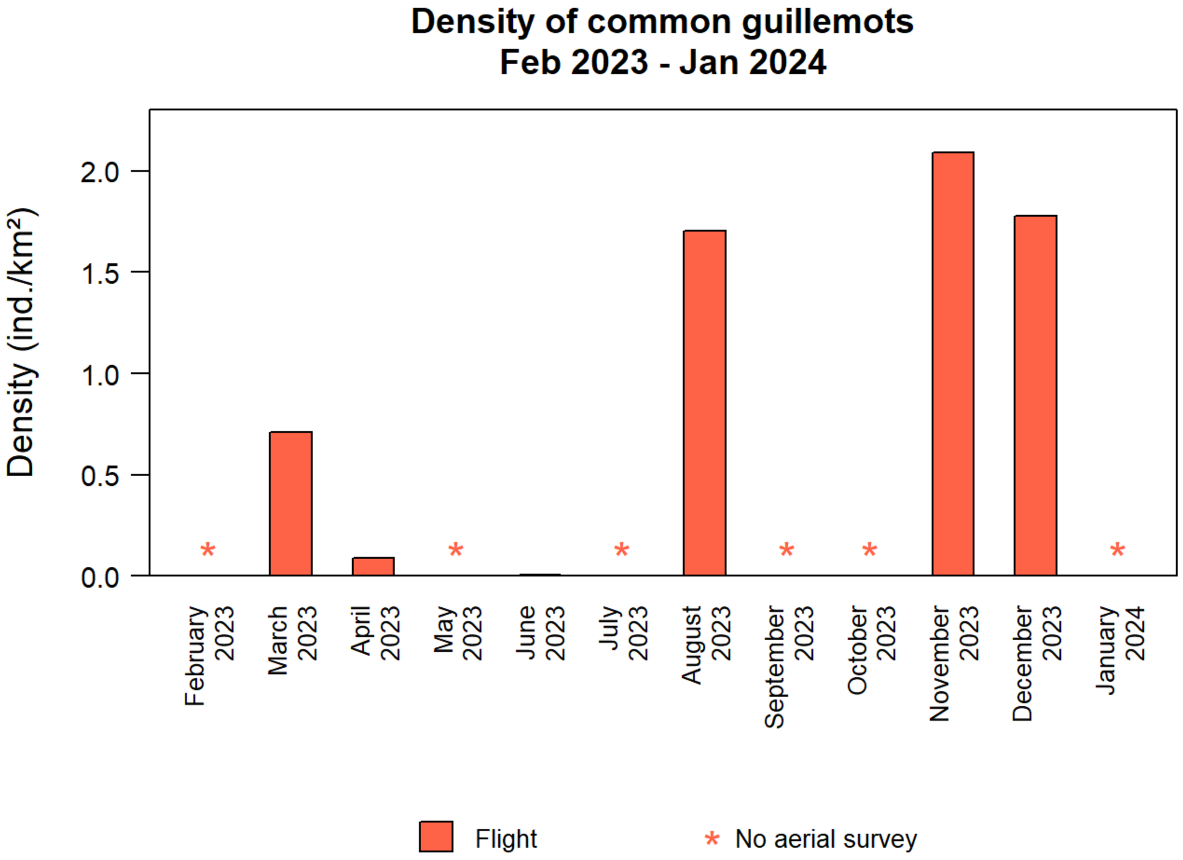


Figure 5-20 Monthly densities of common guillemots during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Spatially, common guillemots occurred throughout the whole pre-investigation area, but with higher densities in offshore regions. In autumn, there was a high concentration of birds in the northeastern part of the pre-investigation area, while in winter, this concentration was less pronounced, and birds were more widely distributed. Medium density grid cells were also seen in the central parts of the pre-investigation area (Figure 5-21).

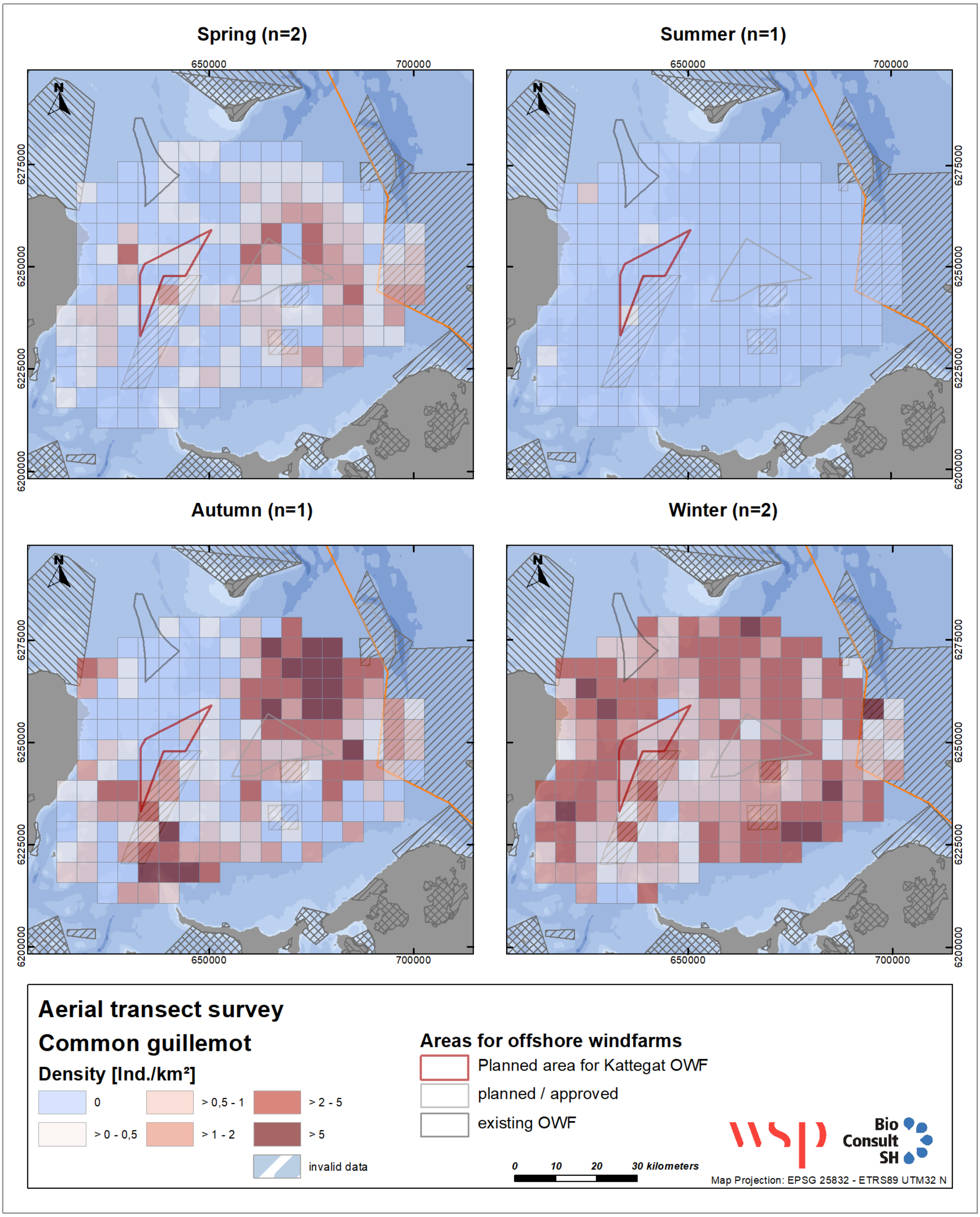


Figure 5-21 Distribution of common guillemots in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

RAZORBILL

The 349 razorbills observed in the area were observed at varying densities during the surveys. The highest density was found in December (0.36 ind./km², winter: 0.31 ind./km²) and the lowest was in April (< 0.01 ind./km²). No razorbills were seen in June (summer season, Figure 5-22).

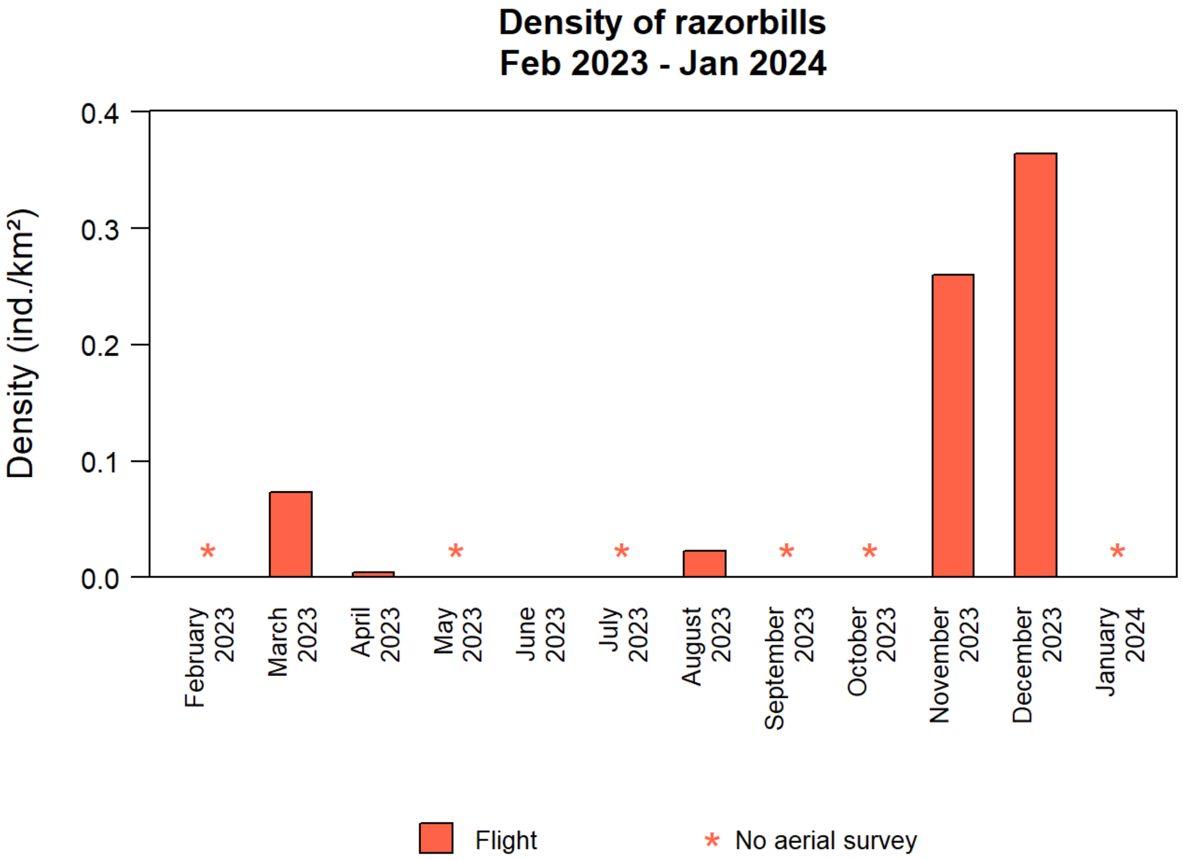


Figure 5-22 Monthly densities of razorbills during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Their spatial distribution was similar to that of the common guillemot, being predominantly an offshore species. Grid cells of medium density were observed scattered across the pre-investigation area especially in winter, when the species was more abundant. A few individuals were also observed within the limits of the planned OWF (Figure 5-23).

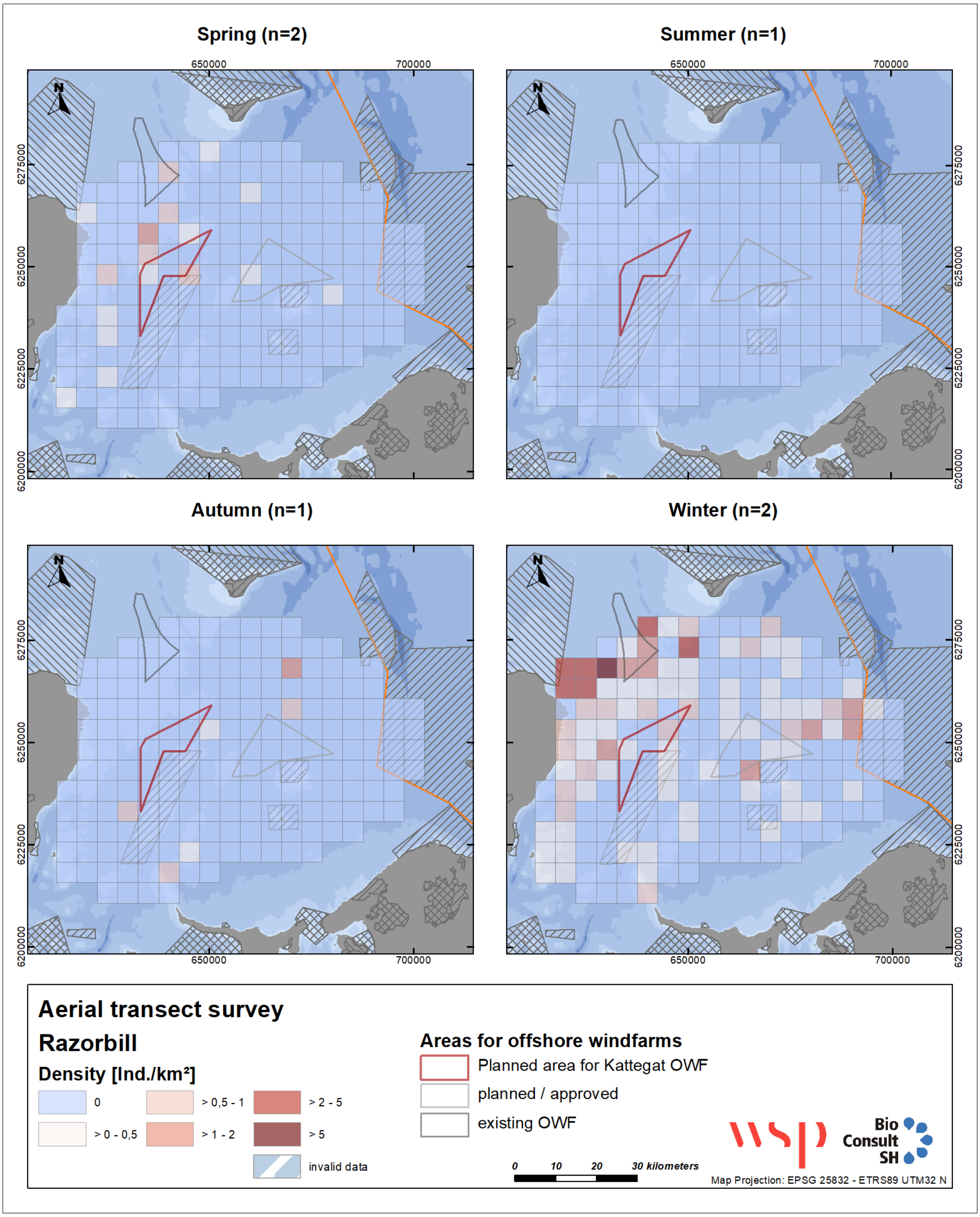


Figure 5-23 Distribution of razorbills in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

BLACK GUILLEMOT

A total of 88 individuals of black guillemots occurred throughout the survey period in the area. No individuals of this species were however seen in April or June. They occurred at a low density in March (< 0.01 ind./km²), and in the highest density was observed in December 2023 (0.1 ind./km²), which corresponded to the winter season and was as well the highest seasonal density (, Figure 5-24).

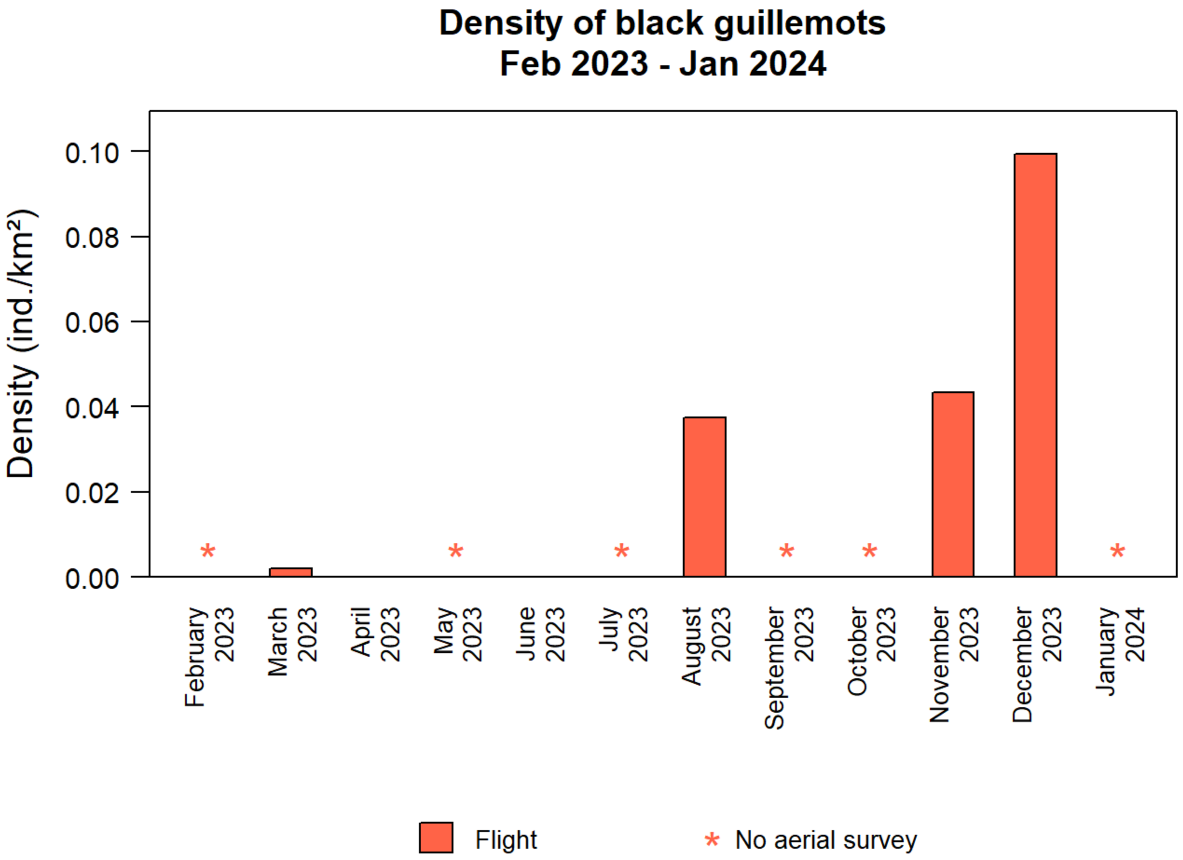


Figure 5-24 Monthly densities of black guillemots during digital aerial surveys in the pre-investigation area between February 2023 and January 2024.

Their numbers were relatively low so it is difficult to infer a spatial pattern but they were occurring mainly in the southern part of the pre-investigation area and localized small groups of birds were seen relatively close to the coast, e.g. at the tip of Sjællands Odde (Figure 5-25).

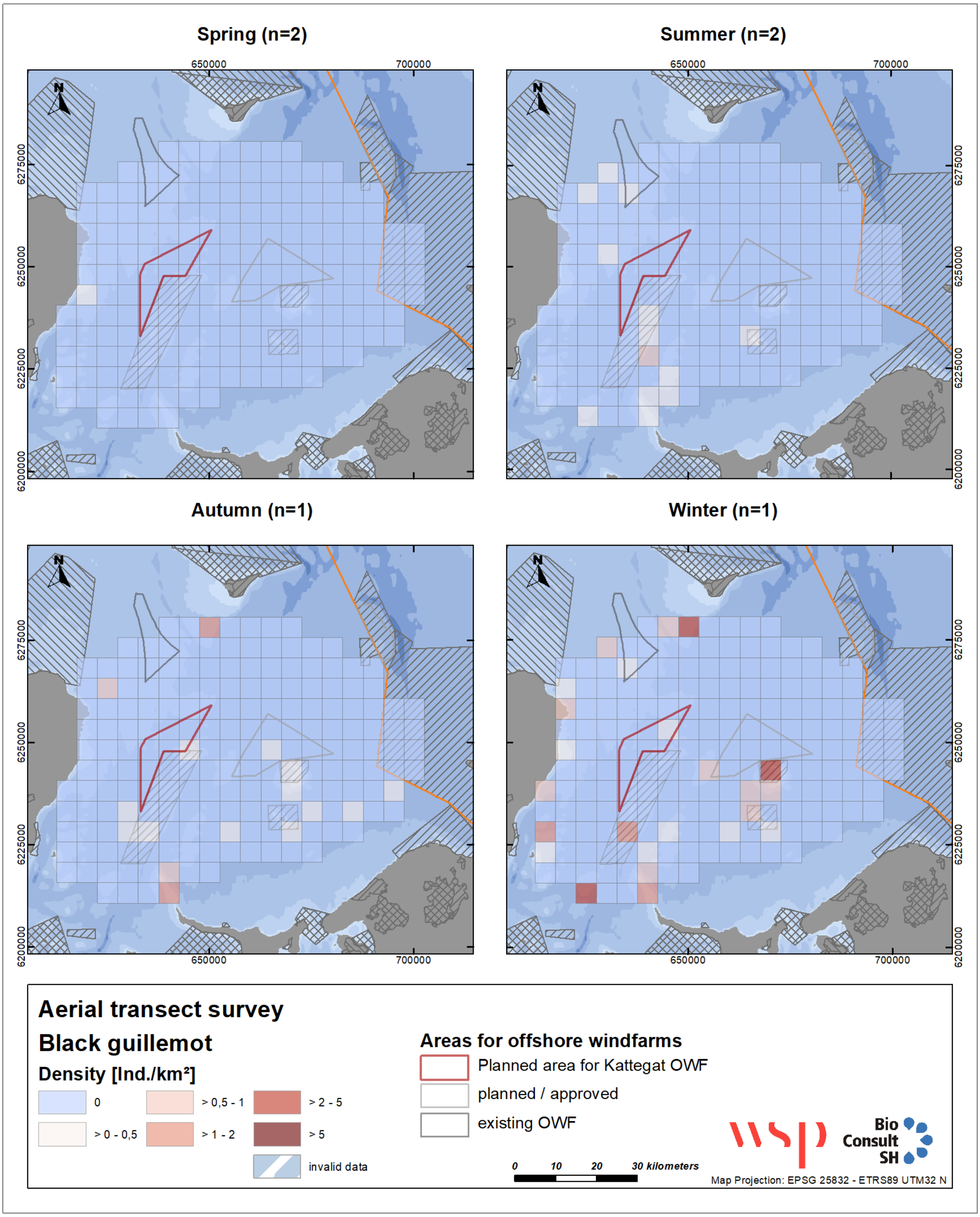


Figure 5-25 Distribution of black guillemots in the pre-investigation area per season during the digital aerial surveys between February and January 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007).

5.2 MIGRATING BIRDS

Bird migration data which included observer-based information (visual sightings, nocturnal flight calls) and radar measurements (vertical and horizontal) is presented in this chapter. Analyses are presented for all migrating bird species first and then for relevant (in terms of abundance) species groups (highlighting individual species). The appendix (Table A-2) includes a species list with information on numbers of all individuals observed, taxonomical information and species conservation status.

5.2.1 OBSERVER-BASED DATA

ALL SPECIES

DAY MIGRATION

SPECIES COMPOSITION

A total of 9,177 birds, of which 94.6% were identified to 67 species, were registered during the 14 days of diurnal observations in spring 2023 at the pre-investigation area Kattegat.

Of the total number of migrating birds observed, 71.6% were geese, most of them were barnacle goose (67.9%), and 1.7% greylag goose. The second most abundant group of migrating birds observed during the survey period were ducks (13.2%), mainly common scoters (10.7%) and to a smaller extent other sea ducks such as common eiders (0.9%), velvet scoters (0.54%) and long-tailed ducks (0.39%). A large number of migrating passerine species make up the third most abundant migrating group of birds in spring 2023 (songbirds, 6.1%) whereas cormorants, gulls and waders represented each less than 3% of all migrating birds in the area during spring 2023 (see Figure 5-26). Of waders (1.4%), the most abundant species was the Eurasian curlew, whereas common gulls were the most abundant species of gulls (0.68%).
Only very few birds of prey were observed in both seasons.

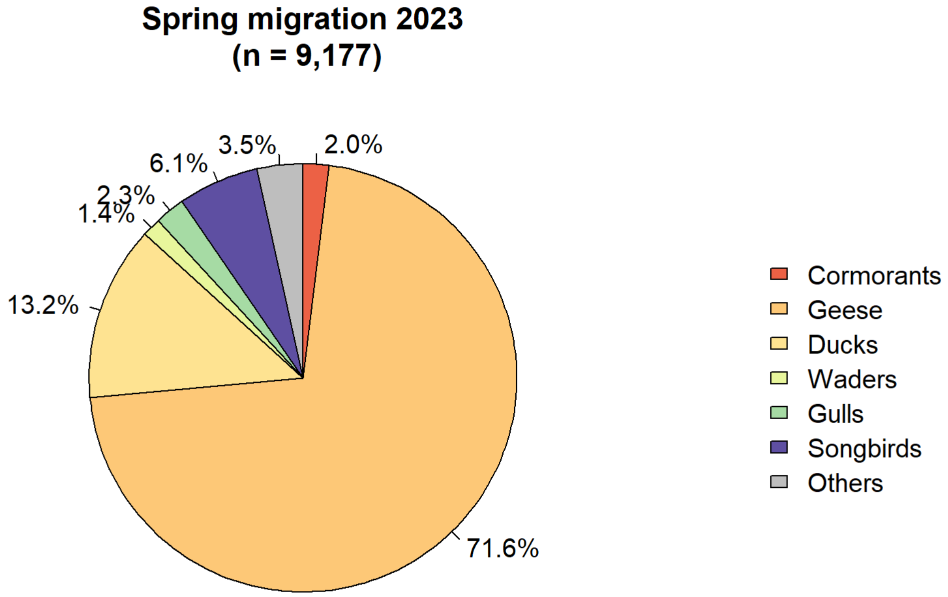


Figure 5-26 Percentage of observed diurnal migratory species in spring 2023 at the pre-investigation area , grouped into high-category taxa. All species groups, whose abundance represent at least 1% of the total are shown and are presented according to taxonomic order (starting at the top, in a clockwise order, thus songbirds appear last). The category "Others" (grey) includes all other bird taxa whose percentage was less < 1%.

A total of 3,105 birds (of which 2,828 birds, 91.1%, were identified to 75 species) were registered during the 18 days of diurnal observations in autumn 2023 at the pre-investigation area.

Of the total number of migrating birds observed in this season half of them were ducks, most of them were common scoters (28.6%) and Eurasian wigeons (10.9%). The second most abundant group of migrating birds observed during the survey period were geese (14.2%) of which barnacle goose were the most abundant species (11.6%). After these, gulls (8.1%), songbirds (8.0%) and auks (6.4%) followed in terms of abundance (see Figure 5-27). Other groups were less abundant: gannets (4%), swans (3.5%), cormorants (2.2%) and waders (1.7%) but will still be mentioned in the next section.

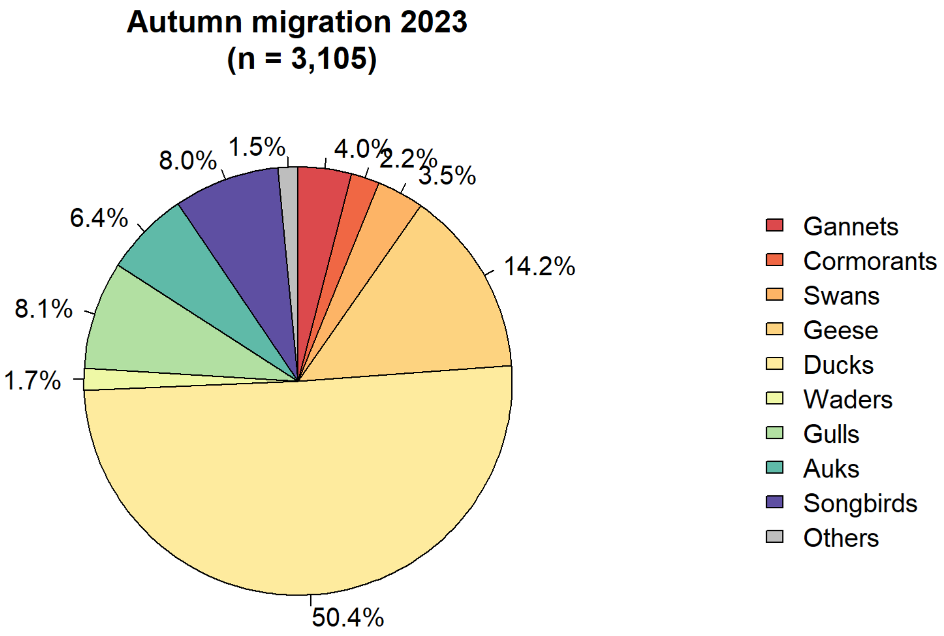


Figure 5-27 Percentage of observed diurnal migratory species in autumn 2023 at the pre-investigation area , grouped into high-category taxa. See Figure 5-26 for details.

MIGRATION INTENSITY

The 14 days of diurnal observations in spring were evenly spread during the season. However, most migrating birds (6,431 birds, 70%) were observed in May 2023. Mean migration intensity across all bird groups was 86.3 (± 52.6) ind./h with the maximum mean migration occurring in May (200.8 ind./h). On the last date of the surveys (the 9th of May 2023), there was a peak migration event when a maximum of 767.8 ind./h were registered (Table 5-3, Figure 5-28). This resulted from a large number of barnacle geese migrating through the area on that day (6,015 birds).

Table 5-3. Monthly and seasonal migration rates (ind./h) calculated from visual observations in spring 2023 at the pre-investigation area .

Spring 2023	Migration intensity (ind./h)			Number of individuals	Number of survey days
	Mean (± SE)	Median	Maximal value		
March	39.2 (± 5.4)	35.7	60.3	1,219	5
April	41.8 (± 7.7)	41.8	69	1,527	5
May	200.8 (± 189.1)	16.7	767.8	6,431	4
Spring	**86.3 (± 52.6)**	**35**	**767.8**	**9,177**	**14**

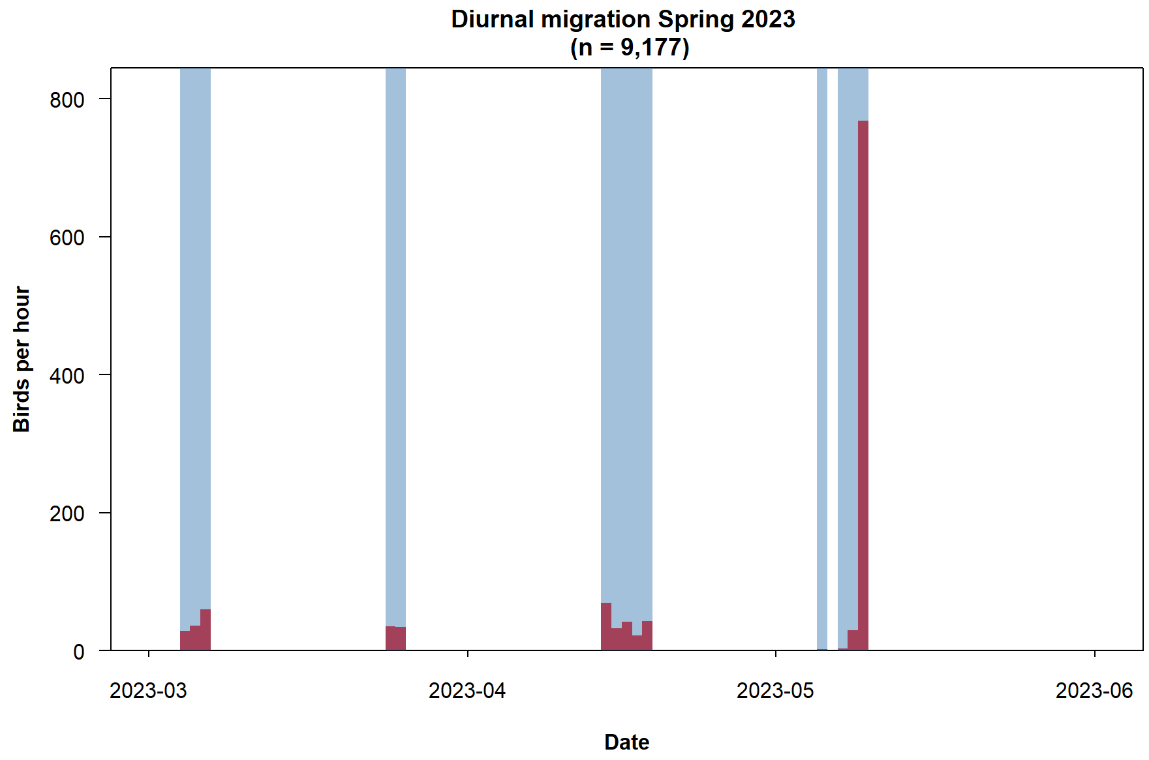


Figure 5-28 Diurnal migration intensity (red bars) derived from visual observations in spring 2023. Light blue shades indicate the dates of the surveys (14 dates).

In autumn, the 18 days of diurnal observations were evenly spread during the season, with about 4-5 days of surveys for each month. Nonetheless, almost half of the birds were observed in October (1,435 birds, 46%). Mean migration intensity across all bird groups was 31.9 (± 7.5) ind./h with the maximum mean migration occurring in October (65.4 ind./h, twice the mean value). There were two dates in October when migration peaks were reached (on the 3rd of October, 103 ind./h and on the 24th of October, 104.2 ind./h, Table 5-4, Figure 5-29). This corresponded to migration events for two relevant groups: ducks and geese (see below).

Table 5-4. Monthly and seasonal migration rates (ind./h) calculated from visual observations in autumn 2023 at the pre-investigation area .

Autumn 2023	Migration intensity (ind./h)			Number of individuals	Number of survey days
	Mean (± SE)	Median	Maximal value		
August	8.5 (± 2.2)	8.4	13.3	253	4
September	24.1 (± 6.5)	17.7	40	824	5
October	65.4 (± 22.1)	67.9	104.2	1,435	4
November	31.5 (± 13.2)	26.1	81.6	593	5
Autumn	**31.9 (± 7.5)**	**19.7**	**104.2**	**3,105**	**18**

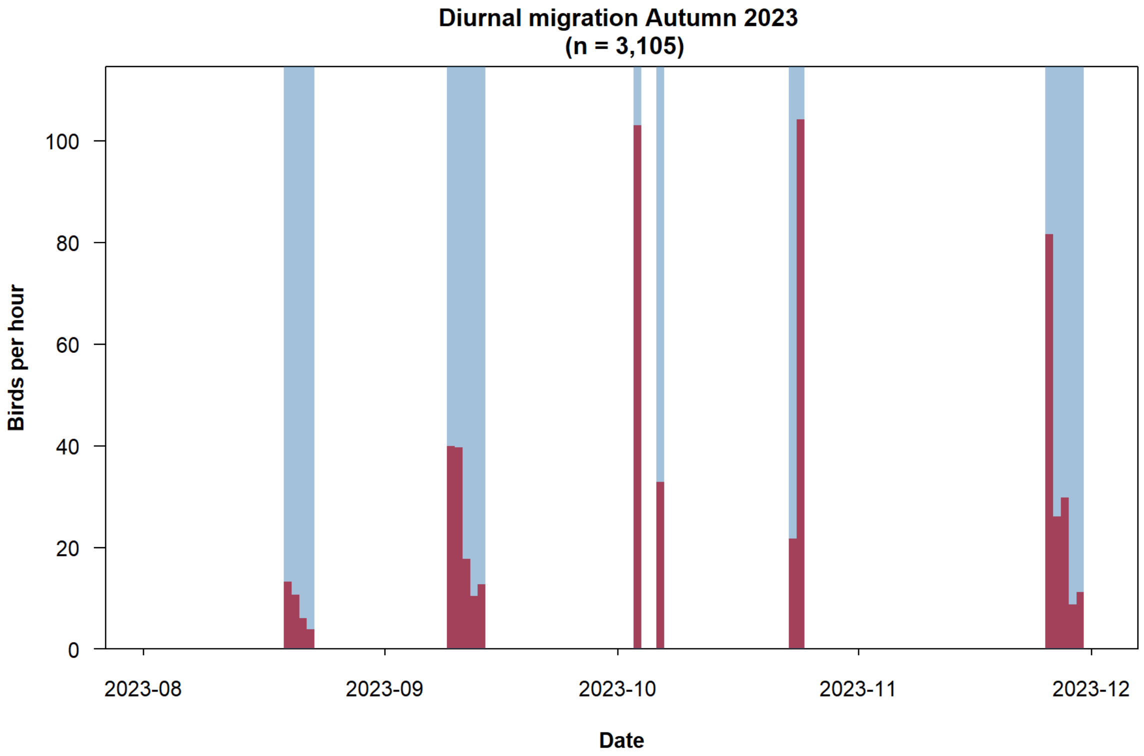
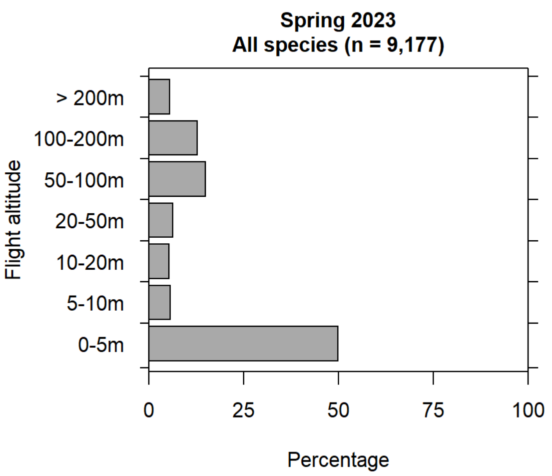


Figure 5-29 Diurnal migration intensity (red bars) derived from visual observations in autumn 2023. Light blue shades indicate the dates of the surveys (18 dates).

FLIGHT ALTITUDE

In spring, half of all migrating birds were observed at very low altitudes (0 – 5 m). About 11% were migrating at altitudes between 5 and 20 m, and a third of all birds (34%) were observed at altitudes between 20 and 200 m. Only 5.4% flew at altitudes above 200 m (Figure 5-30).

In autumn, almost half of all migrating birds were observed at very low altitudes (0 – 5 m). About 28% were migrating at altitudes between 5 and 20 m, and a quarter of all birds (25%) were observed at altitudes between 20 and 200 m. No bird was registered flying above 200 m of altitude (Figure 5-30).



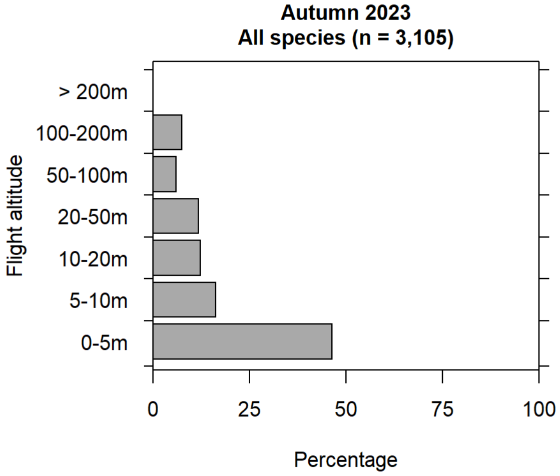
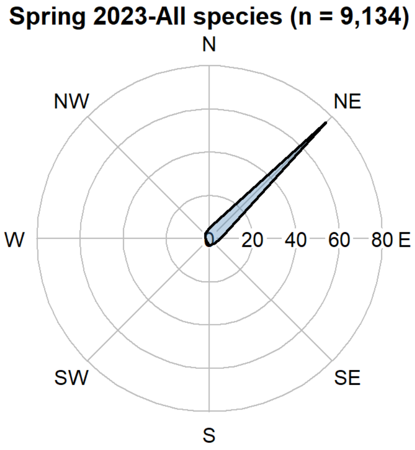


Figure 5-30 Flight altitude distribution of all observed birds during visual observations in spring 2023 (left) and autumn 2023 (right).

FLIGHT DIRECTION

During spring the main migration direction of all visually observed birds was clearly northeast (76.2 % of all observations, most of them geese), with few going directly north (5.5 %) and less than 5% of all birds flying in any other direction (Figure 5-31). During autumn the main migration direction of all visually observed birds was SW (28.6 % of all observations). Nonetheless, birds were observed flying at all directions, depending on the species/species group. Overall, the main direction was S-SW-W, with almost 66% of all birds flying in these directions. Only a third of all birds flew in other directions with 15% flying to the NW (Figure 5-31).



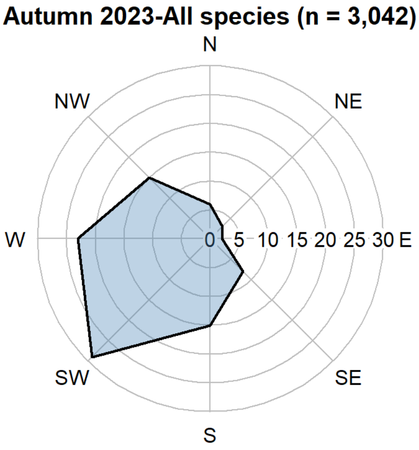


Figure 5-31 Flight directions of all observed birds during visual observations in spring 2023 (left) and autumn 2023 (right). Observers estimated the flying direction in 45° increments: N = North, NE = Northeast, E = East, SE = Southeast, S = South, SW = Southwest, W =West, NW = Northwest. Numbers on the axis represent percentages.

DIURNAL PHENOLOGY

During spring migration, the highest bird migration intensity was observed three hours after the civil morning twilight, when 59% of all birds were detected. In general terms, migration intensity was higher during the first part of the day than in the later hours: most birds were observed migrating during the first four hours after civil morning twilight (85.9%) than later (Figure 5-32).

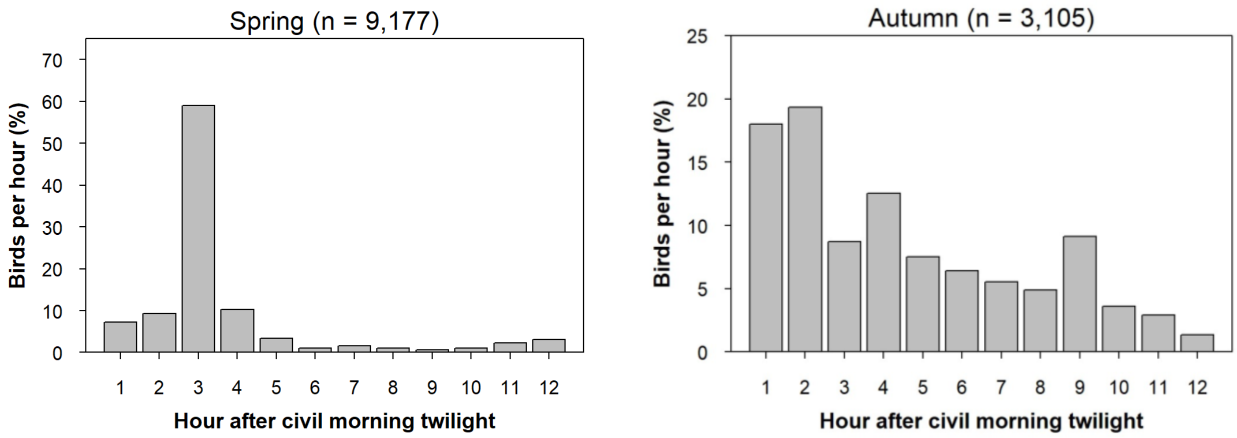


Figure 5-32 Diurnal phenology of all observed birds in spring (left) and autumn (right) 2023. Observations were combined for all observations days during spring, and hours were standardized so that every day would have a 12-hour length, irrespective of the date.

During autumn migration, the highest bird migration intensity was observed in the early hours of the morning. 37% of all birds flew during the first two hours after the civil morning twilight. In general, almost ¾ of all birds flew during the first half of the day (1-6 hours after civil morning twilight, Figure 5-32). There was a general decrease in the number of birds observed during migration with the time of the day.

NOCTURNAL MIGRATION

SPECIES COMPOSITION

In general, there were few night calls registered during spring 2023. Out of a total of 179 bird calls, 162 calls (90.5%) could be identified to species level (15 species in total). Most of the birds heard during night belonged to songbirds: 49.7% were thrushes (*Turdus* spp., among which redwings were most abundant) and 38.5% belonged to other songbird species (e.g. European robins, common chiffchaffs, etc.). Other groups worth mentioning were geese (barnacle goose, 6.7%), waders (3.4% mainly oystercatcher and common sandpipers) and gulls (1.7%, Figure 5-33).

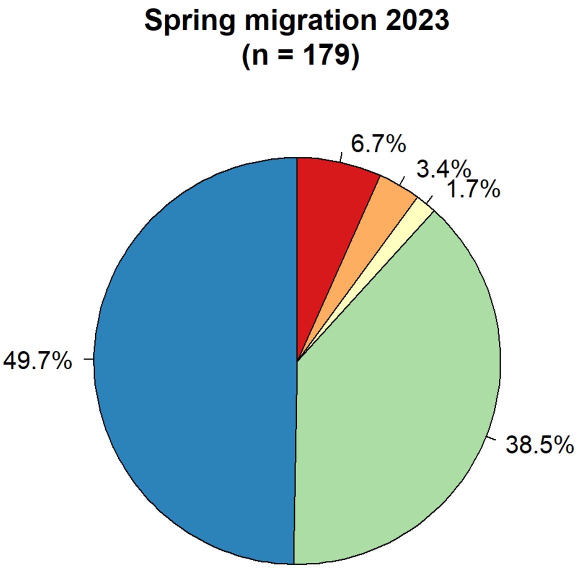


Figure 5-33 Percentage of nocturnal migratory species (based on acoustic observations) in spring 2023 at the pre-investigation area , grouped into high-category taxa. See Figure 5-26 for more details.

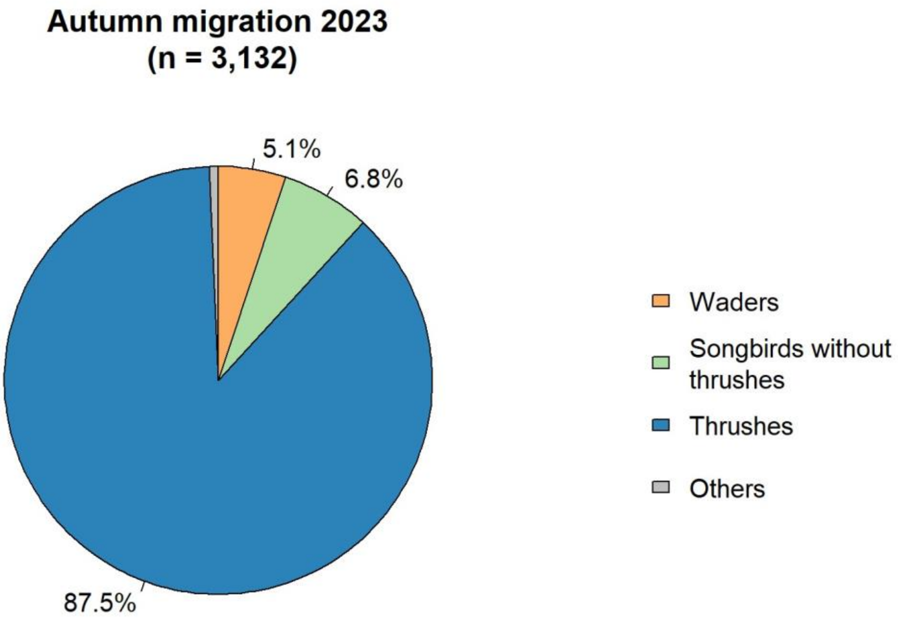


Figure 5-34 Percentage of nocturnal migratory species (based on acoustic observations) in autumn 2023 at the pre-investigation area Hesselø, grouped into high-category taxa. See Figure 5-26 for more details.

A similar number of flight calls (in relation to bird visual observations) was registered during the autumn migration at the pre-investigation area Hesselø. Out of a total of 3,132 bird calls, 3,111 calls (99.4%) could be identified to species level (18 species in total). Most birds heard during the night were songbirds, of which the great majority were thrushes: 87.5% (*Turdus* spp, among which song thrush was the most abundant) and only 6.8% belonged to other songbird species (e.g. robins, etc.). The only other group that was relatively common was waders (5.1%, Figure 5-34).

MIGRATION INTENSITY

No nocturnal flight calls were registered during the first two nights of surveys (4-5.03.2023). Nocturnal calls were heard during the other seven dates at different intensities. Most calls were heard on the night of 23.03.2023 (maximum intensity reached then 30.2 calls/h, Figure 5-35). In March, mean migration intensity was 9 (± 5.6) calls/h whereas in May the mean intensity was just 1.5 ind./h. There were no survey dates during April. Overall, the mean nocturnal migration intensity reached 5.7 ± 3.3 calls/h in spring 2023 (Table 5-5).

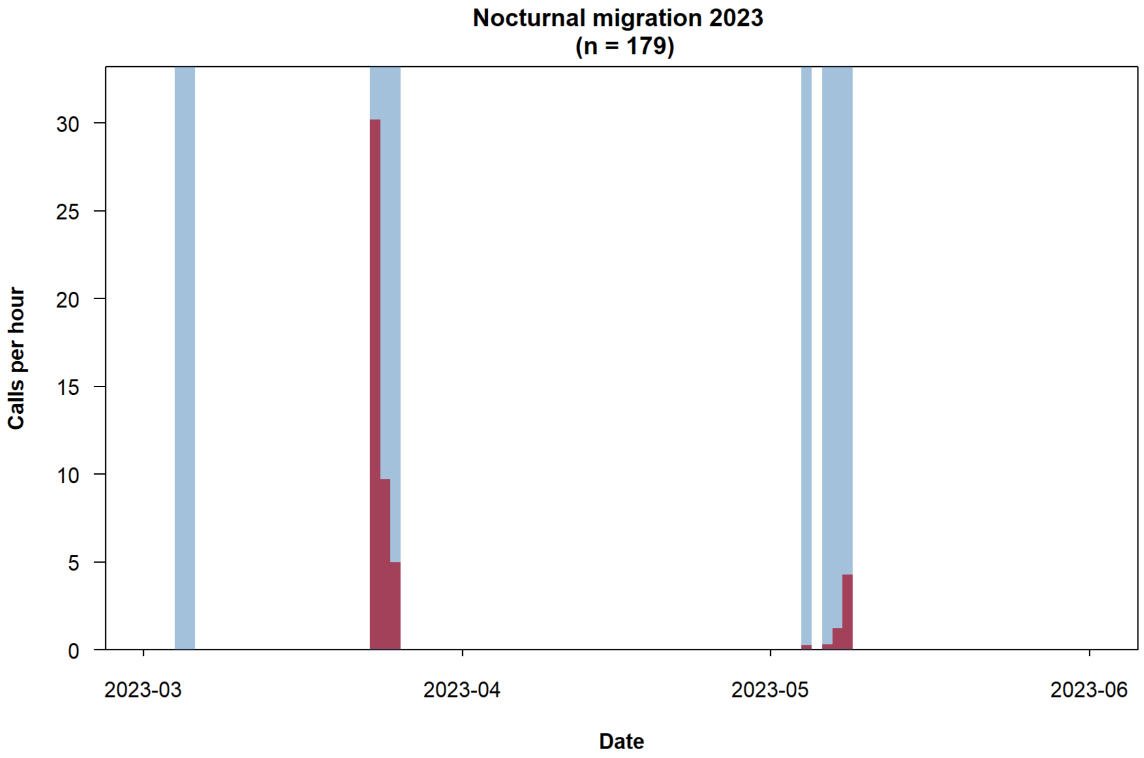


Figure 5-35 Nocturnal migration intensity (red bars) derived from acoustic observations (flight calls) in spring 2023. Light blue shades indicate the dates of the surveys (9 dates).

Table 5-5. Monthly and seasonal migration rates (ind./h) calculated from nocturnal flight calls (acoustic observations) in spring 2023 at the pre-investigation area .

Spring 2023	Migration intensity (calls/h)			Number of calls	Number of survey nights
	Mean (± SE)	Median	Maximum value		
March	9 (± 5.6)	5	30.2	159	5
April	0	0	0	0	0
May	1.5 (± 1)	0.8	4.3	20	4
Spring	**5.7 (± 3.3)**	**1.2**	**30.2**	**179**	**9**

Nocturnal migration intensity was very variable during autumn, with some dates when very low migration intensity was registered, and other nights when many bird calls were heard. The mean nocturnal migration intensity reached 33.2 ± 28 calls/h in autumn 2023, but the median was much lower because of the extreme variation in migration intensity: 1.3 ind./h (Table 5-6). Most calls were heard on the night of 05.10.2023 (maximum intensity reached then 478.3 calls/h, Figure 5-36). Thus, the highest monthly migration intensity was in October (122.5 calls/h). The lowest was in November when only 0.2 calls/h were heard on average (Table 5-6).

Table 5-6. Monthly and seasonal migration rates (calls/h) calculated from nocturnal flight calls (acoustic observations) in autumn 2023 at the pre-investigation area.

Autumn 2023	Migration intensity (calls/h)			Number of calls	Number of survey nights
	Mean (± SE)	Median	Maximum value		
August	15.5 (± 13.3)	3.2	55.2	248	4
September	2.2 (± 0.7)	1.7	4.6	52	5
October	122.5 (± 118.6)	5.8	478.3	2,826	4
November	0.2 (± 0.1)	0.1	0.4	6	4
Autumn	**33.2 (± 28)**	**1.3**	**478.3**	**3,132**	**17**

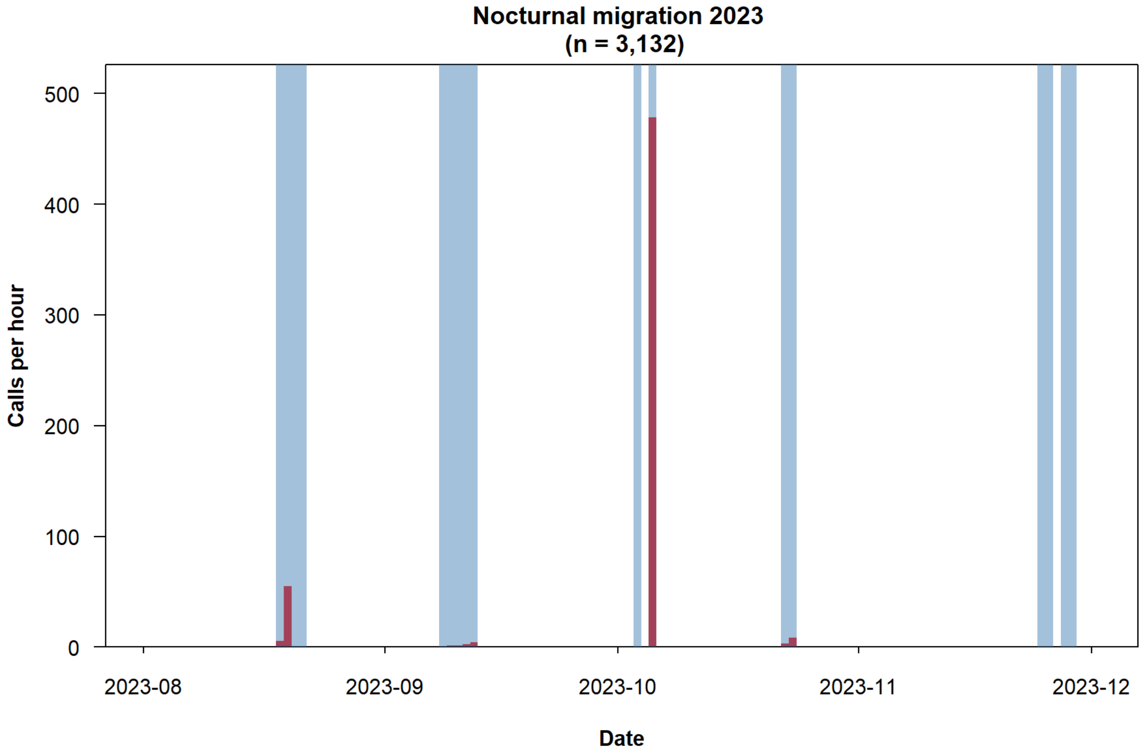


Figure 5-36 Nocturnal migration intensity (red bars) derived from acoustic observations (flight calls) in autumn 2023. Light blue shades indicate the dates of the surveys (17 dates).

NOCTURNAL PHENOLOGY

During spring migration, highest call intensities were recorded late in the night (from the 8th hour after evening civil twilight onwards, 71.7% of all migration was recorded in these last 5 standardised hours). The overall highest migration intensity occurred at 11 hours after civil evening twilight (Figure 5-37).

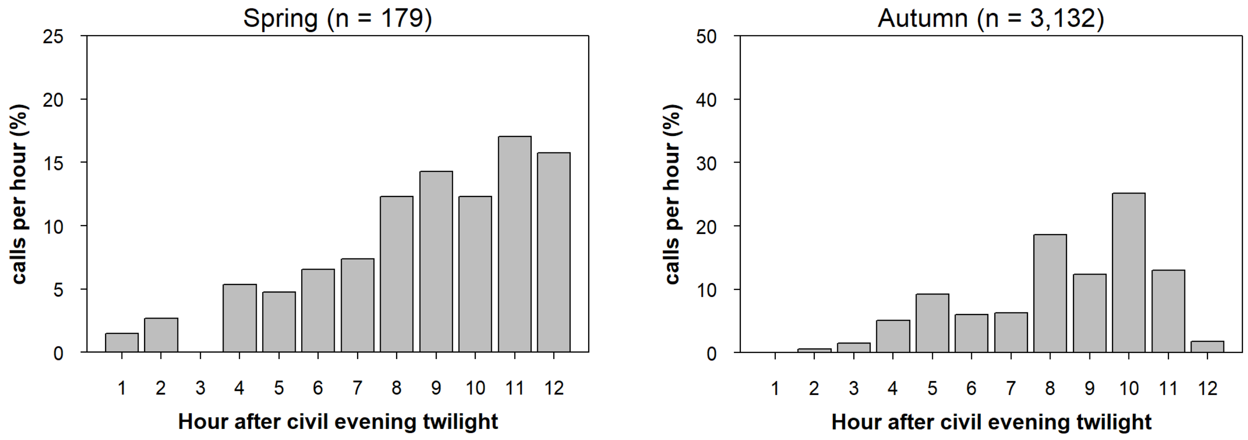


Figure 5-37 Nocturnal phenology of all observed birds in spring (left) and autumn (right) 2023. See Figure 5-32 for details.

During autumn migration, call intensities increased along the night with the highest migration intensities recorded at about 10 hours (standardized hours) after civil evening twilight. In general, 77.4% of all migration was recorded in the last six standardized hours after civil evening twilight (Figure 5-37).

RELEVANT SPECIES GROUPS

In the following section, the migration patterns of the most relevant species groups encountered in spring and autumn at the respective anchor positions are further described. Summaries of migration intensities obtained from visual observations is provided in Table 5-7 whereas information on migration intensity obtained from nocturnal flight calls is provided in Table 5-8.

Table 5-7 Main migration patterns for the species groups found in spring and autumn 2023 during visual observations at the pre-investigation area. Number of individuals and identified species in each group are also indicated together with the mean, maximum and peak date of migration intensity (ind./h. Underlined are those species groups that were more common (higher numbers) and whose patterns are described in this chapter.

Species groups	Number of ind. (spp.)		Migration intensity spring (ind./h)			Migration intensity autumn (ind./h)		
	Spring	Autumn	Mean	Maximum	Peak date	Mean	Maximum	Peak date
Divers	59 (3)	24 (1)	0.63	1.83	04.03.2023	0.28	1.68	06.10.2023
Grebes	4 (1)	0	0.04	0.39	18.04.2023			
Tubenoses	0	3 (1)				0.03	0.33	03.10.2023
Gannets	27 (1)	124 (1)	0.28	0.8	24.03.2023	1.28	4.27	25.11.2023
Cormorants	180 (1)	68 (1)	2.02	12.5	06.03.2023	0.74	2.93	26.11.2023
Herons	1 (1)	5 (1)	0.01	0.14	25.03.2023	0.06	0.53	27.11.2023
Swans	28 (2)	109 (1)	0.31	1.5	06.03.2023	1.61	23.73	25.11.2023

Geese	6,568 (4)	440 (4)	59.45	752.38	09.05.2023	4.66	66.1	24.10.2023
Ducks	1,210 (7)	1,566 (10)	12.58	29	14.04.2023	15.42	70.83	03.10.2023
Birds of prey	14 (5)	4 (3)	0.13	0.75	09.05.2023	0.03	0.29	13.09.2023
Cranes	56 (1)	0	0.66	6.5	06.03.2023			
Waders	131 (3)	52 (7)	1.25	9.66	15.04.2023	0.42	2.4	19.08.2023, 03.10.2023
Skuas	2 (2)	5 (2)	0.02	0.16		0.05	0.27	21.08.2023, 25.11.2023
Gulls	209 (6)	253 (6)	2.02	6.88	09.05.2023	2.36	7.45	20.08.2023, 23.10.2023
Terns	37 (2)	4 (2)	0.33	3.12	09.05.2023	0.03	0.41	20.08.2023
Auks	87 (4)	198 (4)	1	4.33	04.03.2023	2.66	19.47	25.11.2023
Pigeons	1 (1)	1 (1)	0.01	0.14	16.04.2023	0.01	0.13	19.08.2023
Swifts	3 (1)	1 (1)	0.03	0.24	08.05.2023	0.01	0.13	19.08.2023
Songbirds	560 (23)	248 (29)	5.52	21.86	14.04.2023, 18.04.2023	2.24	17.67	03.10.2023

Table 5-8 Main migration patterns for the most relevant species groups found in spring and autumn 2023 during nocturnal acoustic observations.

Species groups	Number of calls (spp.)		Migration intensity spring (calls/h)			Migration intensity autumn (calls/h)		
	Spring	Autumn	Mean	Maximum	Peak date	Mean	Maximum	Peak date
Herons	0	1 (1)				0.01	0.21	12.09.2023
Geese	12 (1)	0	0.41	3.69	08.05.2023			
Waders	6 (2)	159 (6)	0.15	0.92	07.05.2023	2.29	35	19.08.2023
Gulls	3 (1)	20 (2)	0.07	0.38	24.03.2023	0.27	3	18.08.2023
Songbirds without thrushes	69 (7)	212 (4)	2.38	17.1	23.03.2023	2.6	20	19.08.2023
Thrushes	89 (3)	2,740 (5)	2.59	13.1	23.03.2023	28	467.83	05.10.2023

GANNETS

In spring, only 27 gannets (northern gannet, *Morus bassanus*) were seen, and these represented only 0.3% of all birds in the season. They were not present in May and their migration intensity was very low reaching a maximum of 0.8 ind./h on the 24th of March 2023 (Figure 5-38). Thus, gannets were not a common group in this season.

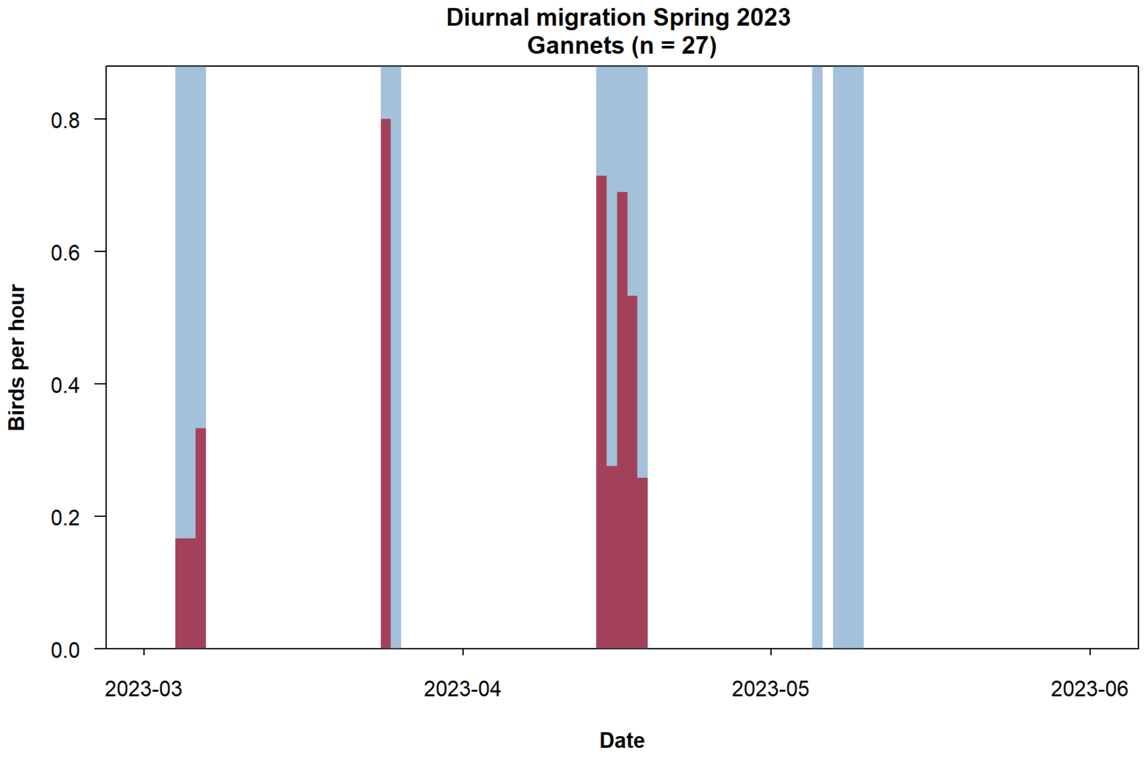


Figure 5-38 Diurnal migration intensity of gannets (northern gannet) in spring 2023. See Figure 5-28 for details.

However, this species made up 4% of all diurnally migrating birds in the area in autumn and are therefore included in this section. They were frequently observed after September and their migration intensity varied between < 0.3 to 4.3 ind./h (Figure 5-39).

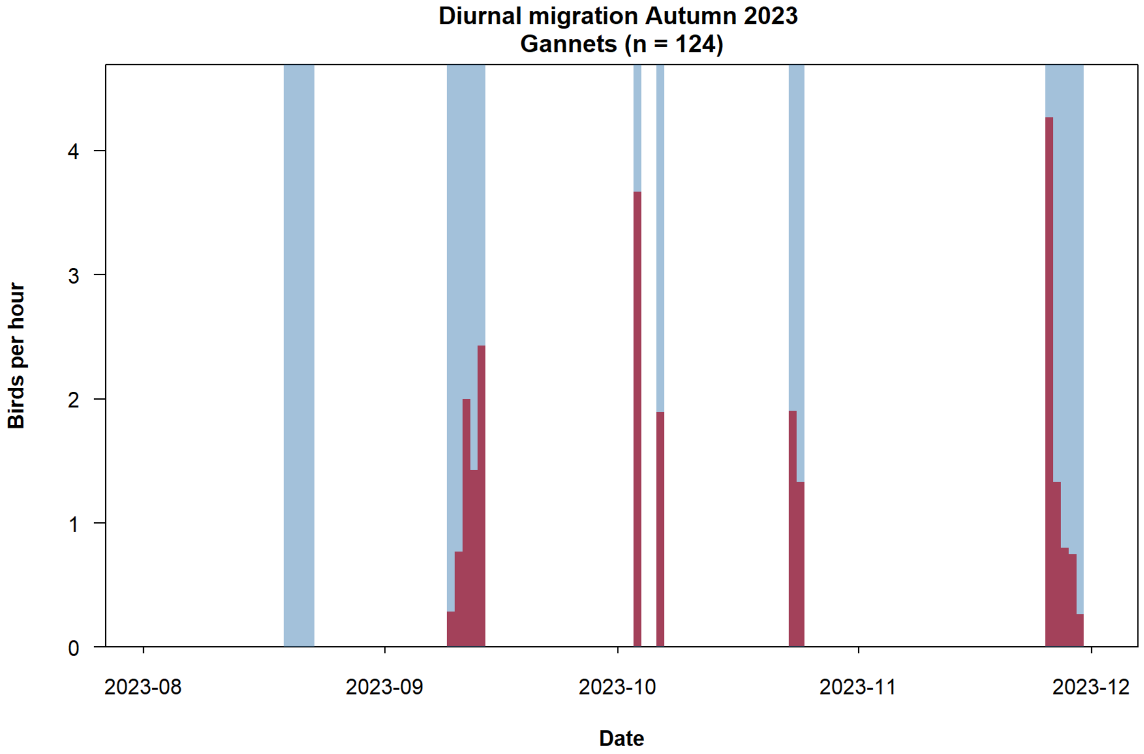


Figure 5-39 Diurnal migration intensity of gannets (northern gannet) in autumn 2023 at the pre-investigation area. See Figure 5-29 for details.

They flew commonly at altitudes ranging between sea level and up to 50 m. Only about 5% flew above 50 m of altitude (in autumn, Figure 5-40).

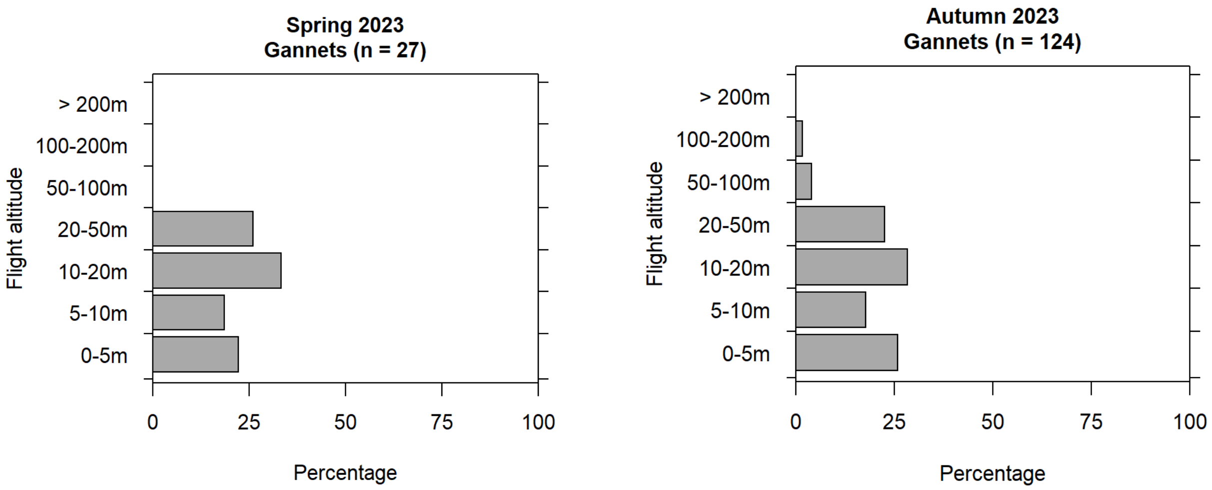


Figure 5-40 Flight altitude distribution of gannets during visual observations in spring (left) autumn (right) 2023. See Figure 5-30 for details.

They flew at different directions with the most common directions being the N and NW (in spring and autumn), indicating that not only migrating birds were observed but also birds moving between different feeding areas. Nonetheless, a large number of birds flew to the W in spring, and to the S, SE and SW in autumn (Figure 5-41).

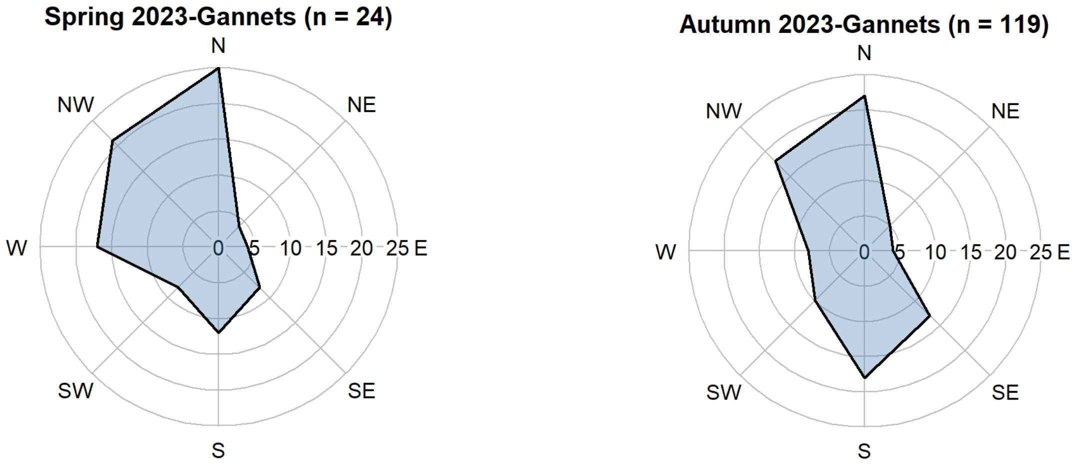


Figure 5-41 Flight direction of gannets during visual observations in spring (left) and autumn (right) 2023. See Figure 5-31 for details.

They were observed at all hours during the day. No temporal pattern could be derived from the data obtained. There was just a small peak at 3-4 hours, or two hours after civil morning twilight (for spring and autumn, respectively), but they were equally common at other times during the day (especially in autumn, Figure 5-42).

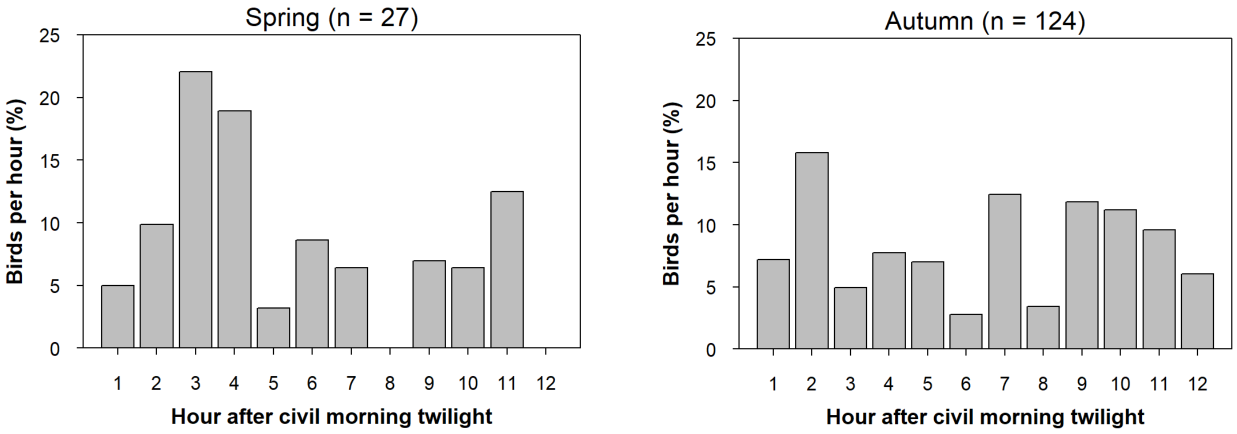


Figure 5-42 Diurnal phenology of gannets in spring (left) and autumn (right) 2023. See Figure 5-32 for details.

CORMORANTS

Cormorants, represented by only one species, the great cormorant (*Phalacrocorax carbo*) were frequently observed. With a total of 180 individuals registered, they made up 2.0% of the total number of birds observed during the surveys in spring. The daily maximum migration intensity (12.5 birds/h) was registered on the March 6th of 2023. The migration intensity decreased the rest of the season (see Figure 5-43).

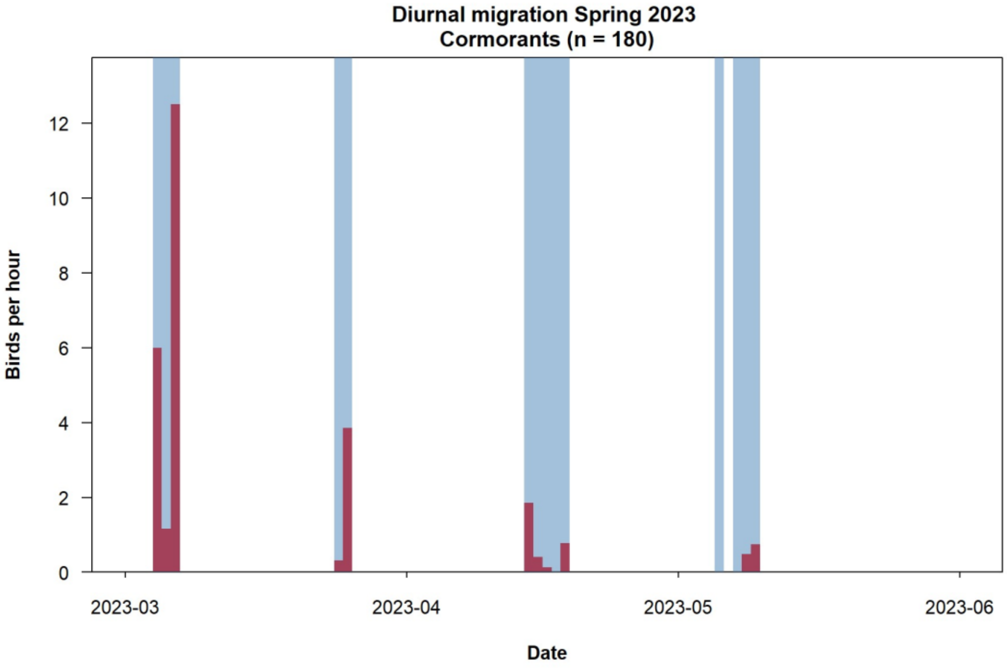


Figure 5-43 Diurnal migration intensity of cormorants (Great Cormorants) in spring 2023 at the pre-investigation area. See Figure 5-28 for details.

In autumn, cormorants were frequently observed but not at very large numbers. A total of 68 individuals were observed and they made up 2.2% of the total number of birds observed during autumn. The maximum migration intensity (2.93 birds/h) was registered on the November, 26th of.2023. Migration intensity tended to increase towards late in the migration period (see Figure 5-44).

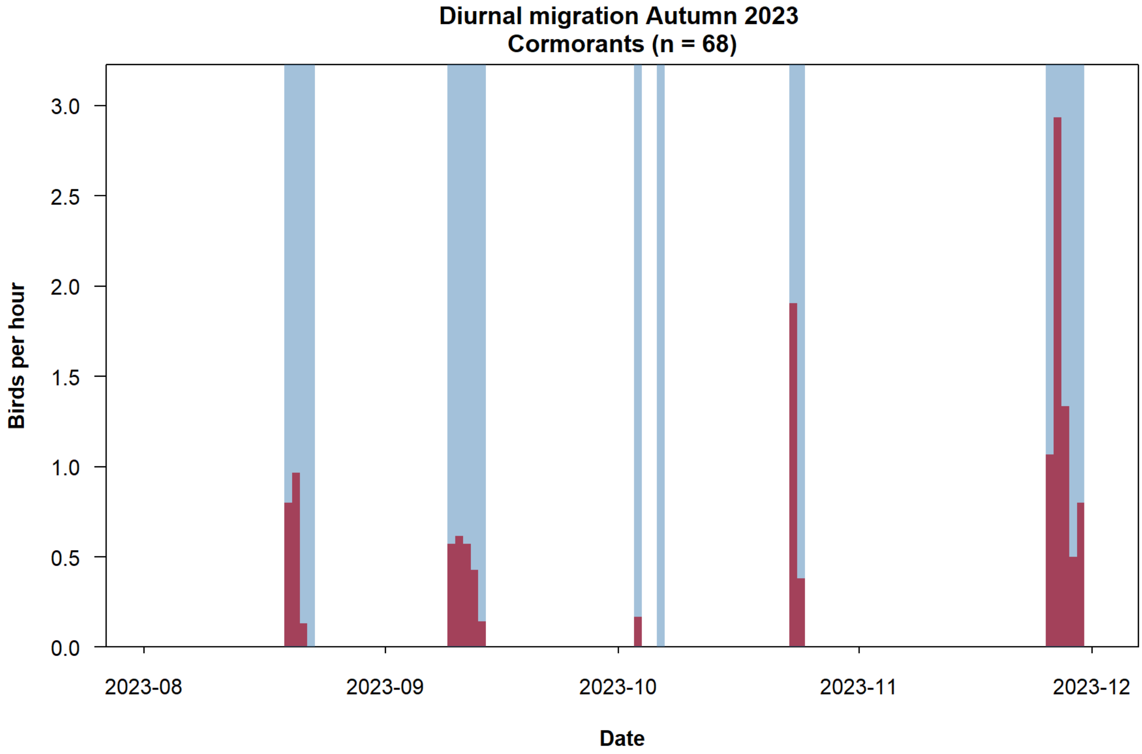


Figure 5-44 Diurnal migration intensity of cormorants (Great Cormorants) in autumn 2023 at the pre-investigation area. See Figure 5-29 for details.

In spring, about 38% of all individuals flew between 20 – 50 m, about 52% flew below 20 m of altitude. Only 10% flew between 50 – 100 m (Figure 5-45). In autumn, about 43% of all individuals flew at very low altitudes (0.5 m), most flew below 20 m of altitude, and a third of all individuals at altitudes between 20 and 50 m. Less than 1.5% flew at higher altitudes (Figure 5-45).

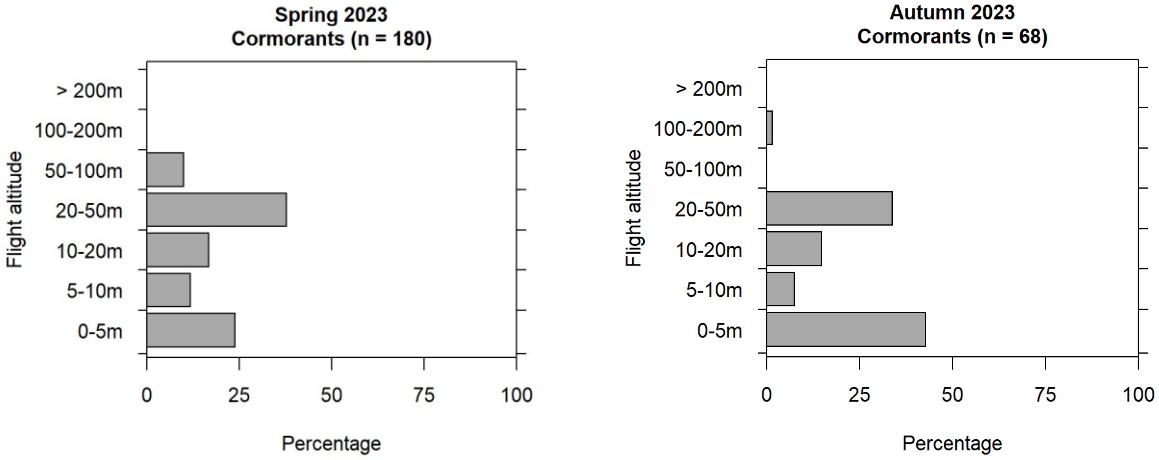


Figure 5-45 Flight altitude distribution of cormorants during visual observations in spring (left) and autumn (right) 2023. See Figure 5-30 for details.

In spring, most individuals were observed flying in a NE and N direction (Figure 5-46) whereas in autumn, the majority were observed flying in a S and NW direction (Figure 5-46).

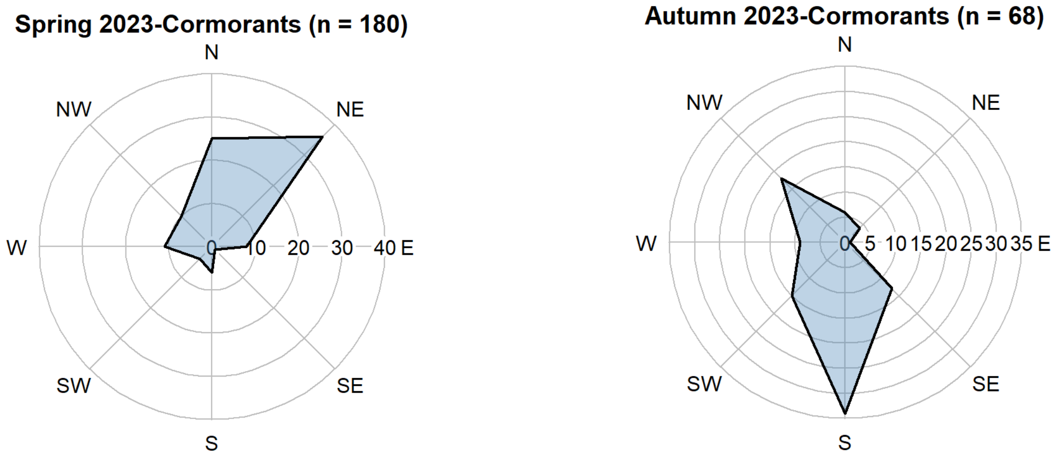


Figure 5-46 Flight directions of cormorants during visual observations in spring (left) and autumn (right) 2023. See Figure 5-31 for details.

In spring, most cormorants were observed flying early in the morning, especially during the first hour after civil morning twilight (50%, Figure 5-47). In autumn, cormorants were seen flying at all hours during the day, except just after civil morning twilight and before civil evening twilight. Almost 25% of all individuals were observed flying at 7 hours after civil morning twilight (Figure 5-47).

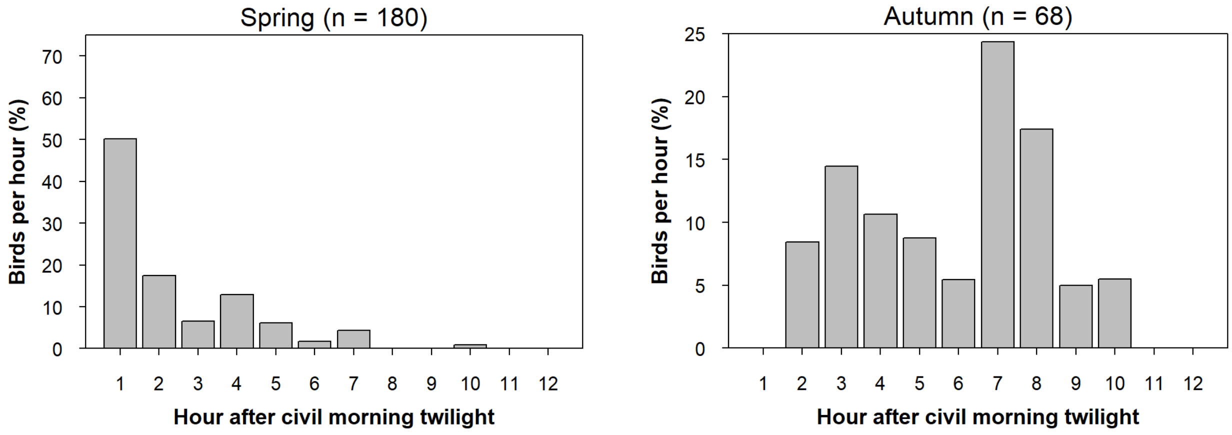


Figure 5-47 Diurnal phenology of cormorants in spring (left) and autumn (right) 2023 at the pre-investigation area . See Figure 5-32 for details.

SWANS

Swans were neither abundant nor frequent. In spring, there were only 28 individuals, two were mute swans and 9 whooper swans, the rest were unidentified swans. In general, in spring, swans were not a common group. They only represented 0.3% of all diurnally migrating birds. Most were observed in March with a maximum intensity of 1.5 ind./h on the 6th of March 2023 (Figure 5-48).

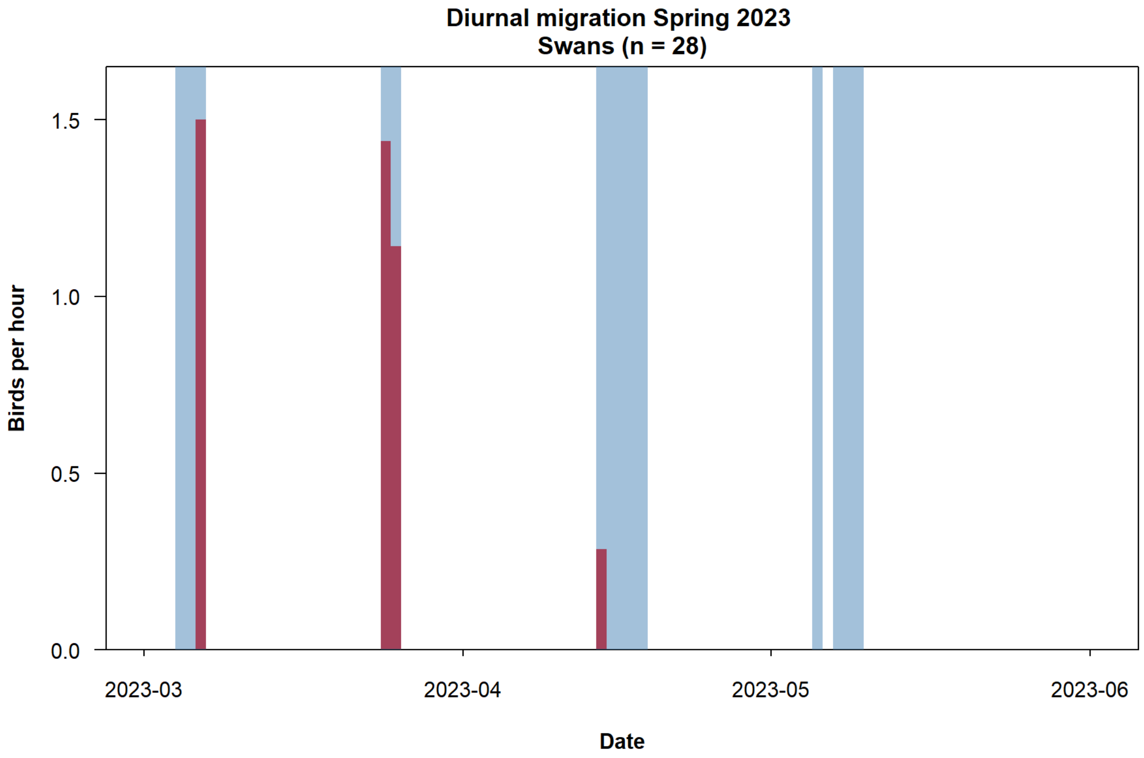


Figure 5-48 Diurnal migration intensity of swans in spring 2023. See Figure 5-28 for details.

In autumn, all swans observed belonged to a single species (whooper swan, *Cygnus cygnus*), and in this season swans made up 3.5% of all diurnally migrating birds. They were observed only on three dates in the last survey period of November, with a peak of migration on November 25th 2023 (23.7 ind./h, Figure 5-49).

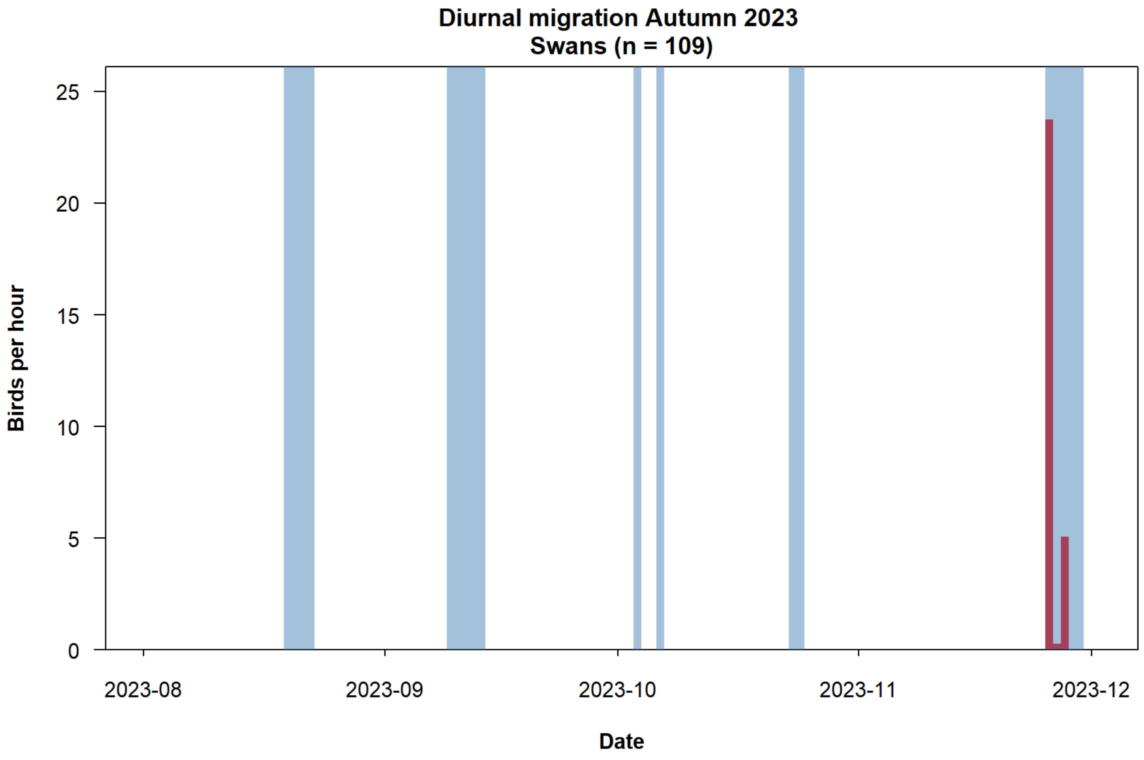


Figure 5-49 Diurnal migration intensity of swans in autumn 2023. See Figure 5-29 for details.

In spring, most swans flew at low altitudes (< 10 m), but > 25% flew between 20 and 50 m of altitude (Figure 5-50). In autumn, many individuals were observed flying at altitudes between 20 and 50 m, but they were also observed at lower altitudes and at higher altitudes (100-200 m, Figure 5-50).

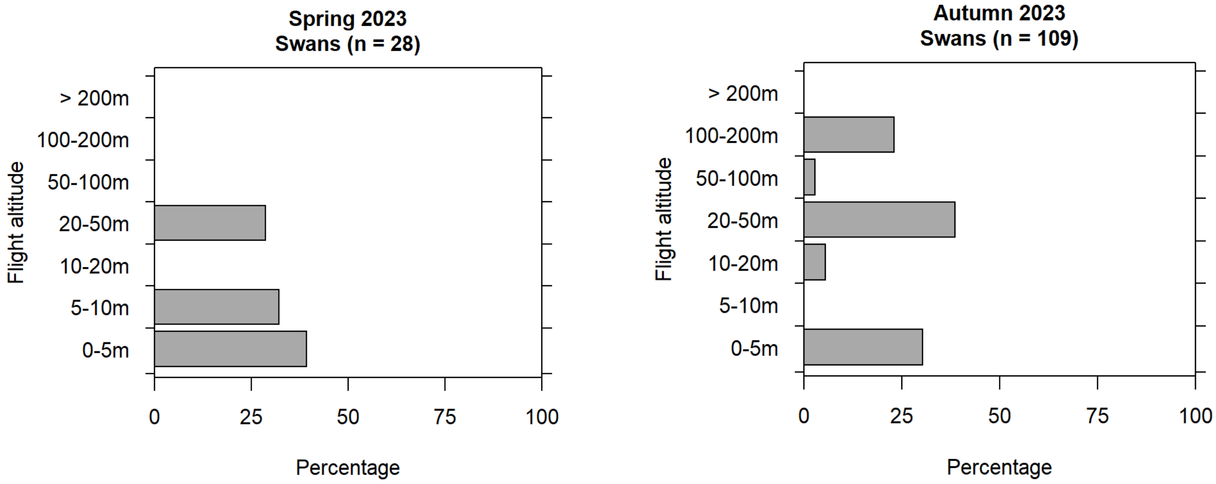


Figure 5-50 Flight altitude distribution of swans during visual observations in spring (left) and autumn (right) 2023. See Figure 5-30 for details.

In spring, they flew to the NW, NE and N, more or less at similar proportions (Figure 5-51). In autumn, they flew in a SW, W, S and to a lesser extent SE direction (Figure 5-51).

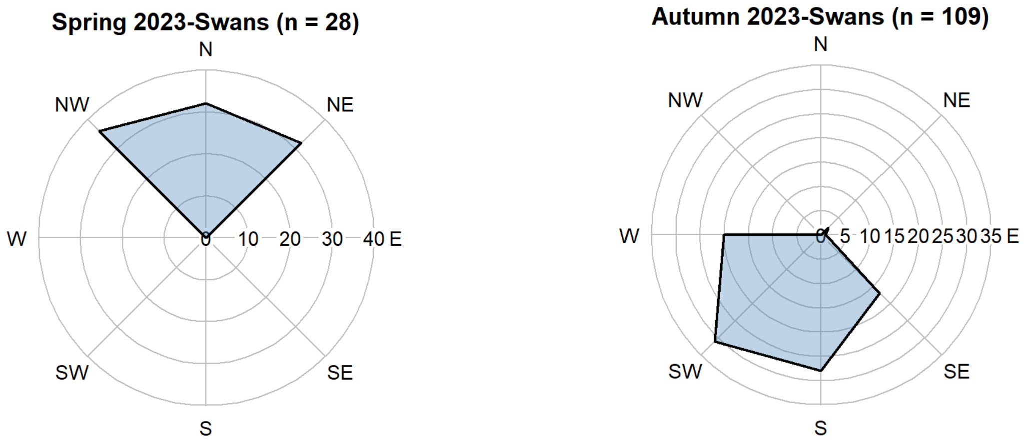


Figure 5-51 Flight direction of swans during visual observations in spring (left) and autumn (right) 2023. See Figure 5-31 for details.

In spring, there were too few individuals to detect a temporal pattern of flight. Nonetheless, they were mainly observed flying in the third hour after civil morning twilight (Figure 5-52). In autumn, swans were observed flying all day long, except not very close to the sunset or to the sunrise. Most of them (30%) flew at 11 hours after morning civil twilight (Figure 5-52).

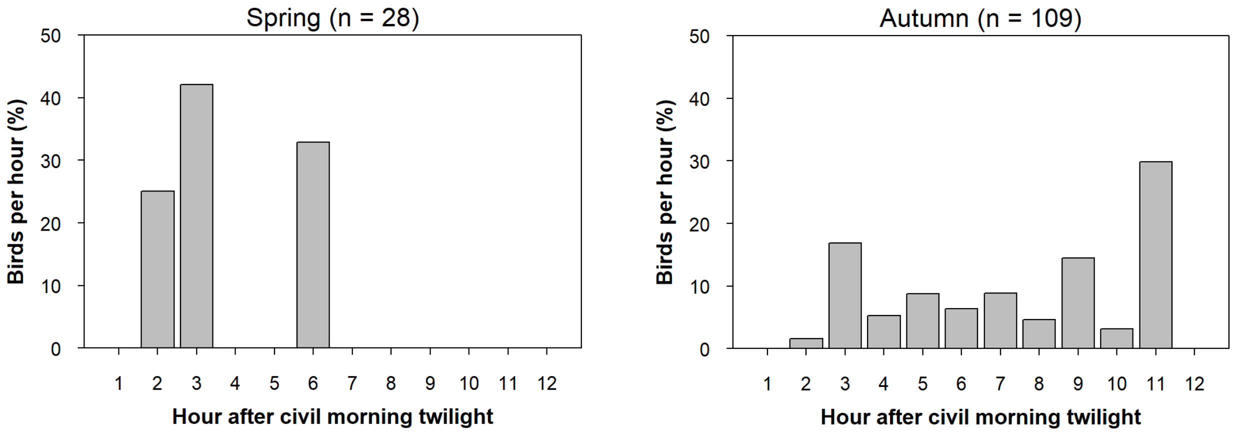


Figure 5-52 Diurnal phenology of swans in spring (left) and autumn (right) 2023. See Figure 5-32 for details.

GEESE

Geese were by far the most abundant taxonomic group observed during diurnal migrations in spring (71.6%). A total of four species were identified but only one was very abundant (barnacle goose, followed by greylag goose, Brent goose and bean goose). Most of the birds were observed on the last day of the surveys (9th of May 2023, during diurnal migrations, Figure 5-53) and the night of May, 8th of 2023 (nocturnal migration, Figure 5-54). The maximum migration intensity of geese was 752.4 birds/h during days and 3.7 calls/h during nights.

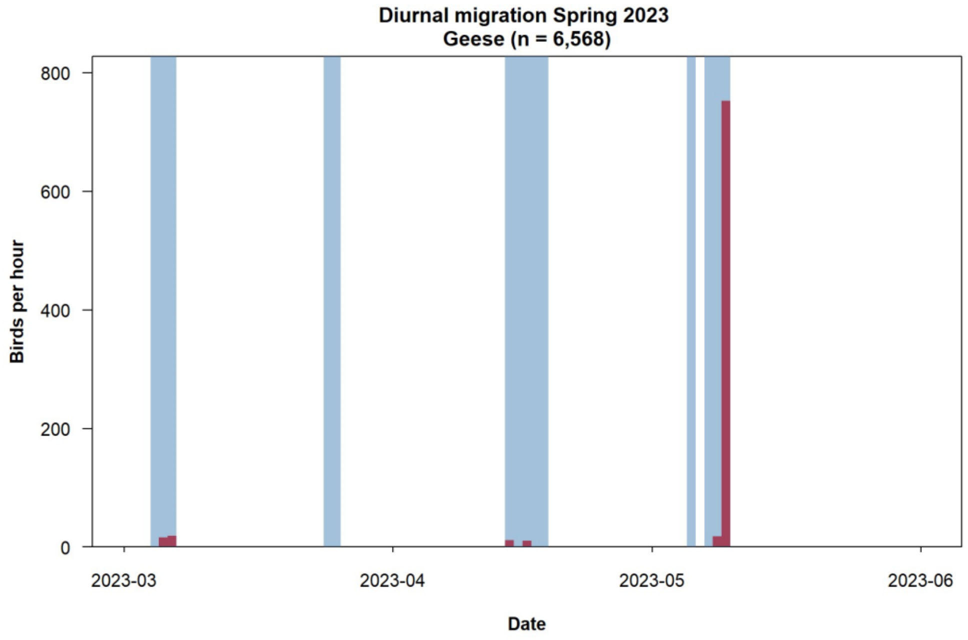


Figure 5-53 Diurnal migration intensity of geese in spring 2023 at the pre-investigation area . See Figure 5-28 for details.

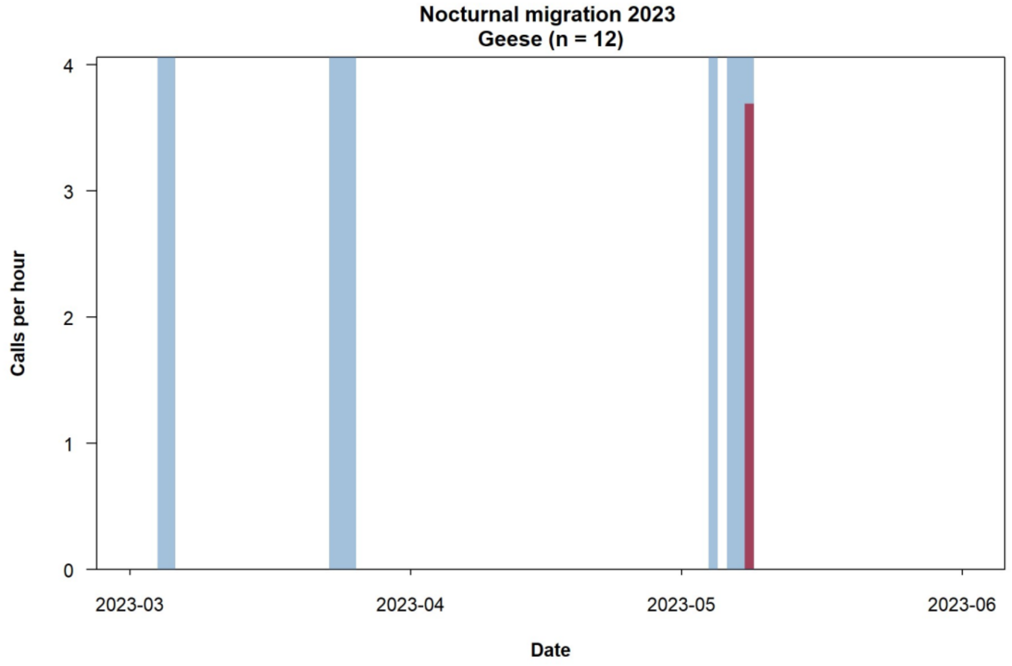


Figure 5-54 Nocturnal migration intensity of geese in spring 2023 at the pre-investigation area Kattegat. See Figure 5-35 for details.

Several species of geese were observed during autumn 2023 and they altogether made up 14.6% of all migrating birds, thus the second most abundant group after ducks in this season. Of all the species registered, the most abundant one was the barnacle goose (11.6%). Geese were observed in the area from September onwards at medium intensities. However, on the 24th of October 2023, there was a peak migration event, in particular of barnacle goose (Figure 5-55). The maximum migration intensity of geese was 66.1 birds/h whereas the mean migration intensity of the group as a whole was 4.7 ind./h.

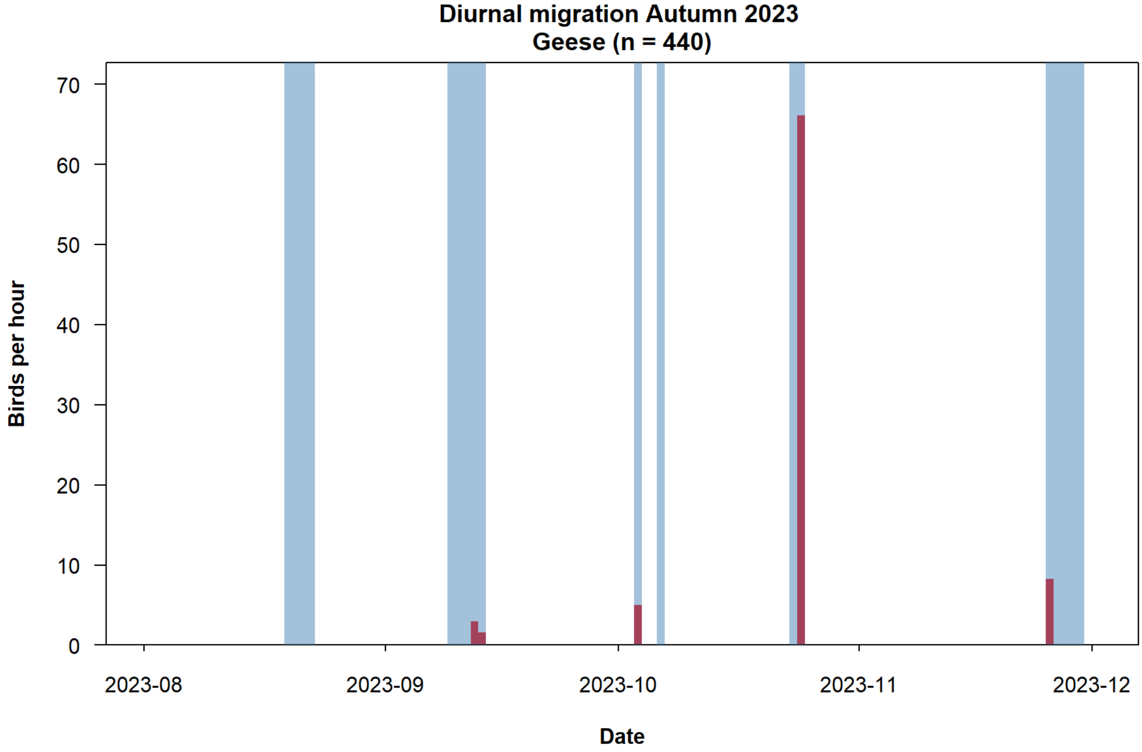


Figure 5-55 Diurnal migration intensity of geese in in autumn 2023 at the pre-investigation area . See Figure 5-29 for details.

In spring, a large proportion of the geese (46%) were observed flying at low altitudes (< 5m), roughly 5% of all individuals were observed flying at altitudes between 5-20 m whereas 42% of the birds flew at altitudes between 20-200m (Figure 5-56). In autumn, most geese (72.5%) were observed flying at high altitudes (50-200 m), and comparatively fewer flew below this range (Figure 5-56).

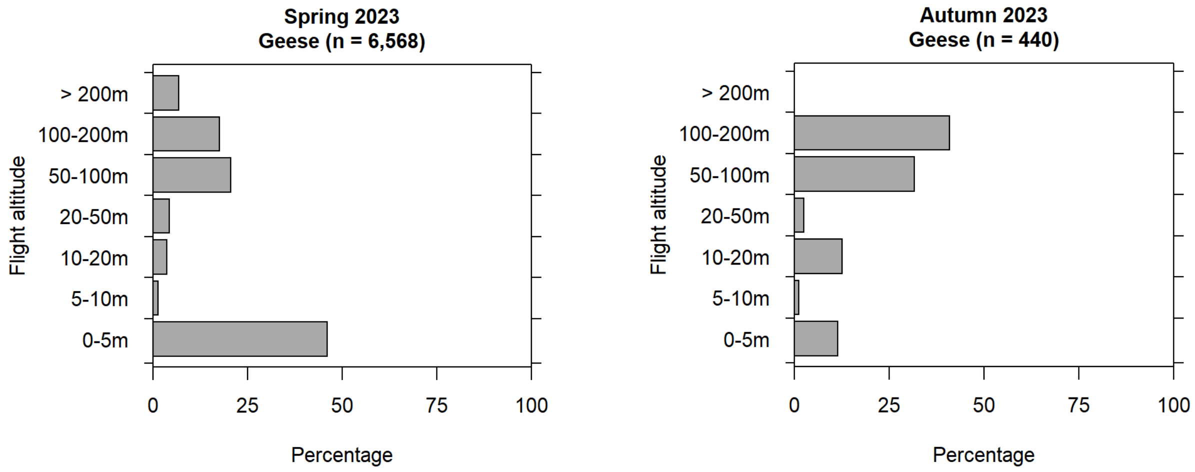


Figure 5-56 Flight altitude distribution of geese during visual observations in spring (left) and autumn (right) 2023 at the pre-investigation area . See Figure 5-30 for details.

The great majority was flying with a clear NE direction in spring (Figure 5-57) whereas in autumn they flew mainly to the west (Figure 5-57).

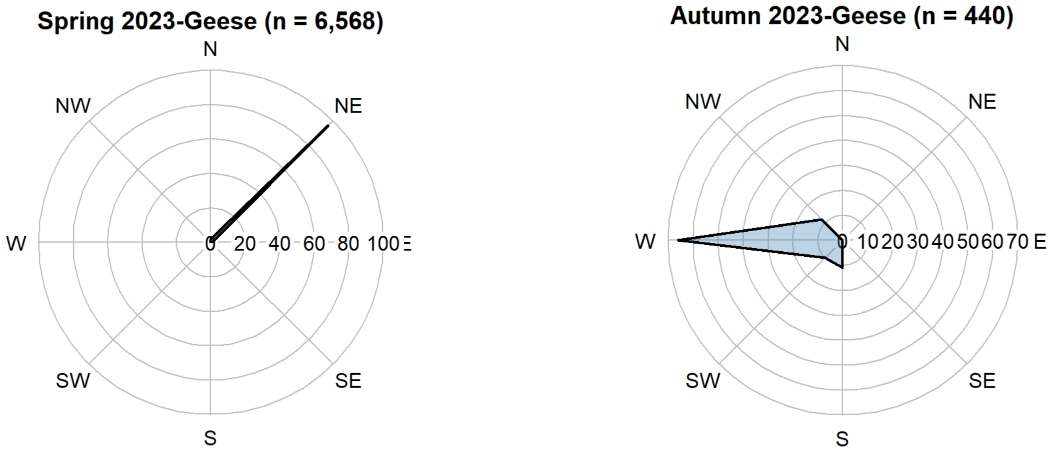


Figure 5-57 Flight directions of geese during visual observations in spring (left) and autumn (right) 2023 at the pre-investigation area . See Figure 5-31 for details.

Geese were observed in large numbers and the majority of the birds migrated three hours after civil morning twilight in spring (this corresponded mostly to migration of barnacle geese, Figure 5-58). In autumn, geese like swans flew more often at the middle of the day and not at the very first hours or last hours of the day. A great number of the geese were observed flying at 4 hours after civil morning twilight and these were mainly barnacle geese (Figure 5-58).

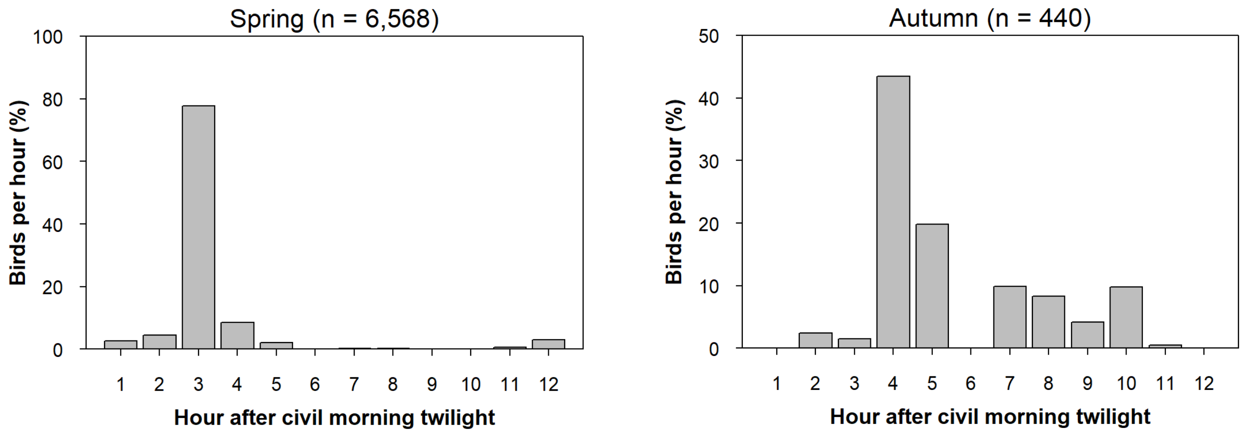


Figure 5-58 Diurnal phenology of geese in spring (left) and autumn (right) at the pre-investigation area . See Figure 5-32 for details.

DUCKS

A total of 1,210 ducks were observed during spring migration, most of them were sea ducks and the majority were common scoters which comprised 10.7% of all migrating birds observed in the season. Other species that occurred at much lower frequencies were common eiders (0.92%), velvet scoters (0.54%) and long-tailed ducks (0.39%). Ducks were observed frequently during all surveys, but their highest migration rates were in April (on the 14th of April, 29 birds/h). In May, their migration intensity decreased (an average of 1.93 birds/h, in comparison to a mean of 15.05 birds/h in March and 18.62 in April (Figure 5-59).

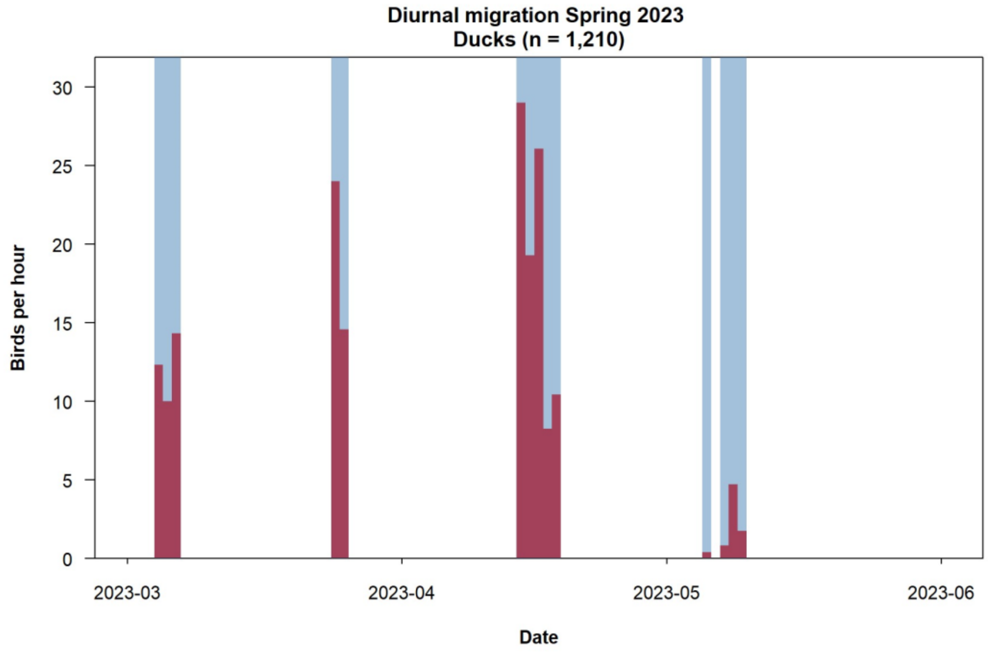


Figure 5-59 Diurnal migration intensity of ducks in spring 2023 at the pre-investigation area. See Figure 5-28 for details.

In autumn, 1,566 ducks belonging to 10 species were observed. Most of them were sea ducks and the majority were common scoters (28.6%), Eurasian wigeons (10.9%), common eiders (2.5%) and velvet scoters (2.4%). Only three individuals of long-tailed ducks were observed. Ducks were observed frequently during all surveys, at all survey dates but their highest migration rate occurred on October 3rd (70.8 ind./h). Migration intensity was also larger at the middle of the season and decreased in November (Figure 5-60).

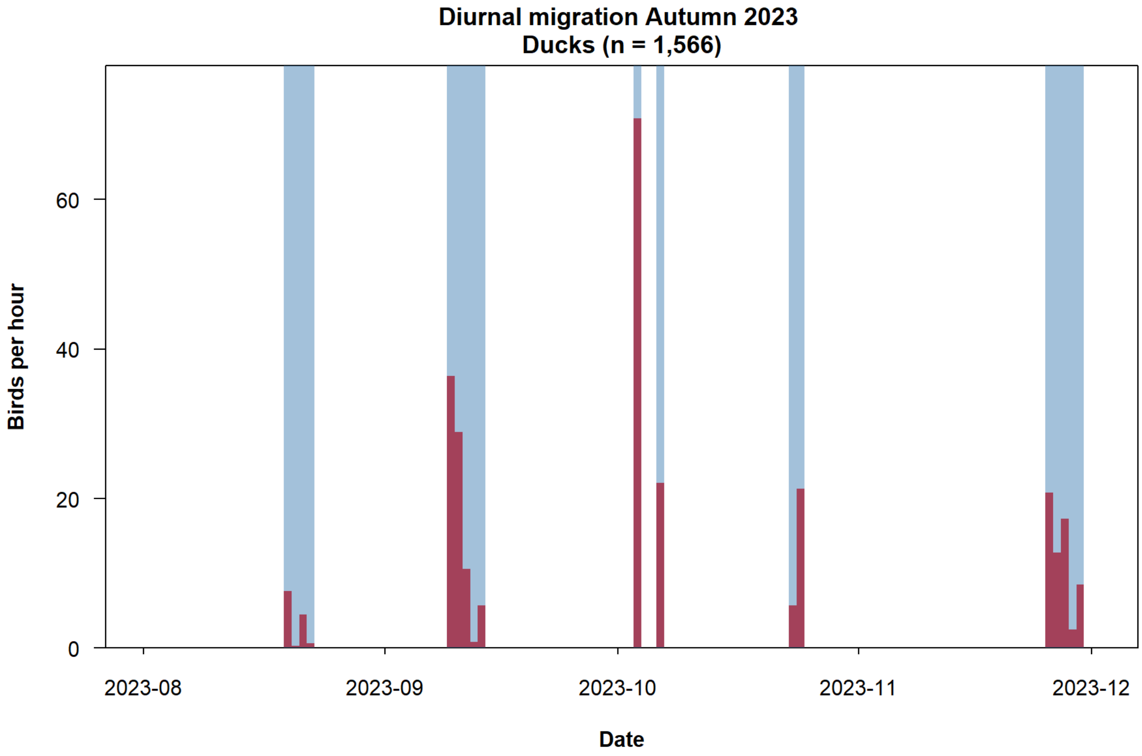


Figure 5-60 Diurnal migration intensity of ducks in autumn 2023 at the pre-investigation area. See Figure 5-29 for details.

Ducks flew at low altitudes. Most of them flew at altitudes up to 5 m (69.2% in spring and 56.1% in autumn) whereas > 90% of all ducks were observed flying up to 20 m height (Figure 5-61). Only few of them were observed at higher altitudes (> 50 m).

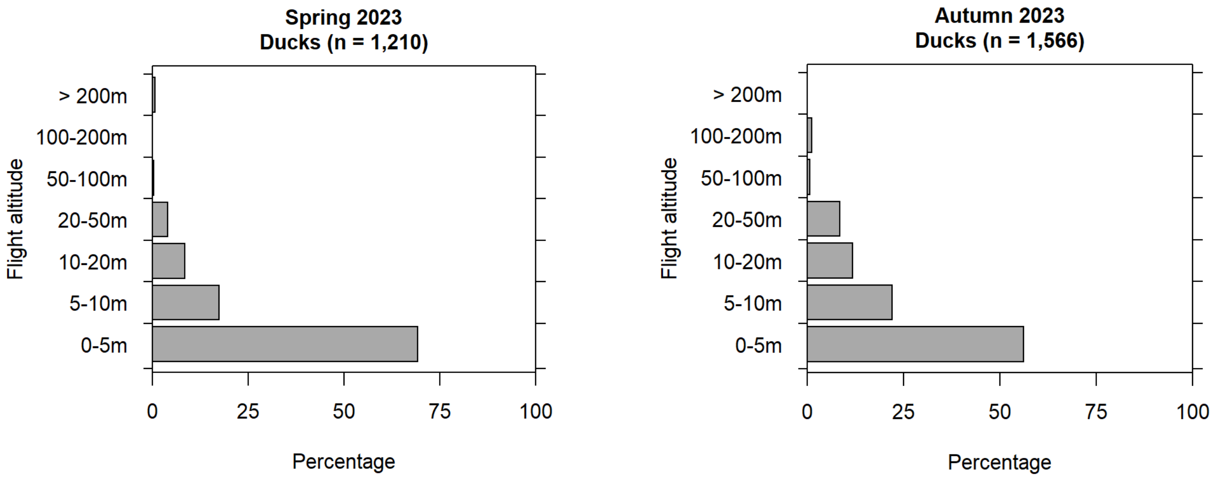


Figure 5-61 Flight altitude distribution of ducks during visual observations in spring (left) and autumn (right) 2023. See Figure 5-30 for details.

In spring, ducks flew in different directions (depending on the species, but also the date). However most, flew in SE, S, E direction (Figure 5-62). In autumn, they flew mainly at a SW direction with some individuals flying also to the NW (Figure 5-62).

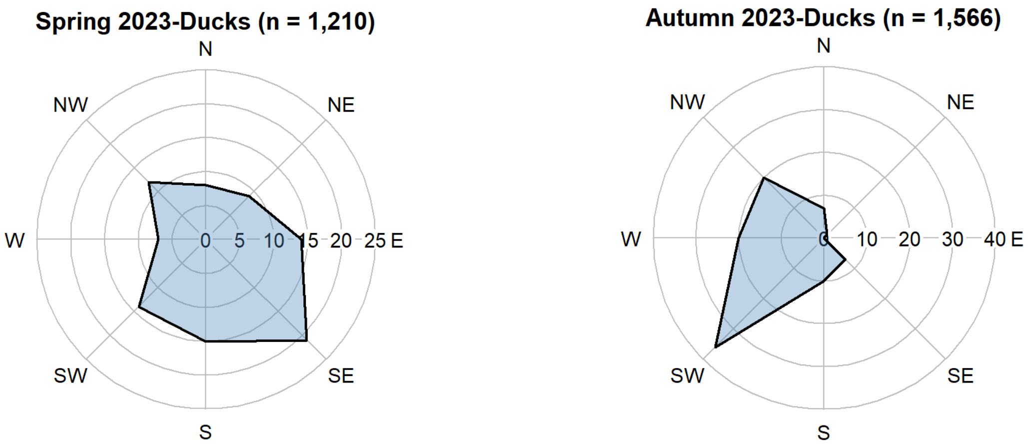


Figure 5-62 Flight direction of ducks during visual observations in spring (left) and autumn (right) 2023. See Figure 5-31 for details.

Ducks flew during all hours of the day, but in larger numbers during the first three hours of the morning, both in spring and autumn with fewer ducks being observed later in the day (Figure 5-63).

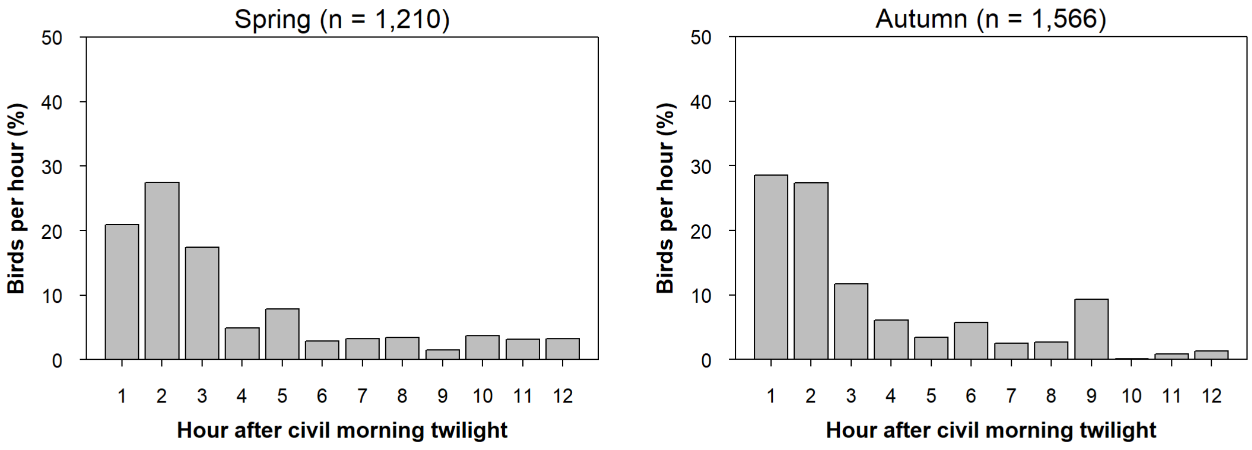


Figure 5-63 Diurnal phenology of ducks in spring (left) and autumn (right) 2023. See Figure 5-32 for details.

WADERS

Waders were neither abundant nor frequent but represented 1.4% of all migrating birds during diurnal observations in spring. Waders were mainly represented by Eurasian curlew (98% of all observed waders belonged to this species). They were observed during three dates, but mainly in April and on the 15th of April when the migration intensity reached 9.7 birds/h (Figure 5-64).

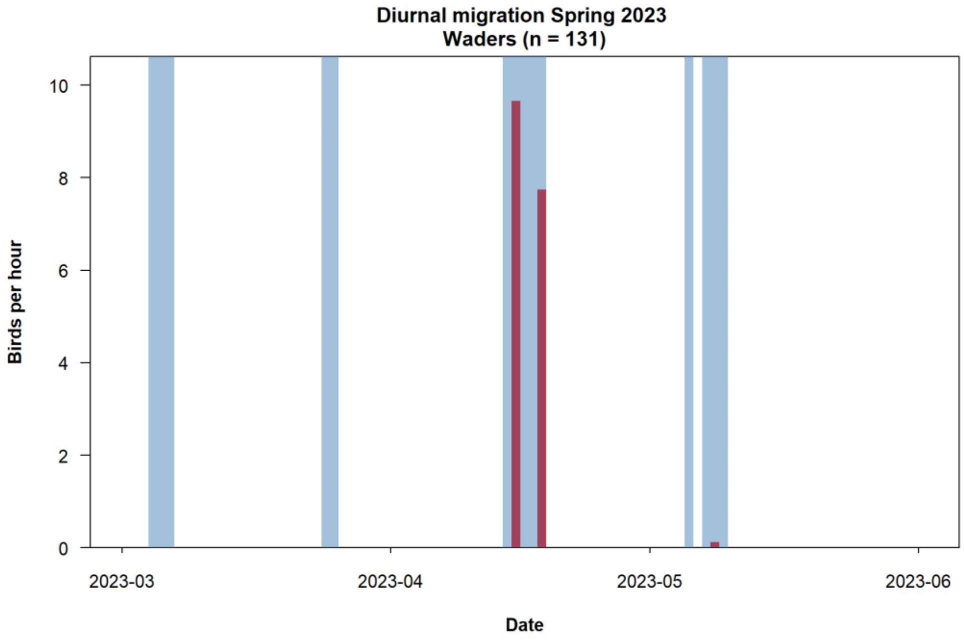


Figure 5-64 Diurnal migration intensity of waders in spring 2023 at the pre-investigation area. See Figure 5-28 for details.

In autumn, they made up for 1.7% of all migrating birds during diurnal observations. A total of seven species of waders were observed, all at relatively small numbers. The most common ones were the ringed plover (0.5%), followed by the golden plover, the red knot and the dunlin. They were observed during the first half of the migration season. The last observation of waders took place on the 3rd of October. In general, they were observed at low migration intensities (varying from 0.1 to 2.4 ind./h, Figure 5-65).

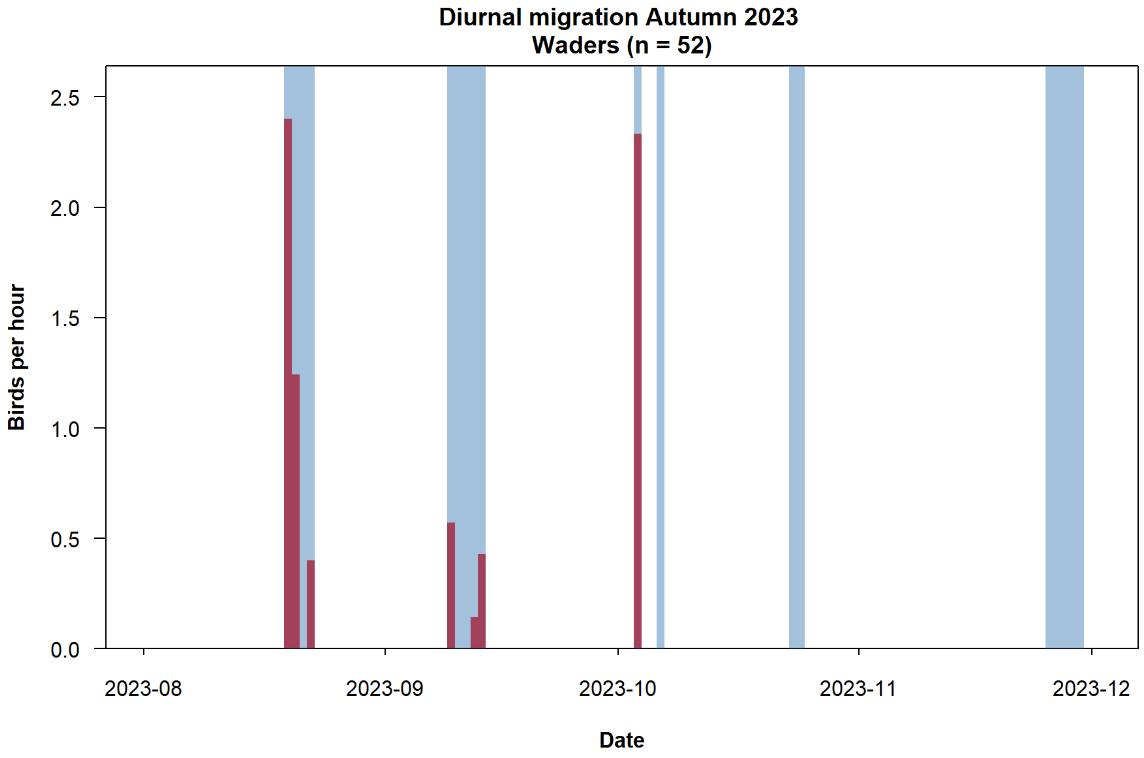


Figure 5-65 Diurnal migration intensity of waders in autumn 2023 at the pre-investigation area. See Figure 5-29 for details.

During nocturnal migration in spring very few calls were heard (all in May) and most of them on May 7th 2023 (0.9 calls/h, Figure 5-66).

In autumn, however, waders were the only taxonomic group after songbirds that occurred at relatively high numbers at night (see Figure 5-34). A total of 159 calls belonging to six species were heard during night migrations. Most of them were Eurasian oystercatcher (1.9%). Ringed plovers (1.3%) and common sandpipers (1.2%) were also relatively common. The mean migration intensity during nights was higher than during days (2.3 calls/h vs. 0.4 ind./h, Figure 5-67). There was a peak migration event for waders, in which all heard species occurred on the night of 19th of August (just at the beginning of the migration season), but just as during diurnal migrations, waders were not heard after the October 5th.

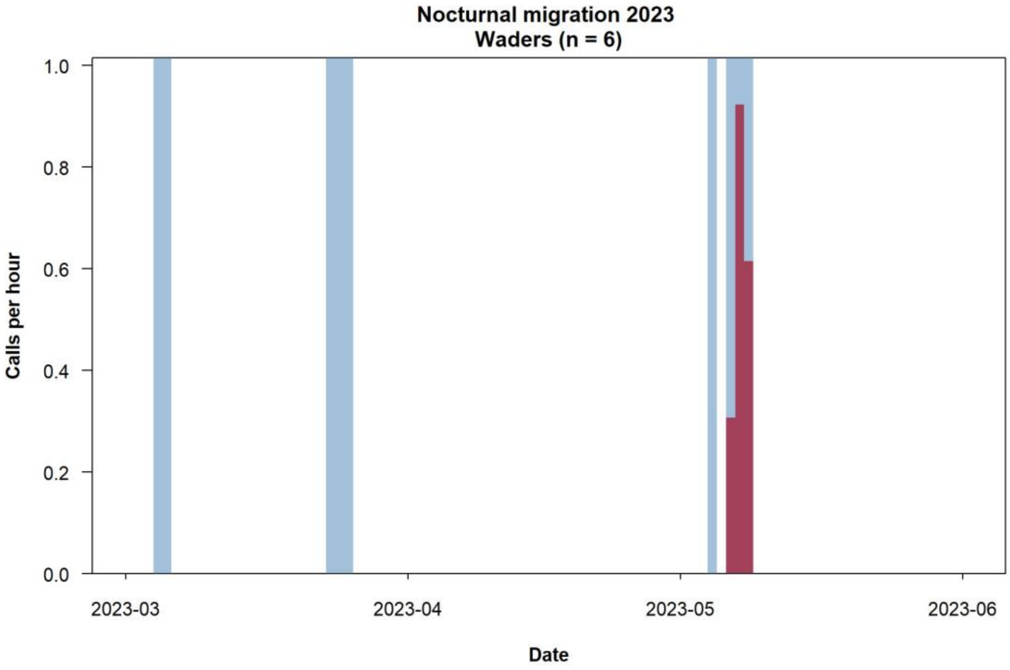


Figure 5-66 Nocturnal migration intensity of waders in spring 2023 at the pre-investigation area. See Figure 5-35 for details.

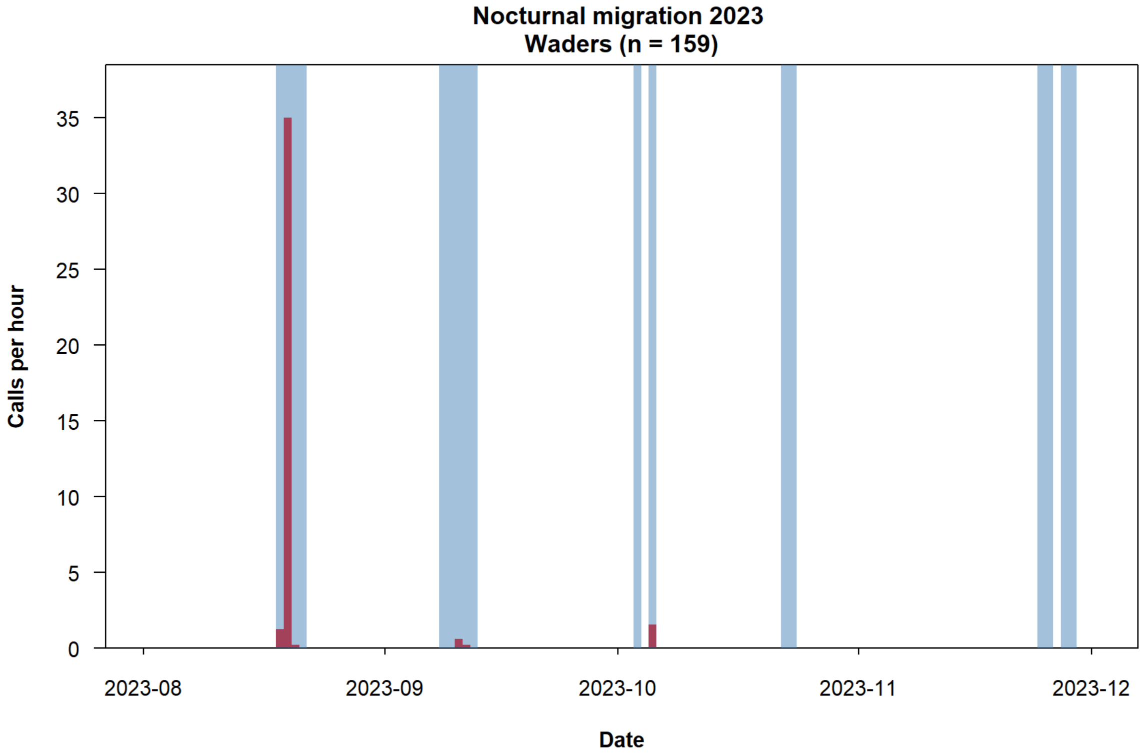


Figure 5-67 Nocturnal migration intensity of waders in autumn 2023 at the pre-investigation area. See Figure 5-35 for details.

Waders flew only at low altitudes (< 10m) in spring whereas in autumn about 11.5% of all individuals were observed flying at 20-50 m of altitude (Figure 5-68).

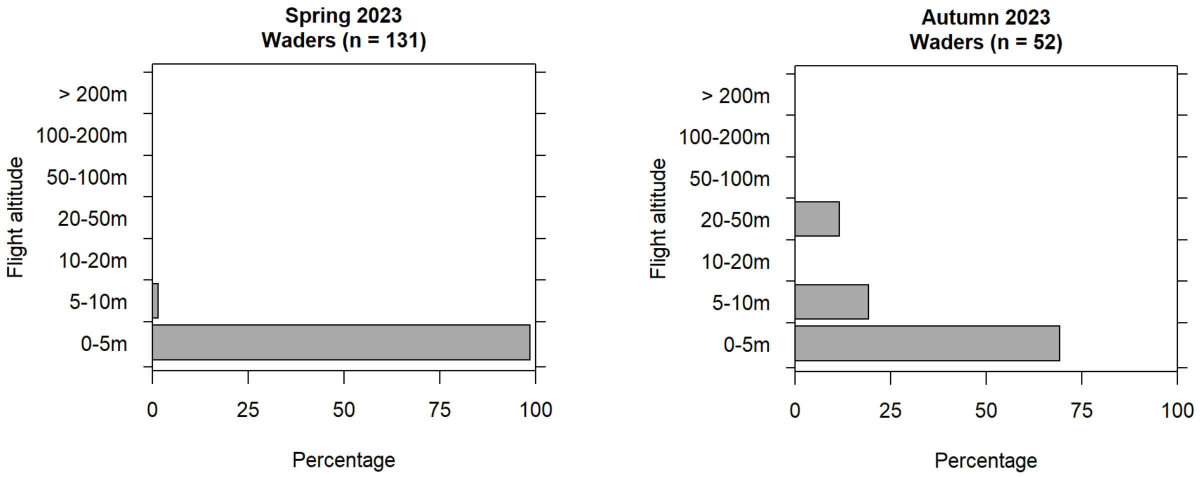


Figure 5-68 Flight altitude distribution of waders during visual observations in spring(left) and autumn (right) 2023. See Figure 5-30 and Figure 5-31 for details.

In spring, they flew to the N and NE while in autumn, most (85%) flew at a distinctive SW direction (Figure 5-69).

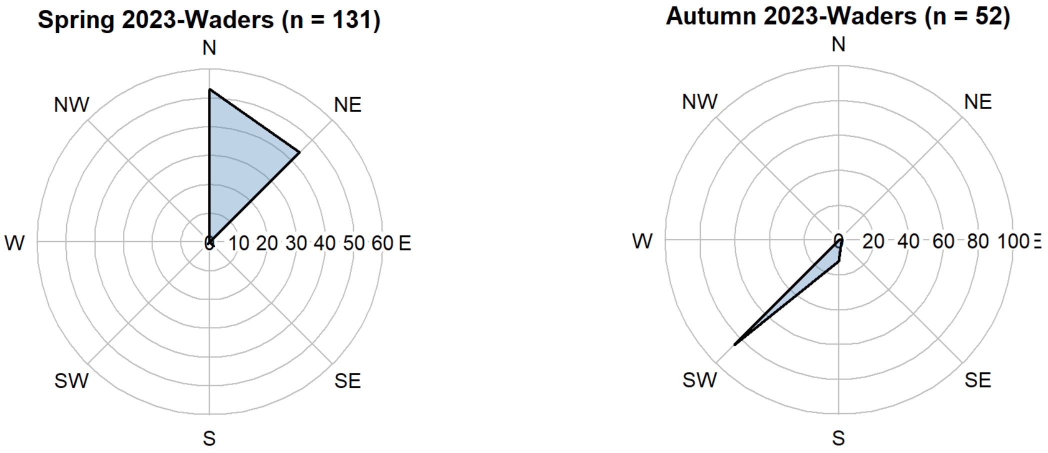


Figure 5-69 Flight directions of waders during visual observations in spring (left) and autumn (right) 2023. See Figure 5-31 for details.

Waders were observed flying throught the day, but more than the half were flying at 11 and 9 hours after morning civil twilight in spring and autumn, respectively (Figure 5-70). They flew in flocks.

Waders were observed flying throught the day, but more than the half were flying at 9 hours after morning civil twilight (Figure 5-70).

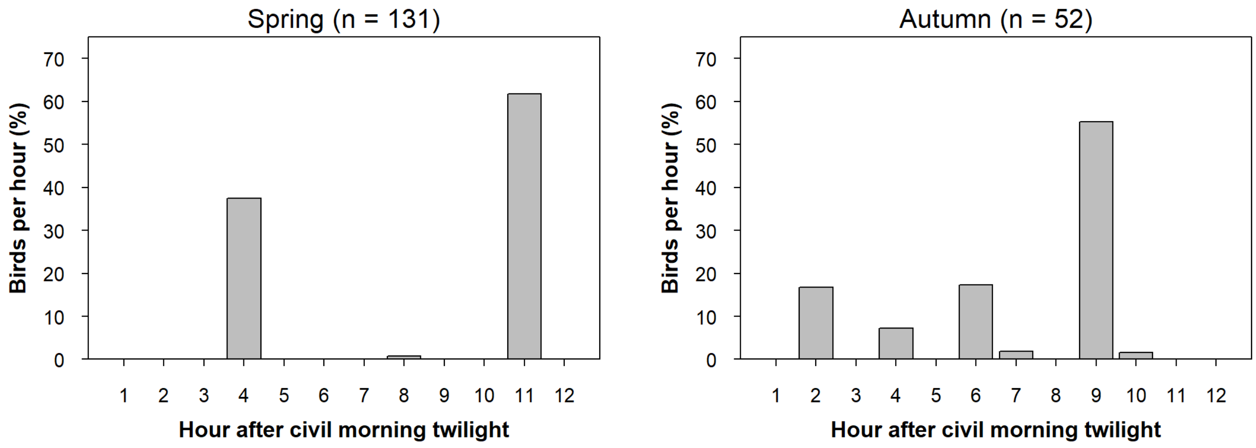


Figure 5-70 Diurnal phenology of waders in spring and autumn 2023. See Figure 5-32 for details.

The few bird calls of different wader species were heard at different hours during the night in spring (Figure 5-71). In autumn, the great majority of the individuals were heard at about 5 hours after civil evening twilight, with very few calls heard at late hours in the night.

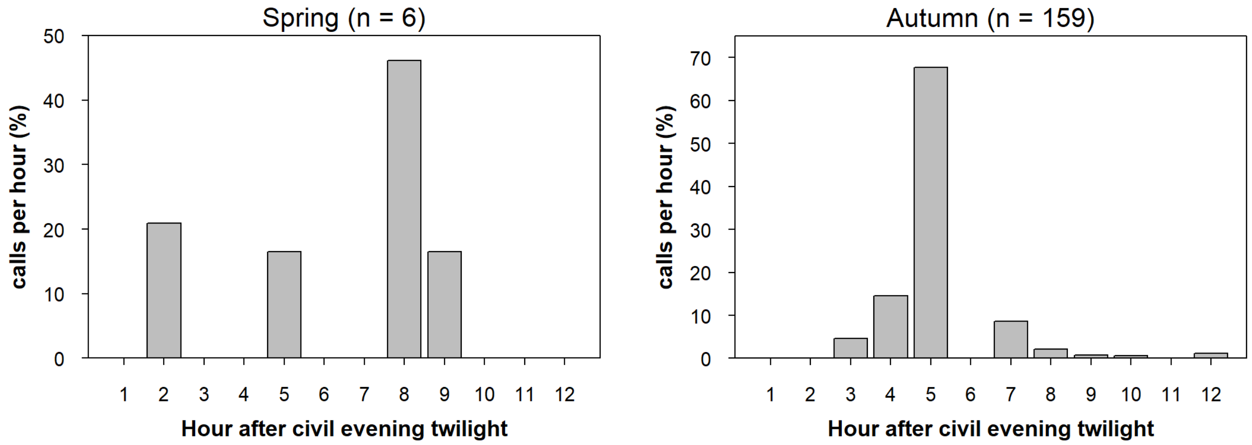


Figure 5-71 Nocturnal phenology of waders in spring and autumn 2023. See Figure 5-32 for details.

GULLS

Gulls made up 2.3% of all migrating birds during diurnal observations in spring. Gulls were represented mainly by five species, all of them observed at rather similar numbers: common gulls (0.68%), lesser black-backed gulls (0.58%), herring gulls (0.47%), black-headed gulls (0.33%) and few great black-backed gulls (0.11%). Diurnal migration intensity was larger in May with the last day of surveys (9th of May.2023) registering most migrating gulls (6.9 birds/h, Figure 5-72).

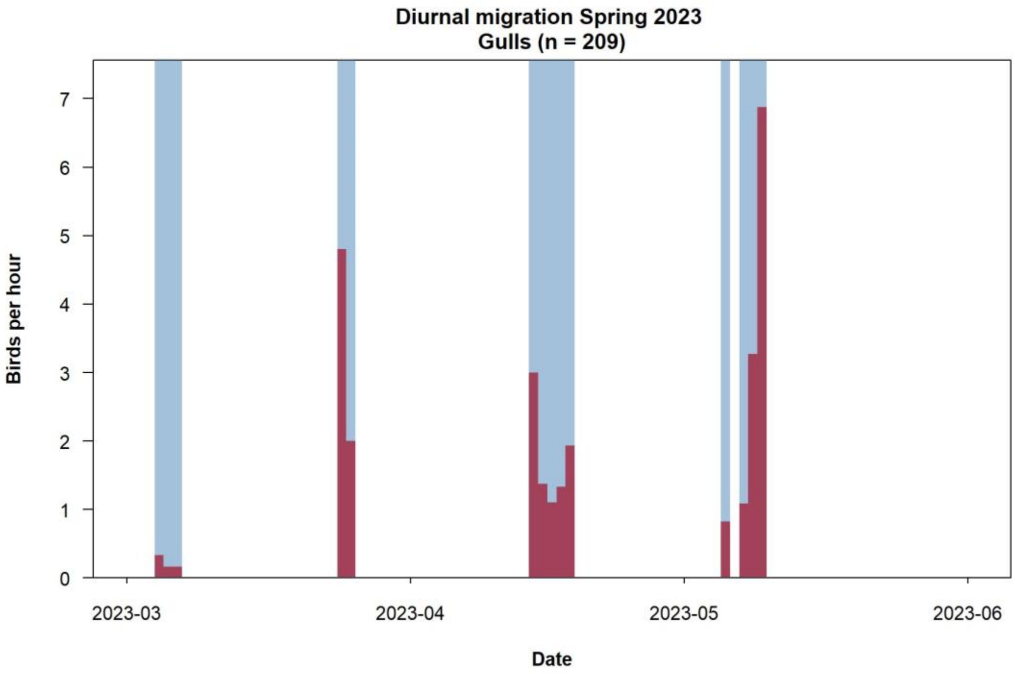


Figure 5-72 Diurnal migration intensity of gulls in spring 2023 at the pre-investigation area . See Figure 5-28 for details.

With 253 individuals, gulls were the third most common group of birds during diurnal migration in autumn 2023. A total of six species were identified, the most common one was the lesser black-backed gull (4.9%), followed by black-legged kittiwakes (1.4%). Gulls were frequently observed during the season at relatively medium migration intensities (0.6 to 7.4 ind./h, Figure 5-73).

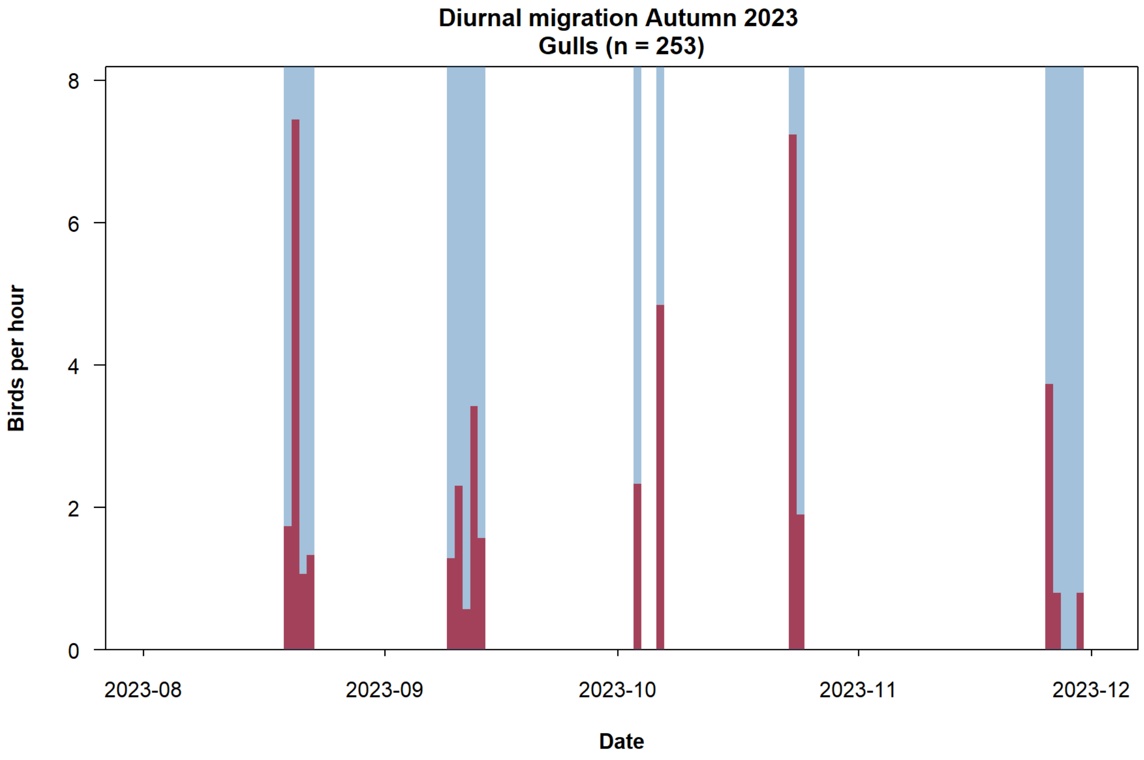


Figure 5-73 Diurnal migration intensity of gulls in autumn 2023 at the pre-investigation area . See Figure 5-29 for details.

During night observations in spring few gulls were heard and only on two dates (Figure 5-74). In autumn, a few gulls were heard, mainly of two species: lesser black-backed gulls and herring gulls, with a maximum migration intensity of 3 calls/h (Figure 5-75).

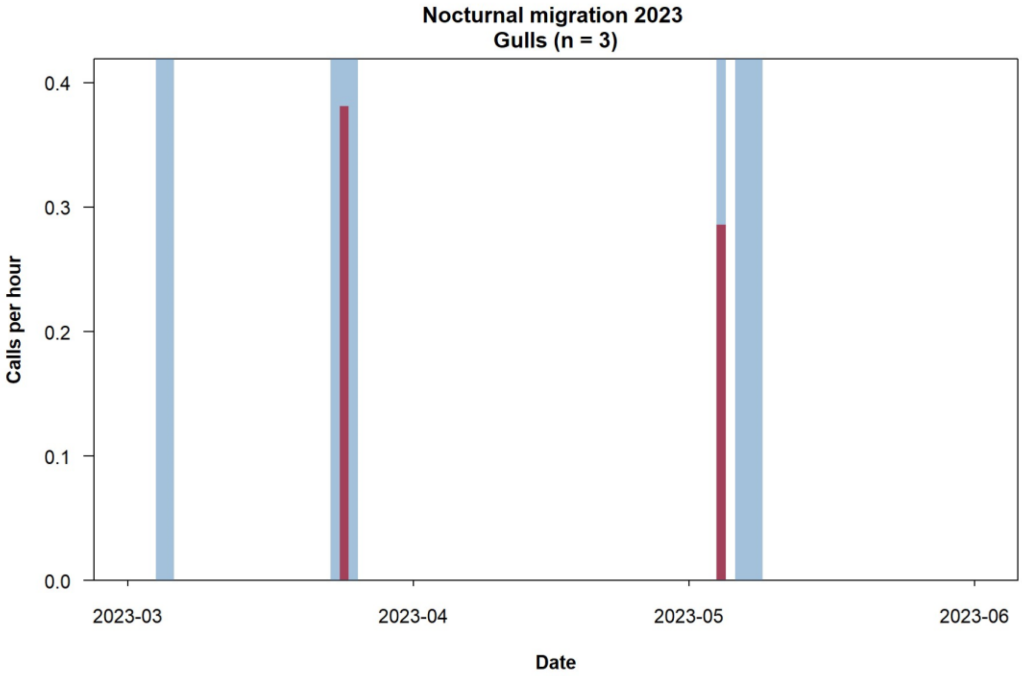


Figure 5-74 Nocturnal migration intensity of gulls in spring 2023 at the pre-investigation area . See Figure 5-35 for details.

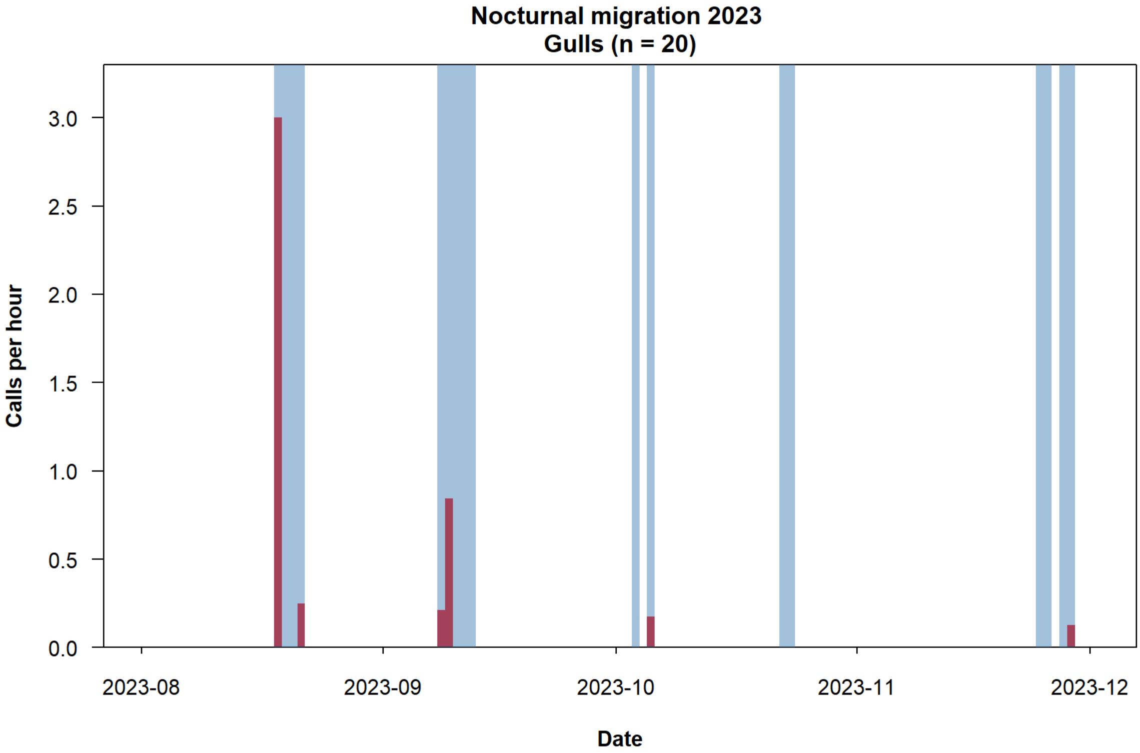


Figure 5-75 Nocturnal migration intensity of gulls in autumn 2023 at the pre-investigation area Hesselø. See Figure 5-35 for details.

Almost all gulls flew below 50 m of altitude in spring and autumn. Only few flew above this altitude (Figure 5-76).

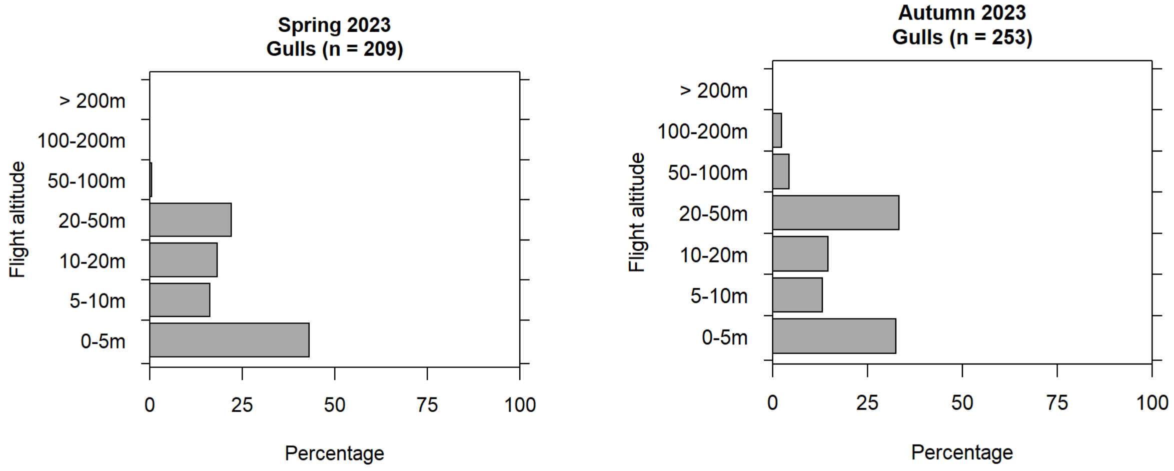


Figure 5-76 Flight altitude distribution of gulls during visual observations in spring and autumn 2023. See Figure 5-30 for details.

In spring, most gulls flew in a NE direction with some flying to the east, and fewer in other directions (SE, S, W, Figure 5-77). In autumn, most gulls flew in a S direction with some flying to the SW and SE. However, they also flew in other directions at smaller proportions (NW, N, NE, Figure 5-77).

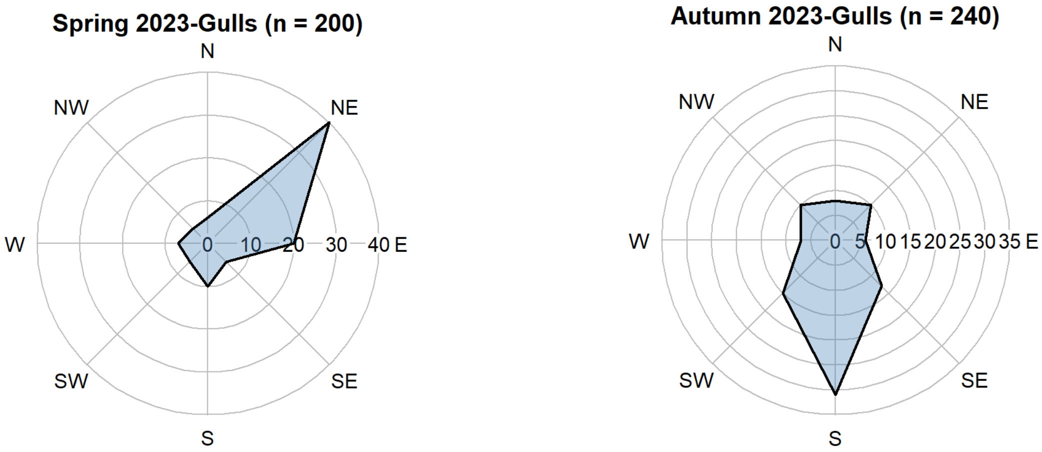


Figure 5-77 Flight directions of gulls during visual observations in spring and autumn 2023. See Figure 5-31 for details.

During day, they were observed flying all day long (Figure 5-78). In autumn, there were however two peaks at two and four hours after civil morning twilight (Figure 5-78).

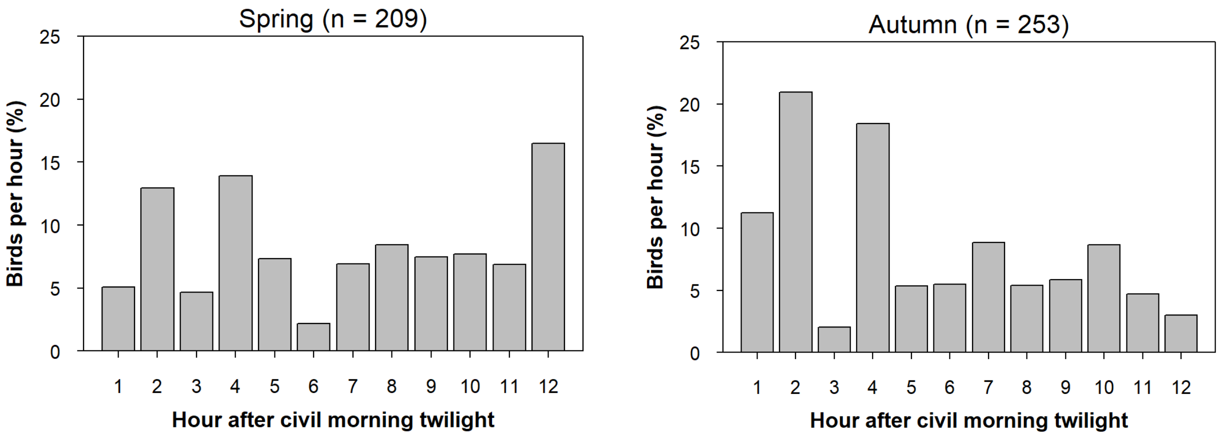


Figure 5-78 Diurnal phenology of gulls in spring and autumn 2023. See Figure 5-32 for details.

Few calls were heard in spring, but in autumn most gulls (almost 60%) were heard just before the civil morning twilight during nocturnal migration (Figure 5-79).

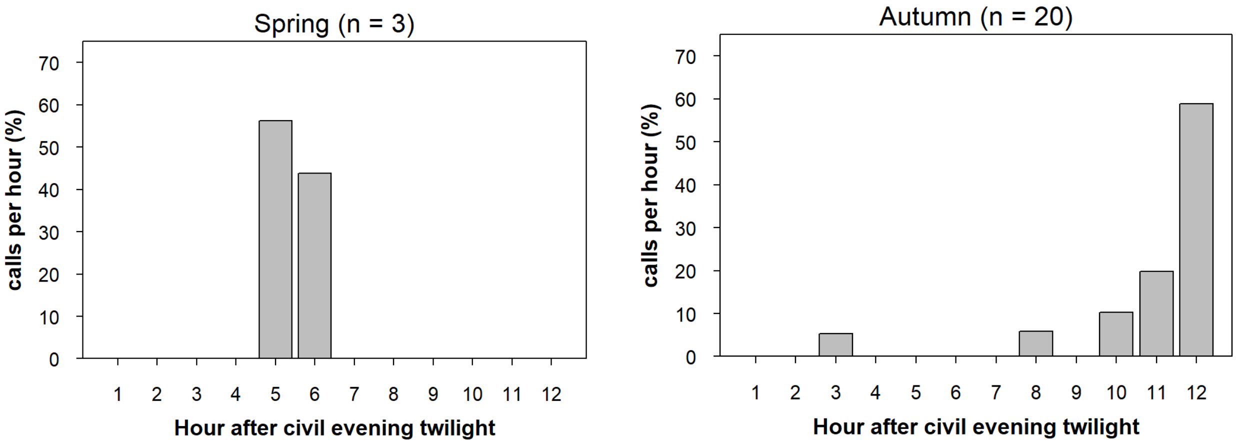


Figure 5-79 Nocturnal phenology of gulls in spring and autumn 2023. See Figure 5-32 for details.

AUKS

Auks were not common in spring. With 87 individuals, they represented just 0.94% of all diurnally migrating birds. There were in total four species sighted, of which razorbills were the most frequent one (0.62%). Other species were common guillemots (0.13%), black guillemots (0.1%) and one individual of Atlantic puffin. Most auks were observed at the beginning of the migrating season (beginning of March) and the maximum migration intensity was 4.3 ind./h (Figure 5-80).

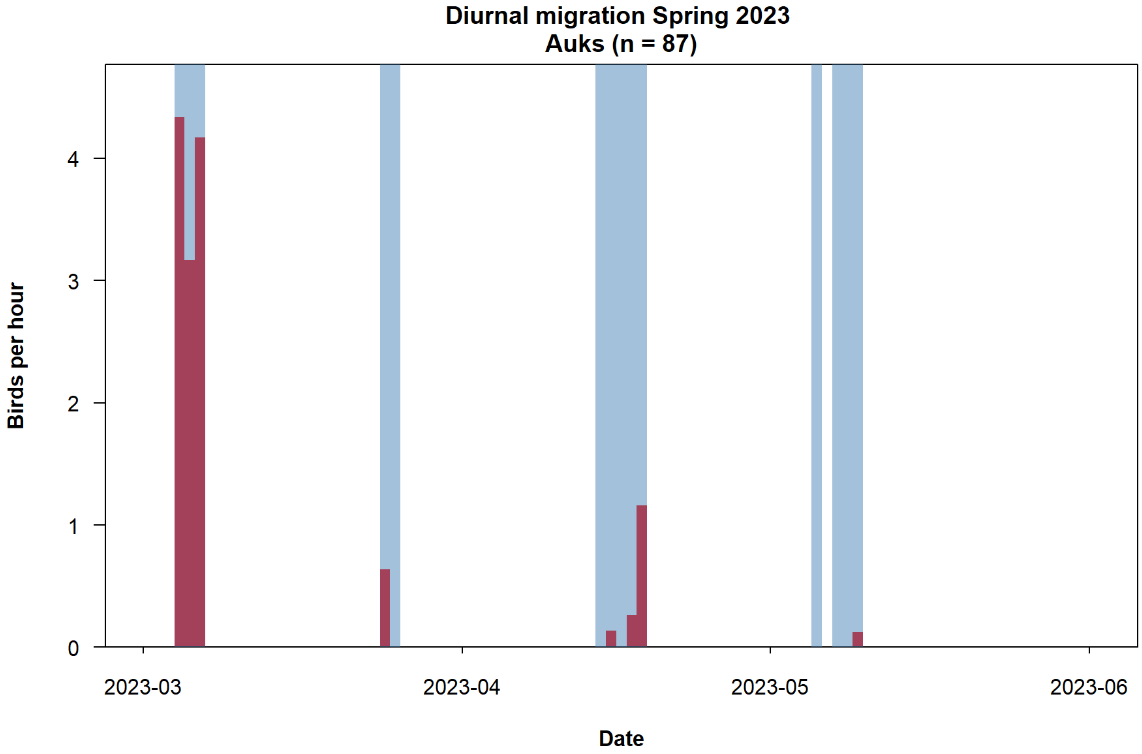


Figure 5-80 Diurnal migration intensity of auks in spring 2023 at the pre-investigation area . See Figure 5-28 for details.

In contrast to waders, auks started to appear at larger numbers late in autumn. A total of four species of auks were identified, the most common ones were common guillemots (2.2%) and razorbills (2.1%). In addition, 1.2% of all birds were grouped as common guillemots/razorbills. A few black guillemots (0.4%) were also present during the autumn migration. Mean migration intensity during days was 2.7 ind./h with a peak migration on the 25th of November 2023 (19.5 ind./h, Figure 5-81).

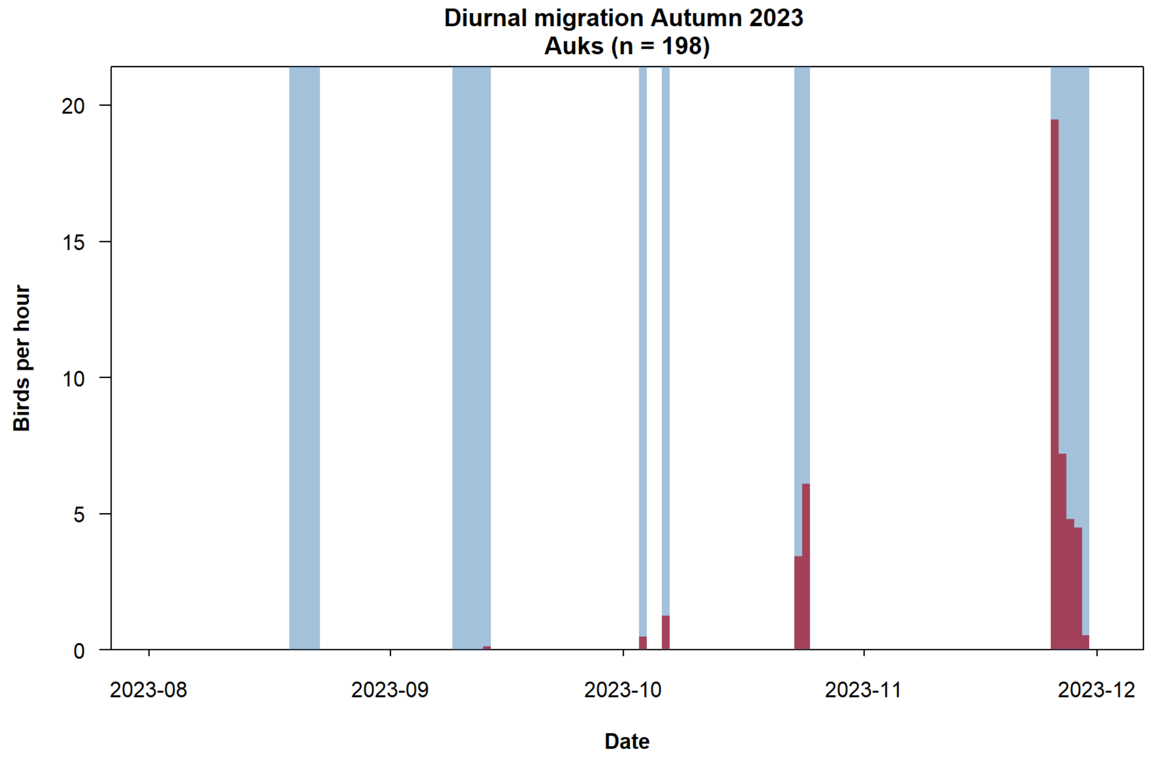


Figure 5-81 Diurnal migration intensity of auks in autumn 2023 at the pre-investigation area . See Figure 5-29 for details.

Most auks were observed at low flying altitudes (< 10 m), and only very few of them were observed at higher (> 200 m, in spring and altitudes between 20-50 m in autumn, Figure 5-82).

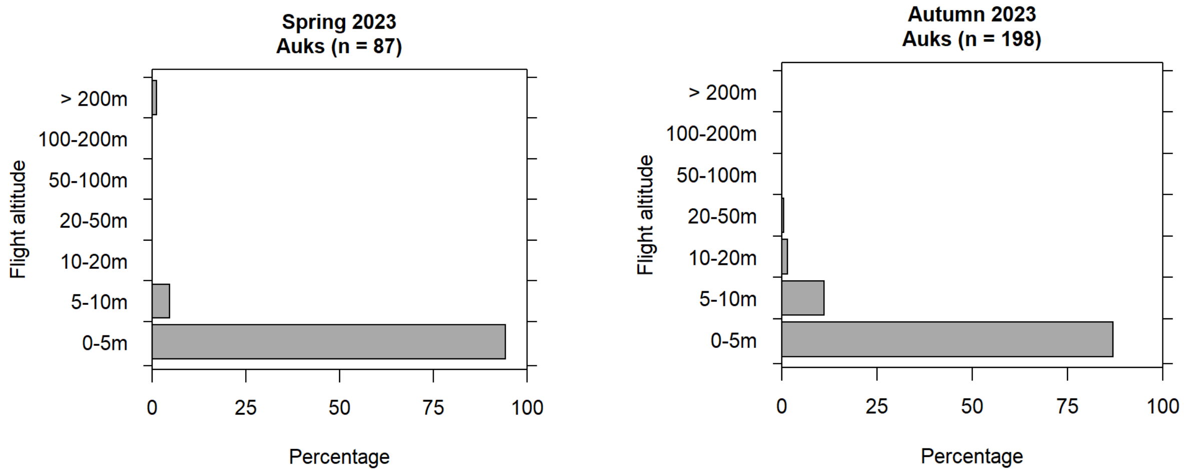


Figure 5-82 Flight altitude distribution of auks during visual observations in spring and autumn 2023. See Figure 5-30 for details.

Flying directions of auks were variable with a large proportion of auks migrating towards the S, NW and N in spring, whereas the main directions were SW, NW and W in autumn (Figure 5-83).

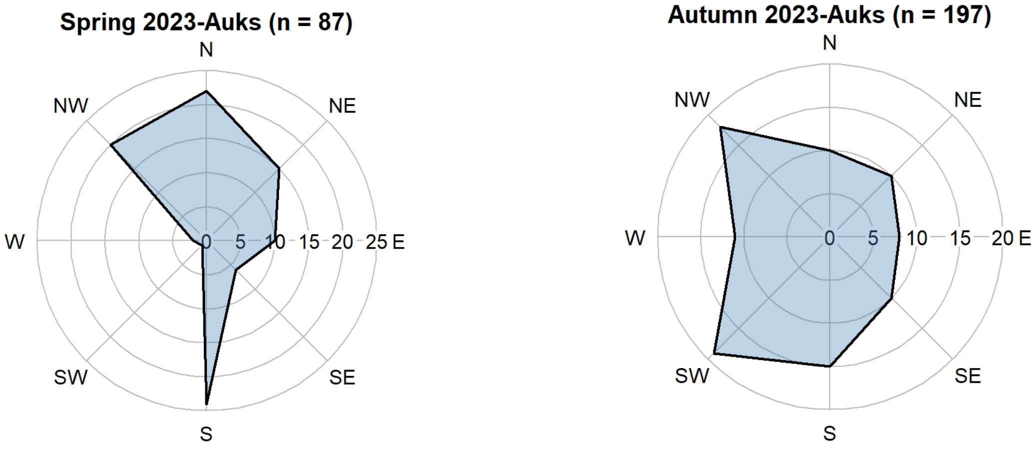


Figure 5-83 Flight directions of auks during visual observations in spring and autumn 2023. See Figure 5-31 for details.

Auks were observed migrating all day long. In spring, almost 50% were flying in the first two hours after civil morning twilight whereas about 20% of them were migrating at the second hour after civil morning twilight in autumn (Figure 5-84).

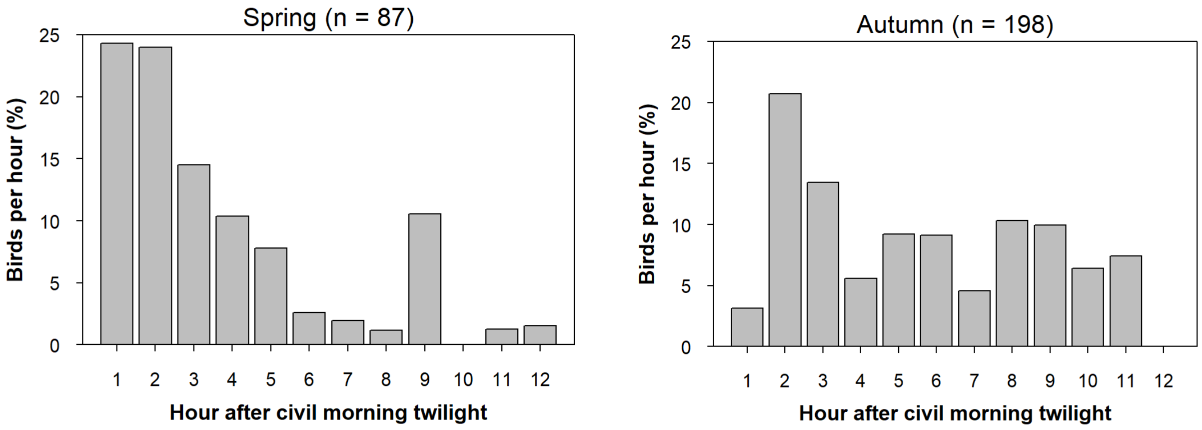


Figure 5-84 Diurnal phenology of auks in spring and autumn 2023. See Figure 5-32 for details.

SONGBIRDS

After geese and ducks, songbirds were the most common group of birds registered during diurnal migration in spring (6.1%). Among the most common species were meadow pipits (0.89%), Eurasian jackdaw (0.52%), barn swallows (0.26%) and bramblings (0.24%). Migration intensity was higher in April (mean of 10.9 birds/h, compared to 3.6 in March and 1.2 in May. The maximum migration intensity was observed on the 14th of April 2023 (21.9 birds/h, Figure 5-85).

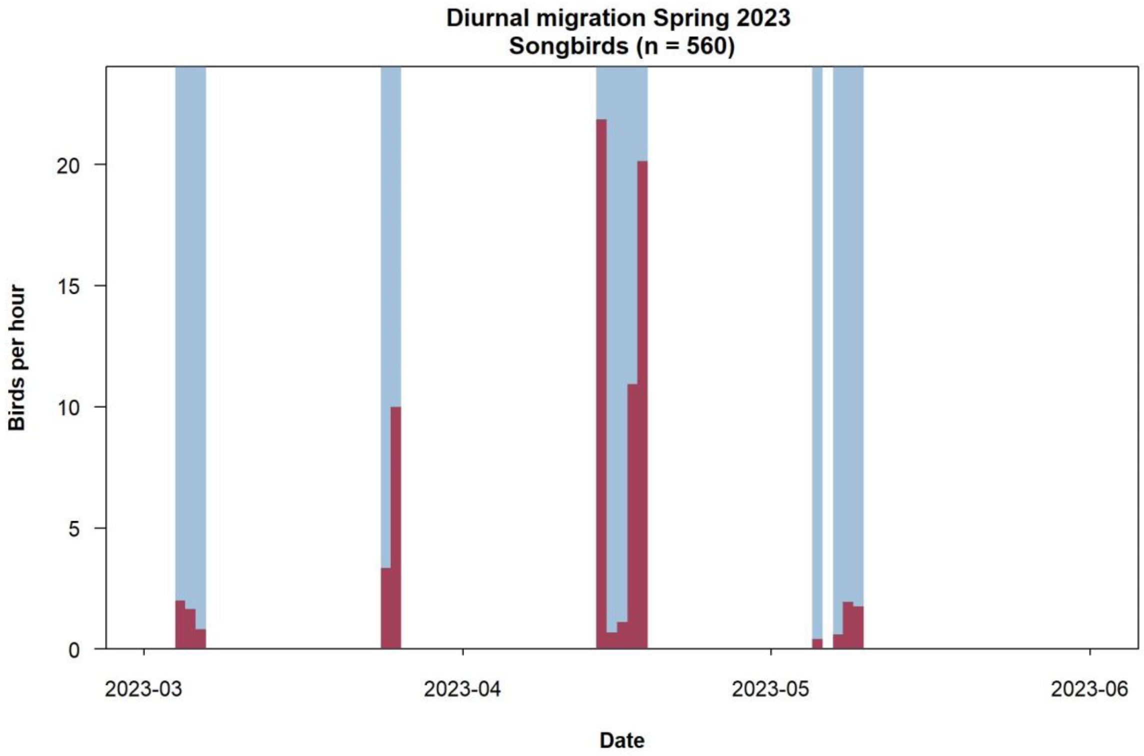


Figure 5-85 Diurnal migration intensity of songbirds in spring 2023 at the pre-investigation area. See Figure 5-28 for details.

During diurnal migration in autumn, several species of songbirds were identified (29 species). They made up 8% of all migrating birds observed during this season. The most commonly occurring species were Eurasian siskin (1.2%), white wagtail/pied wagtail (1%), meadow pipit (0.9%) and yellow wagtail (0.7%).

Migration intensity was variable, but the mean value was 2.2 ind./h. Maximum migration intensity occurred at the middle of the season on the 3rd of October (17.7 ind./h, Figure 5-86). Songbirds were not registered in November.

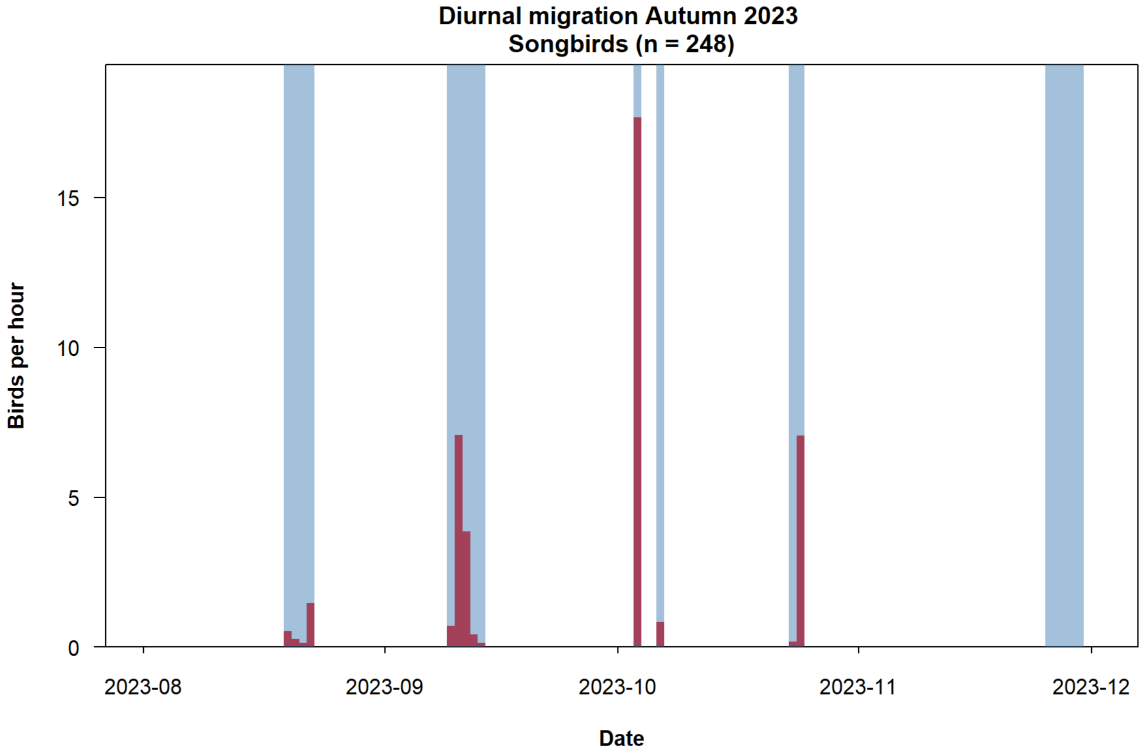


Figure 5-86 Diurnal migration intensity of songbirds in autumn 2023 at the pre-investigation area. See Figure 5-29 for details.

During nocturnal migration, songbirds were the most common birds, representing at least 90% of all birds heard. During nocturnal migration, songbird calls were divided into two groups: thrushes, *Turdus* spp. and all other songbirds. Thrushes were more common (almost 50% of all nocturnally migrating birds) than the other songbirds (Figure 5-33). Of the thrushes the most common species was the redwing (39.7%) followed by the song thrush (6.7%). Among other songbirds the most common species were the European robin (15.6%) and the common chiffchaff (5.6%). Both groups of songbirds were observed mainly on one night (March 23rd, 2023), and their combined maximum migration intensity was 30.2 calls/h (Figure 5-87).

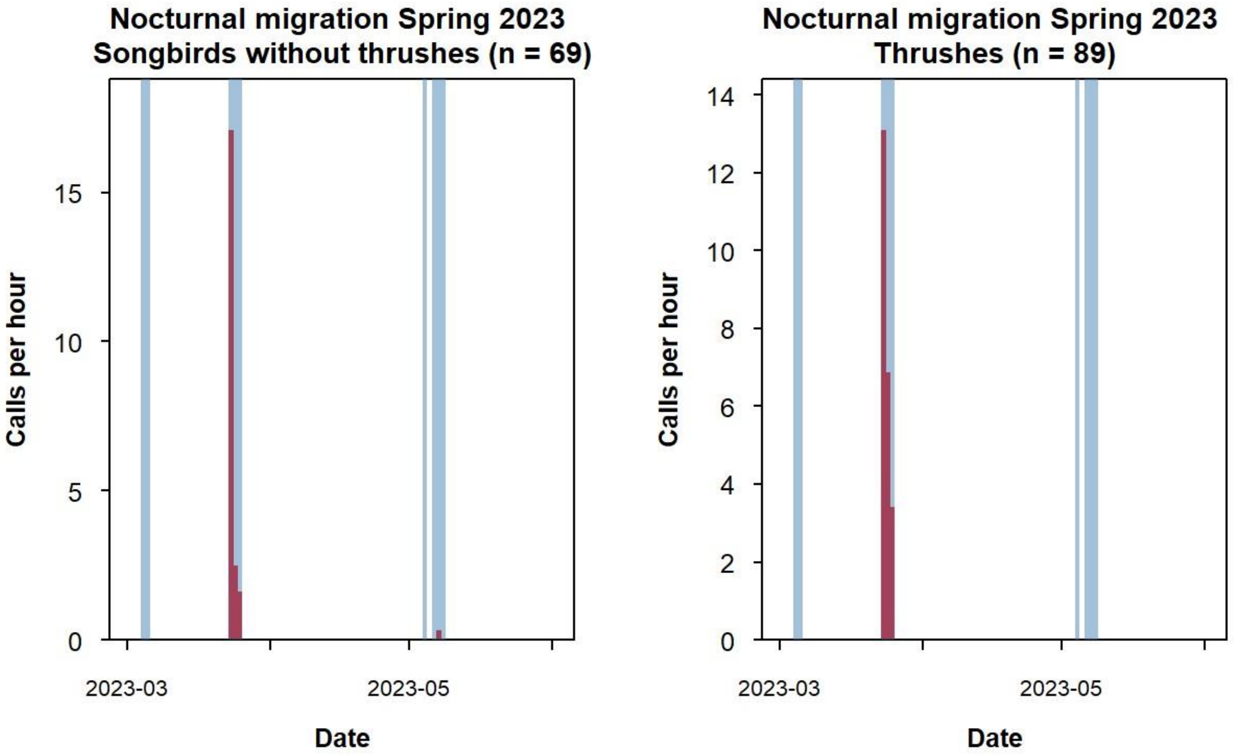


Figure 5-87 Nocturnal migration intensity of songbirds in spring 2023 at the pre-investigation area.. Calls from the large groups of passerines are often divided into thrushes (Turdus spp.) and all other songbirds. See Figure 5-35 for details.

In autumn, thrushes were by far the most commonly occurring group, with 5 identified species, of which the most common one was the song thrush (77.2%) and to a lesser extent the redwing (9.6%). Of the other songbirds the most common species were the European robin (3%). Other species occurred in smaller numbers. Migration intensity of the group of songbirds without thrushes was at a similar scale than that of diurnally migrating songbirds with a mean of 2.6 calls/h. A similar maximum peak migration was observed (20 calls/h) but it occurred at the beginning of the season on the 19.08.2023. Thrushes were heard during the whole season but at very low intensities (< 1, once up to 5 calls/h). Only on the night of the October 5th, there was a peak migration event when nocturnal migration intensity reached 467.8 calls/h (Figure 5-88).

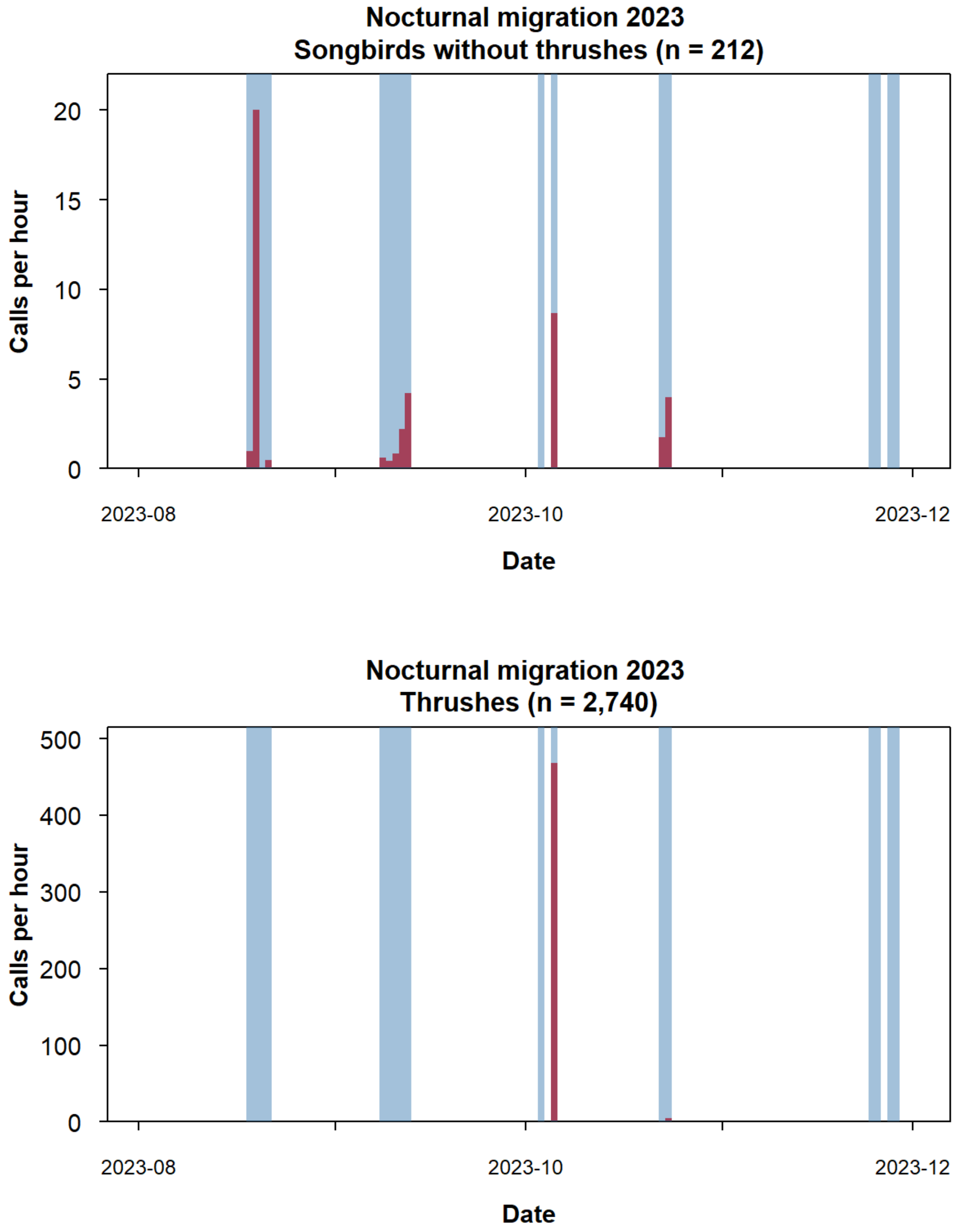


Figure 5-88 Nocturnal migration intensity of songbirds in autumn 2023 at the pre-investigation area. Calls from the large groups of passerines are often divided into thrushes (*Turdus* spp.) and all other songbirds. See Figure 5-35 for details.

In spring, 83.6% of all birds were observed at altitudes below 20m. In autumn, flying altitude of diurnally migrating songbirds decreased progressively with altitude, with most of the migration occurring in altitudes up to 20 m (81%, Figure 5-89).

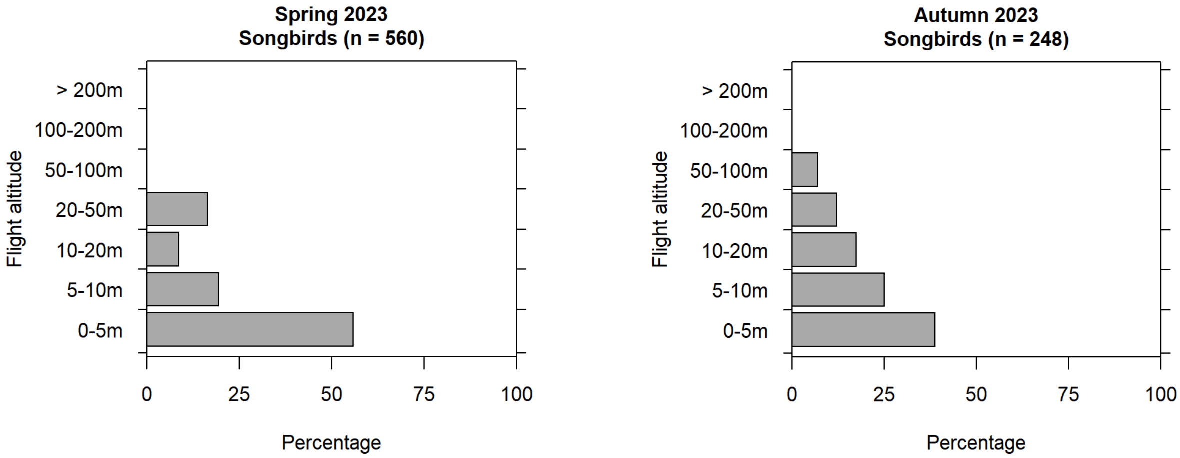


Figure 5-89 Flight altitude distribution of songbirds during visual observations in spring and autumn 2023. See Figure 5-30 for details.

In spring, most birds were flying at a NE direction, and in general > 85% of all birds flew in a N, NE, E direction (Figure 5-90). In autumn, most birds were observed flying at a SW direction (38%), but about 40% flew also to the S and SE (Figure 5-90).

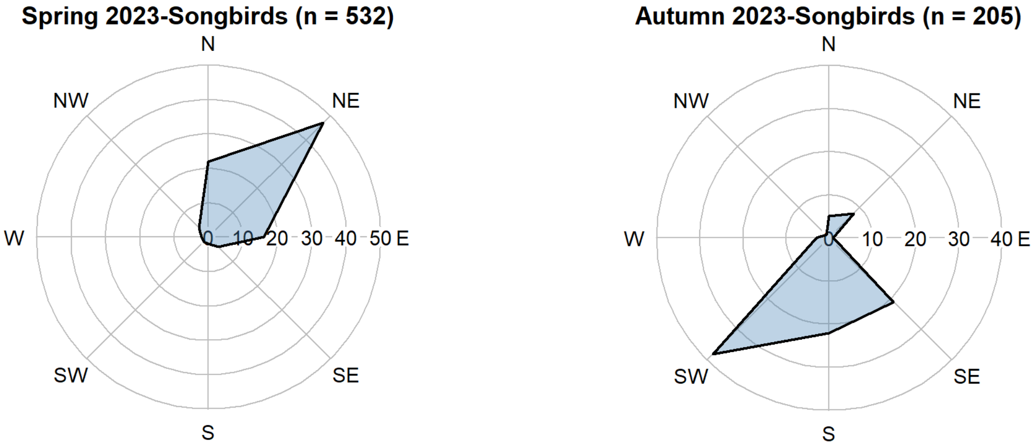


Figure 5-90 Flight directions of songbirds during visual observations in spring and autumn 2023. See Figure 5-31 for details.

The flying pattern was relatively clear for songbirds. During day, they were observed mostly during the first hours of the day, irrespective of the season (Figure 5-91). During nights, they were on the contrary, observed more frequently flying late in the night or few hours before dawn disregarding the season or the group (Figure 5-92).

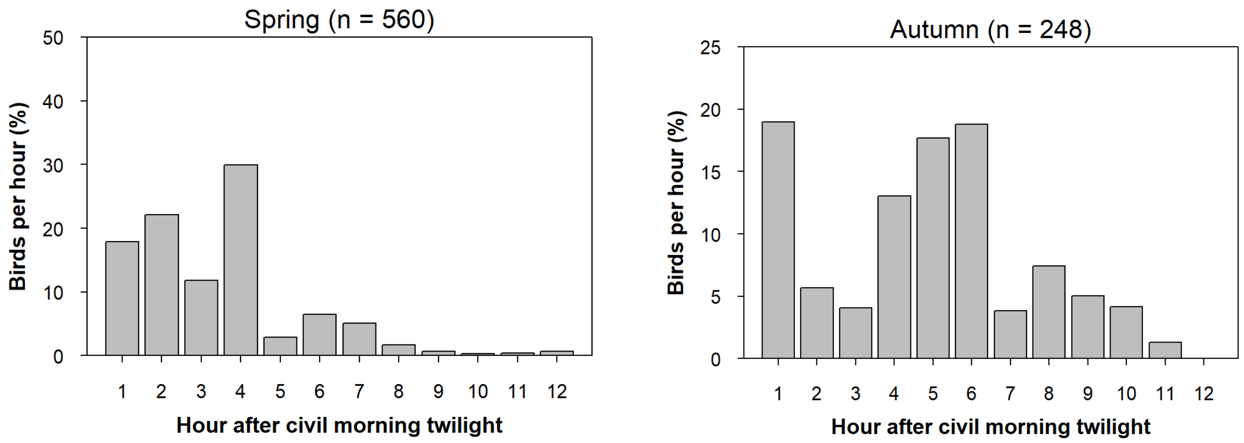


Figure 5-91 Diurnal phenology of songbirds in spring and autumn 2023. See Figure 5-32 for details.

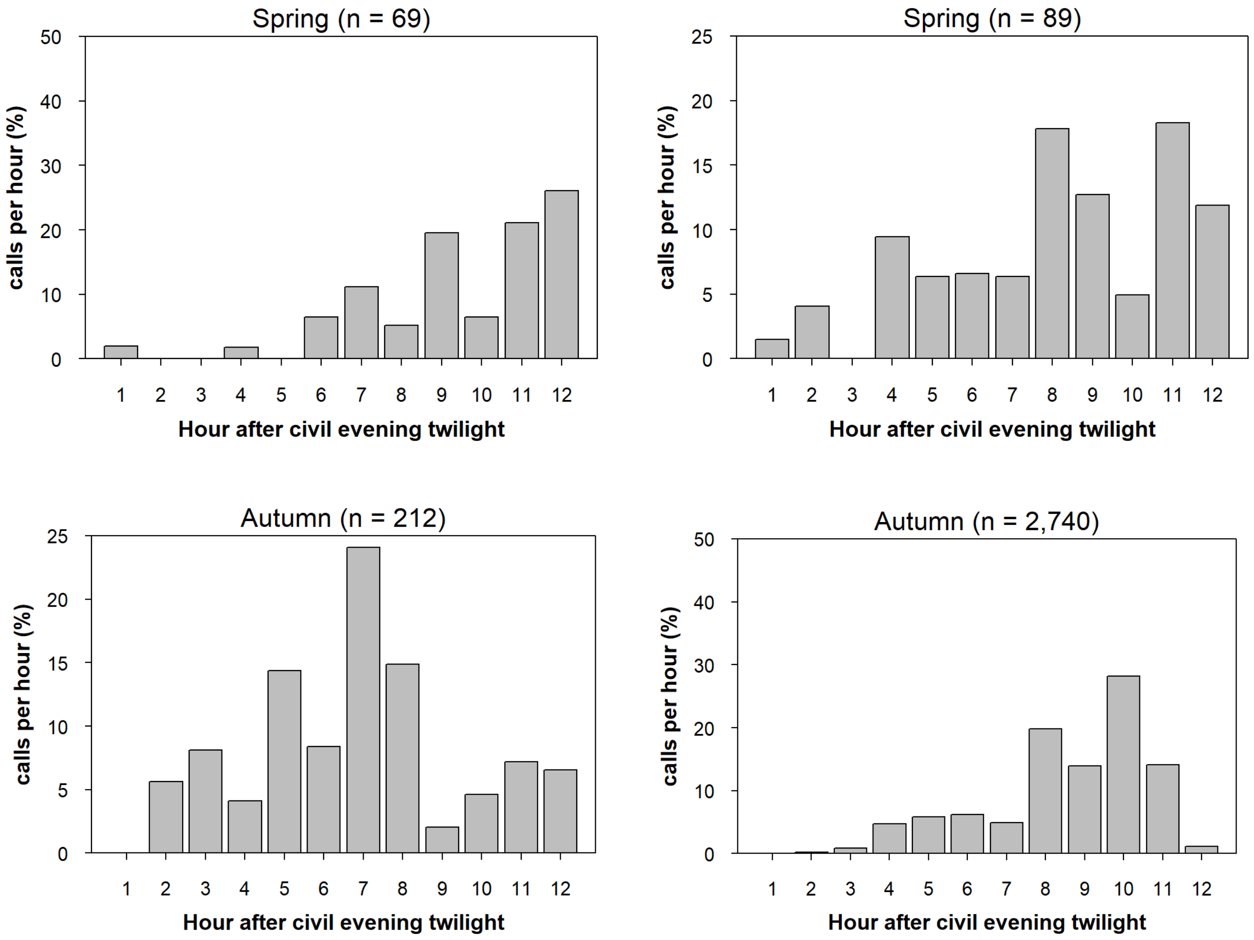


Figure 5-92 Nocturnal phenology of songbirds in spring (top) and autumn (bottom) 2023. Songbirds are divided into two groups during nocturnal migration (left: songbirds without thrushes, right: only thrushes). See Figure 5-32 for details.

5.2.2 HORIZONTAL AND VERTICAL RADAR

MIGRATION INTENSITY

A total of 39 days and 33 nights contained vertical radar signals. However, for the calculations of migration intensity, data from several days and nights were not used because there were not enough hours of collection due to weather (rain, fog, wind >7 Bft) or sea state (< 70% of day length or night length). In the end, 31 days (79%) and 27 nights (82%) were used to calculate average migration intensities for day and night from vertical radar signals (see Table 5-9 and Table 5-10). In spring, mean migration intensity during daytime was 22.3 MTR (signals/(km*h) and 393.1 MTR during nights (**Fehler! Verweisquelle konnte nicht gefunden werden.**). During days, migration intensity was higher in the middle of the season with the highest mean migration taking place in April (28.7 MTR), due to a peak of migration on the 14th of April (68.5 MTR, Figure 5-93). Mean nocturnal migration intensity was higher towards the end of the season. In May the mean value was 662.2, mainly due to a peak migration event taking place on the night of the 7th of May (2010.6 MTR, Figure 5-94).

In autumn, mean migration intensity during days was 22.9 MTR with the maximum migration taking place in November (40.1 MTR) when the maximum value occurred on the 27th of November (60.3 MTR, Figure 5-93). Mean migration intensity during nights was also larger, but not as large as during spring. Mean nocturnal migration intensity in autumn was 109.7 MTR with the highest migration occurring in October (mean monthly value: 309.9 MTR) and the maximum peak migration event was 702.6 MTR which occurred on the night of the 5th of October (Figure 5-94).

Table 5-9. Monthly and seasonal diurnal and nocturnal migration rates (MTR) calculated from vertical radar in spring 2023 at the pre-investigation area.

Spring 2023	Diurnal migration (MTR)				Nocturnal migration (MTR)			
	Mean (± SE)	Median	Maximum	Number of days	Mean (± SE)	Median	Maximum	Number of nights
March	20.5 (± 5.9)	16.3	43.4	5	107.1 (± 69.8)	59.1	304.3	4
April	28.7 (± 10.5)	22.9	68.5	5	342.8 (± 164.4)	228.7	821.8	4
May	17.7 (± 7.3)	11.5	45.5	5	662.2 (± 373.6)	313.7	2010.6	5
Spring	**22.3 (± 4.5)**	**18.3**	**68.5**	**15**	**393.1** (± 157.6)	**174.2**	**2010.6**	**13**

Table 5-10. Monthly and seasonal diurnal and nocturnal migration rates (MTR) calculated from vertical radar in autumn 2023 at the pre-investigation area.

Autumn 2023	Diurnal migration (MTR)				Nocturnal migration (MTR)			
	Mean (± SE)	Median	Maximum	Number of days	Mean (± SE)	Median	Maximum	Number of nights
August	18.9 (± 8.5)	17.1	37.3	4	125.1 (± 115)	10.6	355.2	3
September	12.7 (± 1.8)	11.7	17.6	5	28.4 (± 8.1)	33.2	48.9	5
October	22.6 (± 5.6)	18.1	33.7	3	309.9 (± 198.7)	166.6	702.6	3
November	40.1 (± 7.2)	36.7	60.3	4	29.8 (± 8.1)	28.7	44.3	3
Autumn	**22.9 (± 3.8)**	**17.9**	**60.3**	**16**	**109.7 (± 52.0)**	**36.8**	**702.6**	**14**

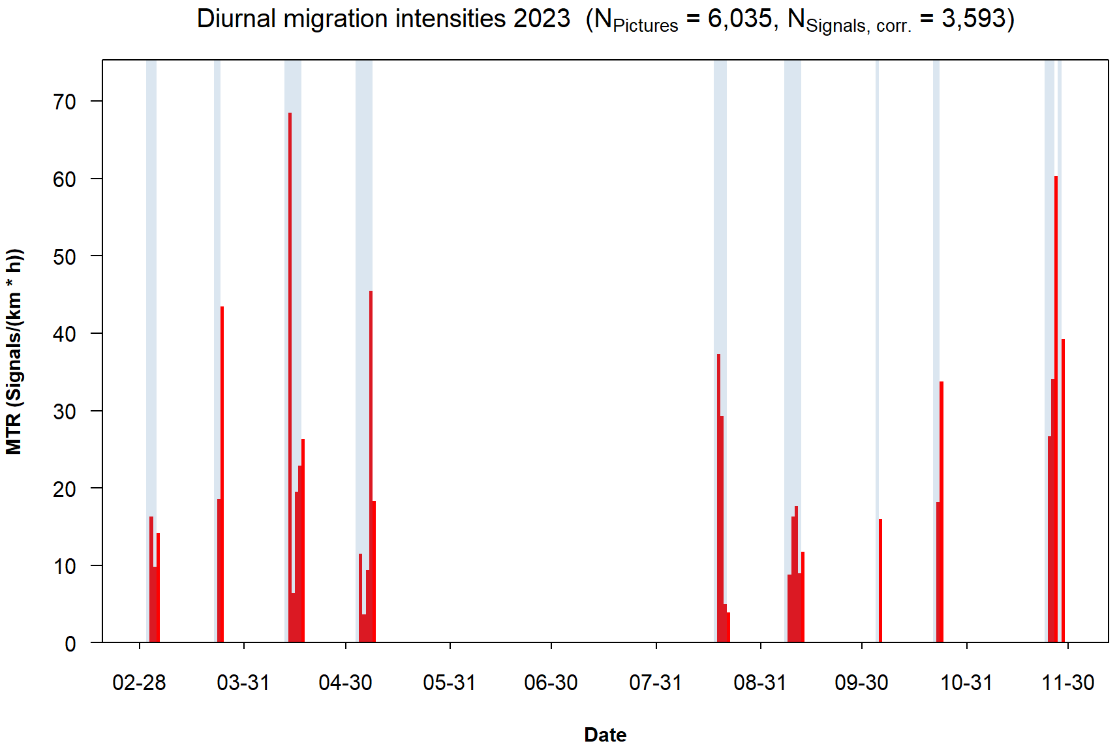


Figure 5-93 Diurnal migration intensity in spring and autumn 2023 based on daily migration traffic rates (MTR) calculated from the vertical radar. MTR is specified as radar signals per km and hour (up to 1,000 m altitude). Areas highlighted in light grey indicate the survey days.

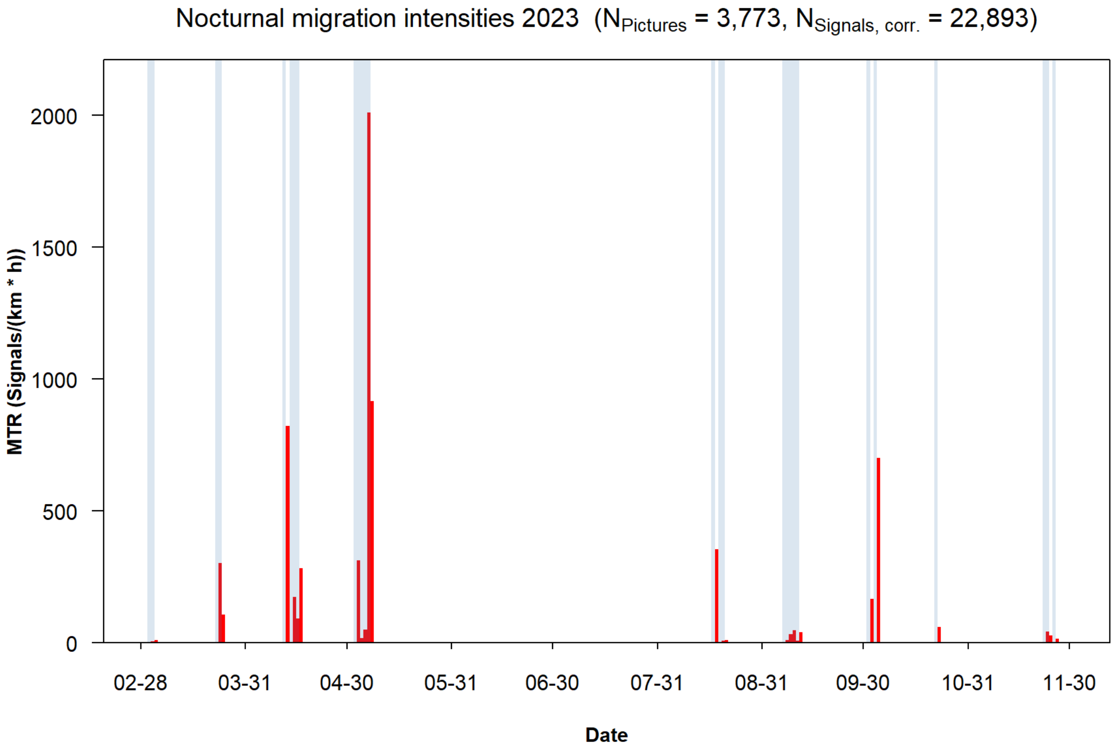


Figure 5-94 Nocturnal migration intensity in spring and autumn 2023 based on daily migration traffic rates (MTR) calculated from the vertical radar. Note the different y-axis scale, when comparing with diurnal migration intensity.

FLIGHT ALTITUDE

For the plotting of altitude distribution all vertical radar signals were used. Bird signals obtained from vertical radar data (up to 1,000 m altitude), showed a different vertical distribution between diurnal and nocturnal migration (Figure 5-95, Figure 5-96). During daytime, the majority of signals (28% and 50% in spring and autumn, respectively) was detected in the very first 100 metres above the water surface in both seasons. Above this layer, a slight decline of bird activity with increasing altitude occurred, reaching from 10.5% and 18% of signals at 100-200 m (in spring and autumn, respectively) to 6% and 0.6% at 900-1,000 m altitude (in spring and autumn, respectively). Nocturnally detected bird signals were more evenly spread over the whole altitude range. In spring, the proportion of signals at each 100 m layer varied between 6% at the highest altitude layer (900 – 1000 m) and 14% (400-500 m, Figure 5-95). In autumn, the first 100 m of altitude contained the highest proportions of signals (22%), the second layer (100 – 200 m) contained 12% of all bird signals and the rest of the layers contained a very similar proportion of signals varying only between 7% (top layer) and 9% (200 – 300 m, Figure 5-96).

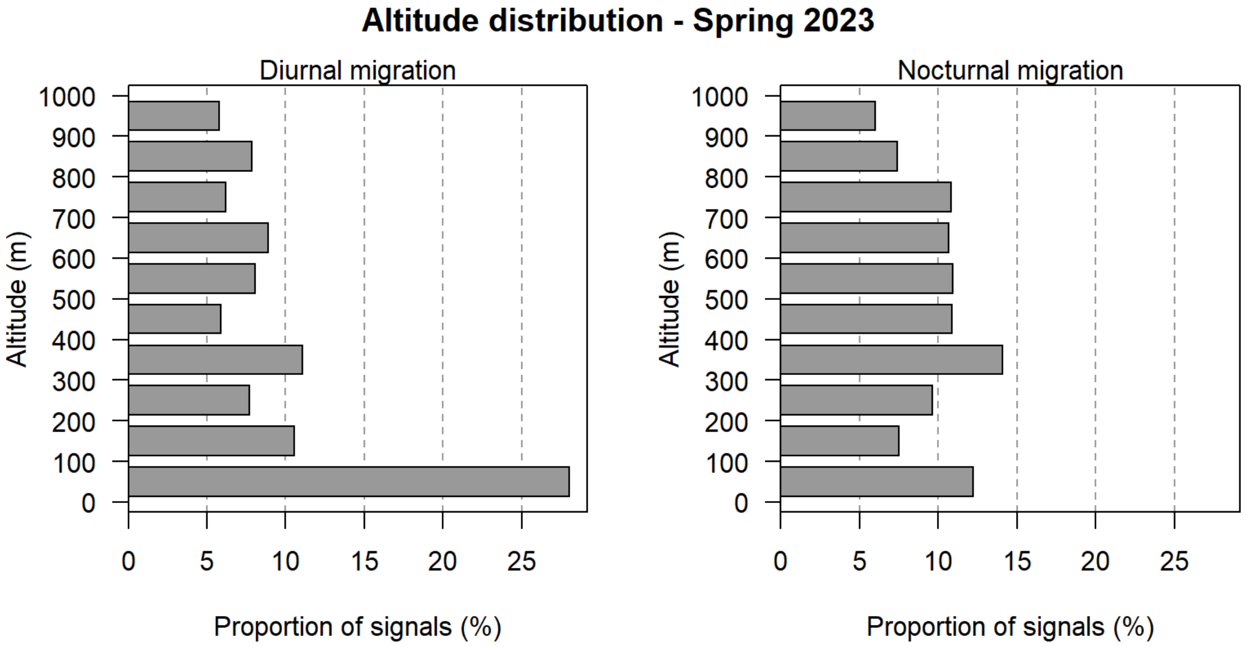


Figure 5-95 **Flight altitude distribution from vertical radar data during spring at the pre-investigation area. Depicted is the relative appearance of signals up to 1,000 m height in 100 m increments. The graph on the left shows the altitude distribution of birds during the daylight phase, the right graph during the night.**

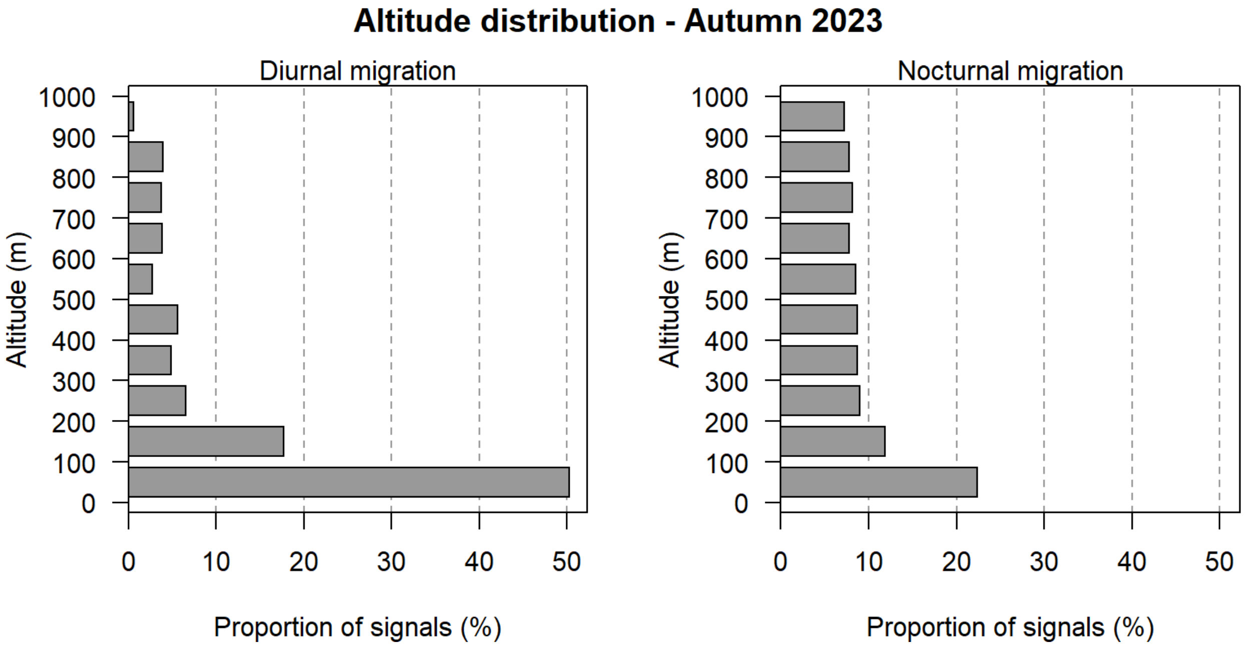


Figure 5-96 **Flight altitude distribution from vertical radar data during autumn at the pre-investigation area. Depicted is the relative appearance of signals up to 1,000 m height in 100 m increments. The graph on the left shows the altitude distribution of birds during the daylight phase, the right graph during the night.**

TEMPORAL PATTERNS

Migration intensity considered in a course of 24 hours also emphasised higher activity during the night than during the daylight phase both in spring (Figure 5-97) and autumn (Figure 5-98). In spring, low migration occurred during all daytime hours except just before the sunset at 17 hours when a relatively large migration occurred. In autumn, migration was the lowest during the middle of the day, but overall, also low. During nights, migration intensity, increased at 19 hours and decreased two hours before sunrise.

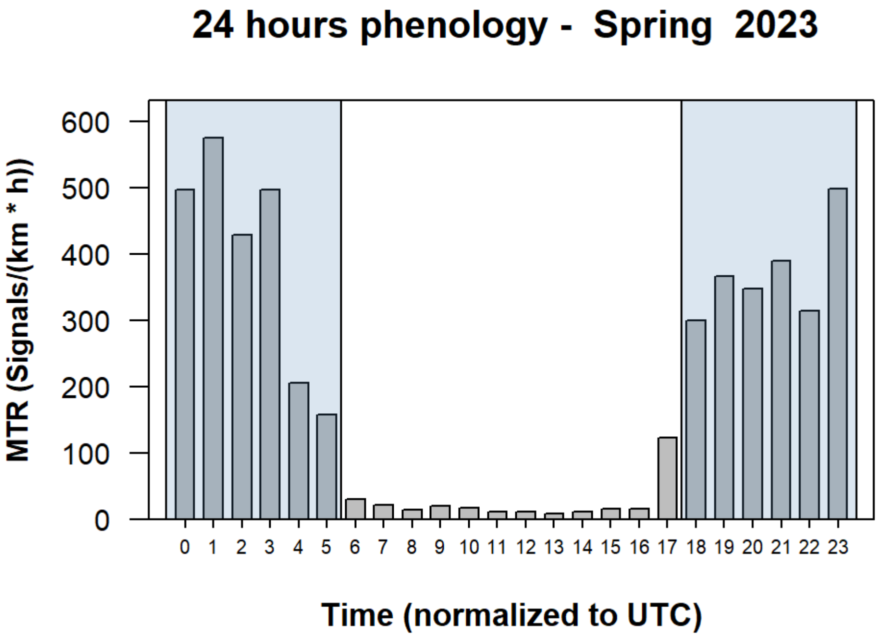


Figure 5-97 24 h migration intensity from vertical radar data in spring at the pre-investigation area. As daylength varies over the year, nocturnal (blue shaded) and diurnal observations of the single survey dates are depicted stretched/compressed to a “normalised” length of 12 hours each. Time data in UTC (minus one hour compared to MET/ two hours to MEST).

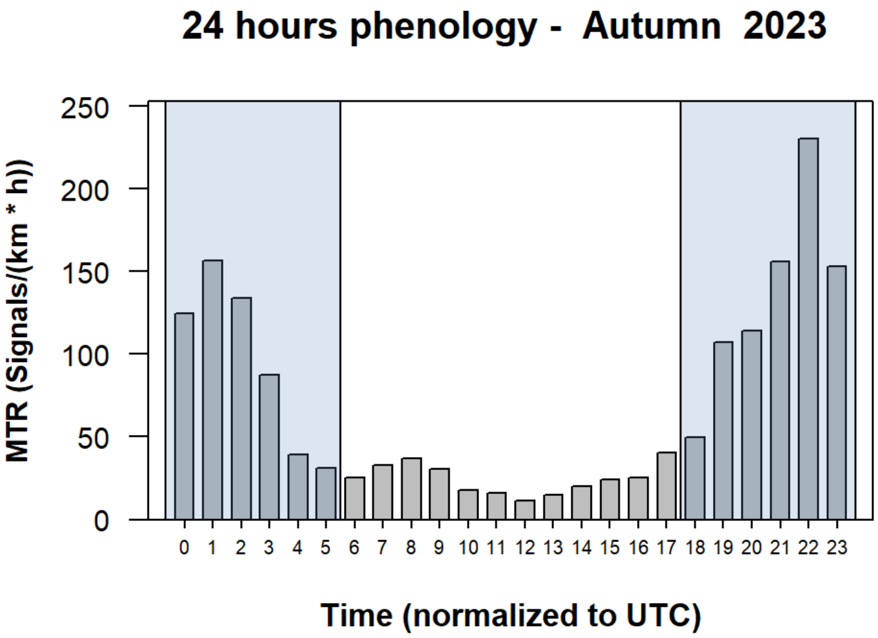


Figure 5-98 **24 h migration intensity from vertical radar data in autumn at the pre-investigation area See Figure 5-97** for details.

FLIGHT DIRECTIONS

Very few bird signals were observed with the horizontal radar in spring. During day, signals indicated different directions of flight. In this case, not a single direction could be significantly chosen. During nocturnal migration, signals indicated however a clear NE direction of flight (despite the few signals, Figure 5-99).

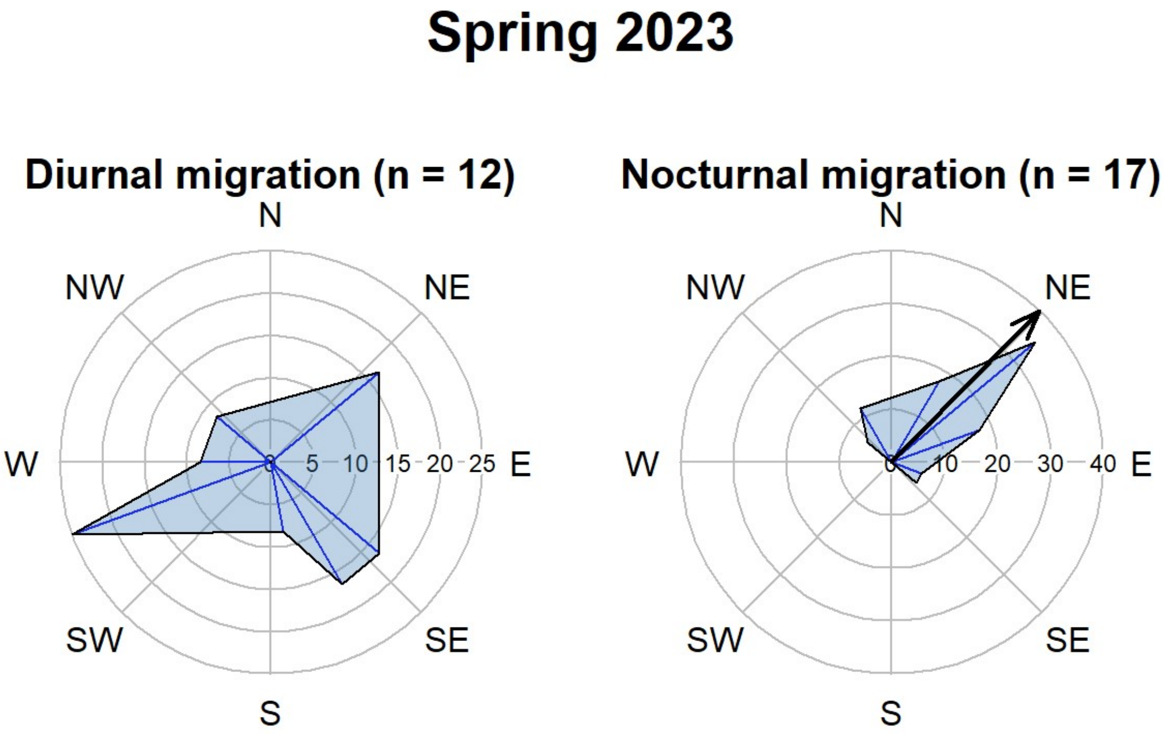


Figure 5-99 Flight direction of bird signals according to the horizontal radar shown in percentage (%) during diurnal and nocturnal migration in spring 2023 at the pre-investigation area. For plotting purposes, flight directions were grouped into groups of 20° increments. Each blue line represents the middle point of the respective grouping. Black arrows indicate a statistically significant mean flight direction of all signals together.

In autumn, more signals were registered than in spring. However, there were fewer bird signals during diurnal migration than during nocturnal migration in this season. In general, there was a difference in the migration directions registered during days (NW) than during nights (SSW) in autumn 2023 (Figure 5-100).

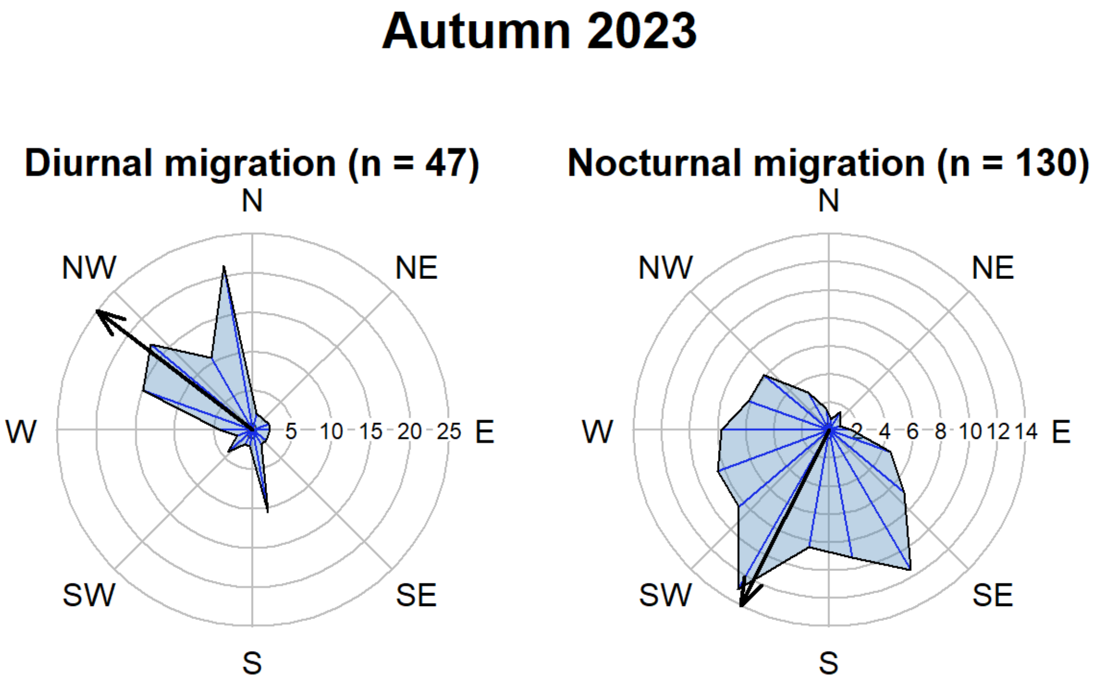


Figure 5-100 Flight direction of bird signals according to the horizontal radar shown in percentage (%) during diurnal and nocturnal migration in autumn 2023 at the pre-investigation area. See Figure 5-99 for details.

6 STATUS

6.1 RESTING BIRDS

6.1.1 AERIAL SURVEYS

In the following section, conclusions from the results of the resting bird surveys will be drawn regarding the importance of the pre-investigation area for the relevant species. Furthermore, the results will be compared with existing data from the area. The main comparison will be with data from PETERSEN ET AL. (2021) and PETERSEN & NILSEN (2011). During the six digital aerial surveys between February 2023 and January 2024, 7,956 resting birds belonging to 23 species were observed.

Common guillemots were the most common species, with 3,064 individuals recorded in total. The second most common species was the common scoter with 1,087 individuals. Of the sea duck family, also common eiders were present in good numbers. Red-throated divers were also frequently present with 500 individuals.

For divers, similar to PETERSEN ET AL. (2021), the highest number of birds in the pre-investigation area was reached in spring (March/April). In that study, the highest counts were found to the northeast and southeast of the pre-investigation area. A comparison of densities with PETERSEN & NILSEN (2011) also showed that the pre-investigation area showed rather low densities up to 0.05 ind./km². Currently, the highest density was 0.37 ind./km² which is also relatively low compared to other key areas like the Pomeranian Bay. However, a comparison of densities between the current and previous studies must be interpreted with care, due to the change in survey method (change from visual to digital surveys). Nevertheless, the general pattern seems consistent across all studies and years. Although the pre-investigation area is not a key area for this species, the potential far-reaching effects of displacement on this species must be considered. Since the overall density of divers is more than 7-fold higher during the present study compared to PETERSEN & NILSEN (2011), it will be important to receive data from the second year of investigation to prove if the higher density of divers during spring is constant over different years.

In the current study, common scoters were present in high numbers only during one survey in April 2023, while usually winter and spring are the periods when the highest densities are reached. However, also in summer, common scoters could be present for moulting (PETERSEN & NIELSEN 2011), but only very small numbers were found during August in the pre-investigation area. According to PETERSEN ET AL. (2021), common scoters were most abundant in the Aalborg Bugt area and in the shallow waters between Læsø and Anholt. In our study, these latter areas were not covered. Instead, in April 2023 most bird aggregated at the tip of Sjællands Odde. Based on our study and previous work, the pre-investigation area does not seem to be a key area for common scoters. However, data from the second year of investigation are needed to check if this pattern is consistent between different years.

Gulls were the third most common species group in the pre-investigation area, with the most abundant species being the herring gull. Similar to findings by PETERSEN ET AL. (2021), gulls were spread widely across the pre-investigation area, with some local concentrations at the coast. PETERSEN ET AL. (2021) identified black-legged kittiwakes as one of the important species in the area, however, in this study only small numbers were found. In general, numbers varied strongly between years and results from the second year will show, if this can also be shown here. Also in previous studies, no high concentrations were found for the pre-investigation area, instead, kittiwakes were located in the eastern part of the pre-investigation area (PETERSEN et al. 2021). The construction of OWF in the pre-investigation area might result in changes in the distribution of gulls, but no significant displacement of these species from the OWF is expected. Changes can rather be expected due to changes in fishing activities, as gulls often follow fishing vessels to feed on discards (GARTHE & SCHERP 2003).

Common guillemots reached the highest densities in the pre-investigation area during autumn and winter and occurred widespread across the area, but the highest densities were reached towards the northeast, in the Middelgrund area. This distribution pattern was also found by PETERSEN ET AL. (2021) and PETERSEN & NILSEN (2011). Towards the west, in the vicinity of the planned OWF, good numbers of birds were recorded as well. Even though common guillemot has recently been shown to display large-scale displacement from OWF in the North Sea (PESCHKO et al. 2024), for the Anholt OWF, which was partly covered by the present surveys, however, no strong displacement effect can be seen during the winter survey and the distribution of these birds does not seem to be strongly influenced by the existing wind farm. However, since no baseline data is available, and the wind farm is only partly covered by the present surveys no clear conclusion on the potential effect of this wind farm can be drawn. Here, data of the second year will help to identify if the distribution of guillemots is influenced by the OWF or not.

Other relevant auk species during the surveys were razorbill and black guillemot. However, these two species were much less common as compared to common guillemot. No potentially important key areas in the vicinity of the proporsed OWF area were identified during this study.

6.2 MIGRATING BIRDS

6.2.1 DIURNAL MIGRATION

A total of 9,177 birds were registered during spring migration at the pre-investigation area during the 14 analysable survey days. Over two/thirds of the diurnally migrating birds registered in the Kattegat area in spring 2023 were barnacle geese. In autumn, 3,105 birds could be observed during the 18 analysable survey days of autumn migration between August and November. One every two of all observed birds during the autumn migration was a duck, of which common scoters (28.6%) and Eurasian wigeons (10.9%) dominated. Other groups of relevance were songbirds, auks and gulls (mainly in autumn).

The most common species in terms of numbers during both seasons was the barnacle goose. Three long-distance migratory populations of barnacle geese exist in the Western Palearctic that migrate in spring to their breeding locations in Russia, Svalbard and Greenland. The pre-investigation area lies within the migratory flyway of the largest of these populations, the Russian population (e.g., GREEN 1998; VAN DER JEUGD et al. 2009). This population that is now estimated at 1,400,000 individuals according to the Waterbirds Populations Portal (http://wpe.wetlands.org, accessed on 11.04.2024), has steadily increased in numbers since the 1980s (e.g., NILSSON & KAMPE-PERSSON 2020). Because of this enormous and rapid growth, these geese have expanded their breeding area towards the southwest within the flyway, with new breeding populations in the Baltic and along the North Sea Coast (see FEIGE et al. 2008; VAN DER JEUGD et al. 2009). These last-mentioned breeding populations of barnacle geese have then become sedentary but share wintering grounds with the migrating populations. Thus, it was not unexpected to find large numbers of this species in the area.

Common scoter was the most common species in autumn and the most common sea duck species in spring (where four out of five ducks was a common scoter). The species breeds at northern latitudes, in tundra regions of Iceland, northern Norway and Siberia, but also in Britain and Ireland (MENDEL et al. 2008). In the North Sea, Skagerrak and Baltic Sea they occur as resting and moulting birds all year, but at especially higher numbers in winter (MENDEL et al. 2008). The main wintering areas are located in the Baltic, Wadden Sea and along the Atlantic coast up to North Africa, with especially high numbers in the shallow parts of the northern Kattegat (SKOV et al. 1995), e.g. in the Aalborg Bugt. The pre-investigation area itself does not constitute an important resting area for these ducks (see section of resting birds), since the area is located on deeper waters than the ones needed for the ducks for foraging. However, it is a bird migration passage area for these birds during autumn migration, for individuals going towards the northern Kattegat and also to further southern resting areas. About 25 years ago, the northern Kattegat was supposed to hold about 38% of the wintering European population of these birds (DURINCK et al. 1994).

The second most common duck and third most commonly seen species during autumn migration at the pre-investigation area was the Eurasian wigeon. Although this duck was seen on several dates in September, October, and also in November, over 82% of all individuals were observed on one day (October 3rd: 46 ind./h). They were mostly seen flying towards the SW, and mostly at low-flying altitudes. The species is palearctic with a breeding distribution in northern Eurasia from Iceland eastwards. Birds that breed in Fennoscandia and western Russia, winter in northwestern Europe (SCOTT & ROSE 1996), and individuals of this population were probably observed on their migration route towards northwestern coastal areas of Europe.

The other two common sea ducks (common eiders and velvet scoters) represented together less than 1.5% and 5% of all migrating birds registered in spring and autumn, respectively. In autumn, both species were mainly seen towards the end of the autumn migration (November survey). The Northern Kattegat is an important wintering area for other ducks as well, but apart from common scoters, it is also known to hold large numbers of common eiders (DURINCK et al. 1994), so it is possible that these ducks were all going towards the Kattegat.

Songbirds as the third most important group in terms of numbers during diurnal migration in spring (6.1%) and the fourth during autumn (8%), were also frequently observed, but no single species occurred at > 1% of abundance in comparison to geese or ducks. Nonetheless, many species were detected (in spring, 23 and in autumn 29), among which meadow pipits and Eurasian jackdaws were most common in spring and Eurasian siskin, wagtails and meadow pipits were the most common in autumn.

Two groups were relevant only during autumn, gulls and auks. Of gulls, two species were the most abundant in autumn: lesser black-backed gulls (4.9%) and black-legged kittiwakes (1.4%). The last species is also worth mentioning because its populations have been declining in the last decades and it is considered vulnerable by the IUCN. Both species also had very different migration patterns. While lesser black-backed gulls were observed between August and October with a third of all individuals flying on August 20th (7 ind./h), kittiwakes, on the other hand, were mostly seen between October and November, and most of them were spotted on October 23rd (4.6 ind./h). Flying directions and altitudes also differed. Lesser black-backed gulls flew to the S while most black-legged kittiwakes flew to the NW, and whereas the first ones flew mainly between 20 and 50 m (45%), the latter mainly flew below 20 m of altitude. Middelgrunden in the northern Kattegat area is also an important bird wintering area for the kittiwakes (DURINCK et al. 1994), so the direction of flight observed would coincide with these birds heading to a wintering location nearby.

Lastly, auks were the last group of birds to mention. Similar number of common guillemots and razorbills were seen at the area, the higher number of individuals of both groups were observed from October onwards and mainly in November (the last days of the survey). They were seen flying in many directions so that possibly they may remain in the area also during winter. It is known from previous surveys in the inner Danish waters that many auks are present in large numbers in winter in areas in the central Kattegat, between Nordsjælland, Anholt and Læsø with water depths of 20-40 m (PETERSEN & NIELSEN 2011). This would coincide with the findings of many auks in the area in the November survey (485.1, Resting birds section).

Altogether, these groups represented the bulk of migrating birds (>90%) during diurnal migration. Nonetheless, there were also some other groups and species that are worth mentioning because they are species whose numbers are threatened and are thus requiring conservation measurements. For example, Eurasian curlews were the most common wader species observed in the area, and is a species considered near threatened by the UICN, because its populations have been declining in the last years.
Birds of prey, which are of great concern regarding potential collision with wind turbines were only seen very rarely. Here, also a second year of data collection will strengthen any conclusions on the occurrence of migrating birds of prey at the planned wind farm sites.

MIGRATION INTENSITIES

The daily mean migration intensity obtained from visual observations during spring was 86 ind./h with a maximum value in May (201 ind./h, due to the peak migration event of geese > 752 ind./h). In autumn, the mean migration intensity was 31.9 ind./h with a maximum value of 104.3 ind./h in October (in autumn, there were two peaks of about the same magnitude, one at the beginning of October, and one by the end of October).

We can compare these values with those of a previous study that used the same methodology in the German North Sea and Baltic Sea (BIOCONSULT SH et al. 2020; IBL UMWELTPLANUNG et al. 2021). In spring, the mean migratory intensity in the area N-7.2 (North Sea) varied between 31 ind./h (in 2019) and 22 ind./h (in 2020), whereas in the area O-1.3 in the German (Western) Baltic Sea, the migration intensity during the same season varied between 48 ind./h in 2016 and 61 ind./h in 2017 (IBL UMWELTPLANUNG et al. 2021). Thus, migration intensities observed during the spring migration in 2023 at the pre-investigation area
were clearly higher as in the two other areas but can be explained by the fact that a day with mass migration of barnacle geese was recorded in the present study and thus the average bird migration intensity was very high. Since the proposed OWP-area Kattegat is only appr. 20 km away from the coast especially species of coastal diurnal migration such as geese can occur in high numbers.
In autumn, mean numbers in N-7.2 were 25.6 ind./h in 2018 and 15.6 ind./h in 2019, which is also lower than the 31.9 ind./h found in the pre-investigation area, which again is due to the fact, that in the offshore area of the North Sea no coastal diurnal migration takes place. In the O-1.3 area, which is located between the island Rügen (Germany) and southern Sweden, autumn migration was considerably more intense with 88.5 ind./h (± 18.5) in 2016 and 126.8 ind./h (± 62.1) in 2017 (IBL UMWELTPLANUNG et al. 2021).

Nonetheless, such comparisons between studies must be treated carefully, however, as they may be based on different days of collection per month, and different years and areas (in the case of the German studies). Moreover, one year of collection as for the current report may not be a representative sample to conclude on general patterns and data of the second year are valuable at this point in order to be able to draw such conclusions.

Migration intensities and flying patterns of the most important groups differed also. Barnacle geese were registered on a few dates from the end of March but were mostly seen at the end of the spring season (May 9th, 2023), when a large migration event occurred, and 752 ind./h were registered. A study using GLS loggers to track the movements of female barnacle geese showed that mid-May was the period in which the majority of the tagged geese were going back to their breeding areas in Russia from the Wadden Sea (EICHHORN et al. 2006). So, the date of peak migration for this species may be coincident with the expected higher migration events. However, the last survey date of the season was indeed May 9th. It is difficult to say whether this was the highest migration point for the barnacle geese or if even higher migration intensities would have been registered if the surveys would have lasted longer. In autumn, most barnacle geese were observed on one date (October 24th, 2023) when 65 ind./h were observed.

Whereas geese mostly occurred in May and on a single date at 752 ind./h during spring, ducks were commonly observed at the pre-investigation area. In comparison to geese, there was no date with a high peak event, but they were seen at mean daily intensities varying between 10 ind./h in March to almost 30 ind./h in April. In May, < 5 ind./h were seen. This indicates that in addition to migrating birds, flying ducks were also recorded as they moved between different resting places.

In autumn, ducks were dominant, especially common scoters. The species was frequently observed and was present on almost all survey dates. Most birds were observed flying however on September 9th and 10th (34 and 29 ind./h). Since common scoters were also seen at relative high densities during the aerial surveys it can be assumed that we registered both, migrating birds and birds moving between different staging areas. Eurasian wigeons, the second most common species in autumn was seen on several dates in September, October and also in November, but over 82% of all individuals were observed on October 3rd (46 ind./h) and indicates that the Kattegat is an important migration area for this species.

Daily mean intensities of songbirds varied roughly between < 3 ind./h in March and in May to > 20 ind./h in April. In autumn, songbirds were frequently observed but only until the last survey date of October. No individual was seen in November. Most of them were seen on October 3rd at 17.7 ind./h. In fact, it is known that diurnally migrating passerine species include low and mid-distance migrants, such as finches and wagtails, which are more dependent on visual orientation cues. Thus, the main migration events of these birds coincide what we know from passage dates of songbirds during autumn migration. Eurasian siskin and meadow pipits, for instance migrated mostly in October, whereas the two species of wagtails were mainly migrating in August and September. Dates of autumn migration passage have been compiled by SOKOLOV and colleagues (SOKOLOV et al. 1999) and agree roughly with the expected migration dates of long-distance (wagtails), and medium-distance (e.g., meadow pipit) and the observed dates of migration of these birds at the area.

In general, migration intensities are very variable between days and also years and highly dependent on the prevailing weather conditions (e.g. WELCKER & VILELA 2019). Birds generally prefer tail winds, fair visibility and no precipitation, and unfavourable weather conditions for longer periods will often lead to mass migration events with very high migration intensities once the weather turns favourable. The high migration peak on May 9th, 2023, coincides with very favourable weather conditions for spring migration. Prevailing winds came from the south-east with wind speeds of about 10 m/s. Also, this date was not only favourable for geese, but it was also the peak migration date for other large birds such as gulls, terns, and a few birds of prey.

Migration intensities from vertical radar during day were on similar levels during spring (22.3 MTR) and autumn (and 22.9 MTR) and thus much lower than the values obtained from visual observations. Vertical radar did not detect the strong peak of migration on the 9th of May during which a large number of geese flew. This can have various causes: it can be assumed that the range of the radar (1,000 m) is far less than the range to which visual observer can detect geese (several kilometres). In addition, the resolution of the radar data can cause the difference: If birds fly in flocks, as geese do for example, then these flocks are only displayed as a single signal on the radar screen and there can therefore be a large difference between the number of sightings and the number of radar echoes. Nonetheless, there was a large migration event detected by the vertical radar during nocturnal migration on the night of the 7th of May, which is most probably caused by typically nocturnal migrating passerines. Also, in autumn, the maximum migration intensity from vertical radar was in November whereas the maximum migration intensity from visual observations occurred in October.

FLIGHT DIRECTIONS

During spring, the main migration direction of all visually observed birds was clearly north-east. This direction was mostly influenced by the direction of flight shown by the most common species/species groups. Geese for instance, moved with a very clear NE direction, whereas other species groups with numerous birds moved also mainly to the NE (e.g., songbirds, gulls, cormorants). However, 21% of the ducks flew to the SE, but they were seen flying in all other directions at similar proportions. This might indicate that some of these ducks may have been resting or foraging. Nonetheless, the overall and clear NE direction observed in most migrating birds meets the expectations of birds crossing the central Kattegat Sea in the shortest possible way across the sea when moving between the wintering areas in southern Europe and breeding areas in northern Scandinavia and Russia. Very few bird signals were available from horizontal radar. Nonetheless, the migration direction of signals during nocturnal migration agrees with the main direction of migration observed during the observer-based surveys.

During diurnal migration in autumn there was not such a strong preference for a single direction as in spring, but most birds (almost 30%) flew in the expected direction: SW. Less than 25% flew to the west but still 15% flew to the south or the northwest. These patterns of flight reflect the directions of flight of the most commonly occurring group: ducks. For example, the most common species in the area in autumn showed different migration directions depending on the period. During their peak migration events on September 9th and 10th, common scoters flew mainly to the NW and W in September, with over half of the birds flying most probably to their wintering areas in the Northern Kattegat. Around 30% of the common scoters registered during the autumn migration flew to the SW and S (mainly those flying later in the season in October and November), probably to other resting areas along the Wadden Sea. The second most common species, Eurasian wigeon was mostly seen flying towards the SW, whereas common eiders were mainly observed flying to the north and velvet scoters were flying mostly towards the SW. Barnacle geese which were also common in autumn was mainly flying towards the west. Directions of flight of most migrating passerines were the SW but also the SE and these agree with expected directions of these birds during autumn migration. Lesser black-backed gulls flew to the S while most black-legged kittiwakes flew to the NW and auks flew in many directions indicating that these birds were no migrants but local birds moving between different resting areas.

Flight directions obtained from horizontal radar signals did not coincide in directions between day and night signals in autumn. During day, most of bird signals were flying mainly to the NW and N whereas during night these were mainly pointing to birds flying towards the SW and SE, with few signals also to the W. When first comparing these results, the patterns may seem strange, but the results of the radar agree with results of observer-based data if looked at carefully. It must be first pointed out that radar signals analysed belonged to data from August and September (see Methods). Most other data was not analysable. Thus, during nocturnal migration, the data reflects mostly passerine migration directions. From diurnally migrating passerines (and from the literature) we know that most passerines flew to the SW, but also to a lesser extent towards the SE, so the directions registered by the horizontal radar point to the expected directions. During days, most of the data registered by the radar probably reflect migration patterns of the most commonly migrating bird in the area during the first survey dates of September (which were the best dates for data analysis of horizontal radar signals): the common scoter which was observed to mainly migrate to the NW and W.

FLIGHT ALTITUDES

About 61% of bird flights visually observed at the pre-investigation area during spring occurred at altitudes between 0 and 20 m, with most (50%) occurring at very low altitudes (0-5 m). Almost 40% of all birds, however, flew at higher altitude classes (> 20 m - > 200 m). This was largely influenced by the flying behaviour of geese. Whereas most flew low, a significant proportion of the migrating geese were flying at altitudes potentially coinciding with rotor height. When weather conditions are good, geese may fly at high altitudes, but if visibility is poor they fly at lower altitudes (cf. PLONCZKIER & SIMMS 2012).

Ducks flew very low (most flew below 20 m) and most passerines also were observed flying at low altitudes. Whereas geese dominated diurnal migration, songbirds were the dominant group during nocturnal migration (90%), as expected.

In autumn, most birds (75%) flew below 20 m of altitude. These were mainly ducks, auks, most passerines and a large number of gulls and other groups. The only group that was migrating at relatively higher altitudes were the geese (72% of geese flew between 50 – 200 m).
It has to be mentioned that the flight height distribution based on visible observation is limited to the higher altitudes and only larger birds (like geese or ducks) can be observed at altitudes >200 m. The detection probability will clearly decrease with distance to the observer and thus also with flight altitude. Therefore, flight height distribution based on vertical radar data are additionally used. These data will be included to the next version of the report.

Data from vertical radar showed also a decrease of bird signals with increasing altitude. In spring and autumn, most signals were detected in the very first 100 meters of altitude, with the proportion being much larger in autumn. Bird signals decreased with increasing altitude but remained at 6-10% in each subsequent layer in spring and below 8% from layers of altitude above 200 m in autumn. In any case, vertical altitude distribution of bird signals from radar data complements and agrees with results obtained from visual observations.

TEMPORAL PATTERNS

During spring migration, the highest bird migration intensity observed visually during daylight, occurred three hours after the civil morning twilight, which was mainly due to the pattern of flight migration of barnacle geese. In general, most birds flew during the first five hours of the day, with decreasing intensities observed after the sixth hour of the day. Of the common groups, only waders showed a high intensity level at later hours of the day.
In autumn, the temporal migration patterns during day were mainly influenced by the most abundant group: ducks. It is known also that common scoters migrate mostly at night (BERNDT & BUSCHE 1993), in fact, their main diurnal migration activity during autumn was during the first two hours after civil morning twilight and very few birds (<3% of all migrating birds) were observed after the 3rd hour after civil morning twilight. Thus, although they were not heard during night migration, it is possible that even a large number of common scoters were migrating during nights. Other species that influenced the temporal pattern during days were the barnacle geese which was mainly active at 4 hours after civil morning twilight.
Temporal patterns during diurnal migration from vertical radar showed constant activity during all day hours in spring and an increase just before sunset, whereas there was a decrease in flight activity at the middle of the day with a slight increase in activity towards the hours close to the sunrise and before sunset in autumn.

6.2.2 NOCTURNAL MIGRATION

Many species of nocturnally migrating birds produce species-specific flight calls during migration, that are thought to serve different functions among which flock maintenance, orientation and stimulation of migration activity are highlighted (FARNSWORTH 2005). Because direct observations of nocturnal migrants are difficult to obtain, the recording of flight calls is often used to study nocturnal migration and is the only method that provides taxonomic information on the migrating species (WELCKER & VILELA 2018). The analysis of flight calls conducted at the pre-investigation area showed that songbirds were the dominant group during nocturnal migration (90% in spring and 94% in autumn), with other groups such as geese, wader and gulls occurring rarely.
It is well known that the bulk of migration movements occurs during the nights (ALERSTAM 1990) and that it is clearly dominated by passerines. Millions of songbirds migrate twice a year between their breeding ranges in Scandinavia and northern Russia and their wintering grounds in southern Europe and Africa (BERTHOLD et al. 2003). The total number of nocturnal passerine migrants has been estimated at about 200-300 million in spring for the western Baltic Sea including Kattegat (BELLEBAUM et al. 2010a).

Since not all bird species vocalise during migration results obtained from the analysis of flight calls only give us additional information on species composition and relative frequency of their abundances as well as the temporal activity pattern. However, it is not possible to compare calls/h with individuals/h, since flight calls may be affected by time of the day and atmospheric conditions (FARNSWORTH 2005; HÜPPOP & HILGERLOH 2012).

In total, relative few calls were heard during spring: 179 calls, and half of all the calls belonged to the group of thrushes (Turdidae), mainly redwings and a smaller number of song thrushes. Other songbirds occurring frequently (non-Turdidae) were European robins and common chiffchaffs. In general, most songbirds were heard migrating at the beginning of the spring (March). But it needs to be mentioned that no valid survey data was available in the month of April when most songbirds were observed during diurnal migration and when according to the literature most songbirds are expected to be passing through the area (e.g., HAEST et al. 2018). For instance, the mean spring migration passage date for redwings, European robin and song thrush has been estimated to take place at April 6th, 16th and 20th at the island of Helgoland, which lies on the migratory flyway of many songbirds and is located about 230 km to the SW of the pre-investigation area (HAEST et al. 2018).

During the night, bird calls increased progressively toward late hours of the night and these reflected patterns observed for both groups of songbirds.

In autumn, on the contrary many calls were heard during the whole survey period: 3,132 calls, with the great majority belonging to the group of thrushes (Turdidae), mostly song thrushes (77.2%) and redwings (9.6%). Other songbirds (non-Turdidae) were not as abundant, but the most numerous species was the European robin (3%). Most of nocturnal migration took place on the night of October 5th (468 calls/h), almost coincident with the date of maximum migration intensity of diurnally migrating passerines (October 3rd).

Results of the vertical radar confirmed that there is a high migration during nights. Migration intensity detected with vertical radars during nights was five (autumn) to over 16 (spring) times larger than during days. There was a very large migration event on the night of the 7th of May and also a second large peak on the next night (8th of May). No comparable peaks were detected by the vertical radar during days, but from visual observations, there was an important migration event of geese observed on the 9th of May. It could be that some of these bird signals reflect also geese that were flying later and at higher altitudes.

Bird signals from vertical radar also indicated a large number of birds flying at all altitudes during nights at relatively similar proportions, especially in spring. In autumn, double as many signals were detected in the first 100 m of altitude. This altitude distribution cannot be compared to data obtained from visual observers but is a known pattern.

7 DATA AND KNOWLEDGE GAPS

The present study shows that quite a good knowledge of birds regularly occurring within the pre-investigation area of the proposed OWF area Kattegat exists. But the analysis of data collected in the field between February 2023 and January 2024 show, that details on fine-scale distribution patterns, seasonal occurrence and absolute density information from different times of the year are very valuable and add a lot of new and additional information to the existing knowledge.

In this study, six digital aerial surveys were conducted covering an area of 4,120.7 km² with 11 % of the area covered to 100 %. The advantage of digital aerial data collection is that densities of seabirds can be assessed quickly and with a uniform collection effort on a large spatial scale in contrast to ship-based surveys and observer-based aerial surveys, where corrections for missing birds in greater distances have to be applied (ŽYDELIS et al. 2019). Still, this method is considered a “snap-shot”-method since the distribution of seabirds is only observed during the specific time frame of a flight and not continuously. Therefore, the results only show the abundance on the specific survey date and during daylight hours, so that distribution pattern can be different comparing results from different days,

Nonetheless our results show that basically the pattern of resting birds in the Kattegat area coincides with the existing knowledge but can give much more precise details on the presence of birds inside and outside the proposed OWF areas. As the distribution of birds always depends on the situation on the respective survey day, surveys should therefore be performed in different months, covering different seasons and preferably two years in order to be able to draw better conclusions about seasonal and spatial distribution patterns.

Even more, the data collected on migrating birds are important to fill the gap of existing knowledge from the offshore areas, since no data are existing from the proposed OWF area itself. Although the extensive literature review provided a solid basis to assess, which migratory bird species should be expected in the investigation area and its surroundings, the field data give precise information on migration intensity, species composition and flight height distribution.

A combination of results from the baseline study in the preliminary investigation area and existing results is therefore crucial. The upcoming additional study period from February 2024 to January 2025 will not only strengthen the overall data-set and the following analysis of the data, but also make it possible to get a better understanding of the annual variability in abundances and distribution patterns, thereby strengthening the conclusions of this study by either confirming or rejecting the conclusions made based on the first-year survey results.

8 CONCLUSION

Resting birds:

The results of the resting birds survey revealed valuable information on their presence and distribution in the pre-investigation area for the proposed OWF Hesselø.

Among the recorded resting bird species, auks, especially common guillemots, were the most abundant in the pre-investigation area with highest densities either in the north during winter or in the northeast and southwest during autumn. Sea ducks were the second most common species group with common scoters being the most frequently observed species, which mostly aggregated at the tip of Sjællands Odde. Gulls were the third most common species group occurring typically widely spread across the pre-investigation area. Divers (particularly red-throated divers) occurred broadly distributed over the entire pre-investigation area but were found in higher numbers than expected. Since divers are especially susceptible to disturbances by wind farms (and ship traffic), data from the upcoming second survey year will be of great importance for this species to determine whether the observed distribution patterns and densities were an exception or steady. The same applies to common guillemots, which were present in large numbers across the entire pre-investigation particularly in winter.

The results generally showed that the observed distribution patterns and abundances of recorded species were generally in line with already published data, thus confirming described patterns, but providing much more precise details at a finer temporal and spatial level. The same applies to species specific seasonal distributions and abundances. Data from the second year will provide relevant information, whether seasonal and spatial patterns will be consistent over time.

Migrating birds:

Results show that the pre-investigation area was subject to large bird migration, especially during spring, in which large numbers of geese (mainly barnacle geese) were observed. In addition, to geese, ducks (common scoters and to a lesser extent, Eurasian wigeons) were frequently observed. These three species dominated migration during daytime, especially occurring at high numbers during days with good weather conditions in which large migration events take place. In addition, songbirds were not as abundantly registered during daytime, but calls from songbirds (especially thrushes, and European robins) dominated nocturnally registered migration in the pre-investigation area, suggesting that the area is part of the broad band nocturnal migration route for passerines.

Flying altitudes of most ducks occurred below 20 m, but most geese were frequently observed flying at higher altitudes, well above 50 m. Especially, in spring, most geese were registered on a single migration day, and flying in the expected direction (NE), whereas the flying directions of common scoters suggest that they might have been heading towards resting areas located relatively close to the pre-investigation area: either in the north (Aalborg Bugt), or towards to the south, closer to the coast of Hesselø Bugt, areas that were previously recognized as important resting areas for common scoters (DURINCK et al. 1994).

Cranes were registered during two days at the beginning of spring flying also in the expected NE direction, however, the number of individuals registered (56), though considerable, was not large enough to represent at least 1% of the total number of migrating birds in any season. Nonetheless, given their large size and their inherent vulnerability to potential collisions with offshore wind turbines, it is worth mentioning that some crane migration was observed in the pre-investigation area. On the other hand, and surprisingly, very few birds of prey were observed. A second year of investigations will certainly provide more information on the patterns of bird migration at the pre-investigation area.

Bird migration intensity measured with the vertical radar confirms a high nocturnal migration flow through the area with higher values in spring than in autumn. While the nocturnal bird migration is relatively evenly distributed across all altitude classes up to 1,000 m, especially in spring, birds clearly favour the lowest altitude class of 0-100 m during the day. Results from the horizontal radar showed that during nocturnal migration, bird signals were detected in the expected migration directions (NE, in spring and SW, in autumn). The comparatively fewer signals registered during diurnal migration, were observed in various and different directions. In autumn, most probably they represent directions chosen by the most common species: common scoters.

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10 APPENDIX

Table A-1: Species list of all birds detected during the five digital aerial surveys between February 2023 and January 2024 at the pre-investigation area. Species names are provided in English, Danish and in Latin names as well as their inclusion in various relevant categories of conservation at European level. Number of individuals and whether the bird is considered a resting or only a migratory bird (and thus not considered in the analysis of resting birds) is also indicated.

Species groups	Common names in		Scientific names	Resting / Migratory	Number of ind.	Conservation/Protection categories			
	English	Danish				Birds Dir	UICN	EU Cat 28	AEWA
Divers	Red-throated diver	Rødstrubet Lom	*Gavia stellata*	R/M	500	I	LC	LC	B 2e
Divers	Black-throated diver	Sortstrubet Lom	*Gavia arctica*	R/M	17	I	LC	LC	B 2c
Divers	unidentified diver		*Gavia sp.*	R/M	18				
Grebes	Great crested grebe	Toppet Lappedykker	*Podiceps cristatus*	R/M	10		LC	LC	C 1
Grebes	unidentified grebe		*Podicipedidae sp.*	R/M	5				
Tubenoses	Northern fulmar	Mallemuk	*Fulmarus glacialis*	R/M	7		VU	EN	
Gannets	Northern gannet	Sule	*Morus bassanus*	R/M	6		LC	LC	C 1
Cormorants	Great cormorant	Skarv	*Phalacrocorax carbo*	R/M	306		LC	LC	C 1
Swans	Mute swan	Knopsvane	*Cygnus olor*	M	2		LC	LC	C 1
Geese	Greylag goose	Grågås	*Anser anser*	M	25		LC	LC	C 1 / B 1
Geese	Canada goose	Canadagås	*Branta canadensis*	M	1		LC	N/A	

Ducks	Mallard	Gråand	*Anas platyrhynchos*	M	2		LC	LC	C 1
Ducks	Common eider	Ederfugl	*Somateria mollissima*	R/M	481		EN	VU	A 4
Ducks	Long-tailed duck	Havlit	*Clangula hyemalis*	R/M	9		LC	LC	A 1b
Ducks	Common scoter	Sortand	*Melanitta nigra*	R/M	1,087		LC	N/A	B 2a
Ducks	Common /velvet scoter		*Melanitta sp.*	R/M	3				
Ducks	Velvet scoter	Fløjlsand	*Melanitta fusca*	R/M	7		VU	VU	A 1b
Ducks	Red-breasted merganser	Toppet Skallesluger	*Mergus serrator*	M	173		NT	NT	B 2c
Ducks	Unidentified merganser		*Mergus sp.*	M	1				
Ducks	unidentified duck		*Anatinae sp.*	M	6				
Birds of prey	Eurasian marsh harrier	Rørhøg	*Circus aeruginosus*	M	1	I	LC	LC	
Birds of prey	Osprey	Fiskeørn	*Pandion haliaetus*	M	1	I	LC	LC	
Birds of prey	Common kestrel	Tårnfalk	*Falco tinnunculus*	M	2		LC	LC	
Waders	Eurasian oystercatcher	Strandskade	*Haematopus ostralegus*	M	4		VU	VU	A 4
Waders	European golden plover	Hjejle	*Pluvialis apricaria*	M	10	I	LC	LC	C 1

Waders	unidentified wader		*Limicolae*	M	20				
Skuas	Arctic skua	Almindelig Kjove	*Stercorarius parasiticus*	R/M	1		EN	EN	
Gulls	Little gull	Dværgmåge	*Hydrocoloeus minutus*	R/M	1	I	LC	LC	A (3c 3e)
Gulls	Black-headed gull	Hættemåge	*Chroicocephalus ridibundus*	R/M	16		LC	VU	B 2c
Gulls	Common gull	Stormmåge	*Larus canus*	R/M	209		LC	LC	B 2c
Gulls	unidentified small gull		*Larus small sp.*	R/M	22				
Gulls	Lesser Black-backed gull	Sildemåge	*Larus fuscus*	R/M	176		LC	LC	A 3c / B 2e / C1
Gulls	Herring gull	Sølvmåge	*Larus argentatus*	R/M	422		LC	VU	B 2c 2e /C1
Gulls	Common/herring gull		*Larus canus / Larus argentatus*	R/M	24				
Gulls	Great Black-backed gull	Svartbag	*Larus marinus*	R/M	138		LC	NT	B 2c
Gulls	unidentified large gull		*Larus (magnus) sp.*	R/M	24				
Gulls	Great / lesser black-backed gull		*Larus fuscus/Larus marinus*	R/M	11				
Gulls	Black-legged kittiwake	Ride	*Rissa tridactyla*	R/M	150		VU	EN	A 1b

Gulls	fulmar/gull		*Fulmarus/Larus*	R/M	6				
Gulls	unidentified gull		*Laridae sp.*	R/M	27				
Terns	Sandwich tern	Splitterne	*Thalasseus sandvicensis*	R/M	2	I	LC	LC	C 1
Terns	Common/Arctic tern		*Sterna hirundo/Sterna paradisaea*	R/M	1	I			C 1
Auks	Common guillemot	Lomvie	*Uria aalge*	R/M	3,064	I * (iberica)	LC	LC	C 1 / B 1
Auks	Common guillemot/razorbill		*Uria aalge / Alca torda*	R/M	642				
Auks	Razorbill	Alk	*Alca torda*	R/M	349		LC	LC	C 1
Auks	Black guillemot	Tejst	*Cepphus grylle*	R/M	88		LC	LC	B 1
Auks	Atlantic puffin	Lunde	*Fratercula arctica*	R/M	1		EN	LC	A 1b
Auks	unidentified auk		*Alcidae sp.*	R/M	126				
Pigeons	Feral pigeon		*Columba livia domestica*	M	1				
Songbirds	unidentified *Fringilla* finch		*Fringilla sp.*	M	12				
Songbirds	unidentified songbird		Passerine sp	M	24				

Birds	unidentified bird		Aves sp	M	262				
Total					8,503				

Table A-2: **Species list of all migrating birds observed (diurnal migration, visual observations) and heard (nocturnal migration, flight calls) during the surveys in spring 2023 at the pre-investigation area Kattegat. Species names are provided in English, Danish and in Latin names as well as their inclusion in various relevant categories of conservation at European level. The number of individual birds seen or calls heard is given as well as the percentage in relation to total for each type of data.**

Species groups	**Common names in**		**Scientific names**	**Conservation/Protection categories**				**Visual observations**		**Flight calls**	
	English	**Danish**		**Birds Dir**	UICN	EU Cat 28	**AEWA**	**N indiv.**	**%**	**N indiv**	**%**
Divers	Red-throated diver	Rødstrubet Lom	*Gavia stellata*	I	LC	LC	B 2e	12	0.13		
Divers	Black-throated diver	Sortstrubet Lom	*Gavia arctica*	I	LC	LC	B 2c	14	0.15		
Divers	White-billed diver	Hvidnæbbet Lom	*Gavia adamsii*		N/A	VU	A 1c	1	0.01		
Divers	unidentified diver		*Gavia sp.*					32	0.35		
Grebes	Red-necked grebe	Gråstrubet Lappedykker	*Podiceps grisegena*		VU	VU	A 3c	1	0.01		

Grebes	unidentified grebe		Podicipedidae *sp.*					3	0.03		
Gannets	Northern gannet	Sule	*Morus bassanus*		LC	LC	C 1	27	0.29		
Cormorants	Great cormorant	Skarv	*Phalacrocorax carbo*		LC	LC	C 1	180	1.96		
Herons	Grey heron	Fiskehejre	*Ardea cinerea*		LC	LC	C 1	1	0.01		
Swans	Mute swan	Knopsvane	*Cygnus olor*		LC	LC	C 1	2	0.02		
Swans	Whooper swan	Sangsvane	*Cygnus cygnus*	I	LC	LC	C 1	9	0.1		
Swans	unidentified swan		*Cygnus sp.*					17	0.19		
Geese	unidentified goose		*Anser/Branta sp.*					68	0.74		
Geese	Bean goose	Tajgasædgås	*Anser fabalis*		VU	LC	A 3c*	25	0.27		
Geese	Greylag goose	Grågås	*Anser anser*		LC	LC	C 1 / B 1	155	1.69		
Geese	Barnacle goose	Bramgås	*Branta leucopsis*	I	LC	LC	C 1	6,235	67.94	12	6.7
Geese	Brent goose	Knortegås	*Branta bernicla*		LC	LC		80	0.87		
Ducks	Common shelduck	Gravand	*Tadorna tadorna*		LC	LC	B 2a	5	0.05		
Ducks	Eurasian teal	Krikand/Amerikansk Krikand	*Anas crecca*		LC	LC	C 1	1	0.01		
Ducks	Common eider	Ederfugl	*Somateria mollissima*		VU	EN	A 4	84	0.92		

Ducks	Long-tailed duck	Havlit	*Clangula hyemalis*		LC	LC	A 1b	36	0.39		
Ducks	Common scoter	Sortand	*Melanitta nigra*		N/A	LC	B 2a	981	10.69		
Ducks	Velvet scoter	Fløjlsand	*Melanitta fusca*		VU	VU	A 1b	50	0.54		
Ducks	Red-breasted merganser	Toppet Skallesluger	*Mergus serrator*		NT	NT	B 2c	14	0.15		
Ducks	unidentified duck		Anatinae *sp.*					44	0.48		
Birds of prey	European honey-buzzard	Hvepsevåge	*Pernis apivorus*	I	LC	LC		2	0.02		
Birds of prey	Hen harrier	Blå Kærhøg	*Circus cyaneus*	I	VU	LC		1	0.01		
Birds of prey	Eurasian sparrowhawk	Spurvehøg	*Accipiter nisus*	I * (granti)	LC	LC		6	0.07		
Birds of prey	unidentified *Buteo* buzzard		*Buteo sp.*					1	0.01		
Birds of prey	unidentified bird of prey		*Falconiformes/Accipitriformes*					1	0.01		
Birds of prey	Common kestrel	Tårnfalk	*Falco tinnunculus*		LC	LC		2	0.02		

Birds of prey	Merlin	Dværgfalk	*Falco columbarius*	I	VU	VU		1	0.01		
Cranes	Common Crane	Trane	*Grus grus*	I	LC	LC	C 1	56	0.61		
Waders	Eurasian oystercatcher	Strandskade	*Haematopus ostralegus*		VU	VU	A 4			3	1.7
Waders	Sanderling	Sandløber	*Calidris alba*		LC	LC	C 1	1	0.01		
Waders	Eurasian curlew	Storspove	*Numenius arquata*		NT	NT	A 4	128	1.39		
Waders	Common redshank	Rødben	*Tringa totanus*		VU	VU	B 2c / C 1	2	0.02		
Waders	Common sandpiper	Mudderklire	*Actitis hypoleucos*		LC	LC	B 2c			2	1.1
Waders	unidentified wader		Limicolae							1	0.6
Skuas	Arctic skua	Almindelig Kjove	*Stercorarius parasiticus*		EN	EN		2	0.02		
Gulls	Little gull	Dværgmåge	*Hydrocoloeus minutus*	I	LC	LC	A (3c 3e)	2	0.02		
Larus Gulls	Black-headed gull	Hættemåge	*Chroicocephalus ridibundus*		VU	LC	B 2c	30	0.33		
Larus Gulls	Common gull	Stormmåge	*Larus canus*		LC	LC	B 2c	62	0.68	2	1.1
Larus Gulls	Lesser black-backed gull	Sildemåge	*Larus fuscus*		LC	LC	A 3c / B 2e / C1	53	0.58		

Larus Gulls	Herring gull	Sølvmåge	*Larus argentatus*		VU	LC	B 2c 2e /C1	43	0.47		
Larus Gulls	Great black-backed gull	Svartbag	*Larus marinus*		NT	LC	B 2c	10	0.11		
Gulls	unidentified gull		*Laridae sp.*					9	0.1	1	0.6
Terns	Sandwich tern	Splitterne	*Thalasseus sandvicensis*	I	LC	LC	C 1	7	0.08		
Terns	Common tern	Fjordterne	*Sterna hirundo*	I	LC	LC	C 1	2	0.02		
Terns	Common tern / Arctic tern		*Sterna hirundo/Sterna paradisaea*	I			C 1	28	0.31		
Auks	Common guillemot	Lomvie	*Uria aalge*	I * (iberica)	LC	LC	C 1 / B 1	12	0.13		
Auks	Common guillemot / razorbill		*Uria aalge / Alca torda*					5	0.05		
Auks	Razorbill	Alk	*Alca torda*		LC	LC	C 1	57	0.62		
Auks	Black guillemot	Tejst	*Cepphus grylle*		LC	LC	B 1	10	0.11		
Auks	Atlantic puffin	Lunde	*Fratercula arctica*		LC	EN	A 1b	1	0.01		
Auks	unidentified auk		*Alcidae sp.*					2	0.02		

Pigeons	Common wood pigeon	Ringdue	*Columba palumbus*	I * (azorica)	LC	LC		1	0.01		
Swifts	Common wwift	Mursejler	*Apus apus*		NT	NT		3	0.03		
Songbirds	Sky lark	Sanglærke	*Alauda arvensis*		LC	LC		10	0.11	3	1.7
Songbirds	Barn swallow	Landsvale	*Hirundo rustica*		LC	LC		24	0.26		
Songbirds	unidentified swallow / martin		*Hirundinidae sp.*					6	0.07		
Songbirds	Meadow pipit	Engpiber	*Anthus pratensis*		LC	LC		82	0.89	2	1.1
Songbirds	unidentified pipit		*Anthus sp.*					3	0.03		
Songbirds	White wagtail / pied wagtail	Hvid Vipstjert	*Motacilla alba*		LC	LC		7	0.08		
Songbirds	Winter wren	Gærdesmutte	*Troglodytes troglodytes*	I * (fridariensis)	LC	LC		2	0.02		
Songbirds	Hedge accentor	Jernspurv	*Prunella modularis*		LC	LC		1	0.01		
Songbirds	European robin	Rødhals	*Erithacus rubecula*		LC	LC				28	15.6
Songbirds	Song thrush	Sangdrossel	*Turdus philomelos*		LC	LC		1	0.01	12	6.7
Songbirds	Redwing	Vindrossel	*Turdus iliacus*		LC	LC		3	0.03	71	39.7

Songbirds	Mistle thrush	Misteldrossel	*Turdus viscivorus*		LC	LC				5	2.8
Songbirds	unidentified thrush		*Turdus sp.*					1	0.01	1	0.6
Songbirds	Common chiffchaff	Gransanger	*Phylloscopus collybita*		N/A	LC		4	0.04	10	5.6
Songbirds	unidentified leaf warbler		*Phylloscopus sp.*					1	0.01	1	0.6
Songbirds	Goldcrest	Fuglekonge	*Regulus regulus*		LC	LC				1	0.6
Songbirds	Eurasian jackdaw	Allike	*Coloeus monedula*		LC	LC		48	0.52		
Songbirds	Rook	Råge	*Corvus frugilegus*		LC	VU		3	0.03		
Songbirds	Crow	Sortkrage	*Corvus corone*		LC	LC		2	0.02		
Songbirds	Carrion crow		*Corvus corone corone*					1	0.01		
Songbirds	Hooded crow	Gråkrage	*Corvus cornix*					7	0.08		
Songbirds	Common raven	Ravn	*Corvus corax*		LC	LC		2	0.02		
Songbirds	unidentified crow		*Corvus sp.*					5	0.05		
Songbirds	Common starling	Stær	*Sturnus vulgaris*		LC	LC		17	0.19		
Songbirds	Chaffinch	Bogfinke	*Fringilla coelebs*	I * (ombriosa)	LC	LC		7	0.08	7	3.9

Songbirds	Brambling	Kvækerfinke	*Fringilla montifringilla*		LC	LC		22	0.24		
Songbirds	unidentified *Fringilla* finch		*Fringilla sp.*					39	0.42		
Songbirds	European goldfinch	Stillits	*Carduelis carduelis*		LC	LC		3	0.03		
Songbirds	Eurasian siskin	Grønsisken	*Spinus spinus*		LC	LC		13	0.14		
Songbirds	Common linnet	Tornirisk	*Linaria cannabina*		LC	LC		1	0.01		
Songbirds	unidentified *Carduelis* finch		*Carduelis sp.*					17	0.19		
Songbirds	Snow bunting	Snespurv	*Plectrophenax nivalis*		LC	LC		9	0.1		
Songbirds	Reed bunting	Rørspurv	*Emberiza schoeniclus*		LC	LC		6	0.07	3	1.7
Songbirds	unidentified songbird		Passerine *sp*					213	2.32		
Total								9177		179	

Table A.3: Species list of all migrating birds observed (diurnal migration, visual observations) and heard (nocturnal migration, flight calls) during the surveys in autumn 2023 at the pre-investigation area Hesselo. Species names are provided in English, Danish and in Latin names as well as their inclusion in various relevant categories of conservation at European level. The number of individual birds seen or calls heard is given as well as the percentage in relation to total for each type of data.

Species groups	Common names in		Scientific names	Conservation/Protection categories				Visual observations		Flight calls	
	English	Danish		Birds Dir	UICN	EU Cat 28	AEWA	N indiv.	%	N indiv	%
Divers	Red-throated diver	Rødstrubet Lom	*Gavia stellata*	I	LC	LC	B 2e	18	0.6		
Divers	unidentified diver		*Gavia sp.*					6	0.2		
Tubenoses	Northern fulmar	Mallemuk	*Fulmarus glacialis*		VU	EN		3	0.1		
Gannets	Northern gannet	Sule	*Morus bassanus*		LC	LC	C 1	124	4		
Cormorants	Great cormorant	Skarv	*Phalacrocorax carbo*		LC	LC	C 1	68	2.2		
Herons	Grey heron	Fiskehejre	*Ardea cinerea*		LC	LC	C 1	5	0.2	1	0
Swans	Whooper swan	Sangsvane	*Cygnus cygnus*	I	LC	LC	C 1	109	3.5		
Geese	unidentified goose		*Anser/Branta sp.*					30	1		
Geese	Greylag goose	Grågås	*Anser anser*		LC	LC	C 1 / B 1	17	0.5		
Geese	Canada goose	Canadagås	*Branta canadensis*		LC	N/A		13	0.4		

Geese	Barnacle goose	Bramgås	*Branta leucopsis*	I	LC	LC	C 1	361	11.6		
Geese	Brent goose	Knortegås	*Branta bernicla*		LC	LC		19	0.6		
Ducks	Eurasian wigeon	Pibeand	*Mareca penelope*		LC	VU	B 2c	337	10.9		
Ducks	Mallard	Gråand	*Anas platyrhynchos*		LC	LC	C 1	2	0.1		
Ducks	Northern pintail	Spidsand	*Anas acuta*		VU	EN	B 1	18	0.6		
Ducks	Greater scaup	Bjergand	*Aythya marila*		LC	EN	C 1	25	0.8		
Ducks	Common eider	Ederfugl	*Somateria mollissima*		EN	VU	A 4	78	2.5		
Ducks	Long-tailed duck	Havlit	*Clangula hyemalis*		LC	LC	A 1b	3	0.1		
Ducks	Common scoter	Sortand	*Melanitta nigra*		LC	N/A	B 2a	887	28.6		
Ducks	Velvet scoter	Fløjlsand	*Melanitta fusca*		VU	VU	A 1b	76	2.4		
Ducks	Common goldeneye	Hvinand	*Bucephala clangula*		LC	LC	B 2c	3	0.1		
Ducks	Red-breasted merganser	Toppet Skallesluger	*Mergus serrator*		NT	NT	B 2c	1	0		
Ducks	unidentified duck		*Anatinae sp.*					136	4.4		
Birds of prey	Eurasian marsh harrier	Rørhøg	*Circus aeruginosus*	I	LC	LC		2	0.1		

Birds of prey	Hen harrier	Blå Kærhøg	*Circus cyaneus*	I	LC	VU		1	0		
Birds of prey	Merlin	Dværgfalk	*Falco columbarius*	I	VU	VU		1	0		
Waders	Eurasian oystercatcher	Strandskade	*Haematopus ostralegus*		VU	VU	A 4			60	1.9
Waders	Ringed plover	Stor Præstekrave	*Charadrius hiaticula*		LC	LC	B 1	17	0.55	41	1.3
Waders	European golden plover	Hjejle	*Pluvialis apricaria*	I	LC	LC	C 1	10	0.32		
Waders	Grey plover	Strandhjejle	*Pluvialis squatarola*		LC	LC	B 2e	1	0.03	2	0.1
Waders	Red knot	Islandsk Ryle	*Calidris canutus*		LC	LC	A 4	8	0.26		
Waders	Dunlin	Almindelig Ryle	*Calidris alpina*	I * (schinzii)	LC	LC	C1	7	0.23		
Waders	Ruff	Brushane	*Calidris pugnax*	I	NT	NT	B 2c	2	0.06		
Waders	Snipe	Dobbeltbekkasin	*Gallinago gallinago*		VU	LC	B 2c			13	0.4
Waders	Whimbrel	Småspove	*Numenius phaeopus*		LC	LC	C 1	7	0.2		
Waders	Common greenshank	Hvidklire	*Tringa nebularia*		LC	LC	C 1			3	0.1

Waders	Common sandpiper	Mudderklire	*Actitis hypoleucos*		LC	LC	B 2c			37	1.2
Waders	unidentified wader		*Limicolae*							3	0.1
Skuas	Arctic skua	Almindelig Kjove	*Stercorarius parasiticus*		EN	EN		1	0		
Skuas	Great skua	Storkjove	*Stercorarius skua*		LC	LC	B 1	4	0.1		
Gulls	Black-headed gull	Hættemåge	*Chroicocephalus ridibundus*		LC	VU	B 2c	3	0.1		
Gulls	Common gull	Stormmåge	*Larus canus*		LC	LC	B 2c	17	0.5		
Gulls	Lesser black-backed gull	Sildemåge	*Larus fuscus*		LC	LC	A 3c / B 2e / C1	152	4.9	10	0.3
Gulls	Herring gull	Sølvmåge	*Larus argentatus*		LC	VU	B 2c 2e /C1	16	0.5	9	0.3
Gulls	Great black-backed gull	Svartbag	*Larus marinus*		LC	NT	B 2c	13	0.4		
Gulls	Black-legged kittiwake	Ride	*Rissa tridactyla*		VU	EN	A 1b	45	1.4		
Gulls	unidentified gull		*Laridae sp.*					7	0.2	1	0
Terns	Sandwich tern	Splitterne	*Thalasseus sandvicensis*	I	LC	LC	C 1	3	0.1		
Terns	Black tern	Sortterne	*Chlidonias niger*	I	LC	LC	B 2c	1	0		

Auks	Common guillemot	Lomvie	*Uria aalge*	I * (iberica)	LC	LC	C 1 / B 1	69	2.2		
Auks	Common guillemot / razorbill		*Uria aalge / Alca torda*					36	1.2		
Auks	Razorbill	Alk	*Alca torda*		LC	LC	C 1	66	2.1		
Auks	Black guillemot	Tejst	*Cepphus grylle*		LC	LC	B 1	12	0.4		
Auks	Little auk	Søkonge	*Alle alle*		LC	NE	C (1)	1	0		
Auks	unidentified auk		*Alcidae sp.*					14	0.5		
Pigeons	Feral pigeon		*Columba livia domestica*					1	0		
Swifts	Common swift	Mursejler	*Apus apus*		NT	NT		1	0		
Songbirds	Sky lark	Sanglærke	*Alauda arvensis*		LC	LC		2	0.1		
Songbirds	Barn swallow	Landsvale	*Hirundo rustica*		LC	LC		5	0.2		
Songbirds	unidentified swallow / martin		*Hirundinidae sp.*					3	0.1		
Songbirds	Olive-backed pipit	Tajgapiber	*Anthus hodgsoni*		LC	N/A		2	0.1		
Songbirds	Tree pipit	Skovpiber	*Anthus trivialis*		LC	LC		6	0.2	15	0.5
Songbirds	Meadow pipit	Engpiber	*Anthus pratensis*		LC	LC		27	0.9		

Songbirds	Yellow wagtail	Gul Vipstjert	*Motacilla flava*		LC	LC		21	0.7		
Songbirds	White wagtail / pied wagtail	Hvid Vipstjert	*Motacilla alba*		LC	LC		31	1		
Songbirds	Winter wren	Gærdesmutte	*Troglodytes troglodytes*	I * (fridariensis)	LC	LC		3	0.1		
Songbirds	Hedge accentor	Jernspurv	*Prunella modularis*		LC	LC				1	0
Songbirds	European robin	Rødhals	*Erithacus rubecula*		LC	LC		3	0.1	95	3
Songbirds	Common redstart	Rødstjert	*Phoenicurus phoenicurus*		LC	LC		4	0.1		
Songbirds	Northern wheatear	Stenpikker	*Oenanthe oenanthe*		LC	NT		1	0		
Songbirds	Common blackbird	Solsort	*Turdus merula*		LC	LC		1	0	13	0.4
Songbirds	Fieldfare	Sjagger	*Turdus pilaris*		LC	LC				5	0.2
Songbirds	Song thrush	Sangdrossel	*Turdus philomelos*		LC	LC				2419	77.2
Songbirds	Redwing	Vindrossel	*Turdus iliacus*		LC	LC		2	0.1	300	9.6
Songbirds	Mistle thrush	Misteldrossel	*Turdus viscivorus*		LC	LC				2	0.1
Songbirds	unidentified thrush		*Turdus sp.*							1	0
Songbirds	Icterine warbler	Gulbug	*Hippolais icterina*		LC	LC		1	0		

Songbirds	Lesser whitethroat	Gærdesanger	*Curruca curruca*		LC	N/A		2	0.1		
Songbirds	Garden warbler	Havesanger	*Sylvia borin*		LC	LC		1	0		
Songbirds	Blackcap	Munk	*Sylvia atricapilla*		LC	LC		2	0.1		
Songbirds	Common chiffchaff	Gransanger	*Phylloscopus collybita*		LC	N/A		5	0.2		
Songbirds	Goldcrest	Fuglekonge	*Regulus regulus*		LC	LC		10	0.3		
Songbirds	Pied flycatcher	Broget fluesnapper	*Ficedula hypoleuca*		LC	LC		1	0		
Songbirds	Blue tit	Blåmejse	*Cyanistes caeruleus*		LC	N/A		7	0.2		
Songbirds	Common starling	Stær	*Sturnus vulgaris*		LC	LC		14	0.5		
Songbirds	Chaffinch	Bogfinke	*Fringilla coelebs*	I * (ombriosa)	LC	LC		3	0.1		
Songbirds	Brambling	Kvækerfinke	*Fringilla montifringilla*		LC	LC		5	0.2	4	0.1
Songbirds	European greenfinch	Grønirisk	*Chloris chloris*		LC	LC		1	0		
Songbirds	Eurasian siskin	Grønsisken	*Spinus spinus*		LC	LC		37	1.2		
Songbirds	Common linnet	Tornirisk	*Linaria cannabina*		LC	LC		1	0		
Songbirds	Lesser redpoll	Stor Gråsisken	*Acanthis flammea*		LC	LC		1	0		

Songbirds	Reed bunting	Rørspurv	*Emberiza schoeniclus*		LC	LC		1	0		
Songbirds	Unidentified songbird		Passerine sp.					45	1.4	97	3.1
Total	83 species							**3,105**	**100**	**3,132**	**100**