ENERGINET ELTRANSMISSION A/S

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

TECHNICAL REPORT BIRDS – HESSELØ 2023 - 2024

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ENERGINET.DK

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
Bft	Beaufort
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency of Germany)
CSR	Conservation status report
DCE	Danish Centre for Environment and Energy
DHI	Dansk Hydraulisk Institut (Danish Hydraulic Institute)
EEA	European Environment Agency
EU	European Union
EUNIS	European Nature Information System
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
SAC	Special Area of Conservation
SCI	Site of Community Importance
SPA	Special Protected Area
UNEP	United Nations Environment Programme
WP	Waypoints

1 SUMMARY

In 2018, all parties in the Folketing (Danish parliament) decided to build three new offshore wind farms, including Hesselø Offshore Wind Farm (OWF), which was part of the next steps towards achieving 100% renewable energy in the electricity system in 2030.

In the agreement about tender framework agreed by the Danish Parliament in May 2025, it was decided that the tender for Hesselø OWF will be launched in autumn 2025, with deadline already in spring 2026. According to the plan, Hesselø OWF should be established in 2032.

This report presents the results of the 2nd year of bird surveys undertaken in the pre-investigation area for the planned Hesselø OWF (DK01), and compares the results obtained with the 1st year of baseline monitoring as well as with available literature of abundance, distribution and presence of the targeted species to determine their importance within the planned OWF.

1.1 RESTING BIRDS:

In this study, resting birds are defined as birds regularly staying in 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. To determine the abundances, densities, phenology and spatial distribution of resting birds, digital aerial surveys were chosen as the best available method. In total, 12 digital aerial surveys covering the planned OWF areas Kattegat and Hesselø were undertaken to record resting birds during two years of baseline monitoring (January 2023 – December 2024).

In 2023, 7,956 individuals from 23 species of resting birds were observed while 9,610 resting birds of 26 species were recorded in 2024. Across both years, auks, especially common guillemots, were the most dominant group, comprising 38.5% of all recorded birds in 2023 and 49.1% for 2024. The highest densities were observed during autumn and winter, particularly around the northern and southwestern sectors of the area, including parts of adjacent Natura 2000 sites.

The results of the two-year baseline study presented in this report revealed valuable information on the presence and distribution of resting and migrating birds in the pre-investigation area for the proposed OWF Hesselø. Results for the resting birds showed that auks, especially common guillemots were the most abundant species in the pre-investigation area with highest concentrations in the north (during winter) or in the northeast and southwest (during autumn).

Divers, primarily red-throated divers, were widely distributed across the entire pre-investigation area, occurring in higher densities based on reviewed baseline data and relevant literature. Sea ducks (common scoter and common eider) were observed in high numbers in coastal waters, like the tip of Sjællands Odde. However, detections of common scoter decreased during the second year of monitoring, potentially revealing strong seasonal or interannual shifts in their winter distribution in the studied area.

1.2 MIGRATING BIRDS:

Migratory birds are all birds that fly across the pre-investigation areas twice a year on their movements between wintering and breeding grounds or during regular local movements (e.g., between different breeding areas and between breeding and feeding areas). Bird migration was investigated by means of vessel-based surveys through 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 (Figure 4.3). 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.

Spring migration

A total of 13,983 birds grouped into 83 species were recorded during the diurnal observations conducted in spring 2023 and spring 2024. These observations were carried out over 28 analysable days (out of 30) at the anchoring point in the centre of the proposed OWF Kattegat. Of the total number of migrating birds observed during both years, two thirds were geese (66.6%), most of them barnacle goose (*Branta leucopsis,* 63.5%). The second most abundant group of migrating birds observed during the survey period were ducks (17.5%) and these were mainly composed of common scoters (14.8%). A large number of migrating passerine species comprised the third most abundant migrating group of birds in spring (songbirds, 5.1%) whereas cormorants, gulls and waders represented each 3% or less of all migrating birds in the area during spring. The mean migration intensity across all bird groups, combining data from both years, was 66.0 ±145.6 ind./h, with a median of 29.3 ind./h. Maximum peaks for each year were detected on similar dates: May 9th, 2023 (768 ind./h) and May 8th, 2024 (285 ind./h). These peaks were mainly due to migratory events of barnacle geese. Data from vertical radar confirmed higher migration intensity during nights compared with daylight phases with 27.0 MTR (migration traffic rate is defined here as the number of radar signals—interpreted as birds—crossing a 1 km vertical line within 1 hour, at altitudes up to 1000 meters) on average during day and 344.9 MTR on average during night (both years combined).

Autumn migration

A total of 9,060 diurnally migrating birds grouped into 93 species were recorded during the diurnal observations conducted in autumn 2023 and autumn 2024. These observations were carried out over 38 analysable days (out of 39) at the anchoring point in the centre of the proposed OWF Hesselø. Of the total number of migrating birds observed over the two years, almost two thirds (64%) were ducks, most of which were common scoters (50.9%) and Eurasian wigeons (4.3%). The second most abundant group of migrating birds observed during the survey periods were geese (9.8%) of which barnacle goose were the most abundant species (5.7%). After these, songbirds (8.2%), gulls (5.8%) and auks (2.8%) 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 39.3 ± 35.4 ind./h whereas the median was 28.7 ind./h. In 2023, two dates in October reached similar high migration peaks (on the 3rd of October, 103 ind./h and on the 24th of October, 104.2 ind./h) whereas in 2024, the daily maximum intensity was reached on the 6th of August (168.9 ind./h).

Autumn vertical radar data again confirmed higher migration intensity during nights compared with daylight phases. During daytime, the lowest bird migration was at noon.

For migrating birds, the results showed that the pre-investigation area is crossed by migrating birds in quite high numbers compared to other areas in the western Baltic Sea or the North Sea. The Kattegat Sea itself is a transition area between the North and the Baltic Sea. The pre-investigated area is part of a larger area in which the coastal diurnal movements – with geese (mainly barnacle goose) and ducks (mainly common scoter) as dominant species – take place. They occur 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 (Aalborg Bugt) or in the south of the pre-investigated area, closer to the coast of Hesselø Bugt. Songbirds, as part of the diurnal migration, crossed the area regularly. However, results from the bird calls at night suggest that the pre-investigation area is part of the broad band nocturnal migration route for passerines. Some crane migration (63 individuals) was registered in spring as well.

2 INTRODUCTION

In 2018, all parties in the Folketing (Danish parliament) decided to build three new offshore wind farms, including Hesselø Offshore Wind Farm (OWF), which was part of the next steps towards achieving 100% renewable energy in the electricity system in 2020. It was decided in the climate agreement in 2020 that Hesselø OWF should distribute power to the electricity market in 2027. However, the tender process was put on hold in June 2021 after preliminary studies had shown areas of soft seabed in large parts of the area. In the climate agreement from June 2022, it was decided that the area for the Hesselø OWF should be moved to the southwest of the original area. The installed power remains the same, namely 800-1,200 MW, and there have been no changes to the corridor for the export cables to land or to the plan for the associated facilities on land.

In the agreement about tender framework agreed by the Danish Parliament in May 2025, it was decided that the tender for Hesselø OWF will be launched in autumn 2025, with deadline already in spring 2026. According to the plan, Hesselø OWF should be established in 2032.

The planning area for the Hesselø OWF is located in the Danish part of the Kattegat, approximately 30 km north of Zealand and approximately 25 km east of Djursland (Figure 2.1). The area covers approximately 166 km^2. The offshore wind farm is connected to the electricity grid on land via export cables, which are brought ashore at Gilbjerg Hoved, west of Gilleleje on Zealand's north coast..

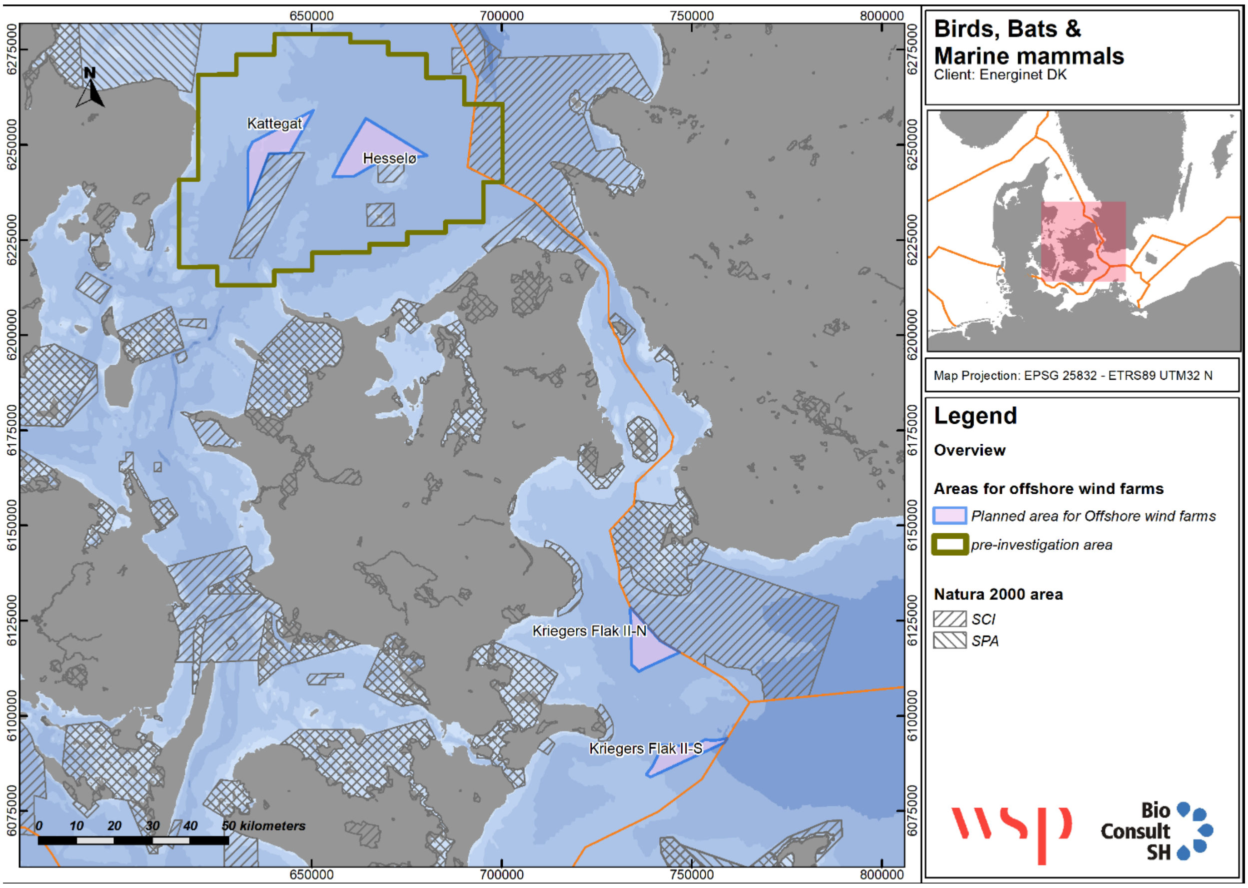


Figure 2.1 Map showing the location of the parallel investigated wind farm areas Kattegat, Hesselø and Kriegers Flak II (North and South). The present report focuses on Hesselø.

The report analyses the occurrence of birds in the pre-investigation area. 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 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 can be classified as migratory or resting birds. These species will be addressed in both parts of this report.

For both resting and migratory birds, the report first presents a compilation of data based on already available publications, followed by a description of the methods used in the baseline studies of birds for the planned Hesselø OWF. Finally, the data obtained are brought into context based on the existing knowledge and presented in the discussion section.

2.1 GEOGRAPHICAL DEFINITION

The following section provides and overview of the Baltic Sea, including geographical definitions commonly accepted and use, area-specific terminology and relevant nomenclature to ensure clarity in the interpretation of the project results.

2.1.1 DESCRIPTION OF THE BALTIC SEA

The Baltic Sea is a brackish body of water in northern Europe connected through the Skagerrak with the North Sea and bordered by nine countries: Denmark, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland, and Germany. Its complex hydrography was used by the *Convention on the Protection of the Marine Environment of the Baltic Sea Area* (Helsinki Convention or HELCOM) to subdivide it into 18 sub-basins (Figure 2.2). Article 1 of the Convention determined that “the entrance to the Baltic Sea bounded by the parallel of the Skaw in the Skagerrak at 57° 44.43’N” as agreed by all bordering nations. The Baltic Sea has a surface area exceeding 412,000 km^2 and an average depth of 52 m. The catchment area of over 1,730,000 km2 causes a continuously declining salinity gradient from southwest to northeast approaching zero salinity at the northern end of the Bothnian Bay (Figure 2.3).

The change in salinity causes physiological stress in the Baltic fauna and flora resulting in an almost complete turnover in species composition along the gradient. Furthermore, the low salinity (together with lower temperatures in the north) allows for frequent freezing of the sea surface in winter, whereas ice cover only builds up occasionally in the southwestern part of the Baltic Sea.

The only connection of the Baltic Sea from the Kattegat to the North Sea and the Atlantic Ocean is characterized by a constant outflow of hyposaline surface water and an occasional inflow of oxygenated bottom water. The inflow of salty bottom water through the geographical bottlenecks of the Sound and the Great Belt is usually driven by westerly winter storms.

The seven sub-basins 1 to 7 are frequently called the **Western Baltic Sea**, and within it, the four sub-basins 2 to 5 are called the **Belt Sea**, whereas the six sub-basins 8 to 13 constitute the **Baltic Proper**.

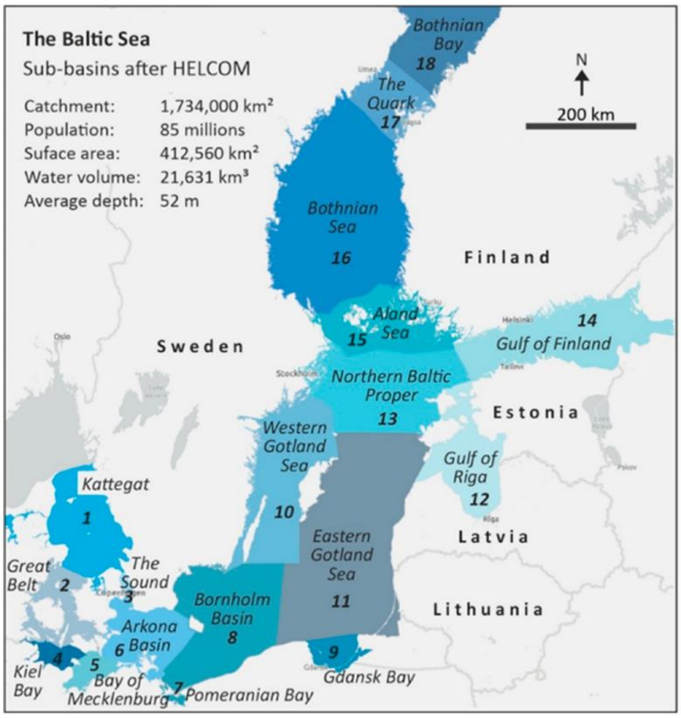


Figure 2.2 The 18 sub-basins of the Baltic Sea as defined by HELCOM; extracted from SCHERNEWSKI ET AL. (2024).

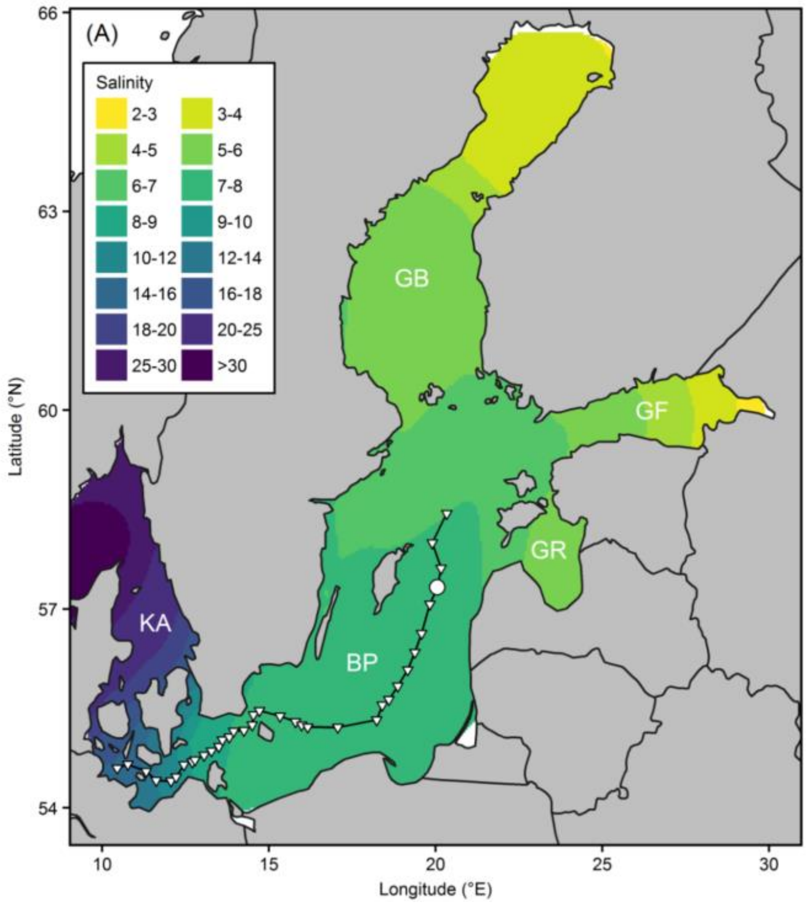


Figure 2.3 Surface salinity distribution throughout the Baltic Sea; extracted from MÜLLER (2018)

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 migrating birds potentially present in the pre-investigation area is given.

Birds potentially utilising the pre-investigation area can roughly be 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 (i.e. twice a year). In addition, some migrating birds may also be seen on regular local movements (e.g. alternating between feeding and breeding areas). 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.

Nearby the planned OWF Hesselø, several Natura 2000 sites are found in the vicinity of the investigated area. These sites were concealed to provide protection to either specific species and/or habitats and they hold different levels of protection (EUROPEAN UNION 2010). Their location, level of protection and targeted species and/or habitats are described below.

The Nordvestlige Kattegat site (code DK00FC371) is located northwest of the planned OWF Hesselø, with an area of 4525.86 km^2 and established in 2021. The main species of protection in terms of resting birds are red-throated diver, common eider, velvet and common scoter. However, other species such as terns, geese, waders, passerines and/or owls are also protected due to their importance within this Special Protection Area (SPA, EEA 2021).

North of the planned OWF, Anholt og havet nord for site (code DK00DX146) was established in 1998 with an extension of 134.22 km^2. Created to protect mainly habitats (sandbanks, dunes, bogs and coastal lagoons) but also marine mammal species such as harbour porpoise, grey seal or harbour seal. This protected area is considered as Site of Community Importance (SCI) and SPA (EEA, 1998).

To the east, the Nordvästra Skånes havsområde (code SE0420360) Natura 2000 site, with 1342.41 km^2 and created in 2016. Two types of habitats (sandbanks and reefs) and more than 40 species are considered of special relevance for this SPA and SCI. Regarding the resting bird community, several species of divers, grebes, cormorants, sea ducks, gulls, terns and auks are of special relevance in terms of conservation (EEA, 2016).

Within close proximity and southeast of the planned OWF Hesselø, there are two Natura 2000 sites. The Lysegrund (code DK00VA299) and Hesselø med omliggende stenrev (code DK003X202) sites, both designated for their importance regarding habitats (sandbanks, reefs, lagoons and cliffs) and marine mammals. Covering an area of 31.73 km^2 and 42.13 km^2 and designated in 2002 and 1995, respectively, these two SCI and SAC are the closest ones to the investigated area (EEA 1995, 2021b).

To the west of the pre-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 covered by water all the time, as well as reefs.

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.

In the following paragraphs, the resting bird species or species groups, which were identified as most relevant for the investigation area, are described in more detail.

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

Divers, also called loons, are species of fish-eating birds strongly linked to aquatic environments that inhabit the taiga and tundra regions of the Holarctic. All divers are migratory, and the focal geographic population of this study breeds in freshwater lakes mainly in Scandinavia and in Russia, spending the winter season at sea (DURINCK et al. 1994; BIOCONSULT SH et al. 2019; HEMMER 2020). There are four commonly migratory or winter visitor diver species occurring in Danish waters (NOVANA & VIHLBORG STAALSEN 2024), of which two species are commonly found in the Western Baltic Sea, namely the red-throated diver (*Gavia stellata*) and the black-throated diver (*Gavia arctica*).

Both species use the Western 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; BIOCONSULT SH et al. 2019) which will arrive at or cross the area from October to January, and leave by June. BELLEBAUM and colleagues (2010a) reported 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 (BIOCONSULT SH et al. 2019) suggest that individuals are rather evenly spread across the area, instead of large coastal aggregations as in BELLEBAUM and colleagues (2010a) findings.

Flight heights of both diver species are generally observed 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 stage, divers forage on a broad range of fish species (KLEINSCHMIDT et al. 2019). For the Western 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 the red-throated diver and the black-throated diver are widely distributed in the Baltic Sea. Most individuals occur in the Gulf of Riga at water depths less than 30 m (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 Western Baltic Sea in September, increase in numbers during the winter, peaking in February and March in the Kattegat area (SKOV et al. 2011). This area has been identified as a high frequented staging site, especially in spring, for red-throated divers during their annual migratory movements to-from wintering and breeding grounds (KLEINSCHMIDT et al. 2022). The phenology of occurrence of divers during spring have been reported as well during baseline monitoring surveys for nearby OWFs in the area (PETERSEN & STERUP 2019).

Divers start leaving the areas in April and May to migrate to their breeding grounds. Therefore, they are expected to be present in the investigation area from September to June. During the rest of the year, they appear sporadically. In a report by DHI (2019) for the nearby Hesselø site, low densities were found during winter and spring in offshore areas in Kattegat. In contrast, medium to high densities were detected during spring in coastal areas with water depths < 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 at water depths between 10 and 22 m. Similar high densities were observed on the northern coasts of Sjælland, as well as close to the coast of Falster. In contrast, SKOV ET AL. (2011) reported low densities for these areas, with northwest of Skåne showing the highest densities in that region with 0.22 ind./km^2.

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) and 390,000 – 590,000 black-throated divers (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, accessed on 23.02.2022). It is still unclear whether populations of both species are in decline in the North Sea (VILELA et al. 2021; GARTHE et al. 2023).

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 (HELCOM 2013a). Within the Danish part of the Baltic Sea, most of the wintering divers are found southwest of Lolland and north of Sjælland (Figure 3.1).

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).

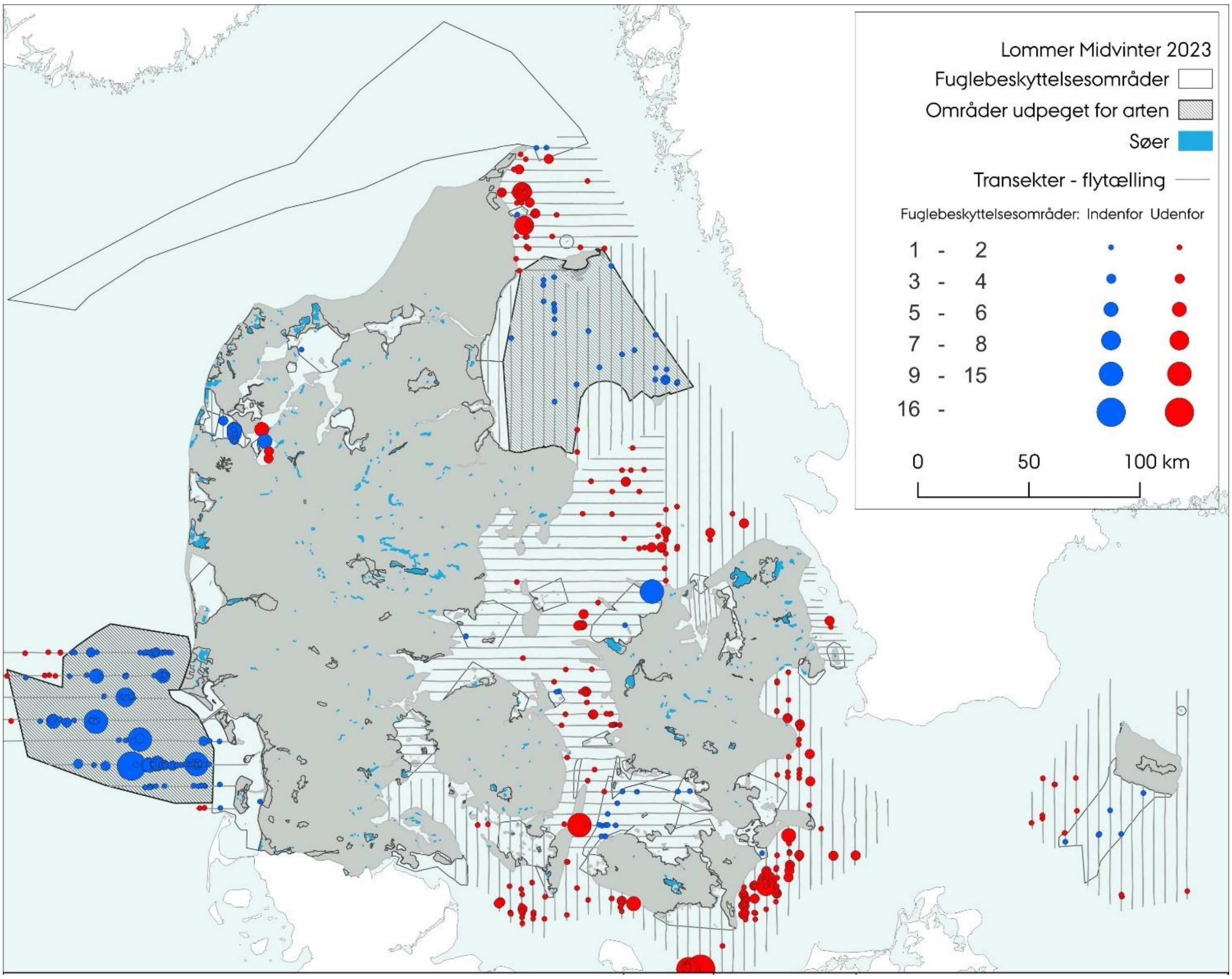


Figure 3.1 Spatial distribution of divers in winter 2023. The map shows distributions inside (*indenfor; blue*) and outside (*udenfor; red*) of bird protected areas in which circle sizes are increasingly proportional to the number of counts. In the legend: midwinter counts of divers for 2023. Blank rectangle refers to nature reserves or protected bird areas, while the grey rectangle refers to areas specifically designated for the species and/or species group. Blue rectangle refers to inner water bodies such lakes. Transect lines refer to the transects taken during aerial surveys. From https://novana.au.dk.

3.1.2 GREBES

Grebes occur in coastal areas with shallow waters during the non-breeding season. 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 in the Pomeranian Bay. In the Western 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 (2019).

An estimated of 3,500 pairs of great-crested grebes breed in Denmark (BIRDLIFE INTERNATIONAL 2015). 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). However, within the the Baltic, the red-necked grebe wintering population is considered as endangered (HELCOM 2019a).

3.1.3 GANNETS

The only breeding species from the Sulidae family found in European waters is the northern gannet (*Morus bassanus*). Although gannets do not breed in the Baltic sea, there are large colonies located in Norway, UK, France and, the closest to the proposed OWF, Germany – Helgoland with 887 breeding pairs registered in the latest census in 2023 (Dierschke et al. 2024). Gannets are considered as Least Concern by IUCN and their population size is estimated at 1,600,000 individuals in the north Atlantic, where 75% of the population is concentrated in the north-east Atlantic (Burnell et al. 2023) with an increasing trend (Wetlands International 2022, AEWA CSR 8, accessed on 20.03.2025). Gannet's presence in the Baltic Sea has been reported sporadically as occasional observations (Sonntag et al. 2006) and with gps-tagged individuals (Kleinschmidt et al. 2022), however their presence has significantly increased in the last years during the winter period.

The migratory route of gannets is diverse and take them to spend the winter in Northwest Africa but also in Europe. Tagged gannets from Helgoland have been found to spend their non-breeding period in the area of Kattegat, with an indexed increase of 30% of relative abundance (Garthe et al. 2024). Recovered rings showed similar patterns with ringed gannets in the breeding colonies from the Channel Islands, from which their dispersal towards the Baltic seems to occur among second and third year birds (Veron & Lawlor 2009). In Danish waters, winter censuses report their sporadic presence mainly in coastal areas, but they have been sighted in offshore areas as well (Figure 3.2).

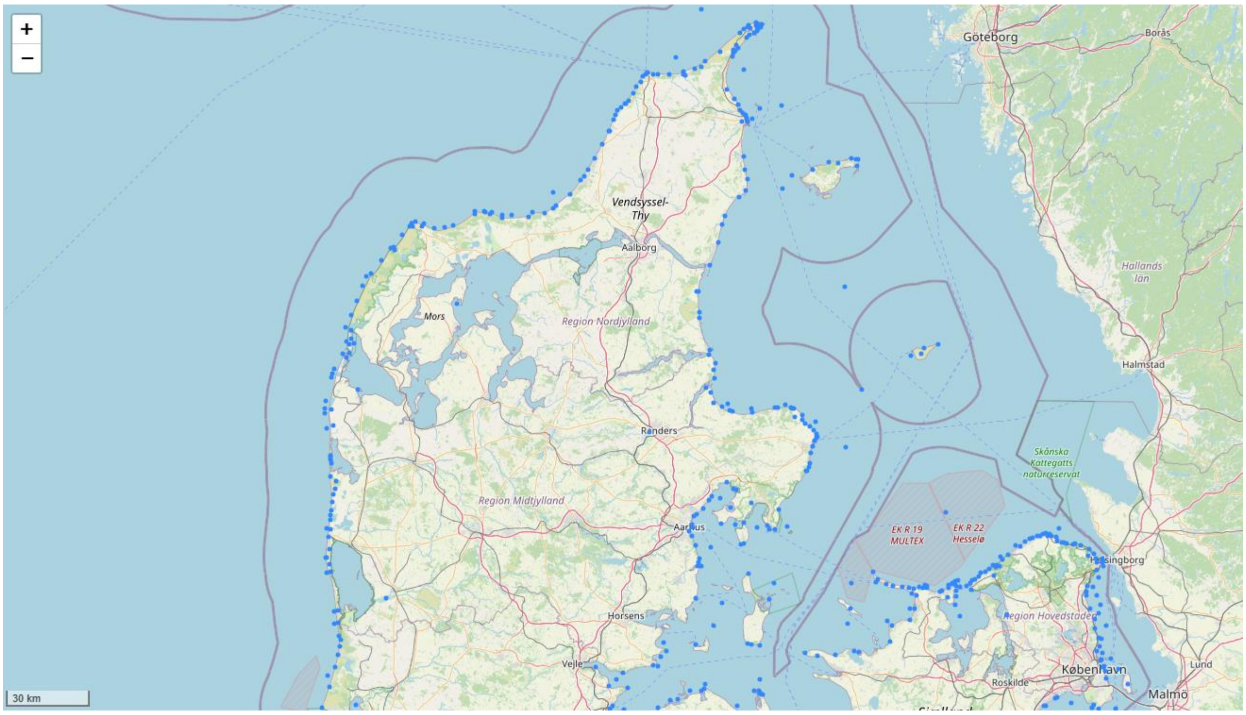


Figure 3.2 Reported observations (blue dots) by the public of northern gannet (*Morus bassanus)* along the Danish EEZ for the period 01/01/2023 – 12/12/2024. Information retrieved and available at DOFbasen (DOF 2025, https://dofbasen.dk/ accessed on 20.03.2025).

3.1.4 GREAT CORMORANT

Two of the

six subspecies of the great cormorant (*Phalacrocorax carbo*) may occur in northern Europe: *P. carbo carbo* and *P. carbo sinensis*, the latter is the subspecies that can occur in the pre-investigation area. Cormorants are diving birds that mainly feed on herring, perch, eelpout, cyprinids and sprat and 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 and mainly associated with coastal habitats. The largest concentrations are 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 5,000 ind./km^2 (Figure 3.3).

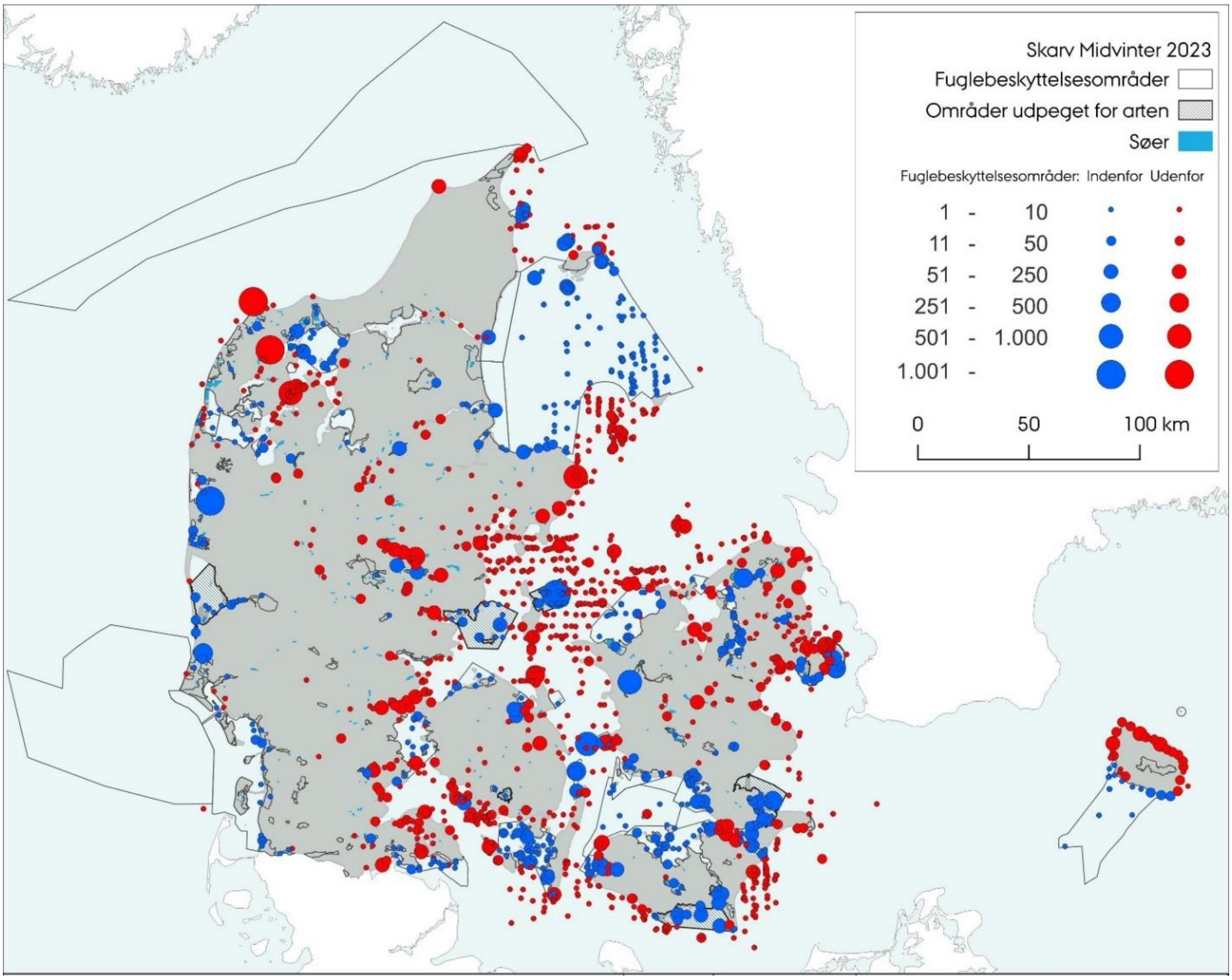


Figure 3.3 Spatial distribution of cormorants in winter 2023. The map shows distributions inside (*indenfor; blue*) and outside (*udenfor; red*) of bird protected areas in which circle sizes are increasingly proportional to the number of counts. In the legend: midwinter counts of cormorants for 2023. Blank rectangle refers to nature reserves or protected bird areas, while the grey rectangle refers to areas specifically designated for the species and/or species group. Blue rectangle refers to inner water bodies such lakes. Transect lines refer to the transects taken during aerial surveys. From https://novana.au.dk.

Between 2014 and 2022, there were an estimated 30,000 - 33,000 breeding pairs in Denmark with several colonies in the Kattegat area. The largest and closest colony to the pre-investigated area is in Hovvig (north Sjælland), with a count of 770 nests in 2022. Recent studies have shown an increase in residence time of cormorants during winter in Danish waters. They are staying closer to their regional breeding colonies due to milder winters, and areas like Kattegat are experimenting an increase of density of wintering cormorants (FREDERIKSEN et al. 2018; BREGNBALLE et al. 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 (BOSTRÖM et al. 2012b). Most likely , 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 resting sites, allowing them to expand their foraging grounds further offshore (DIERSCHKE et al. 2016).

3.1.5 SEA DUCKS

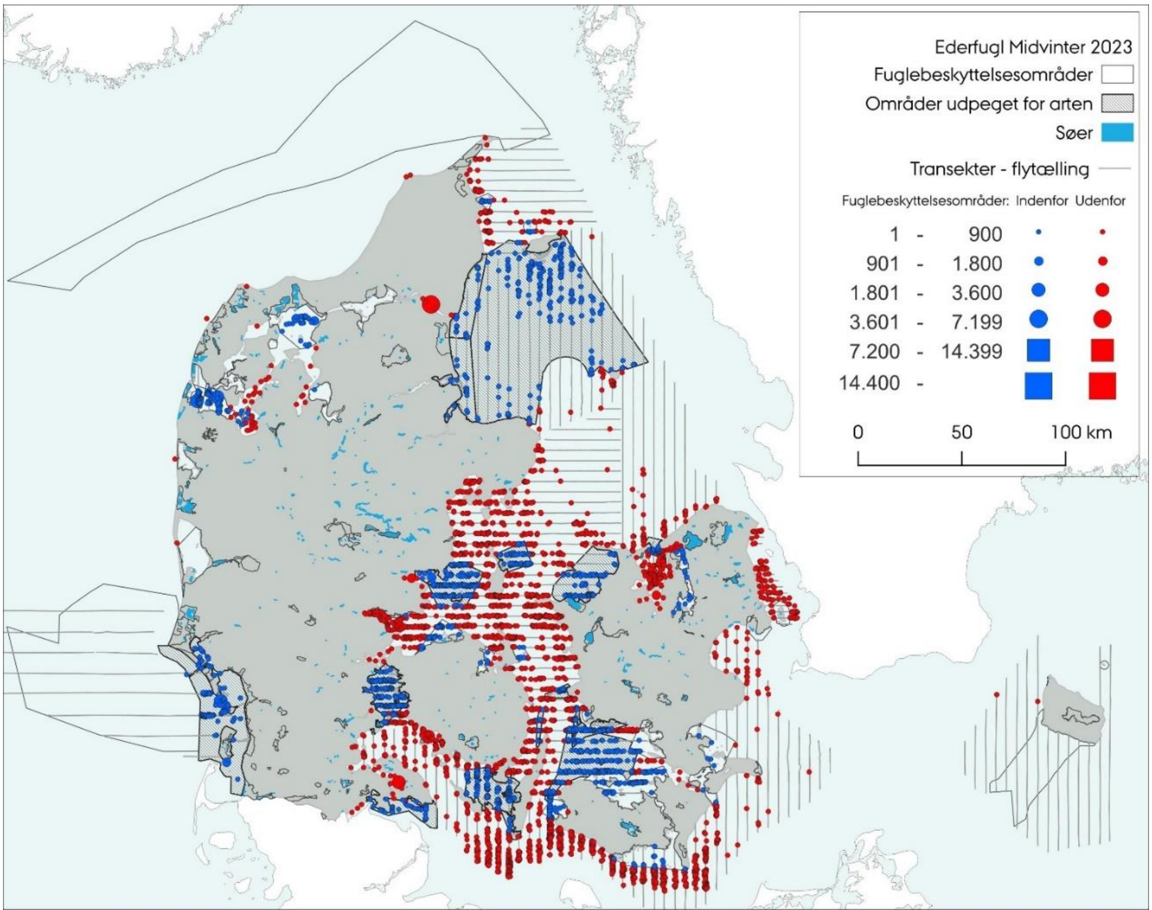
Sea ducks spend their non-breeding season in marine environments feeding mainly on bivalves (MADSEN 1954; NEHLS 1989, 2001; MEISSNER & BRÄGER 1990; MENDEL et al. 2008). The Baltic Sea offers important moulting and wintering sites for sea ducks with individuals mainly located in coastal waters and shallow 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 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 displacement, while other species may be less disturbed (FLIESSBACH et al. 2019). The same applies to the disturbance caused by OWFs, where the reaction differs among species as well (PETERSEN & FOX 2007; PETERSEN et al. 2014; DIERSCHKE et al. 2016).

COMMON EIDER

The breeding population of common eiders (*Somateria mollissima*) in Denmark increased during the 20th century (LYNGS 2000). The censuses indicate a population of about 23,000 breeding female common eiders between 1988 and 1993 (DESHOLM et al. 2002). Based on Petersen and Nielsen (2011), estimates suggested 503,000 common eiders wintering in Danish waters during 2008, and evaluations between 2000 and 2008/09 estimated this population to be stable (EKROOS et al. 2012). However, during the 21st century, the population has showed a declining trend. The last censuses conducted between 2018-2022 estimated a population of 17,000 breeding pairs in Denmark, which implies a decline of 31.9% of the population compared to 2010. In the Kattegat region, 704 nests were recorded in 2020 census, a decline of 44.7% compared to 1990 (CHRISTENSEN & BREGNBALLE 2024).

During summer, common eiders are mostly located in the coastal areas. The highest densities have been reported in the Lillebælt area, with up to 259.51-419.60 ind./km^2. The island of Anholt and the coastal areas of Djursland (the closets to the planned Hesselø OWF) have medium densities during the summer, with <100 ind.km^2 (PETERSEN & NIELSEN 2011). During winter, their main concentration areas are found along the Samsø belt and Vejje fjord, and especially around the southwestern coast of Fyn with up to 419.60 ind./km^2 (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 listed in the Annex II B 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.



Fugle talt i alt:	136.585	Procentandel:	Firkantet signatur: Antallet overstiger
Heraf talt i fuglebeskyttelsesområder:	63.819	46,7 %	gældende 1%-bestandskriterium
Heraf talt i fuglebeskyttelsesområder udpeget for arten:	39.698	29,1 %	(Vandfugleaftalens CSR8)
Fugle talt i fuglebeskyttelses- og habitatområder (Natura 2000)	70.251	51,4 %	Kriteriet for bestanden er: 7.200

Figure 3.4 Spatial distribution of common eider in winter 2023. The map shows distributions inside (*indenfor; blue*) and outside (*udenfor; red*) of bird protected areas in which circle sizes are increasingly proportional to the number of counts. In the legend: midwinter counts of common eider for 2023. Blank rectangle refers to nature reserves or protected bird areas, while the grey rectangle refers to areas specifically designated for the species and/or species group. Blue rectangle refers to inner water bodies such lakes. Transect lines refer to the transects taken during aerial surveys. From https://novana.au.dk

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 in 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 (Figure 3.5) 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). In the investigated area, number of individuals seems to be in low numbers, with mean densities <0.5 ind/km^2 (HELCOM 2013b).

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 influence 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).

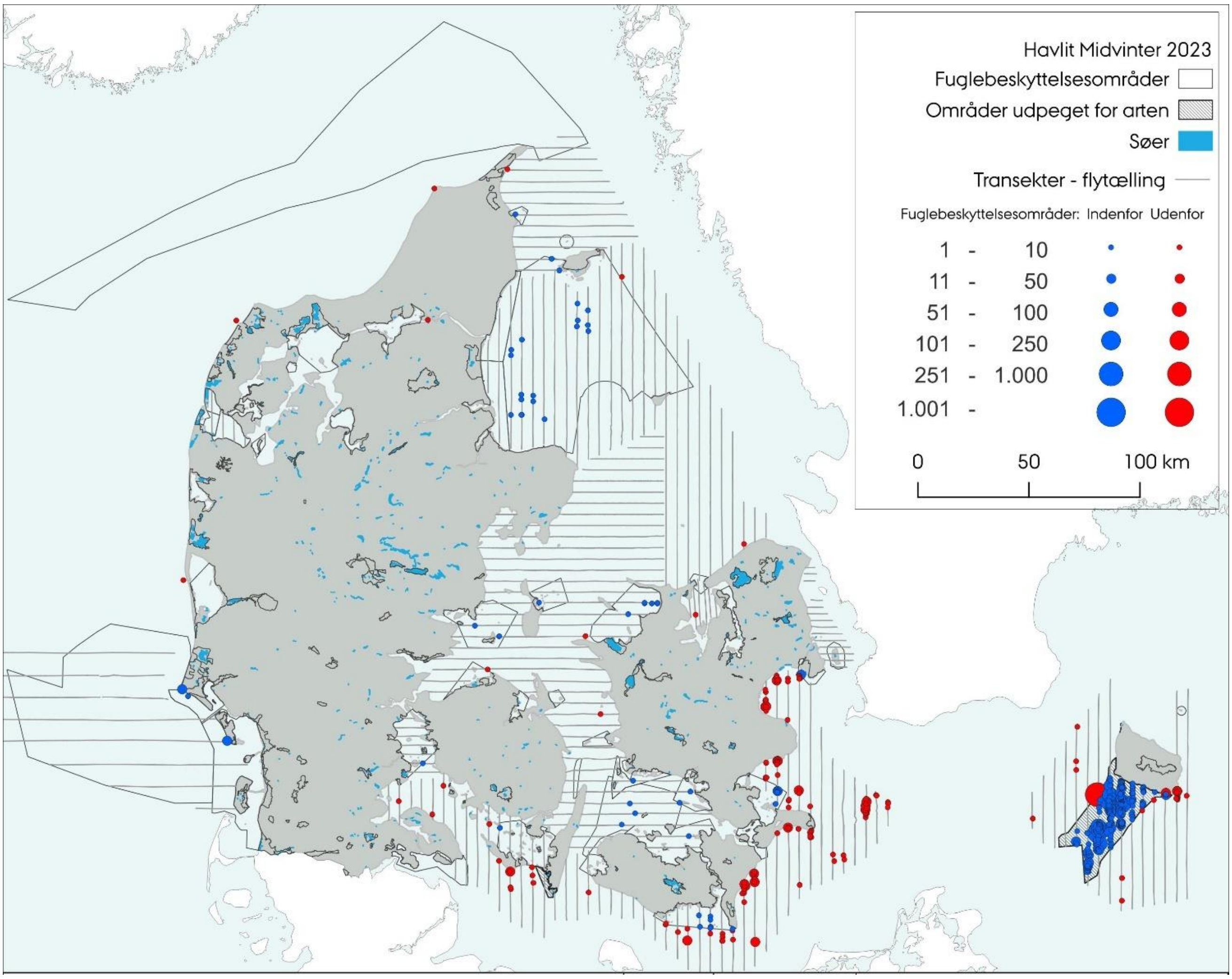


Figure 3.5 Spatial distribution of long-tailed duck in winter 2023. The map shows distributions inside (*indenfor; blue*) and outside (*udenfor; red*) of bird protected areas in which circle sizes are increasingly proportional to the number of counts. In the legend: midwinter counts of long-tailed duck for 2023. Blank rectangle refers to nature reserves or protected bird areas, while the grey rectangle refers to areas specifically designated for the species and/or species group. Blue rectangle refers to inner water bodies such lakes. Transect lines refer to the transects taken during aerial surveys. From https://novana.au.dk

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 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.

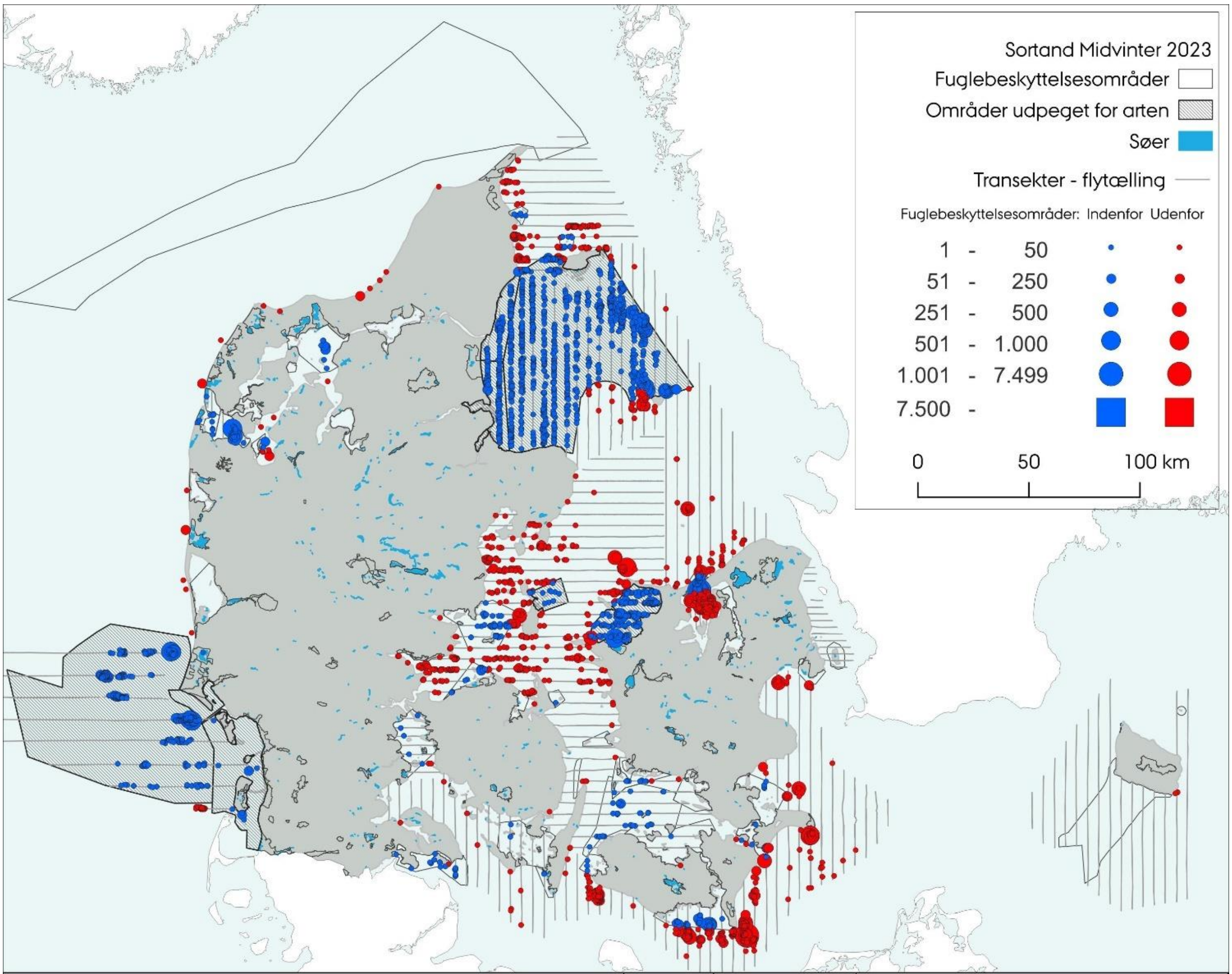
The results of the Baltic coordinated survey in 2007 to 2009 indicate that the winter population of common scoters has declined markedly from 783,310 birds in 1988–1993 to 412,000 birds in 2007–2009, equivalent to a 47% decline over 16 years (HELCOM 2019b). However, recent evaluations for the Northwest 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 (northern Kattegat) and the areas around Læsø and Anholt with up to 303 ind./km^2 (PETERSEN & NIELSEN 2011) and lower densities in the Sejerøbugten with up to 105 ind./km^2 (Figure 3.6). In the pre-investigation area, winter densities were rather low (0-5 ind./km^2), which contrasts the summer presence of common scoters with densities of up to 40 ind./km^2. In Figure 3.6, locally high numbers were recorded, but the aggregations were found near the coast and close to the islands of Læsø and Anholt. In summer during their moulting period, high common scoter densities were again 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 Sejerøbugten 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 but with a clear preference for coastal waters.

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). The pre-investigated area in Kattegat does not seem to be of importance for this species as the mean winter densities are <0.5 ind./km^2. However, the location of Laholm Bay (~60 km east of the planned OWF, Sweden), has shown winter densities of <5 ind./km^2 (SKOV et al. 2011; HELCOM 2019c), perhaps due to higher food availability in the shelter bay.

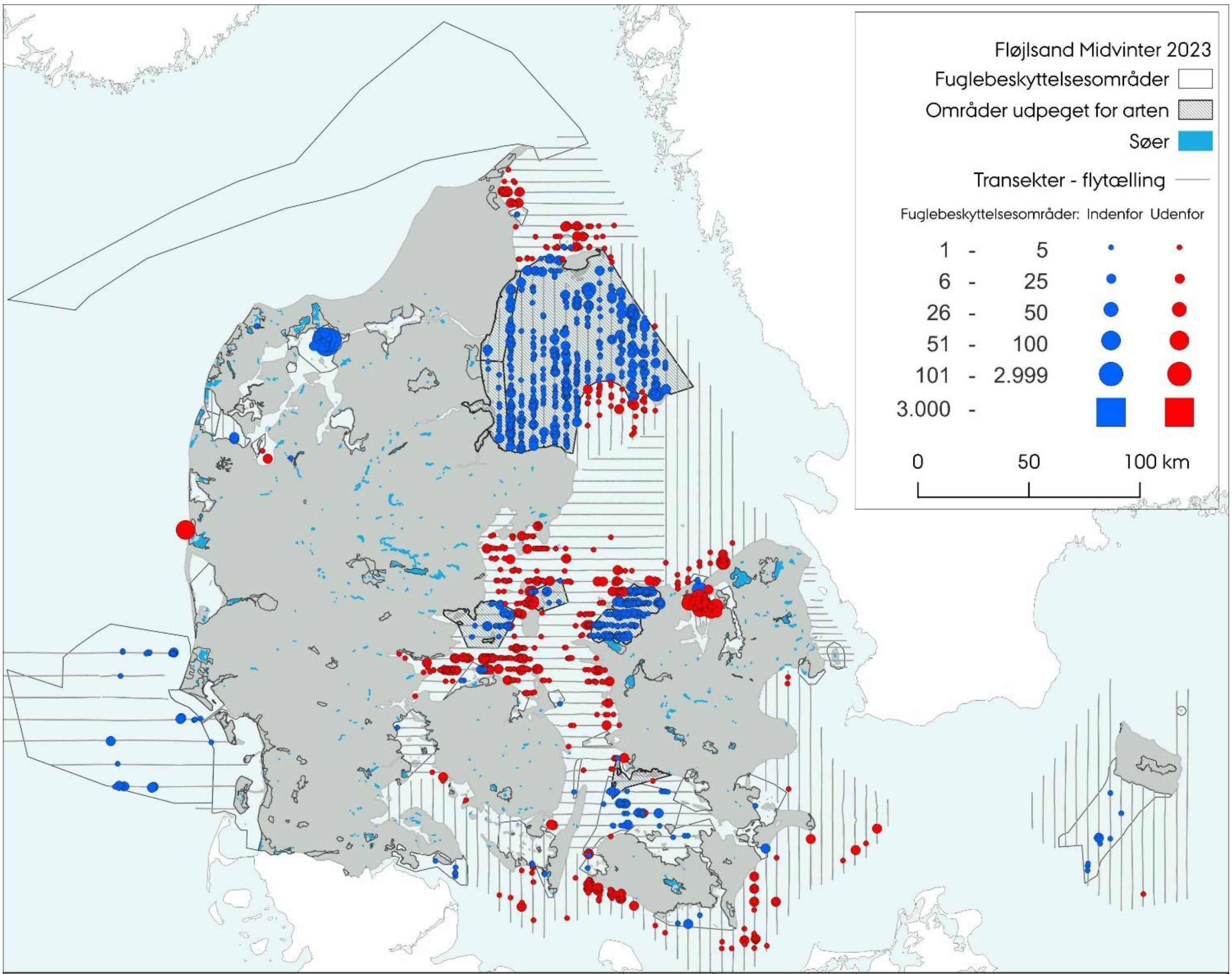
A study of velvet scoters wintering along the Lithuanian coast demonstrated a preference for marine areas with sandy substrates at depths between 2 and 30 m (ZYDELIS 2000). In the Pomeranian Bay the species occurred in waters with sandy sediments up to 30 m depth but was most frequently found up to 15 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). In Figure 3.7 the wintering distribution showed velvet scoter aggregation to the north and south of the pre-investigation area, but almost no overlap.

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. Regionally, velvet scoter is considered a vulnerable species as breeder and endangered as wintering bird, which is the same designation for common scoter wintering population (HELCOM 2019c).



Fugle talt i alt:	87.880	Procentandel:	Firkantet signatur: Antallet overstiger
Heraf talt i fuglebeskyttelsesområder:	46.879	53,3 %	gældende 1%-bestandskriterium
Heraf talt i fuglebeskyttelsesområder udpeget for arten:	34.279	39,0 %	(Vandfugleaftalens CSR8)
Fugle talt i fuglebeskyttelses- og habitatområder (Natura 2000)	50.902	57,9 %	Kriteriet for bestanden er: 7.500

Figure 3.6 Spatial distribution of common scoter in winter 2023. The map shows distributions inside (*indenfor; blue*) and outside (*udenfor; red*) of bird protected areas in which circle sizes are increasingly proportional to the number of counts. In the legend: midwinter counts of common scoter for 2023. Blank rectangle refers to nature reserves or protected bird areas, while the grey rectangle refers to areas specifically designated for the species and/or species group. Blue rectangle refers to inner water bodies such lakes. Transect lines refer to the transects taken during aerial surveys. From https://novana.au.dk



Fugle talt i alt:	8.376	Procentandel:	Firkantet signatur: Antallet overstiger
Heraf talt i fuglebeskyttelsesområder:	4.870	58,1 %	gældende 1%-bestandskriterium
Heraf talt i fuglebeskyttelsesområder udpeget for arten:	3.278	39,1 %	(Vandfugleaftalens CSR8)
Fugle talt i fuglebeskyttelses- og habitatområder (Natura 2000)	5.224	62,4 %	Kriteriet for bestanden er: 3.000

Figure 3.7 Spatial distribution of velvet scoter in winter 2023. The map shows distributions inside (*indenfor; blue*) and outside (*udenfor; red*) of bird protected areas in which circle sizes are increasingly proportional to the number of counts. In the legend: midwinter counts of velvet scoter for 2023. Blank rectangle refers to nature reserves or protected bird areas, while the grey rectangle refers to areas specifically designated for the species and/or species group. Blue rectangle refers to inner water bodies such lakes. Transect lines refer to the transects taken during aerial surveys. From https://novana.au.dk

3.1.6 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*), the herring gull (*Larus argentatus*), the common gull (*Larus canus*) 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).

BLACK-HEADED GULL

Black-headed gulls (*Chroicocephalus ridibundus*) are a small species of gull with widespread distribution across the northern hemisphere. The population within the Baltic Sea is considered as migratory, performing seasonal movements between their breeding and wintering areas from northeast to southwest Europe or northwest Africa. However, part of the population remains in milder areas of northwestern Europe over wintering. In Denmark, coastal and inland breeders are found year round. However, the breeding population in Denmark declined 82% in the period 1970-2010, with an estimated breeding population of 67,300 pairs. The closest active breeding colony to the planned OWF is located on the islet of Treskelbakkeholm near the mouth of Mariager Fjord, approximately 60 km away. This colony has experience a sharp decline, from >12,000 breeding pairs in 1999 to 250-750 during the 2012-2014 census (BREGNBALLE et al. 2015).

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 pre-investigated area throughout all year but might be more numerous in winter, where densities on land in the nearby island of Anholt were found at 19-34 ind./km^2 (DANSK ORNITOLOGISK FORENING & BIRDLIFE DANMARK 2025, accessed on 04.07.2025). During winter, low densities are expected in the Kattegat offshore 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). The breeding population in Denmark has experienced a decline of ~75%, while the wintering population has increased by ~200% (DANSK ORNITOLOGISK FORENING & BIRDLIFE DANMARK 2025, accessed on 04.07.2025). 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 2013c). 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) in the Baltic sea. 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 (2013c).

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, significant declines in bird populations of have been observed across parts of the Baltic region, particularly in Finland (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 Middelgrundene area, 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 (2013d). 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.

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). The species is considered a species of least concern based on the recent IUCN Red List (BirdLife International 2021).

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 and Skagerrak areas are 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 mid 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.

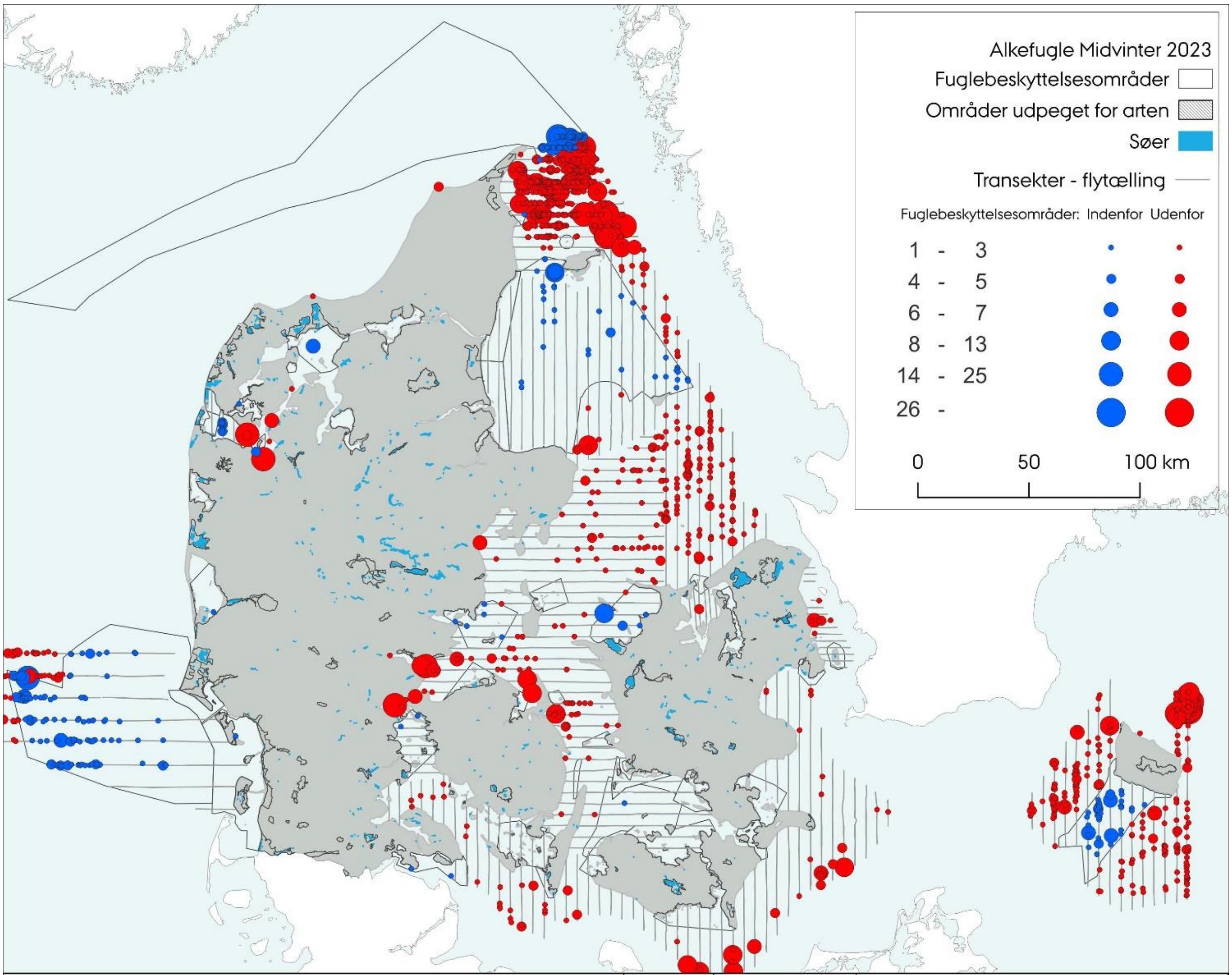
The Atlantic biogeographical population of the black-legged kittiwake (to which individuals in the study site would mainly belong) was recently estimated to be 6.1 million individuals (AEWA CSR 8, http://wpe.wetlands.org/, accessed 22.04.2024), with a declining trend.

3.1.7 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. For the area of interest, common guillemots and razorbills are considered as winter visitors, while black guillemots are confirmed breeders in the nearby areas of Anholt and Djursland. The black guillemot is one of the species for which e.g. 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 (Sweden), which are famous for hosting the largest fish-eating seabird colonies of the Baltic Sea (OLSSON & HENTATI-SUNDBERG 2017). Other colonies are 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 Western Baltic Sea found razorbills/guillemots almost exclusively in the central area of Denmark, 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 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 pre-investigation area (PETERSEN et al. 2021). Recent surveys from winter 2023 also detected the presence of auks south of Anholt, towards the coast of Sjælland and by the northwestern tip of Djursland (Figure 3.8; https://novana.au.dk, accessed 20.01.2025). Of black guillemots, only a small population winters in northern Kattegat (DURINCK et al. 1994). Higher densities of this species may occur in the Pomeranian Bay and south of Rønne Bank (DURINCK ET AL. 1994; MENDEL ET AL. 2008b). Compared to the other two auk species, black guillemots prefer shallower waters (depths < 25 m, DURINCK et al. 1994).

While the two most common auk species have relatively stable populations or are increasing, other auk species are threatened (HELCOM 2019d). 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 went extinct. Both the common guillemot and the razorbill are listed as 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 vulnerable (BIRDLIFE INTERNATIONAL 2021).



Fugle talt i alt:	3.469	Procentandel:
Heraf talt i fuglebeskyttelsesområder:	696	20,1 %
Heraf talt i fuglebeskyttelsesområder udpeget for arten:	0	0,0 %
Fugle talt i fuglebeskyttelses- og habitatområder (Natura 2000)	827	23,8 %

Figure 3.8 Spatial distribution of auks in winter 2023. The map shows distributions inside (*indenfor; blue*) and outside (*udenfor; red*) of bird protected areas in which circle sizes are increasingly proportional to the number of counts. In the legend: midwinter counts of auks for 2023. Blank rectangle refers to nature reserves or protected bird areas, while the grey rectangle refers to areas specifically designated for the species and/or species group. Blue rectangle refers to inner water bodies such lakes. Transect lines refer to the transects taken during aerial surveys. From https://novana.au.dk.

3.2 MIGRATING BIRDS

Throughout the annual cycle, 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 from year to year depending, for example, on recent breeding success. The distance covered during migration varies among species as well, some migrate over long distances of several 100 or 1000 km, whereas others travel short distances of only a few kilometers, also conducting local movements between breeding or roosting areas and feeding areas. Among some species, only part of the population is migratory (BAIRLEIN et al. 2014; CORDES & MAY 2023).

Estimates for the western Baltic Sea (including Belt Sea area) suggest that up to 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 remainder is composed of larger Non-passerines such as seabirds and other waterfowl including divers, grebes, ducks, geese, waders, gulls, terns and auks (BSH 2021). Daytime migrants, in particular, such as thermal gliders including birds of prey and cranes, tend to avoid crossing the open sea during migration (ALERSTAM 1978) and thus are frequent migrants in the Belt Sea/Kattegat area with shorter distances across sea areas compared to the other parts of the Baltic Sea. Thermal gliders prefer to follow land masses until a crossing of open water becomes unavoidable and thus concentrate at terrestrial bottlenecks such as peninsulas or other narrow stretches of land in order to reduce the risks and energy expenditures associated with active flight over water (ALERSTAM 1990).

Bird migration can be variable and at times difficult to predict. The timing of migration is influenced by weather conditions such as ambient temperature, precipitation, fog, wind speed and direction, since the energetic costs of 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). Therefore, migration mostly takes place during only a few days of favourable weather conditions during the migration period (BSH 2021).

Many Scandinavian and Siberian breeding bird species cross the western Baltic Sea including the pre-investigation area as part of their annual migration route (WELCKER & VILELA 2020) (see Figure 3.9 for an example of autumn migration routes). Numerous night-migrating songbirds are thought to cross the offshore area in a broad front mainly with a south-western/north-eastern orientation (depending on the season), but local aggregations and deviating directions may also be likely at least in some species. Most daylight-migrating birds follow landmarks such as from the eastern edge of the Djursland peninsula over the island of Anholt to the Swedish mainland in the Kattegat area in spring or from the Falsterbo peninsula in southern Sweden across the Danish islands of Zealand and Lolland and German island of Fehmarn to mainland Europe in autumn. However, parts of those populations may also cross the open water directly. Waterfowl such as geese, ducks or divers move through the area mainly in an east-westerly direction (BELLEBAUM et al. 2010a).

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

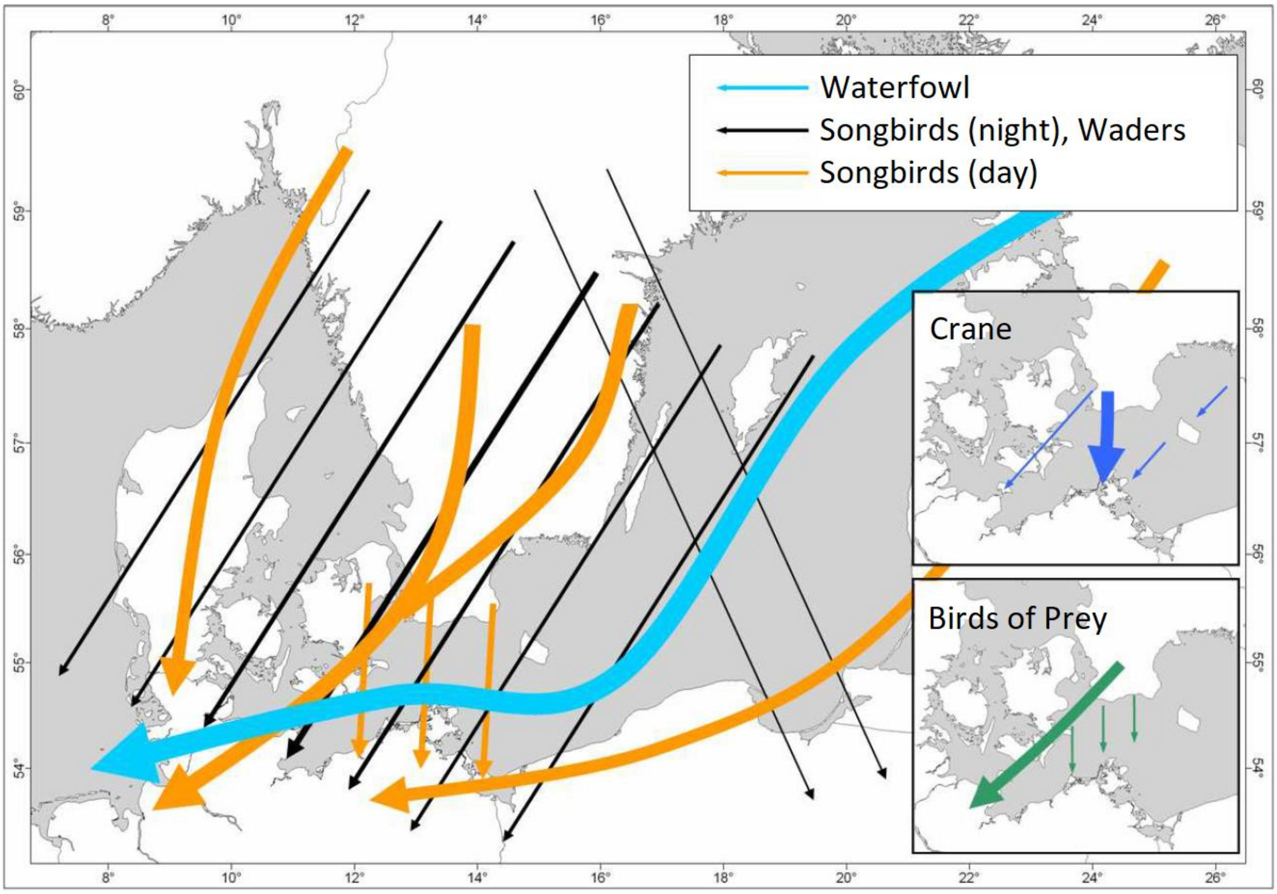


Figure 3.9. Most important migration routes in the Baltic Sea during autumn. From Bellebaum et al. (2010a).

In the following, the migratory bird species or species groups identified to be most relevant for the study area are described in more detail. We consider and define most relevant groups in terms of abundance, but also in terms of their potential susceptibility to the construction of offshore wind farms, i.e., those species groups that may be more subject to collision risk or avoidance behaviour and are otherwise requiring conservation measures.

3.2.1 GEESE AND SWANS

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

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 between Denmark and southwestern Europe by September, reaching their winter quarters in peak numbers in January and February and migrate back to their breeding areas from March onwards (SCOTT & ROSE 1996).

Only the greylag goose (*Anser anser*) breeds relatively close to the pre-investigation area as it is a common breeding bird in Denmark with about 18,000 breeding pairs (HOLM et al. 2021) and migrates further south in winter. The populations of the barnacle goose (*Branta leucopsis*), on the other hand, have only recently established new breeding sites in the western Baltic Sea, but more distant to the Kattegat area (FEIGE et al. 2008), e.g., 4.500 pairs on Saltholm close to Copenhagen in 2019 (HOLM et al. 2021). Whooper swans (*Cygnus cygnus*) overwinter in Denmark with numbers of 57,303 in 2020 and 60,612 in 2021 (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 of geese have increased in recent years. This increase also resulted in some conflict with humans. *B. b. bernicla* has increasingly turned to new food sources grazing on cultivated crops near the coast thus causing a conflict with farmers, for example, in Britain (SALMON & FOX 1991). Consequently, studies have been conducted to evaluate, whether an increase in the hunting bag of some of these goose species could help to limit their populations without presenting a threat to their survival. Similar conflicts arose with several other species of swans and geese, and the following (sub)species are listed on Annex I of the EU Birds Directive (2009/147/EC) rendering them subject of special conservation measures: Bewick's swan (*Cygnus bewickii*), whooper swan (*Cygnus cygnus*), great white-fronted goose (*Anser albifrons flavirostris*), lesser white-fronted goose (*Anser erythropus*), barnacle goose (*Branta leucopsis*), and red-breasted goose (*Branta ruficollis*). However, only the swan species and the barnacle goose may be expected to cross the study area on a more or less frequent basis.

Geese and swans are known to show avoidance behaviour to wind farms. For example, 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, 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 diurnal birds of prey are inhabiting Europe (THOMPSON et al. 2003). On a world-wide scale, more than half of the species known (at least 62% or 183 species) undertake seasonal migrations with many of them being long-distance migrants undertaking sometimes intercontinental flights (BILDSTEIN 2006). Several species of raptors can soar, meaning they are able to maintain flight without flapping their wings by making use of the rising air currents (so-called thermals) and thereby reducing energetic costs. Soaring is an efficient form of transport, both during and outside of long-distance migration (BILDSTEIN 2017). Especially large-bodied, diurnal long-distant migrants are strongly dependent on soaring flight. However, when crossing large waterbodies such as the Kattegat area, which usually lack upward winds, soaring provides a challenge. Other species such as ospreys, harriers and most accipiters and falcons migrate with powered flight by flapping their wings. Most raptors are daylight migrants, but few species such as peregrine falcons, ospreys, and merlins also migrate during night.

The migration corridors of raptors, which frequently travel in flocks, are well-known (BILDSTEIN 2006). Their most important flyway in Europe is the western European–western African flyway (BILDSTEIN 2017). A comparative study of satellite tracking results and ring recoveries in four common raptor species gathered detailed information on the preferred routes (STRANDBERG et al. 2009).

At Falsterbo in South Sweden, raptor migration in autumn 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 the Kattegat area and the Belt Sea. An average of 46,000 migrating raptors and falcons are observed annually. The most common species at Falsterbo are the Eurasian sparrowhawk (*Accipiter nisus)*, the common buzzard (*Buteo buteo)* and the red kite (*Milvus milvus)* (KJELLÉN 2019). Species with more southerly distributions breeding close to Falsterbo are more commonly observed compared to species with more northerly distributions (KJELLÉN 2019). Similarly, thermal migrants tend to be more concentrated at Falsterbo than active flyers. 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 observed numbers of the most common birds of prey have either increased or remained stable within the last decades (cf. KJELLÉN 2019). Three species, however, 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 an earlier study of trends in raptors in the same area from the 1940s to the late 1990s, there appeared 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 study area revealed the area of Gjerrild to be the second most important site after Skagen – as mentioned above – for landbirds migrating between Jutland and Sweden in spring (DHI 2009: Anholt OWF Baseline 2009). Although the numbers are much lower than at Skagen, especially common and honey buzzards, sparrowhawks, and red kites are migrating regularly and in high numbers across the area.

The number of raptors observed during the autumn migration every year, however, tends to vary greatly. This may - at least partially – be linked to more birds being counted under favourable weather conditions. When birds have to fly against the wind, they tend to fly at lower altitudes and thus may be observed and counted more easily. It could also represent changes in population numbers, of course, due to changes in reproduction or survival. Species such as the Eurasian honey buzzard and the rough-legged buzzard are known to produce varying numbers of offspring depending on the availability of prey such as wasps and rodents, respectively, 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 several years to mature before breeding (DWYER et al. 2018). Hence, they occur naturally in 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 render them extremely susceptible to anthropogenic threats such as land use change, direct killing, poisoning and environmental contaminants, electrical injuries causing death as well as collisions in general 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 vulnerable diurnal raptor species include habitat loss, intensification of agricultural habitats, direct persecution (e.g. shooting), pesticide contamination, collision, disturbance of nest sites, and many others (THOMPSON et al. 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 already faced during the first half of the last century (BIJLEVELD 1974; BILDSTEIN 2017), they are among the rarest birds in Europe: 46% of all European bird species with less than 1,000 breeding pairs are birds of prey (THOMPSON et al. 2003). Many of these species are protected by European legislation and have been included under protective conventions (see Figure 3.9 for the most common species likely to cross through the Baltic Sea).

Since no collision victim search underneath offshore wind turbines is possible, all studies measuring potential mortality caused by wind turbines are based on onshore studies. Direct mortality from collisions with onshore wind turbines is relatively common in birds of prey. Collisions of individuals with wind turbines were already observed at the first large wind farms erected at Altamont Pass in California and have been documented in many other onshore sites 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 number of all collisions (HÖTKER 2017). Some species are especially susceptible. Among them are red kites, whose breeding populations in Germany have been rapidly declining since 1991 (MAMMEN et al. 2017) making them a focal species for 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 by a German database (RASRAN & DÜRR 2017). According to that study, most frequently killed birds of prey at onshore wind farms were red kite and common buzzards, with other species such as white-tailed eagles, common kestrels and black kites also frequently 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 this collision risk altitude (MAMMEN et al. 2017). Nonetheless, preliminary results of the Eurokite project indicate that other anthropogenic factors are more important mortality causes for this species than collisions with wind turbines (e.g., poisoning, road and rail collisions, electrocution, etc., RAAB 2024),

Whereas collisions with onshore turbines have been documented for at least 34 species of birds of prey, the effect this may have at the population level has been explored only for few species. For example, a study modelling the population of red kites in Germany 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 as well as 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 (JOHNSTON et al. 2014a). 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 the Kattegat area, 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 displayed avoidance behaviour towards the OWF with three quarters of all reacting birds turning back to the mainland. These results clearly indicated that an OWF could potentially act as a barrier forcing some birds to use alternative routes. Accordingly, the authors recommended 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 were 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 of potential collision victims in offshore areas are based on models such as the famous BAND model (BAND 2012).

3.2.3 CRANES

The population of common cranes breeding in Northwest Europe and Scandinavia increased in recent decades and is estimated to support 350,000 individuals now (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 migrating cranes are not observed in high numbers (HOLM et al. 2021). The Rügen-Bock region in Mecklenburg-Vorpommern, 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 portion of the cranes will also move in a south-westerly direction over the area of Bornholm (Figure 3.10). Especially in spring, common cranes migrate also towards the north potentially crossing the pre-investigation area (cf. bird migration atlas, https://migrationatlas.org/).

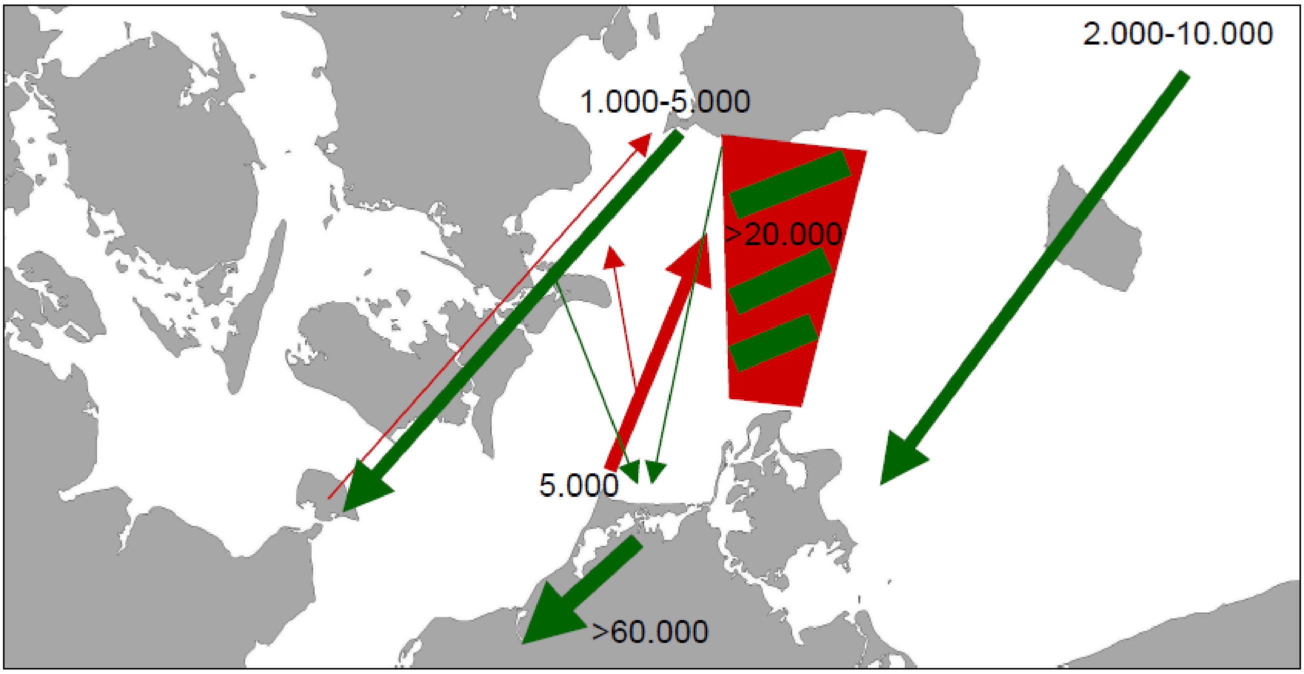


Figure 3.10: Migration routes of common cranes in the southern Baltic area (BSH 2021 based on Falsterbo, Bornholm and other observation data). Red = spring migration, green = autumn migration. Estimated numbers may be higher today due to an increasing population trend.

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 altitude of cranes migration crossing the western Baltic Sea including the Kattegat area. Cranes tend to use soaring flight over land, but due to the lack of thermal updrafts over open water, they keep altitude in powered flight after leaving the coasts (ALERSTAM 1990). Studies of flight altitudes of cranes in the Baltic offshore region so far revealed some variation, with cranes observed flying clearly below 200 m altitude 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 to be 99.93-100% (DRACHMANN et al. 2021), their aerial behaviour and altitude during the crossing of the Baltic Sea leads to a theoretical risk of collision in the offshore area that cannot be ruled out. Therefore, this species is a significant factor in discussion about potential shutdowns of turbines in the western Baltic Sea.

3.2.4 TERNS

Terns in general are not abundant but can be seen with certain regularity in Danish waters as well as 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 numbered 5,125 breeding pairs in 2021, but the majority bred in the North Sea region (HOLM et al. 2021).

The Arctic tern (ca. 1700 breeding pairs in Denmark in 2021), the common tern (ca. 880 breeding pairs) and the little tern (ca. 630 breeding pairs) may also be observed close to the pre-investigation area, but predominantly close to the coast and only in the summer months. None of the tern species occurs abundantly and as seabirds they all require protection (listed in Annex I of the European Birds Directive and under the AEWA). Furthermore, at least the Sandwich tern appears 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 existence of a larynx or the arrangement of toes facilitating perching, respectively.

Since passerines include a very large number of species, it is not surprising that they also comprise the bulk of migrating bird species. One of the best studied bird migration systems is the one involving the Palearctic-African flyway which includes the Baltic Sea. 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). Recent estimates suggest only a much reduced number of ~ 2.1 billion birds to migrate from Europe to Africa every autumn with almost three quarters of those birds corresponding to the migration of 16 passerine bird species across the Mediterranean Sea (HAHN et al. 2009). European passerines show a variety of migration patterns and strategies of which many are still unknown (BUSSE 2001). European passerine birds typically travel from their breeding sites in the north of Europe to their wintering quarters in warmer regions in southern Europe or Africa. Passerine migration is frequently occurring in broad fronts instead of corridors (see Figure 3.11 for an example).

Some passerine species are long-distance migrants with their breeding and wintering sites geographically separated by thousands of kilometres (e.g., trans-Sahara migrants) thus only crossing the pre-investigation area or using it as a stopover site during migration. Other species are short-distance migrants with their wintering grounds close to or overlapping with their breeding sites. For several species it is known that their populations migrate only partially. For example, there may be different migration patterns between sexes or age classes or even populations. For example, only northern populations of European robins are migratory, whereas southern populations are resident and populations at intermediate latitudes 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).

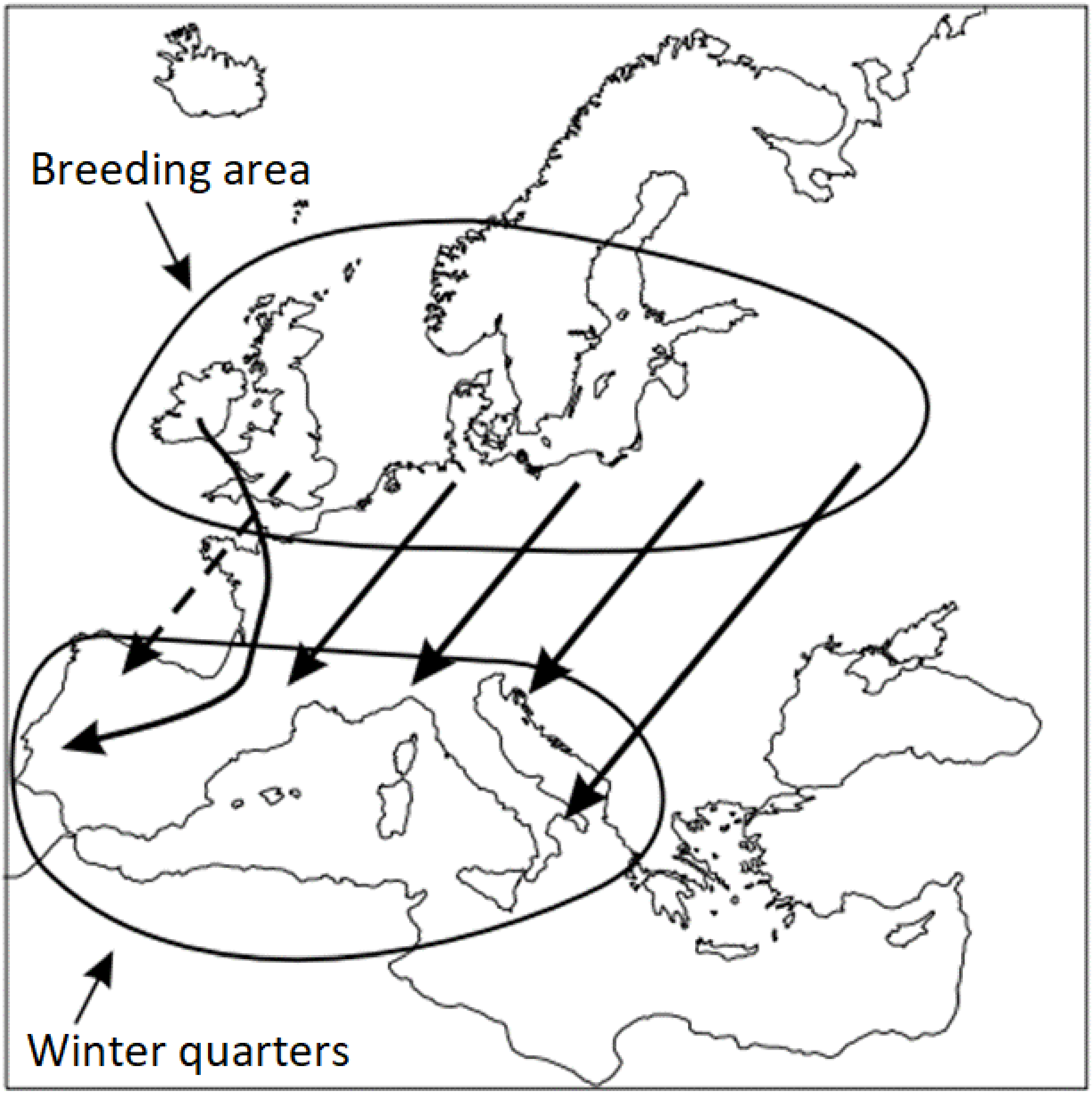


Figure 3.11: Example of broad front migration from the breeding region to the wintering quarter. Taken from Busse (2001).

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 3.12 (BUSSE et al. 2014). The different lines shown in Figure 3.12 connect breeding sites with wintering quarters (as deducted from ring recoveries). Most (passerine) birds fly along these routes across broad fronts, but there are some passages with various bottlenecks for different species.

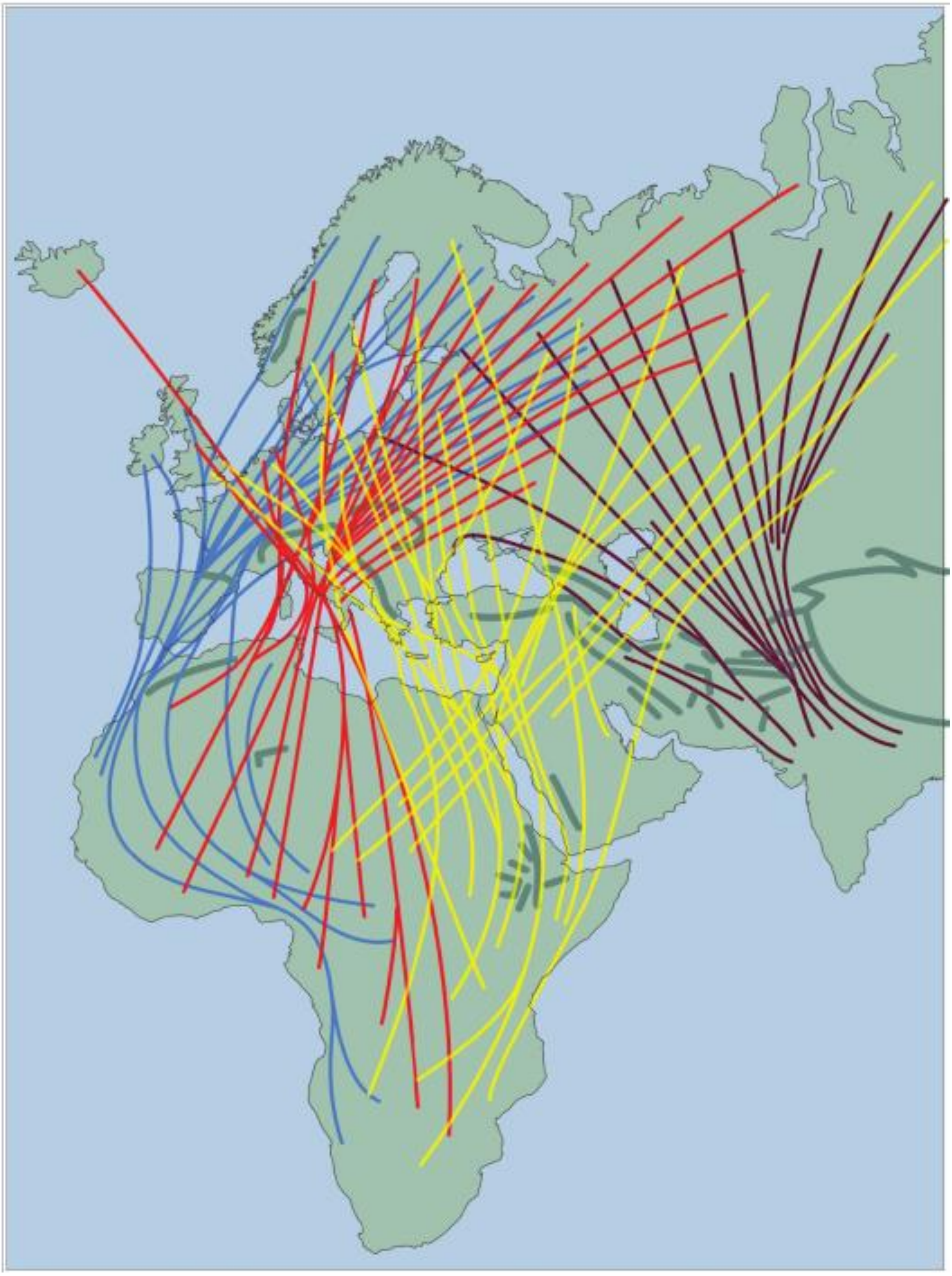


Figure 3.12: The four main fly way routes occurring in the Palearctic: 1) the western/Atlantic (blue), 2) the Central (Apennine, red), 3) South-Eastern (Balkan, yellow) and 4) Eastern (Indian, brown). Taken from Busse et al., 2014.

In general, migration of passerine birds occurs during day and night with different species having adapted to migrate at a particular time of day. Most diurnally migrating species include short- and mid-distance migrants, such as finches and wagtails, which appear to orient more along 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 depicted in Figure 3.9 and Figure 3.12, most common migratory passerines cross the Kattegat area in autumn in a south-westerly direction (as part of flyway 1). Nevertheless, there are also some individuals or populations migrating in a south-easterly direction (BELLEBAUM et al. 2010a).
Given the large number of passerine bird species crossing the Baltic Sea including the pre-investigation area during the autumn migration, they may be potentially affected by wind turbines, especially during mass migration events. Some studies have shown that many species and a large proportion of individuals killed by turbines are passerines. For example, a quarter of all species and all individuals killed by wind turbines in South Africa corresponded to Passeriformes. They fell second only in terms of collision kills only to raptors (PEROLD et al. 2020).

In temperate climates and during migration, the proportion of passerines affected by direct collisions with wind turbines may be much larger. HÜPPOP ET AL. (2006) found over 98% of all carcasses recovered at FINO1, an offshore research platform in the North Sea, were passerine birds. Despite the study by HÜPPOP ET AL. (2006) covering the German Bight in the southeastern North Sea, some of the overall findings may also be expected for the Baltic Sea. Migration activity concentrates during few days and nights of the whole migration period with typically about three quarters of all migrants recorded during one to two sixths of migration days/nights of the study. These results obtained from visual observations were also confirmed from nocturnal studies of radar echoes. Regarding flight altitudes during migration, almost half of the radar echo signals (recorded up to an altitude of 1,000 m) corresponded to the bottom 200 m of altitude within the range of wind turbine 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 in 2014 became 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, twelve aerial surveys were conducted between January 2023 and December 2024. In this report, we present the six aerial surveys conducted between January and December 2024 and compare the results with the previous year of monitoring, from January to December 2023. 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 within one survey (see Figure 4.1).

For the analysis, results from the whole survey are presented for each of the two 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 an average of 887.9 ±. 5.0 km covered per survey in 2023 and 889.1 ± 3.6 km covered per survey in 2024 (see Figure 4.1, Table 4.1 and Table 4.2). The transects ran parallel to each other in a north-south direction and were 5 km apart. In total, 4,120.7 km² were covered during the surveys.

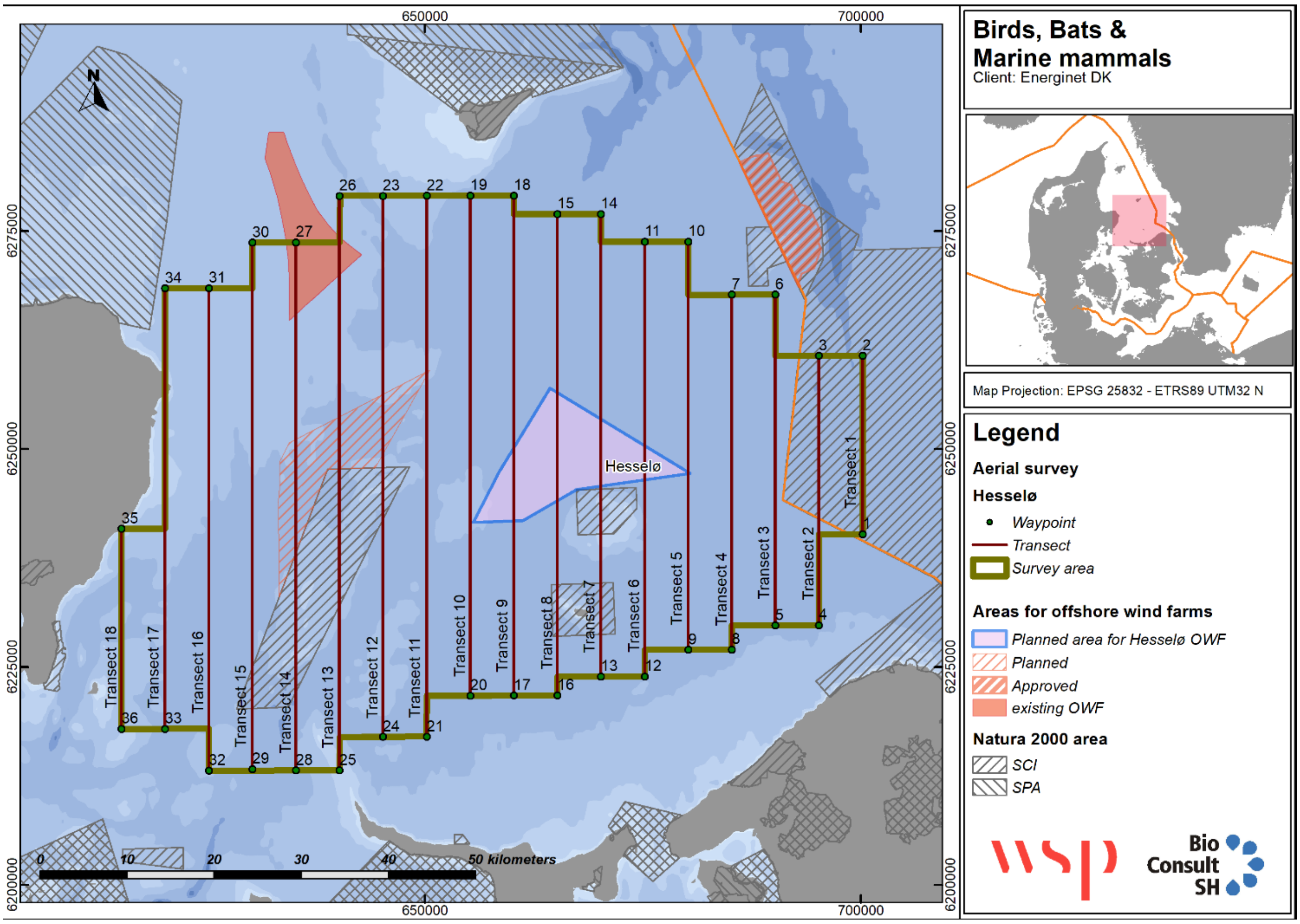


Figure 4.1 Aerial survey transect design for the pre-investigation area used during all flights. The figure includes the proposed OWF area Hesselø (pink) and nearby Natura 2000 sites (diagonals, crosshatched).

Table 4.1 Overview of the six digital aerial surveys carried out in the pre-investigation area between January and December 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	17.02.2024	868.8	472.09	11.5
2	06.04.2024	889.0	483.02	11.7
3	18.06.2024	873.7	474.98	11.5
4	07.08.2024	890.9	484.07	11.7
5	23.10.2024	890.4	483.8	11.7
6	17.12.2024	891.1	484.2	11.7
		Total: 5,303.9	**Total: 2,882.2**	**Average: 11.7**

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

Transect	Start Transect	End Transect	Length [km]
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 total pre-investigation area was covered.

The aircraft flew at an average speed of approx. 220 km/h (120 knots) at an altitude of 509 m. A GPS device (Garmin GPS Map 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).

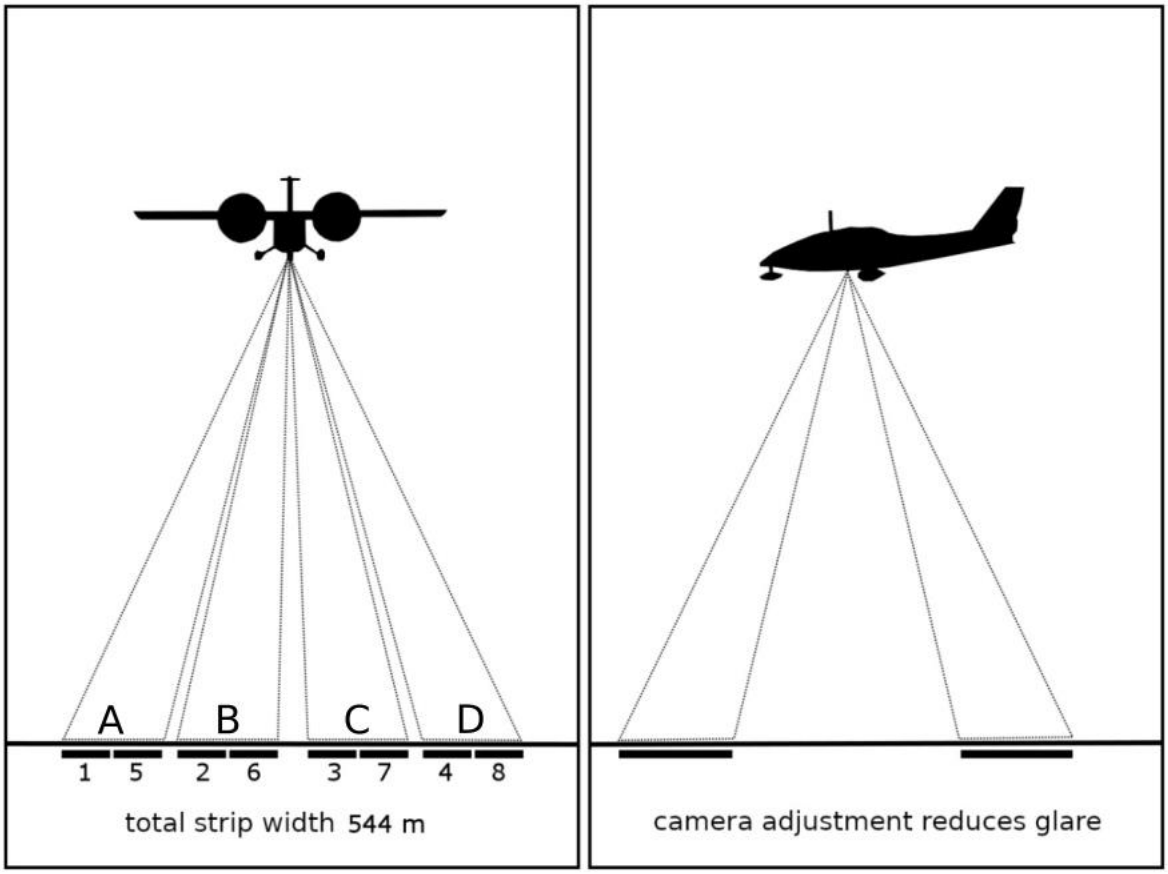


Figure 4.2. The HiDef Camera-System. The four cameras (A to D) cover an effective strip width of 544 m of the sea surface at a flight altitude of 549 m (left: frontal view; right: side view). The numbering indicates the camera images as they are used in the evaluation (the images from each camera are 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./km² 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 altitude), migration direction, phenology and migration intensity as well as acoustic observations during night for adding information on migration intensity (especially of thrushes) and species composition crossing the area during night (only for calling species in the lower altitudes). Standardised (vertical and horizontal) radar surveys (4.2.3) were applied continuously when the ship was laying at anchor for migration intensity and flight height distribution as well as flight directions. Table 4.3 indicates the type of information that is possible to investigate with 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 a vessel 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 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 bird observations or prevented the vessel from maintaining the anchoring position at the survey site. Weather conditions (precipitation, wind speed and direction, temperature, visibility, and wave height/seastate) 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.

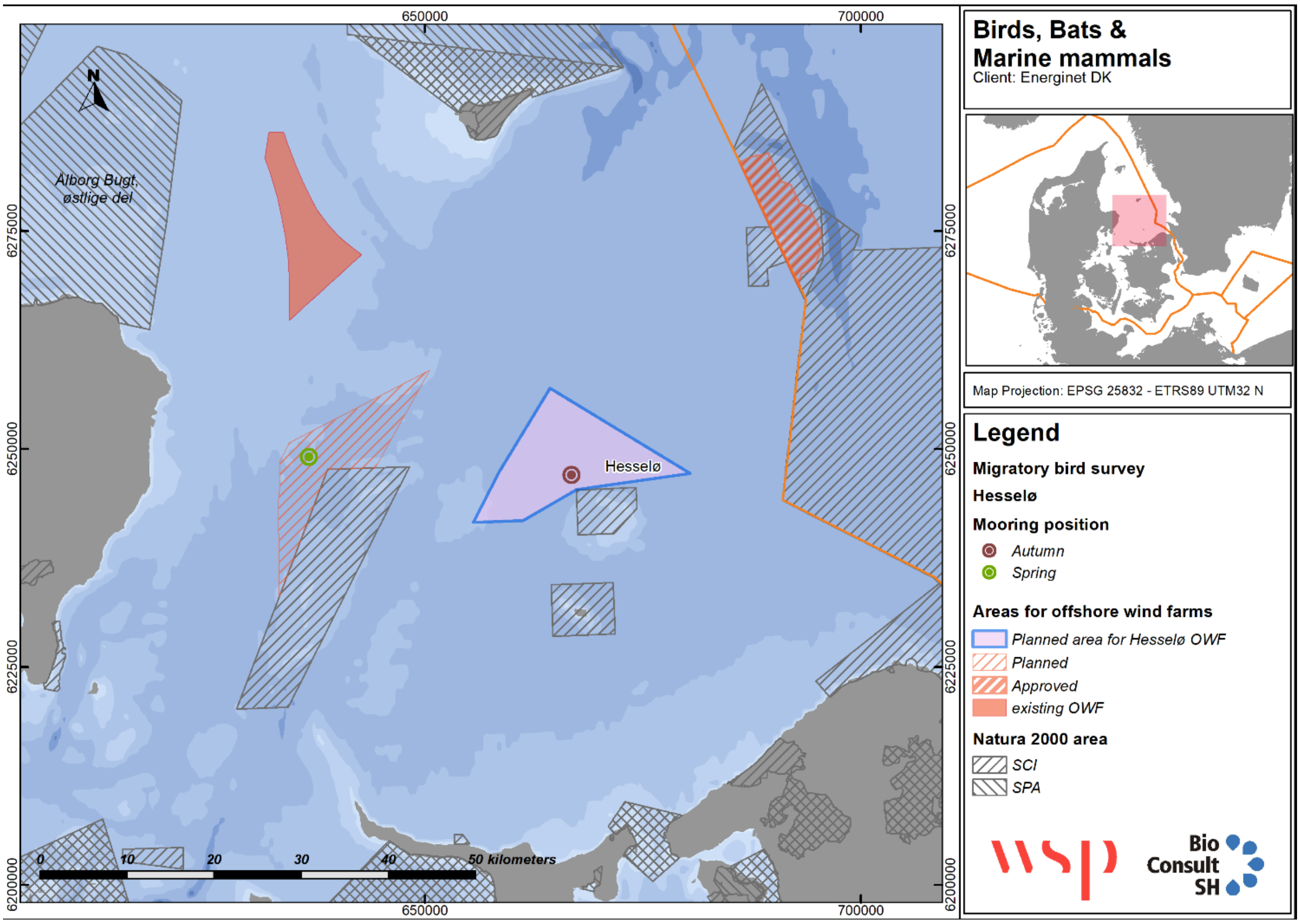


Figure 4.3 Overview of the anchoring points in the middle of the areas of the proposed OWF Kattegat and Hesselø (spring and autumn 2023 and 2024).

4.2.1 SURVEY EFFORT

All surveys were conducted from board of the ship 'Skoven'. In spring, surveys were conducted between March 4th and May 5th, 2023 and March 1st and May 11th, 2024 (Table 4.4), whereas in autumn, the surveys were between August 18th and November 29th, 2023 and August 4th and November 10th, 2024 (Table 4.5). Observations usually began either at dawn (civil morning twilight) or dusk (civil evening twilight) of a given date (Table 4.4 and Table 4.5) and then continued for three to six 24-h cycles. Civil twilight is defined as the moment when the sun is 6 degrees below the horizon, corresponding to the time when the light is barely enough for reading.

In spring 2023, 15 observation days and 11 nights were completed. In spring 2024, 15 observation days and 15 nights were completed (Table 4.4). In autumn 2023, a total of 19 observation days and 18 observation nights were completed whereas in autumn 2024, a total of 20 observation days and 21 observation nights 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 for the proposed OWF area Kattegat. Starting and finishing periods of every survey and number of days/nights, dates for the collection of every type of data in spring 2023 and spring 2024.

Survey	Survey periods		Number of 24 h cycles	Number of days/nights with	
	Start: Date and time	End: Date and time		visual observations	nocturnal flight calls
			2023		
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 2023				**15 (14)**	**11 (9)**
			2024		
1	01.03.2024, 15:35	05.03.2024, 12:01	4	4 (3)	4
2	05.03.2024, 12:44	06.03.2024, 17:00	1	1	1
3	05.04.2024, 17:45	10.04.2024, 04:15	4.5	4	5
4	10.04.2024, 05:00	10.04.2024, 18:00	0.5	1	0
5	06.05.2024, 03:00	11.05.2024, 03:00	5	5	5
Total 2024:			**15**	**15 (14)**	**15 (15)**

In 2023, 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 to conduct reliable analyses.

In 2024, one date of collection (02.03.2024) was discarded due to low visibility.

Table 4.5 Survey information for the proposed OWF area Hesselø. Starting and finishing periods of every survey and number of days/nights, dates for the collection of every type of data in autumn 2023 and autumn 2024.

Survey	Survey periods		Number of 24 h cycles	Number of days/nights with	
	Start: Date and time	End: Date and time		visual observations	nocturnal flight calls
			2023		
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	2.5	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 2023:			**18.5**	**19 (18)**	**18 (17)**
			2024		
1	04.08.2024, 19:00	09.08.2024, 12:00	4.5	5	5
2	01.09.2024, 18:00	06.09.2024, 18:00	5	5	5
3	11.10.2024, 16:15	14.10.2024, 16:30	3	3	3
4	29.10.2024, 15:57	30.10.2024, 20:30	1.5	1	2 (1)
5	04.11.2024, 14:43	10.11.2024, 15:30	6	6	6
Total 2024:			**20**	**20 (20)**	**21 (20)**

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).

In addition, the survey of late October 2024 had to be interrupted due to bad weather conditions. Accordingly, only few hours of data collection were possible, and data from the 30th of October 2024 was therefore not taken into account.

4.2.2 OBSERVER-BASED DATA

VISUAL OBSERVATIONS (DIURNAL 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) by eye. Observers also noted if birds were visibly associated with the observers' vessel or other (especially fishing) vessels, because birds were assumed to be foraging in those cases rather than migrating. The observers entered the observation data directly via a tablet, and data were backed up daily into a database to prevent data loss.

DATA ANALYSIS

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

Migration intensity was calculated as a rate of birds per hour, extrapolating from 30 minutes of observations per hour. Based on this, the annual as well as the daily course of migration intensity were presented for all birds combined as well as for relevant species groups. Relevant species groups are chosen based on their abundance (> 100 individuals seen over the two years) or their inclusion in a conservation category (see Results for details). Only data from days during which the observations covered at least 70 % of the daylight period were used. In addition, observations when weather conditions indicated low visibility were discarded. For example, observations on the 2nd of March 2024 were discarded due to low visibility.

To evaluate the distribution of flight altitudes, the recorded migratory altitudes of all observations were grouped into altitudinal ranges (0-5 m, 5 - 10 m, 10 - 20 m, 20 - 50 m, 50 - 100 m, 100 – 200 m, > 200 m), as proposed by German authorities (BSH 2013), and presented 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 altitudes and directions among other parameters are presented combined including data of 2023 and 2024, unless patterns of each year would differ strongly.

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 series 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 shorter 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 antennae 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 day and night (Table 4.3). The vertically rotating radar antennae were aligned perpendicular to the assumed main migratory direction and manually readjusted 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 for analysis.

During a reanalysis of the vertical radar data of 2023, it was realised that afterglow duration was not always set to 45 seconds, but sometimes erroneously to 60 seconds. Migration intensities have then been recalculated using the corresponding afterglow duration and thus slightly higher migration intensities values are provided for 2023 (see Results).

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.

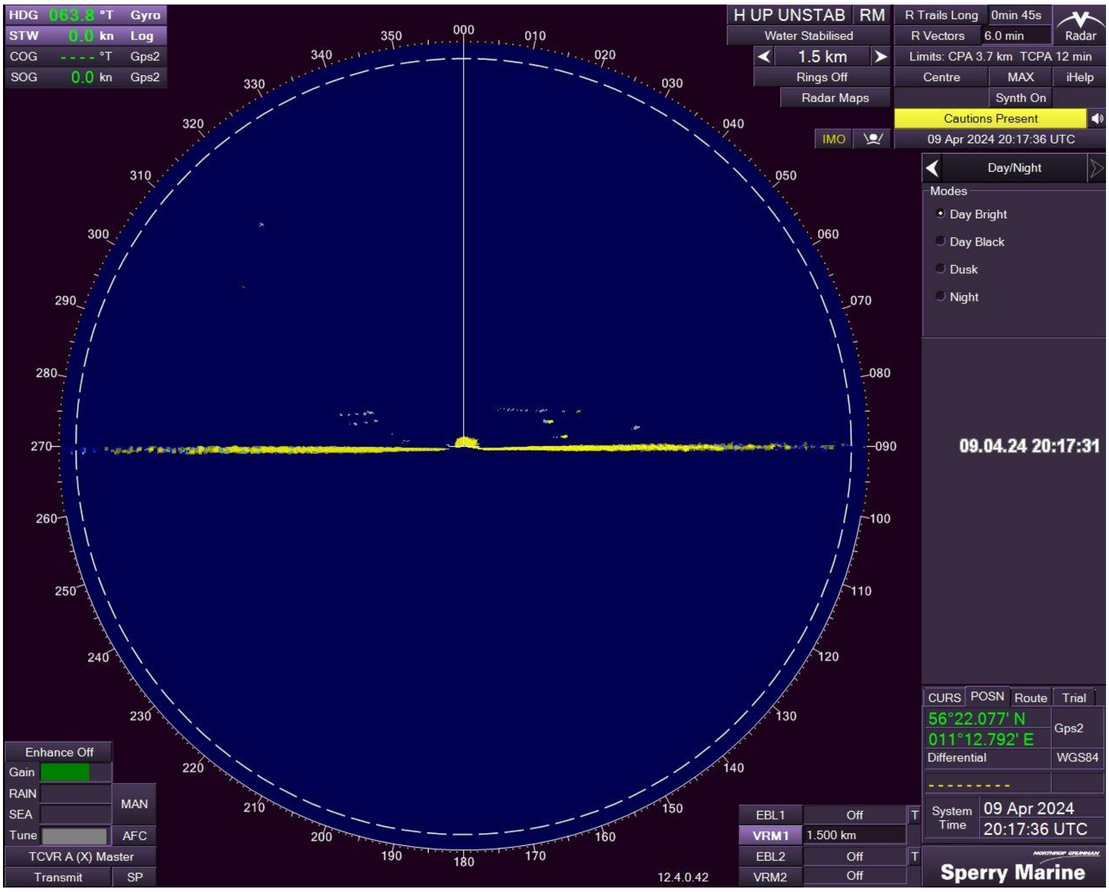


Figure 4.5 Example of a screenshot from vertical radar with characteristic bird signals (the yellow line represents the sea surface, the signals in the upper half of the radar area are bird echoes).

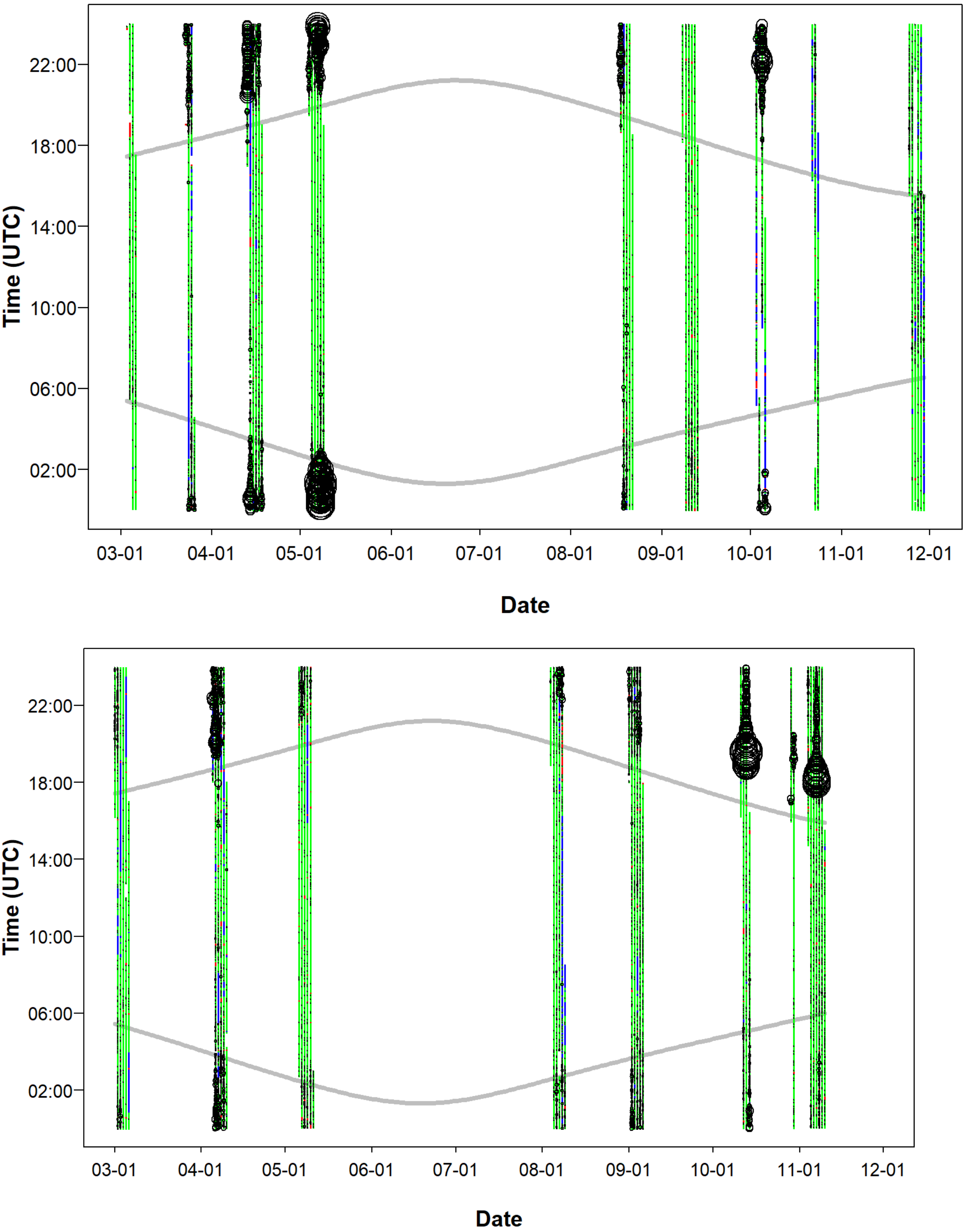


Figure 4.6 Effort of vertical radar in 2023 (top) and 2024 (bottom). Colours during the time of recording indicate the possibility to analyse the data: green indicate periods with analysable data, blue are periods not evaluable due to precipitation, red are periods not analysable due to other disturbances. Black circles indicate the number of bird signals and grey lines mark the sunrise and sunset.

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 (R CORE TEAM 2022). "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 (AIC). 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 1000 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. Furthermore, in order to show potential differences in altitudinal distribution between days/nights with high and low migration intensity, this evaluation was also conducted separately for the five days/nights with the highest migration intensities compared to the rest of days and nights sampled.

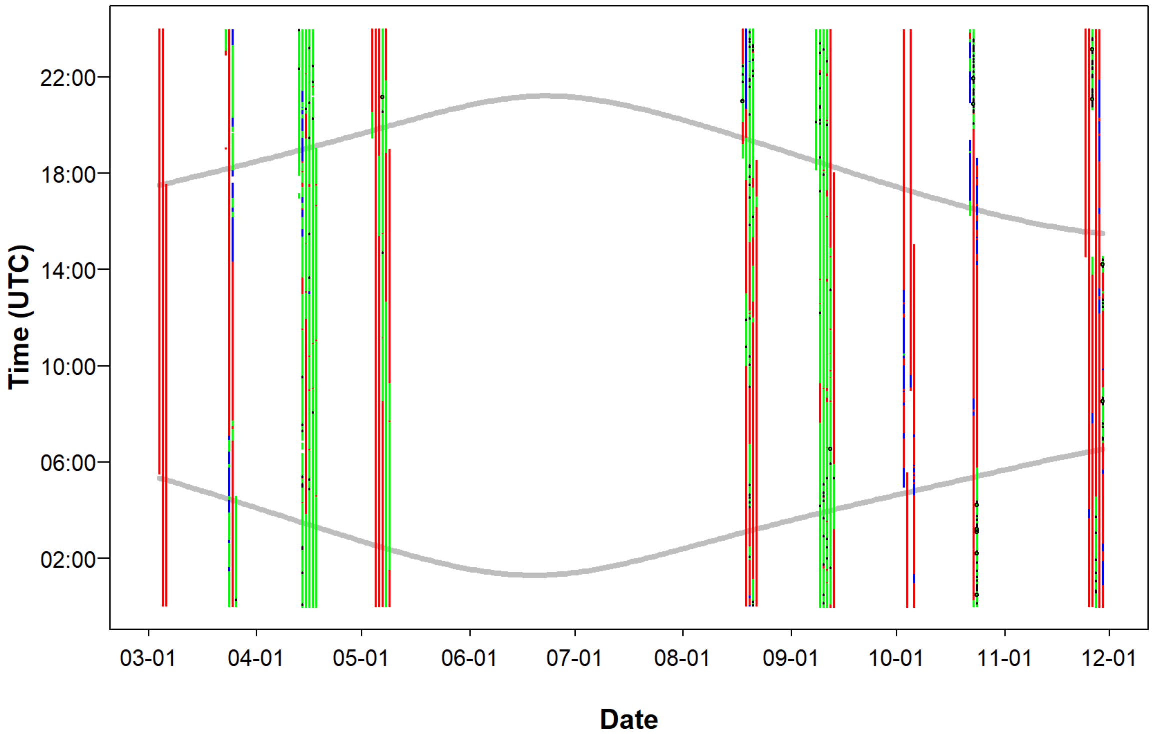
HORIZONTAL RADAR

Flight directions of birds were determined with the horizontal radar (Table 4.3). A radar device similar to the one used for vertical radar 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 extended 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 for analysis.

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.



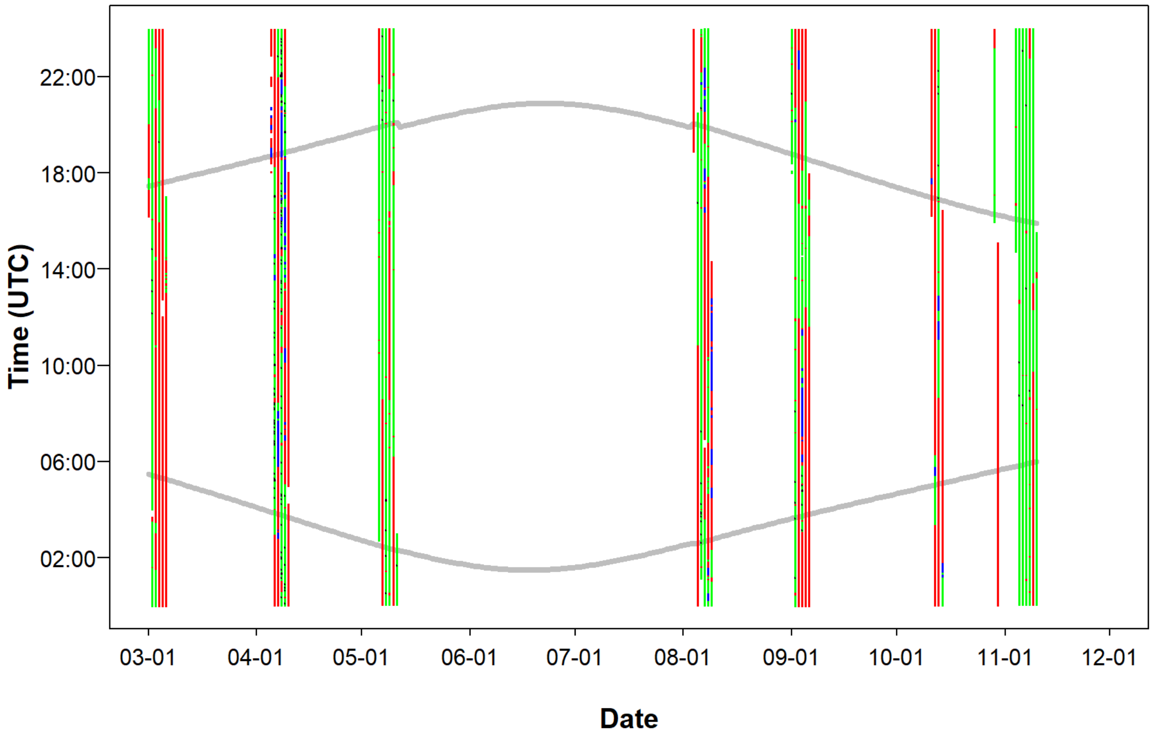


Figure 4.7 Effort of horizontal radar in spring and autumn 2023 (top) and 2024 (bottom). Colours during the time of recording indicate the possibility to analyse the data: green indicate periods with analysable data, blue are periods not evaluable due to precipitation, red are periods not analysable due to other disturbances (mostly sea state). Black dots indicate the number of bird signals and grey lines mark the sunrise and sunset.

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 4.7.

FLIGHT DIRECTION

The flight direction distribution was presented by season for both day and night migration. For plotting, flight directions were grouped into 20° increments. Using the Rayleigh test, directional migration was confirmed 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

The following section presents the results obtained from the data analysis of six aerial surveys conducted during the second year of baseline monitoring between February and December 2024 in the planned OWF Hesselø. Additionally, it combines results obtained during the first year of monitoring, 2023, for comparison purposes. When feasible, comparisons are given regarding proportion of specific species among resting birds or comparisons of absolute numbers found during the two years of baseline monitoring. Temporality of sightings is exemplified with raw counts and densities within the studied area.

Further description of the most abundant species is provided for those whose frequency of occurrence exceeded a threshold of 0.5% among detected resting birds. Species description is presented in ascending order according to Euring codes (EURING 2024).

The spatial distribution of the sightings is represented and grouped by season, according to the phenology described in the specific classification for each species by Garthe et al. (2007). The maps combine data from the two years of baseline monitoring, from January 2023 to December 2024. Additionally, specific results from the first year of monitoring can be found at Castillo et al. (2024).

5.1.1 ALL SPECIES

Table 5.1 depicts the total number of species observed during the six digital aerial surveys between February and December 2024. Table 5.2 includes monthly densities for each of the months at which digital aerial surveys were conducted. The phenology and spatial distribution of species which represented at least 0.5% of total abundance, are described in more details in the next sections.

Additionally, within the annexes, a complete list with all recorded species and/or species groups is presented along with the conservation status of each (Table A 1).

Table 5.1 Bird counts and percentages of all resting bird species during the six digital aerial surveys between February and December 2024. Species representing at least 0.5% of total abundance are highlighted in bold.

Species groups	English name	Scientific name	All digital surveys	
			N ind.	Percentage
Divers	Red-throated diver	*Gavia stellata*	660	**6.87**
	Black-throated diver	*Gavia arctica*	14	0.15
	Great Northern diver	*Gavia immer*	1	0.01
	unidentified diver	*Gavia sp.*	15	0.16
Grebes	Great crested grebe	*Podiceps cristatus*	23	0.24
	Red-necked grebe	*Podiceps grisegena*	1	0.01
	Slavonian grebe	*Podiceps auritus*	12	0.12
	Red-necked Grebe / Great crested grebe	*Podiceps grisegena/Podiceps cristatus*	1	0.01
	Unidentified grebe	*Podicipedidae sp.*	7	0.07
Tubenoses	Northern fulmar	*Fulmarus glacialis*	3	0.03
Gannets	Northern gannet	*Morus bassanus*	59	**0.61**
Cormorants	Great cormorant	*Phalacrocorax carbo*	403	**4.19**
Sea ducks	Common eider	*Somateria mollissima*	548	**5.7**

Species groups	English name	Scientific name	All digital surveys	
			N ind.	**Percentage**
	Long-tailed duck	*Clangula hyemalis*	21	0.22
	Common scoter	*Melanitta nigra*	138	**1.44**
	Velvet scoter	*Melanitta fusca*	13	0.14
Skuas	Great skua	*Stercorarius skua*	1	0.01
	Arctic / pomarine skua	*Stercorarius parasiticus/Stercorarius pomarinus*	1	0.01
Gulls	Little gull	*Hydrocoloeus minutus*	2	0.02
	Black-headed Gull	*Chroicocephalus ridibundus*	95	**0.99**
	Common gull	*Larus canus*	503	**5.23**
	Unidentified small gull	*Larus small sp.*	30	0.31
	Lesser Black-backed gull	*Larus fuscus*	235	**2.45**
	Herring gull	*Larus argentatus*	614	**6.39**
	Great Black-backed gull	*Larus marinus*	122	**1.27**
	Common Gull / Herring gull	*Larus argentatus/Larus canus*	12	0.12
	Unidentified large gull	*Larus (magnus) sp.*	17	0.18
	Great Black-backed gull / Lesser Black-backed gull	*Larus fuscus/Larus marinus*	3	0.03
	Unidentified Larus gull	*Larus sp.*	36	0.37
	Black-legged kittiwake	*Rissa tridactyla*	341	**3.55**
Terns	Sandwich tern	*Thalasseus sandvicensis*	1	0.01
	Common tern / Arctic tern	*Sterna hirundo/Sterna paradisaea*	12	0.12
Auks	Common guillemot	*Uria aalge*	4729	**49.21**
	Common guillemot / Razorbill	*Uria aalge / Alca torda*	312	**3.25**
	Razorbill	*Alca torda*	307	**3.19**
	Black guillemot	*Cepphus grylle*	139	**1.45**
	Atlantic puffin	*Fratercula arctica*	3	0.03
	Unidentified auk	*Alcidae sp.*	176	**1.83**
Total			**9,610**	**100**

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 to December 2024. The maximum value is also indicated (bold font). 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	February 2024	April 2024	June 2024	August 2024	October 2024	December 2024	Max
Red-throated diver	**0.771**	0.437	0.002	0	0.008	0.165	**0.771**
Black-throated diver	0.002	**0.010**	0	0	0.010	0.006	**0.010**
Great northern diver	0	**0.002**	0	0	0	0	**0.002**
Great crested grebe	**0.025**	0.004	0	0.006	0	0.012	**0.025**
Red-necked grebe	0	**0.002**	0	0	0	0	**0.002**
Slavonian grebe	0	**0.025**	0	0	0	0	**0.025**
Northern fulmar	0	0	0	0	0	**0.006**	**0.006**
Northern gannet	0	**0.046**	0	0.002	0.045	0.029	**0.046**
Great cormorant	**0.229**	0.041	0.211	0.093	0.110	0.159	**0.229**
Common eider	**0.386**	0.335	0.025	0.012	0.048	0.337	**0.386**
Long-tailed duck	**0.386**	0.335	0.025	0.012	0.048	0.337	**0.386**
Common scoter	**0.191**	0.031	0	0.017	0.029	0.023	**0.191**
Velvet scoter	0.006	0.006	0	0	0.006	**0.008**	**0.008**
Great skua	0	0.002	0	0	0	0	**0.002**
Little gull	**0.004**	0	0	0	0	0	**0.004**
Black-headed gull	0.002	0.079	0	**0.081**	0.031	0.004	**0.081**
Common gull	0.250	0.201	0.015	0.006	0.260	**0.314**	**0.314**
Lesser black-backed gull	0	**0.352**	0.067	0.058	0.010	0	**0.352**
Herring gull	**0.530**	0.211	0.074	0.025	0.081	0.363	**0.530**
Great black-backed gull	0.076	**0.114**	0.002	0.010	0.017	0.035	**0.114**
Black-legged kittiwake	0.057	0	0	0	0.101	**0.547**	**0.547**
Sandwich tern	0	0	0	**0.002**	0	0	**0.002**
Common guillemot	**3.319**	2.083	0.008	1.708	0.676	2.061	**3.319**
Razorbill	0.047	0.017	0	0.012	0.275	**0.285**	**0.285**
Black guillemot	0.028	0.079	0	0.012	0.079	**0.091**	**0.091**
Atlantic puffin	0	**0.006**	0	0	0	0	**0.006**
Divers	**0.784**	0.453	0.002	0	0.025	0.182	**0.784**
Cormorant	**0.229**	0.041	0.211	0.093	0.110	0.159	**0.229**
Sea ducks	**0.619**	0.381	0.025	0.029	0.083	0.368	**0.619**
Gulls	0.119	0.095	0.002	0.081	0.172	**0.570**	**0.570**
Auks	**3.622**	2.242	0.008	1.806	1.335	2.786	**3.622**
No. of surveys	**1**	**1**	**1**	**1**	**1**	**1**	

During the six digital aerial surveys carried out between February and December 2024 (see Table 4.1), a total of 10,521 birds were observed of which 9,610 were classified as resting birds. The resting birds identified in this study belonged to 10 groups and summed up to 26 species (see Table 5.1). Of these, 622 birds could not be identified to species level (6.5% of the total number of resting birds). The total number of all observed birds, together with their scientific names, Danish common names and conservation status are shown in Table A-1 in the appendix.

The most common species group was auks (Figure 5.3) which represented more than half of all resting birds seen during the second year of monitoring (59.0%, Figure 5.1). The proportion was similar to 2023 (Figure 5.2). Auks were dominated by common guillemots, which represented 49.2% (n= 4,729) of all resting birds in 2024, an approximate absolute increase of 10% in occurrence when compared to 2023 (Figure 5.2). Razorbills and black guillemots represented 3.2% (n= 307) and 1.5% (n= 139) of all resting birds in the pre-investigation area in 2024.

Gulls were the second most common species group (20.9%, n=2,010), of which five species will be analysed in detail in the following sections: black-headed gull, common gull, lesser black-backed gull, herring gull, great black-backed gull and black-legged kittiwake. Sea ducks were the third most common species group (7.5%, n= 720). Common eider and common scoter were the two most common species of sea ducks. These species represented 5.7% (n= 548) and 1.4% (n= 138) of all resting birds. However, common scoters were spotted in a different proportion compared to 2023 (from 1,087 sightings to 138, Figure 5.2). Divers were the fourth most common species group in the area (7.2%, n= 690) with most of them being red-throated divers. The last species group was formed by one species, the great cormorant which represented 4.2% (n= 403) of all resting birds. A single species from the Sulidae family, northern gannet, was recorded during the surveys and represented 0.6% (n= 59) of all resting birds.

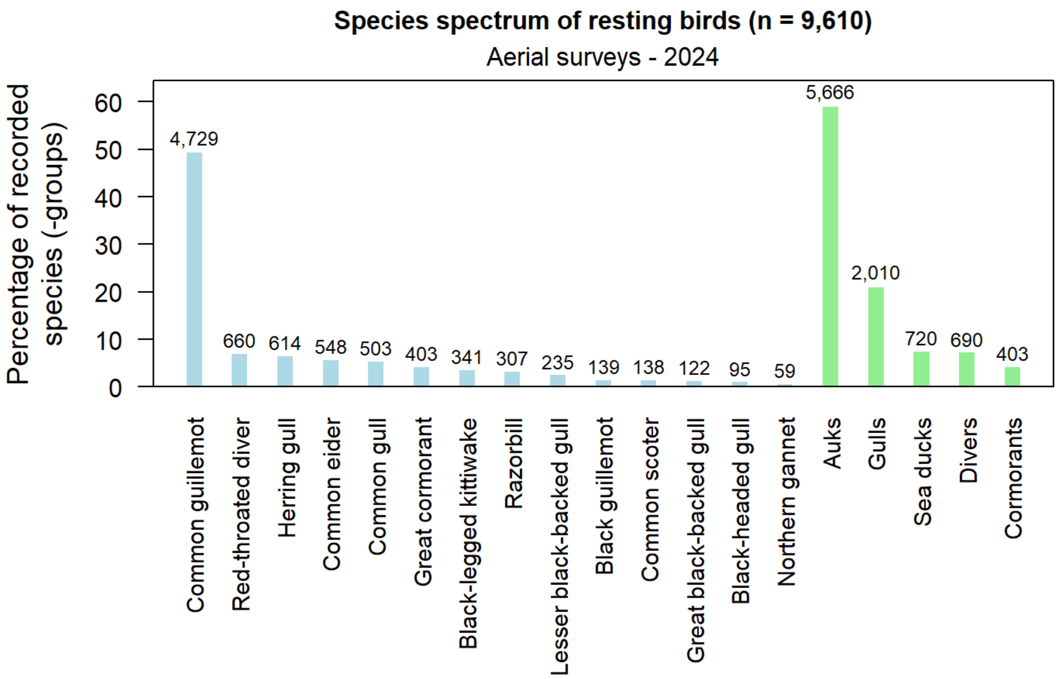


Figure 5.1 Percentage of the most common species or species groups representing at least 0.5% of the total number of resting birds recorded during aerial surveys in the pre-investigation area between February and December 2024 (number of individuals shown above each bar). Species are depicted in blue, species groups in green bars.

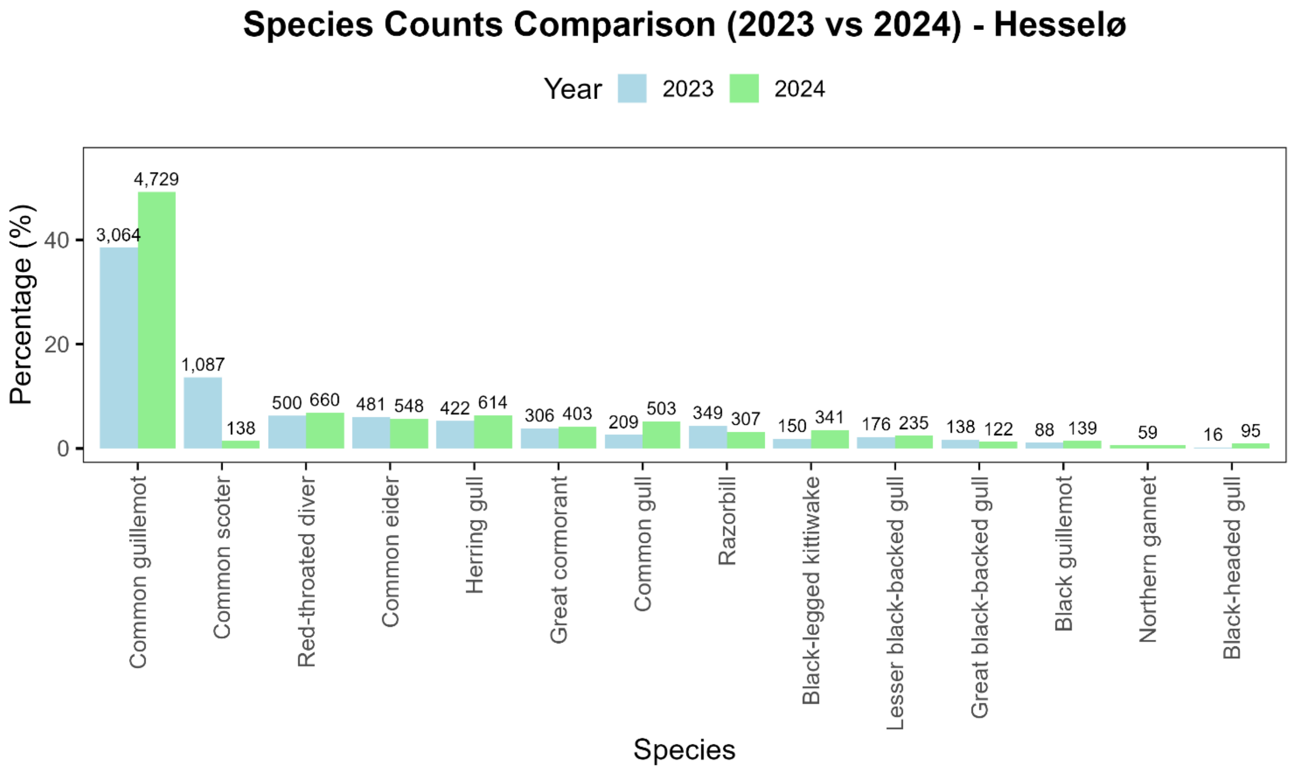


Figure 5.2 Percentage of the most common species representing at least 0.5% of the total number of resting birds recorded during aerial surveys in the pre-investigation area. Comparison between the first year of baseline monitoring, 2023 (blue), and the second, 2024 (green). Absolute values of reported sightings are included above bars for clarity.

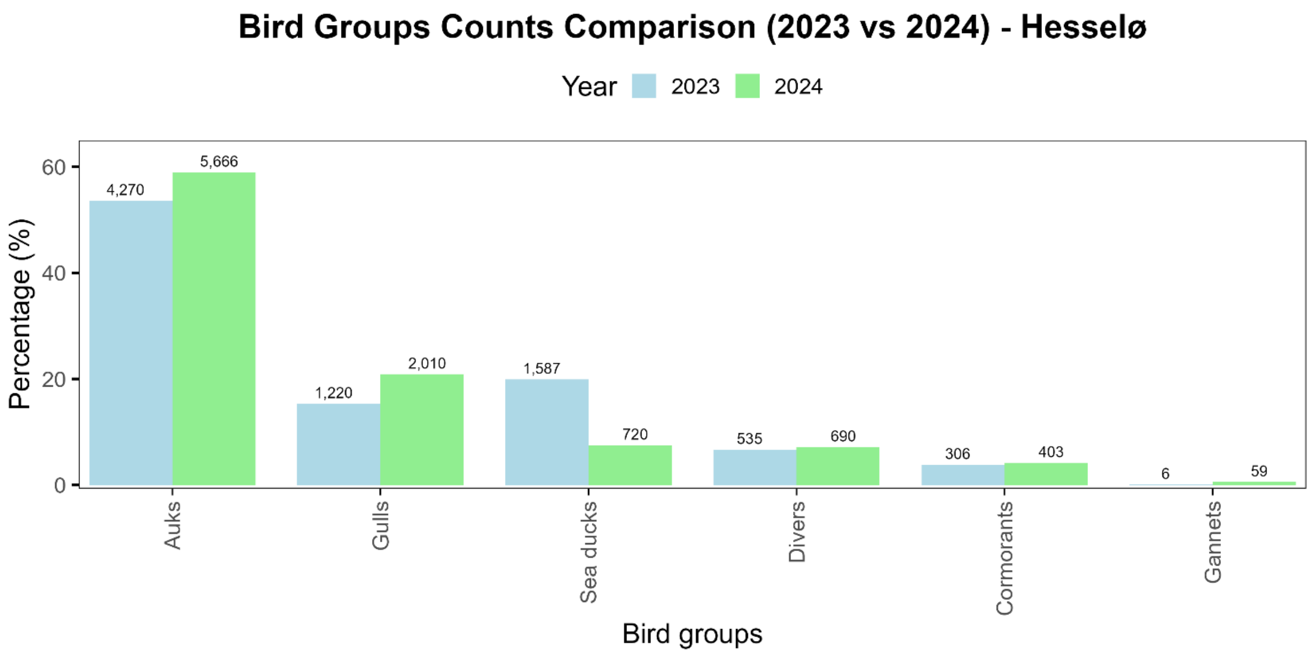


Figure 5.3 Percentage of the most common species groups of resting birds recorded during aerial surveys in the pre-investigation area. Comparison between the first year of baseline monitoring, 2023 (blue), and the second, 2024 (green). Absolute values of reported sightings are included above bars for clarity.

5.1.2 ABUNDANCE AND DISTRIBUTION OF THE MOST COMMON SPECIES

DIVERS

Two species of divers were recorded in the pre-investigation area: red-throated and black-throated divers. However, red-throated divers (660 individuals) were much more common representing over 98% of all identified divers seen in the area. Only 14 divers were identified as black-throated divers.

RED-THROATED DIVER

A total of 660 red-throated divers were registered in the pre-investigation area during the six digital surveys in 2024. They represented 6.8% of all detected resting birds, which is within a similar range as in the first year of monitoring in 2023, representing 6.3% (n= 500) of all observed resting birds (Figure 5.2). However, the absolute number of detected individuals increased by 32% for 2024. The temporal distribution of detections followed the same pattern as in 2023, with February being the month with maximum number of observations.

The highest monthly density was observed in February 2024 and reached 0.77 ind./km² (Figure 5.4). Densities decreased towards the summer season. No diver was seen during the June or August surveys, in 2023 and 2024 respectively, and their numbers increased again during the winter months.

Red-throated divers were widespread throughout the survey area, especially in spring when densities were higher. During this season, they were also observed within the limits of the planned OWF area. Higher densities were detected close to shore, northeast and southeast of the peninsula Djursland (Figure 5.5).

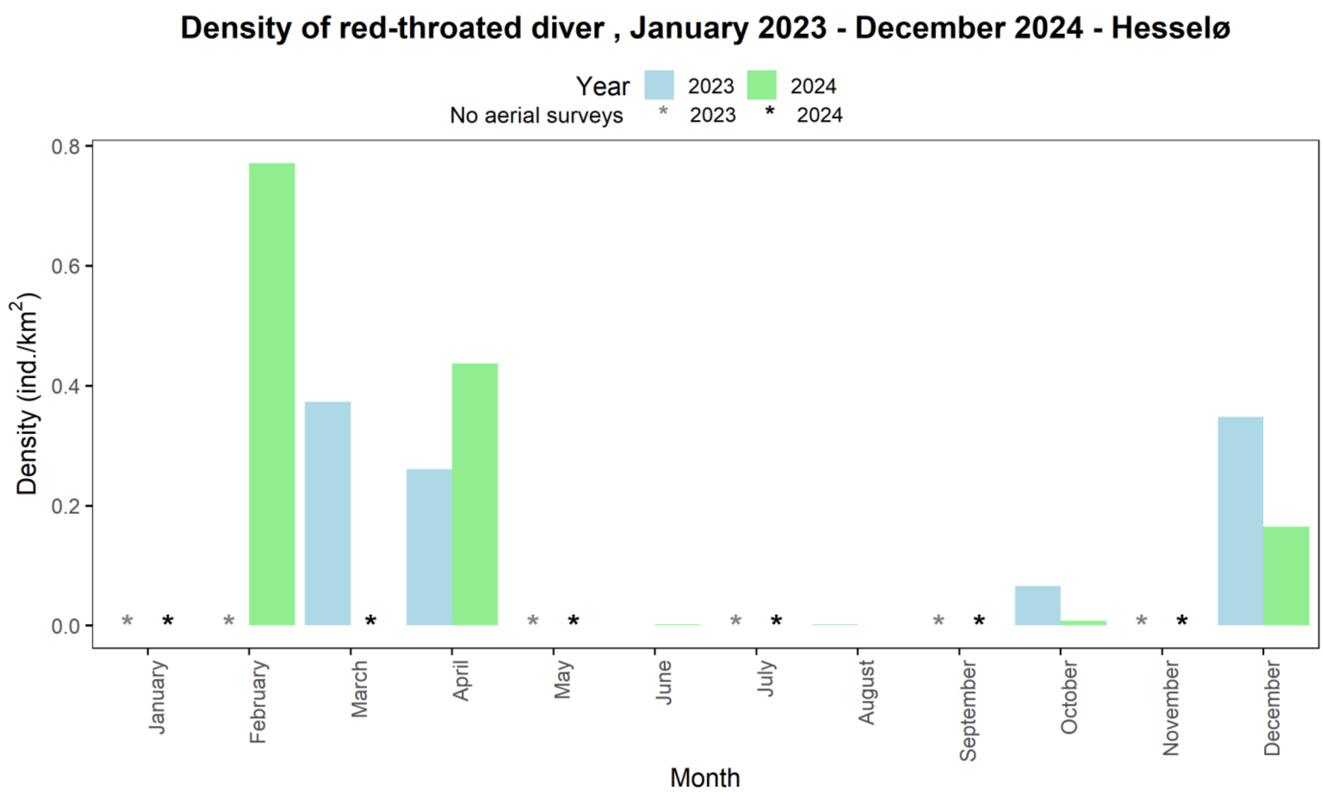


Figure 5.4 Monthly densities of red-throated diver during digital aerial surveys in the pre-investigation area between January 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

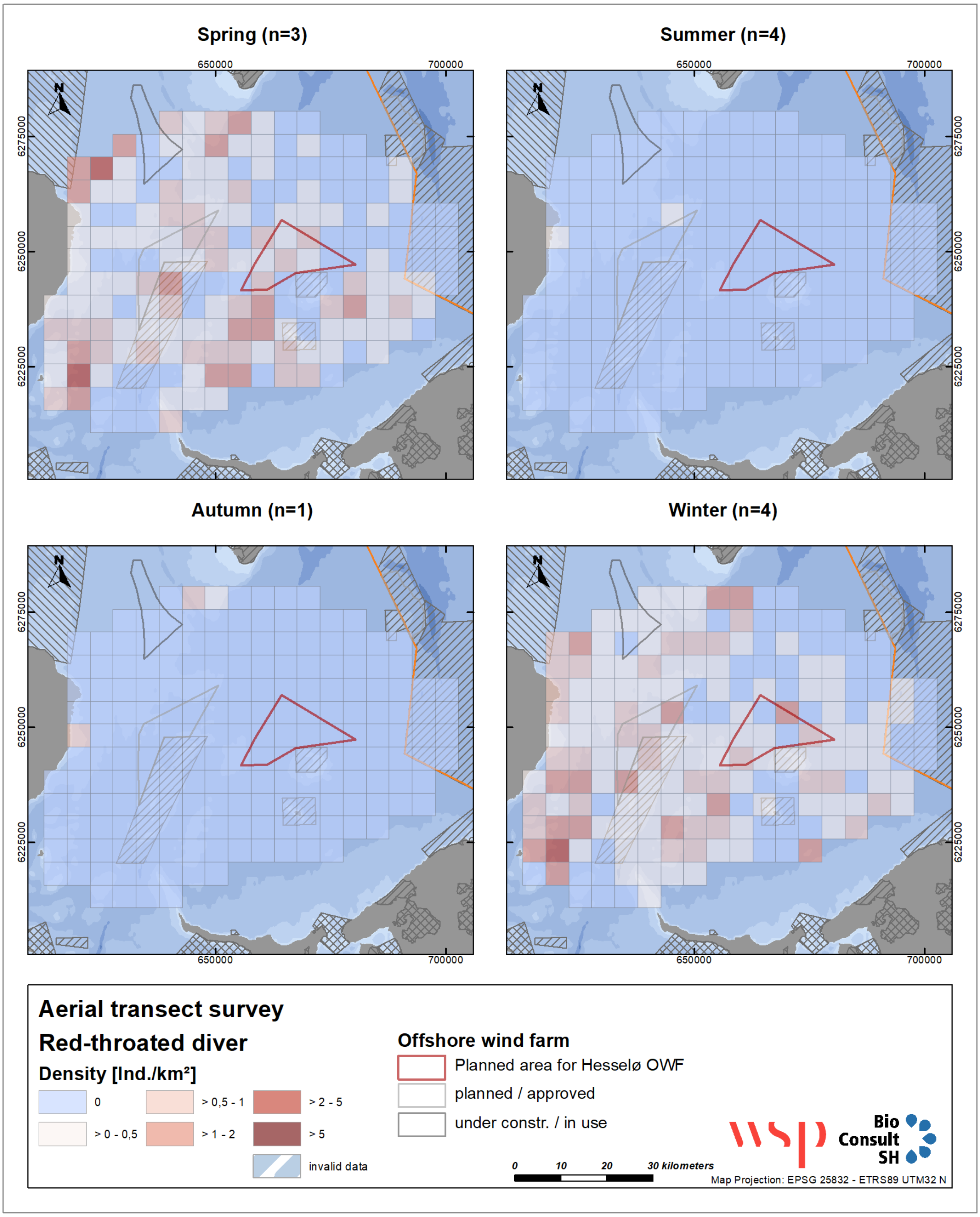


Figure 5.5 Distribution of red-throated diver in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

GANNETS

Gannets represented <0.5% of resting birds during the monitoring period in 2023 and therefore were excluded from the 1st year report. However, during the 2024 campaign a total of 59 individuals were sighted, accounting for 0.61% of all resting birds detected, implying an absolute increase of sightings of 983.3% (Figure 5.2). Despite this increase, this species remains as non-significant in the area studied due to low numbers.

The highest densities were recorded during April and October 2024, with maximum values of 0.05 ind./km^2 (Figure 5.6). The temporality of the sightings was concentrated in the late autumn and winter months, when 61.0% of all sightings were recorded.

Gannets were dispersed around the monitored area; their presence was spatially located in coastal areas by the east side of the Jutland Peninsula Djursland. Although their presence was registered in several grid cells, gannets were mostly found southwest of the planned OWF, near the tip of Sjællands Odde, where the Schultz and Hastens Grund samt Briseis Flak Protected Area is located (Figure 5.7).

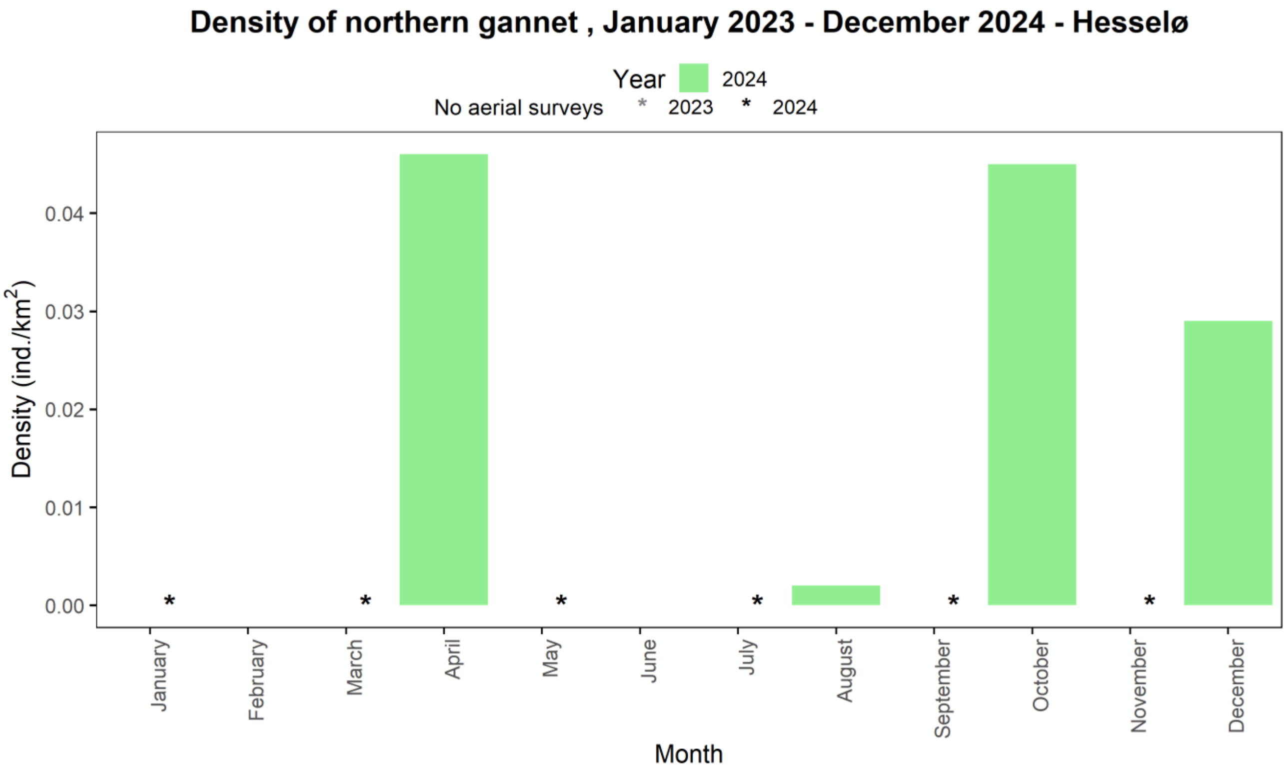


Figure 5.6 Monthly densities of northern gannet during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

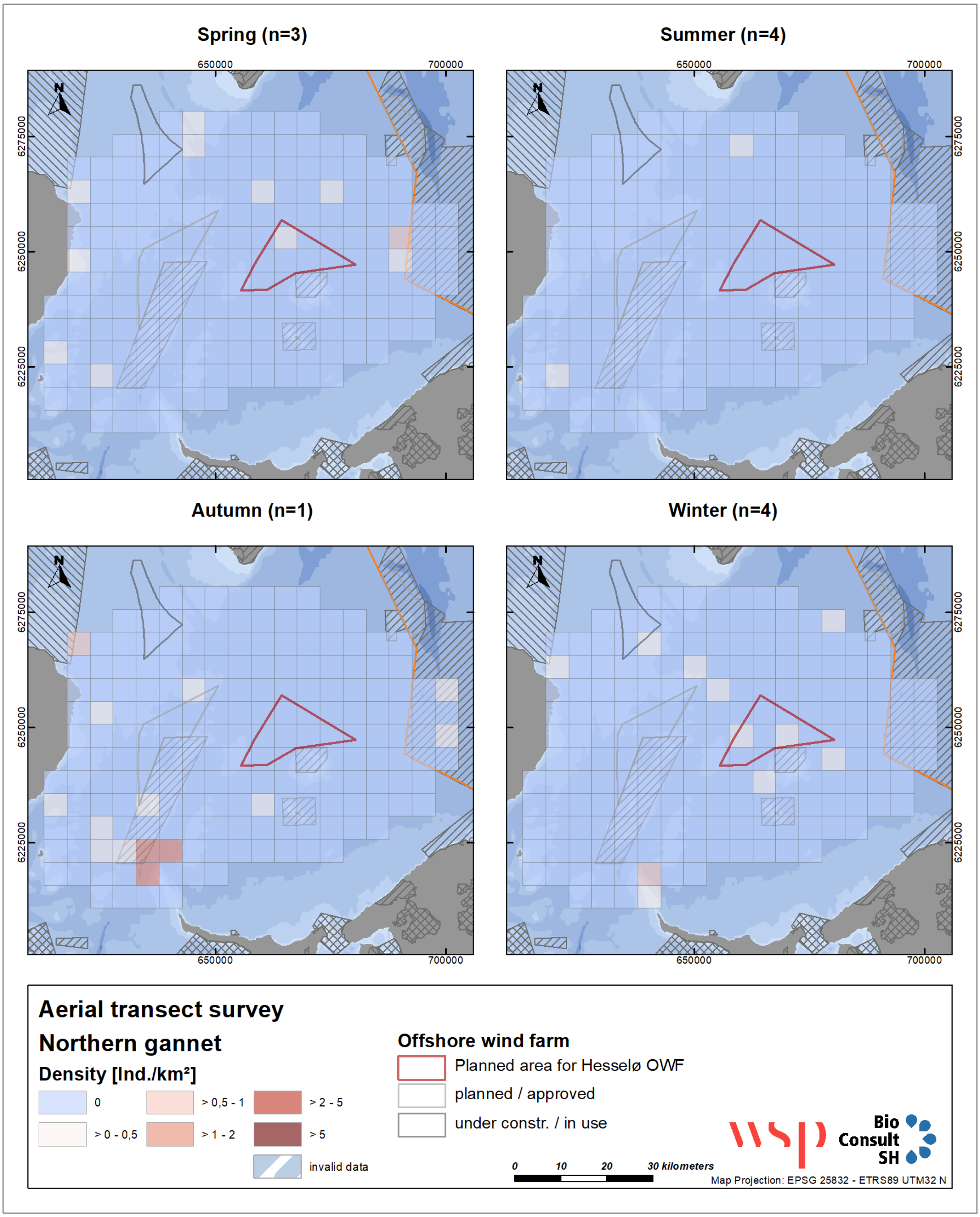


Figure 5.7 Distribution of northern gannet in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

GREAT CORMORANT

A total of 403 great cormorants were detected during the surveys in 2024, representing 4.2% of all resting birds in the pre-investigation area. A similar proportion was detected in 2023 (Figure 5.2), when 3.8% (n= 306) of all resting birds belonged to this species. However, absolute detected individuals increased by 31.9% (n=97).

Cormorants were present throughout the entire study period. Their abundance was highest in December 2023 as well as February and June 2024, while the lowest densities were found in June 2023. However, the species was present during all surveys. The maximum seasonal density was detected in winter (0.23 ind./km^2 for December 2023 and February 2024), whereas the seasonal density was lowest in summer (0.02 ind./km^2 June 2023, Figure 5.8).

Great cormorants were mainly found towards the west and south of the pre-investigation area, closer to shore. Some individuals were also seen in offshore regions, but at low densities (Figure 5.9). In spring, higher numbers were found within the Anholt OWF.

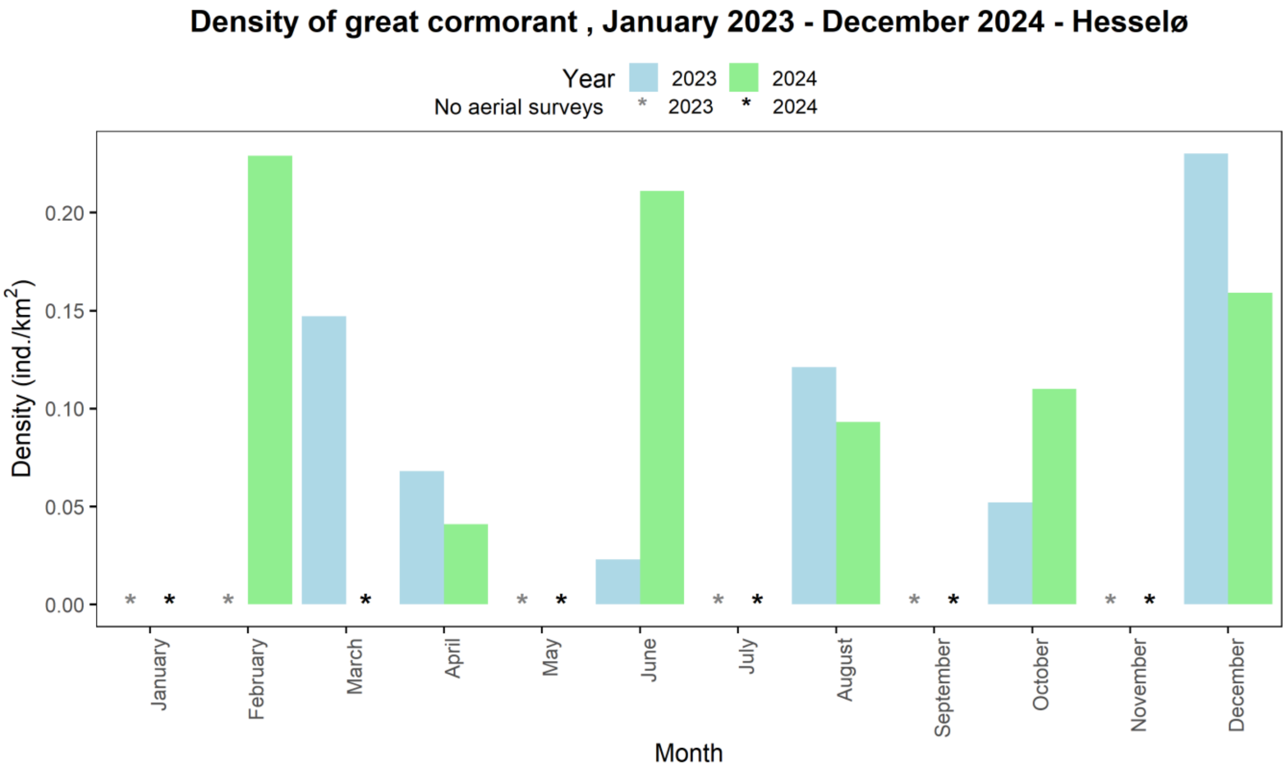


Figure 5.8 Monthly densities of great cormorant during digital aerial surveys in the pre-investigation area between January 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

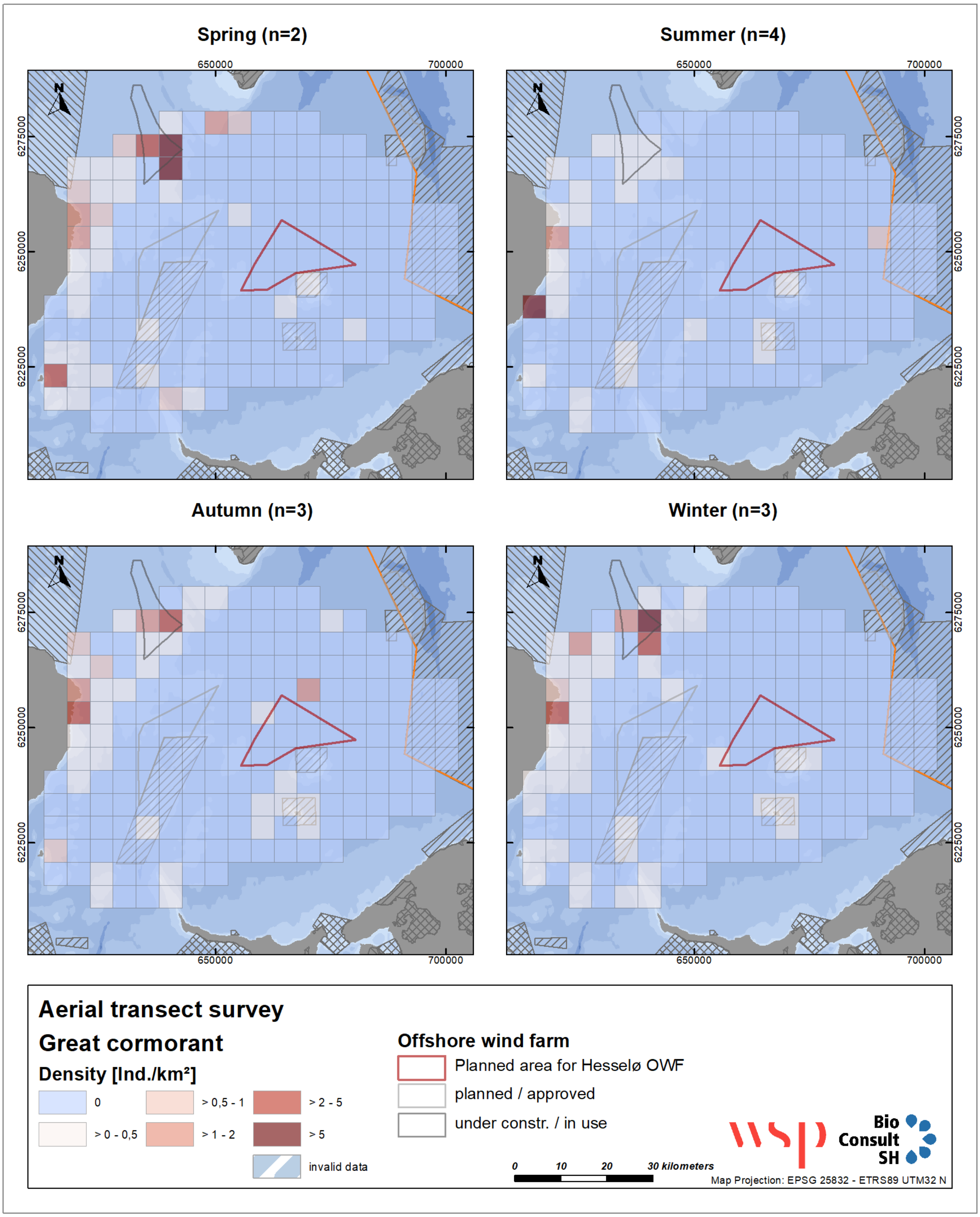


Figure 5.9 Distribution of great cormorant in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

DUCKS

Sea ducks

were the third most common species group and represented 7.5% (n= 720) of the total resting birds. Two species were dominant: common eiders (5.7%, n= 548) and common scoters (1.4%, n= 138).

COMMON EIDER

A total of 548 common eiders were registered in the pre-investigation area during the six digital surveys in 2024. Although the absolute number of common eiders was lower during 2023 surveys (n= 481), it represented a similar frequency of occurrence, signifying 6.0% of all observed resting birds (Figure 5.3). The temporal distribution was marked for the period between winter and spring, in which February 2023 and March 2024 represented the highest detection rates of this species.

The highest monthly density occurred during the surveys of February 2024 and March 2023, with 0.39 ind./km^2 and 0.41 ind./km^2, respectively (Figure 5.10) and coincided with the spring season. The lowest density was observed during August surveys, which correspond to the summer season of the species (June to August).

This species was more commonly found towards the west of the pre-investigation area. Present in the centre of the pre-investigation area, they were observed close to protected areas. Additionally, individuals regularly occurred at the tip of Sjællands Odde in high densities and in coastal waters near the Jutland peninsula (Figure 5.11), although medium densities were detected south of the OWF during the winter season.

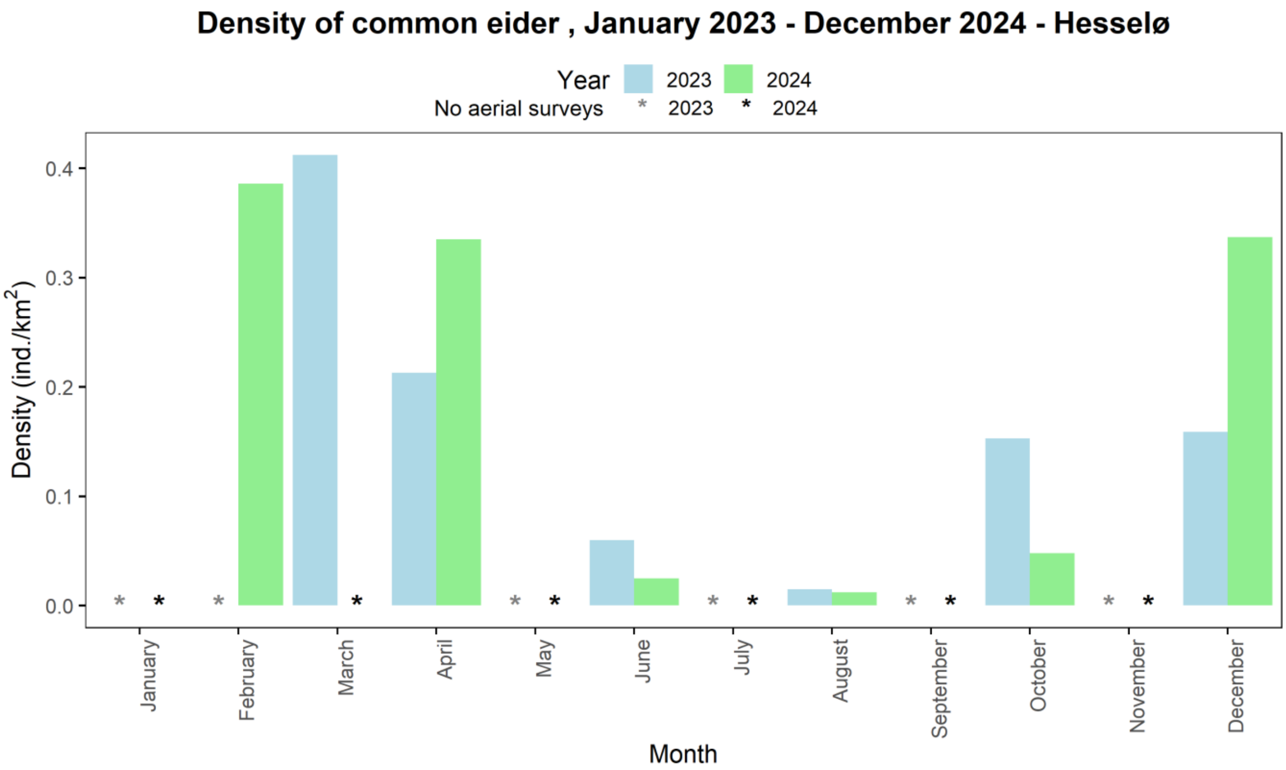


Figure 5.10 Monthly densities of common eider during digital aerial surveys in the pre-investigation area between January 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

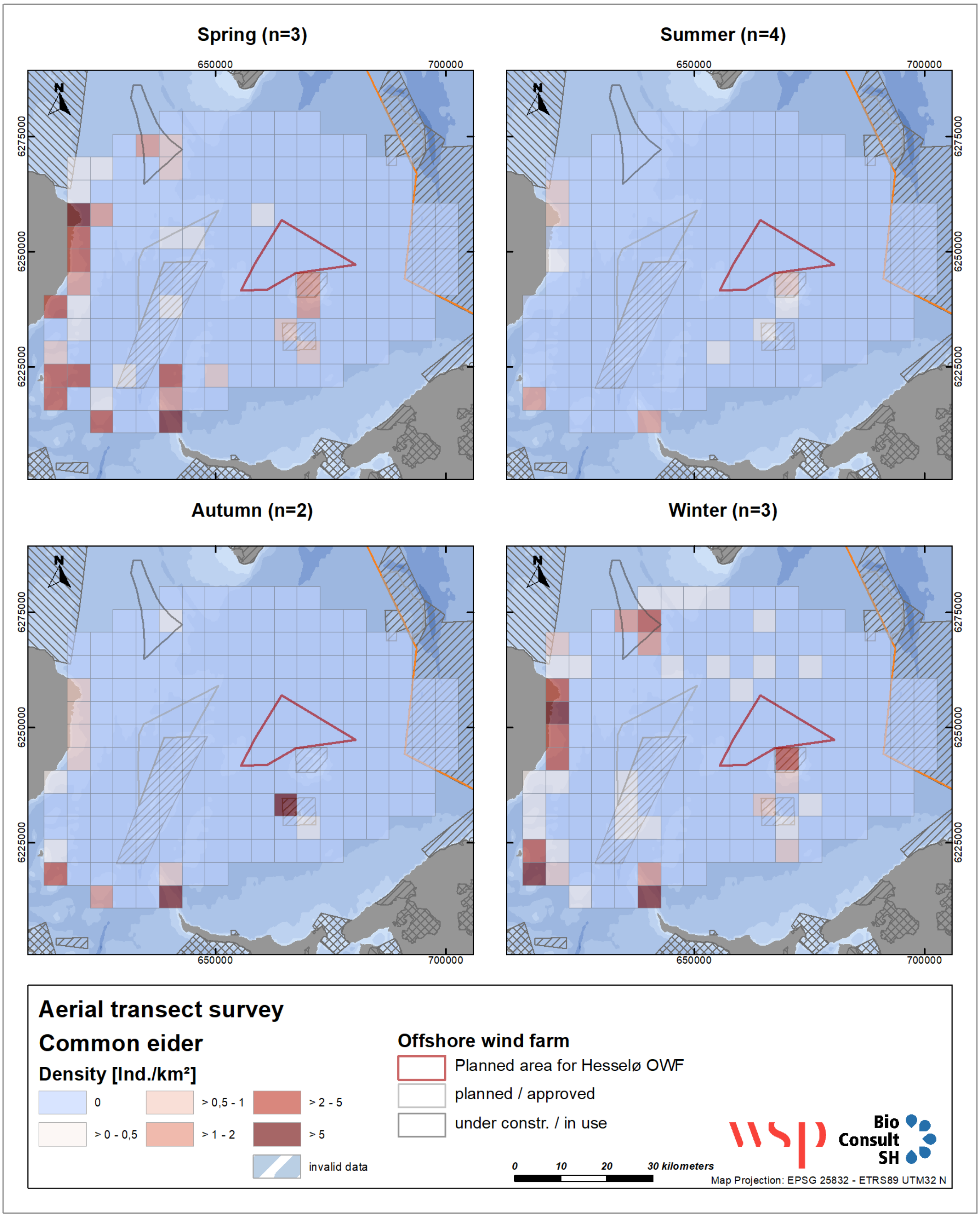


Figure 5.11 Distribution of common eider in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

COMMON SCOTER

Common scoters were the second most abundant duck species in the pre-investigation area, but their overall abundance declined compared to 2023 (Figure 5.2). In 2024, 138 individuals were recorded, accounting for 1.4% of resting birds—a noticeable 87.3% decrease in sightings compared to the previous year, when 1,087 were observed, making up 13.6% of the total species composition of resting birds for 2023. February was the month with maximum observations, unlike in 2023 when the peak happened during April.

Regarding density, the maximum was reached during April 2023, when up to 2.10 ind./km^2 were detected, a high contrast when compared to 2024, when only 0.03 ind./km^2 were observed. Common scoters were not detected during the surveys of June and October 2023 (Figure 5.12).

Common scoters were distributed in high numbers northwest of Sjæland and in several grid cells by the coast of Jutland during 2023. However, only groups with less than 5 individuals were reported during 2024, a significant difference when compared to 2023, when groups of over 500 individuals were reported in one grid cell at the tip of Sjællands Odde (Figure 5.13).

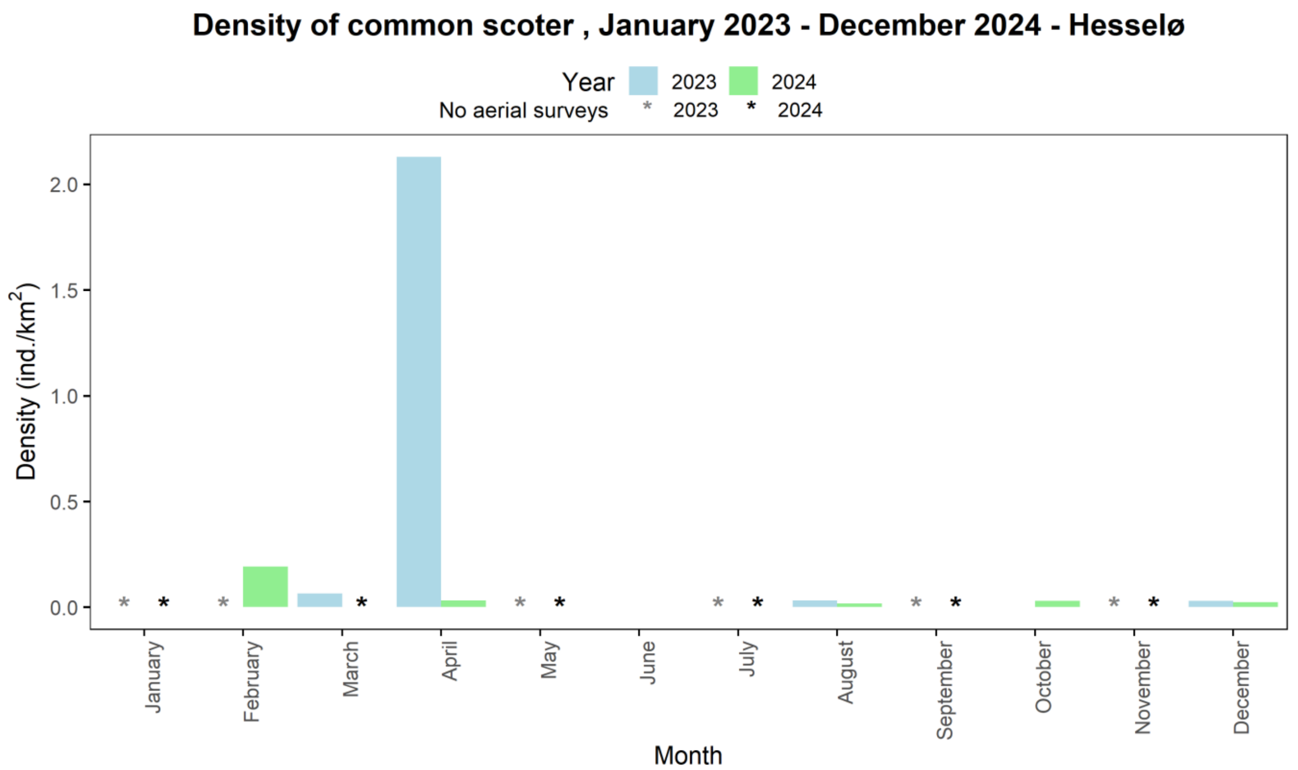


Figure 5.12 Monthly densities of common scoter during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

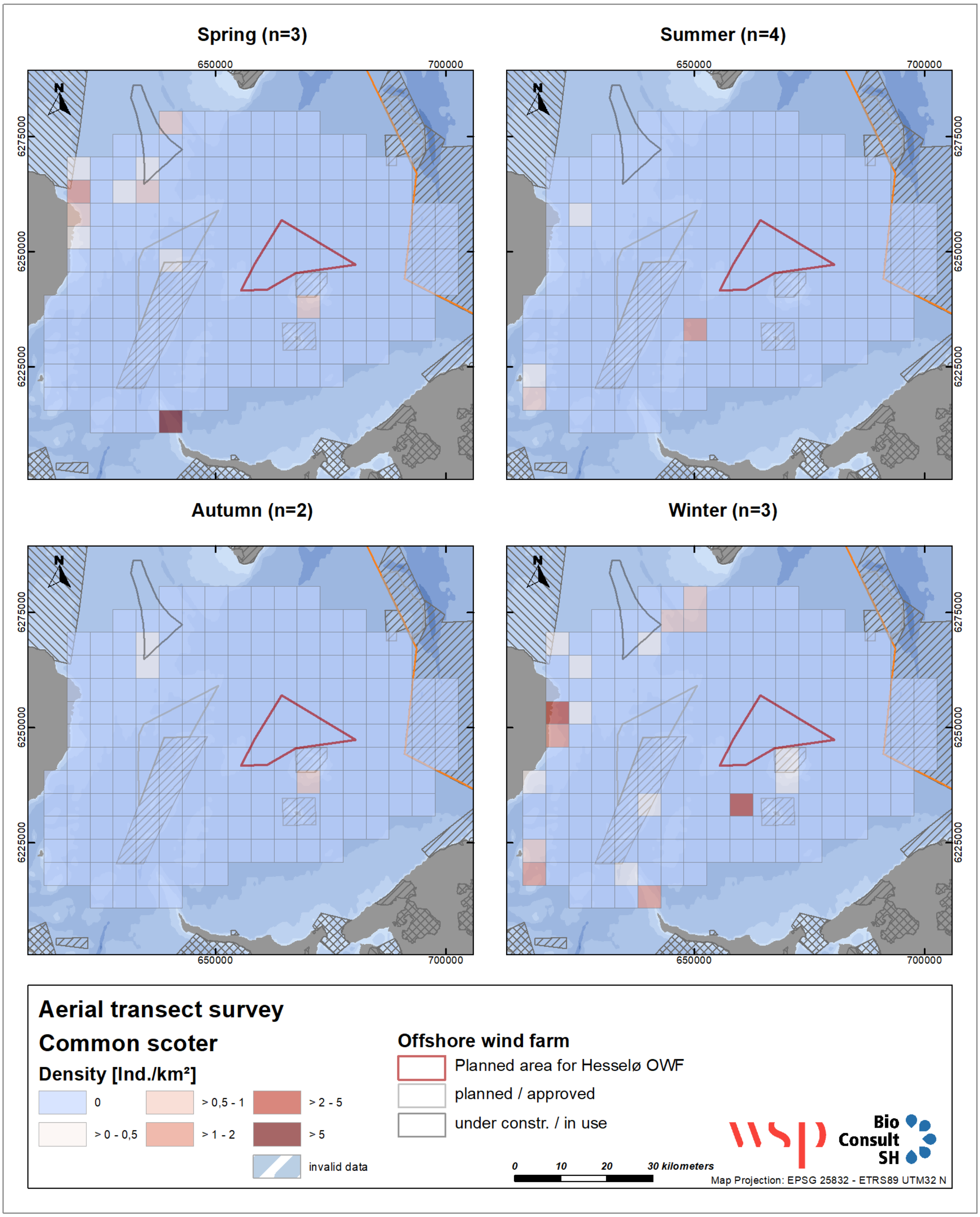


Figure 5.13 Distribution of common scoter in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

GULLS

Seven gull species were observed in the pre-investigation area during the six digital aerial surveys in 2024. The most sighted was the herring gull whose total abundance represented 6.4% (n= 614) of all resting birds seen in the area. In order of abundance, the following species occurred in the area as well: common gulls (5.2%, n= 503), black-legged kittiwakes (3.6%, n= 341), lesser black-backed gulls (2.5%, n= 235), great black-backed gulls (1.3%, n= 122), black-headed gulls (1.0%, n= 95), and only two individuals of little gull (0.02%). The abundances of the first named five species are described in the following pages as they surpass the threshold of 0.5%. The species are described in ascending order according to the Euring codes (EURING 2024).

BLACK-HEADED GULL

A total of 95 individuals of black-headed gulls were observed in the pre-investigation area during the six digital aerial surveys in 2024. This represents a 593.7% increase in absolute terms when compared to the previous year of monitoring (n= 16), rising from 0.2% to 0.99% of all resting birds (Figure 5.2). Peak months of observations coincided with spring and summer, with April (n= 38) and August (n= 39) showing the highest counts for the second year of monitoring.

Their maximum densities occurred in April and August 2024 (0.08 ind./km² for both months). The lowest densities were detected during winter but also in June, when no sightings were recorded in both years (Figure 5.14).

Black-headed gulls were sparsely distributed across the entire pre-investigation area, but higher densities were observed at locations closer to the coast, mostly towards the western shores from the pre-investigation area (Figure 5.15). This species was not spotted within the limits of the planned OWF.

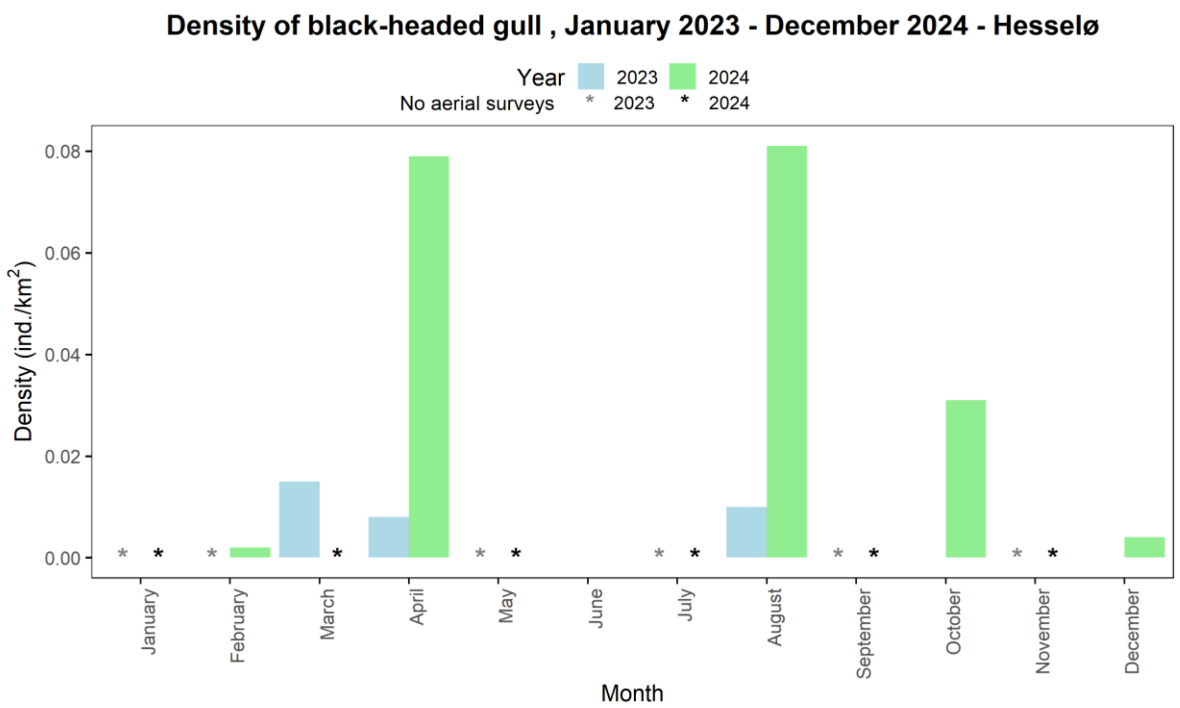


Figure 5.14 Monthly densities of black-headed gull during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

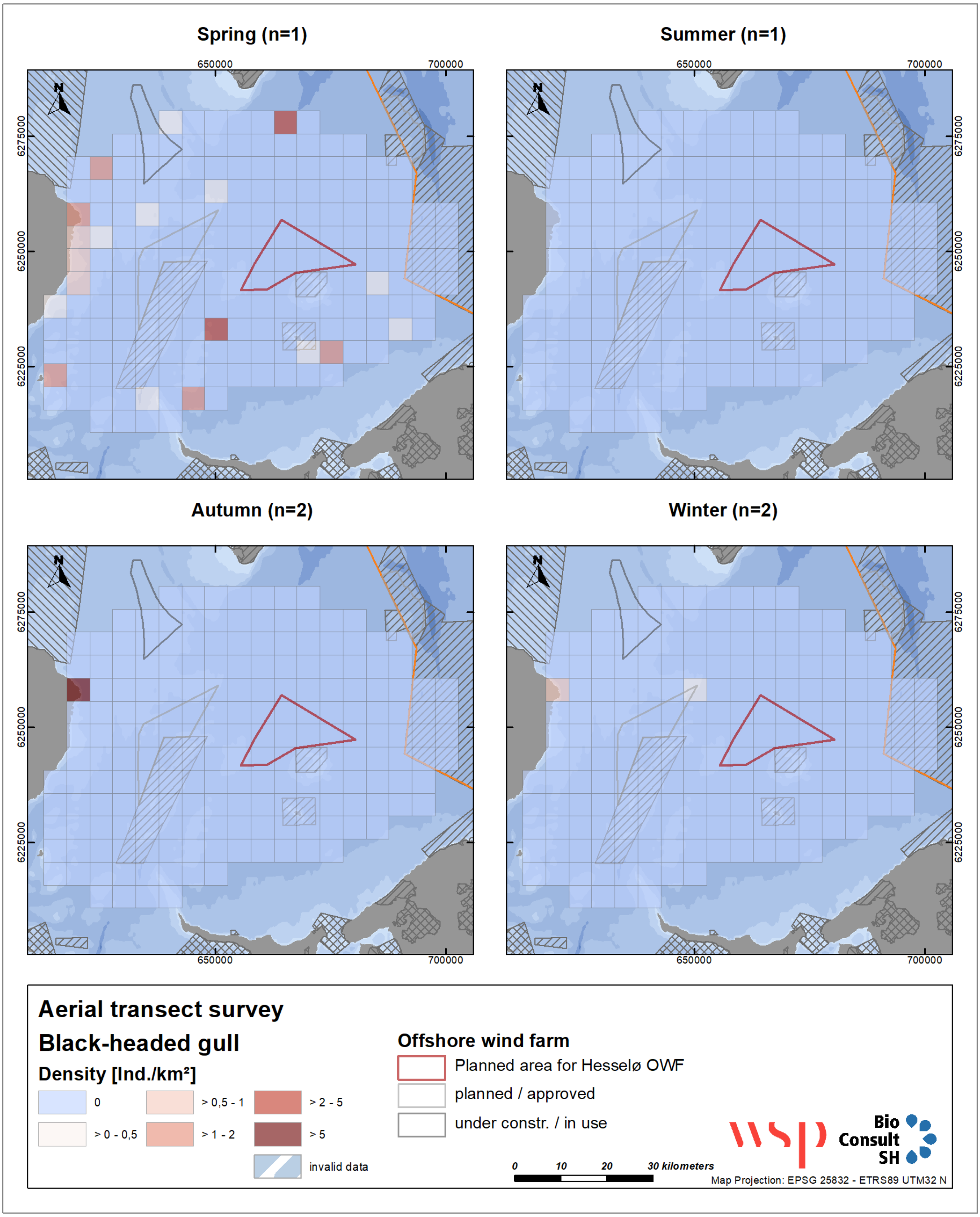


Figure 5.15 Distribution of black-headed gull in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to Garthe et al. (2007). The number of flights per season is given as n.

COMMON GULL

Common gulls were the second most common gull species in the area. A total of 503 individuals were observed in the pre-investigation area during the six digital aerial surveys in 2024. This represents a 240.7% increase in absolute terms when compared to the previous year of monitoring (n= 209), rising from 2.6% to 5.2% of all resting birds (Figure 5.2). Peak months of observations coincided with the winter period, with December 2024 showing the highest counts for the second year of monitoring.

The highest density occurred in December 2024 (0.31 ind./km²), which corresponded to the winter season. The lowest densities were detected during the summer months. Common gulls were not seen in August 2023 (which corresponded to the autumn season for this species according to Garthe et al. (2007)). In spring, the average density was 0.07 ind./km² and 0.20 ind./km², for 2023 and 2024 respectively, whereas in summer the density was very low at 0.01 ind./km² for both years (Figure 5.16).

Common gulls were distributed across the entire pre-investigation area, but higher densities were observed at locations closer to the coast (northern and western part of the pre-investigation area (Figure 5.17). They occurred within the limits of the planned OWF in spring and winter.

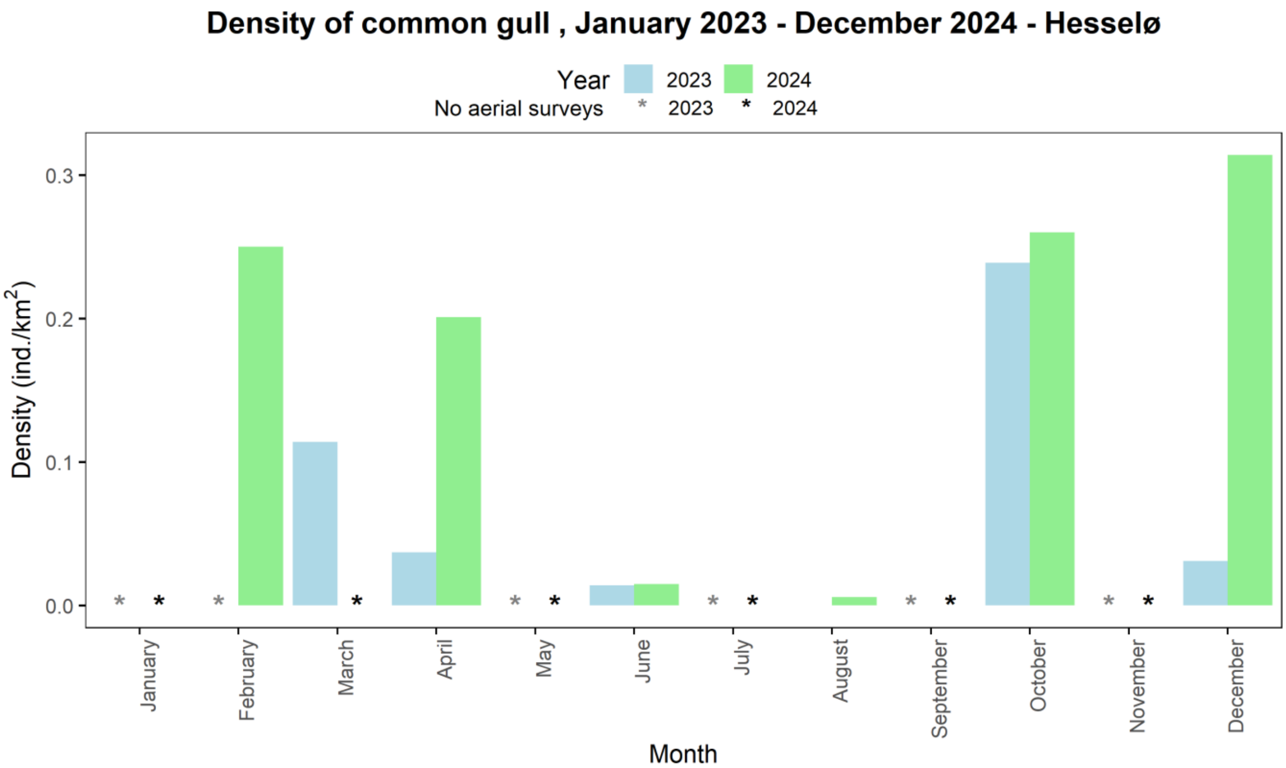


Figure 5.16 Monthly densities of common gull during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

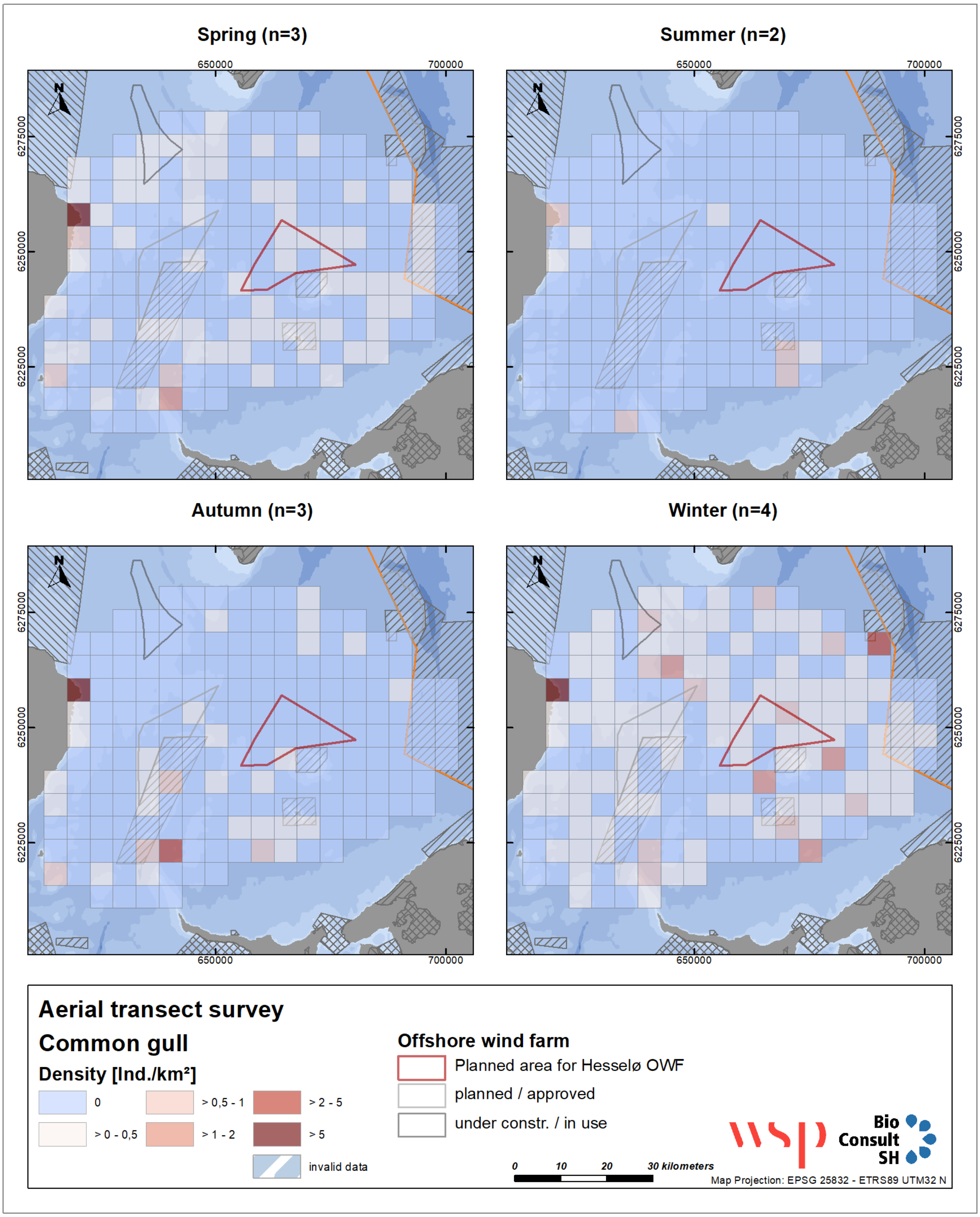


Figure 5.17 Distribution of common gull in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

LESSER BLACK-BACKED GULL

A total of 235 lesser black-backed gulls were observed between February and December 2024. The proportion among resting birds was 2.4%, closely matching the 2.2% (n= 176) recorded in 2023 (Figure 5.2). The temporal distribution was similar when compared to 2023, as the maximum number of sightings for both years was recorded during April.

This species was found during all the surveys conducted, excluding December and February 2024. The highest densities were reported in April, with 0.18 ind./km^2 and 0.35 ind./km^2 for 2023 and 2024, respectively. The winter season had the lowest density for this species, with no sightings during the 2024 observation period (Figure 5.18).

Lesser black-backed gulls were mainly distributed in the eastern part of the pre-investigation area (especially in spring, when their densities were higher). To the east of the pre-investigation area is the Nordvästra Skånes havsområde Natura 2000 site (code SE0420360) which is specifically designated for the protection of gulls, among other seabirds. In autumn and winter, lesser black-backed gulls were also seen towards the western part of the pre-investigation area closer to the coast (Figure 5.19). In autumn, an aggregation of gulls was found at the tip of Sjællands Odde.

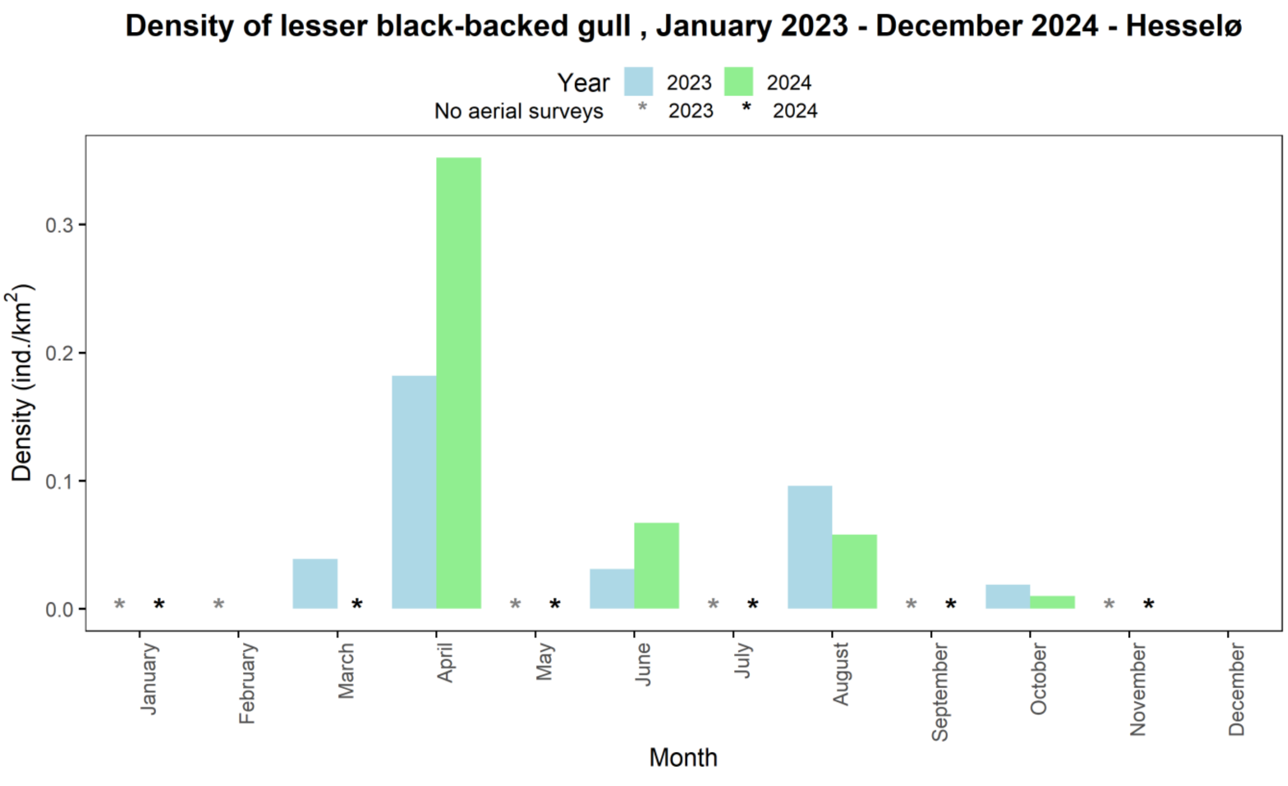


Figure 5.18 Monthly densities of lesser black-backed gull during digital aerial surveys in the pre-investigation area between January 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

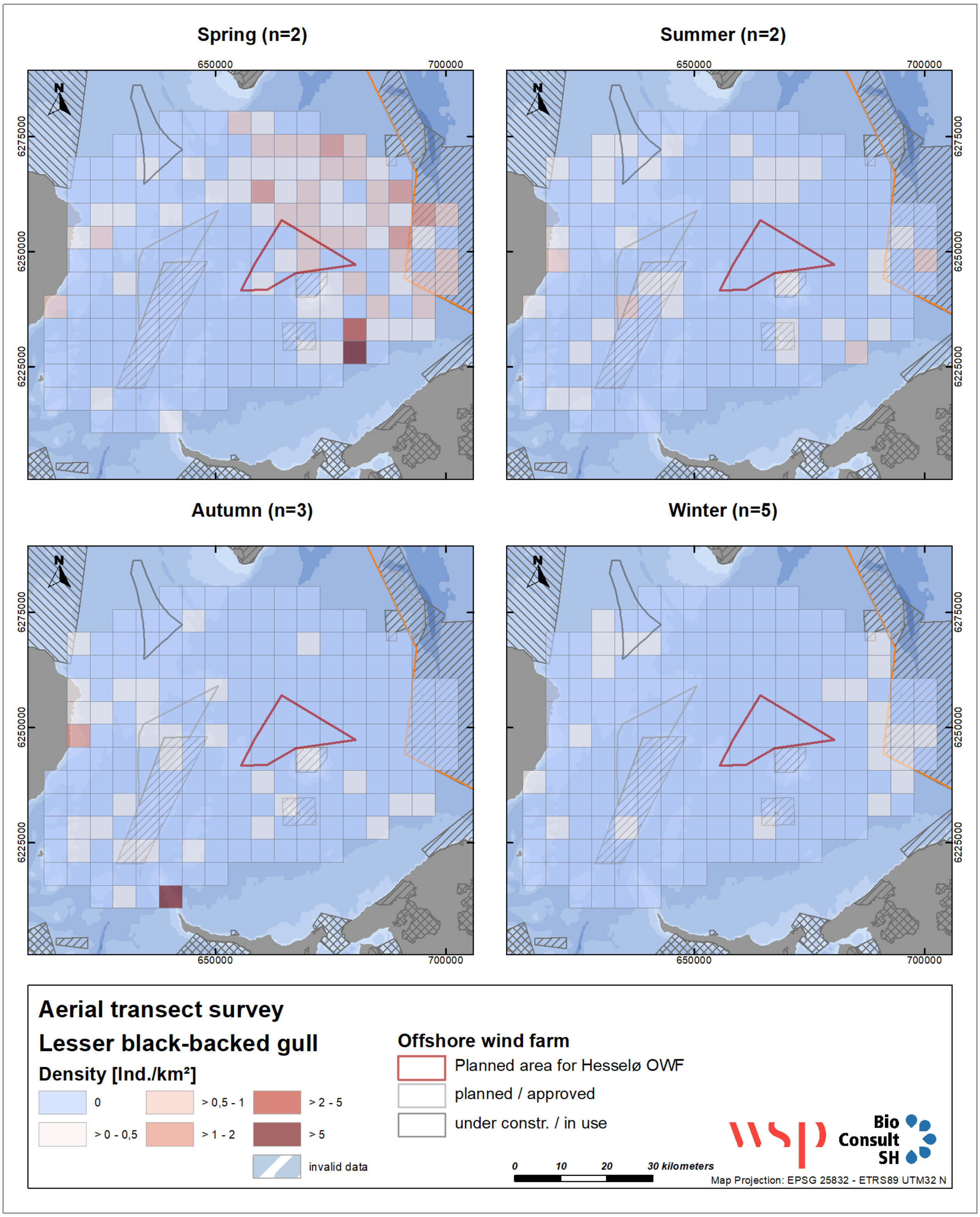


Figure 5.19 Distribution of lesser black-backed gull in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

HERRING GULL

Herring gulls were the most common gull species in the area. A total of 614 individuals were observed in 2024 representing 6.4 % of all resting birds found. A similar percentage of occurrence was observed in 2023, when 5.3% (n= 422) of all detected resting birds were herring gulls (Figure 5.3). Although this species was detected during all surveys, 86.0% of sightings were recorded between December and April. A similar pattern was followed during 2023, when winter months accounted for the highest absolute numbers of sightings (Figure 5.20).

They were present during all the surveys conducted, at relatively similar densities, but their densities were lower in August 2023 (0.01 ind./km²). The highest density was found during February 2024 (0.53 ind./km²). In terms of seasons, while they were slightly more abundant during summer 2023 (June, 0.22 ind./km²), the highest value per season was found during winter 2024, when up to 0.44 ind./km² were recorded.

Herring gulls were spread over the pre-investigation area without a specific pattern, excluding summer when they were found in coastal areas at higher densities. The 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 5.21).

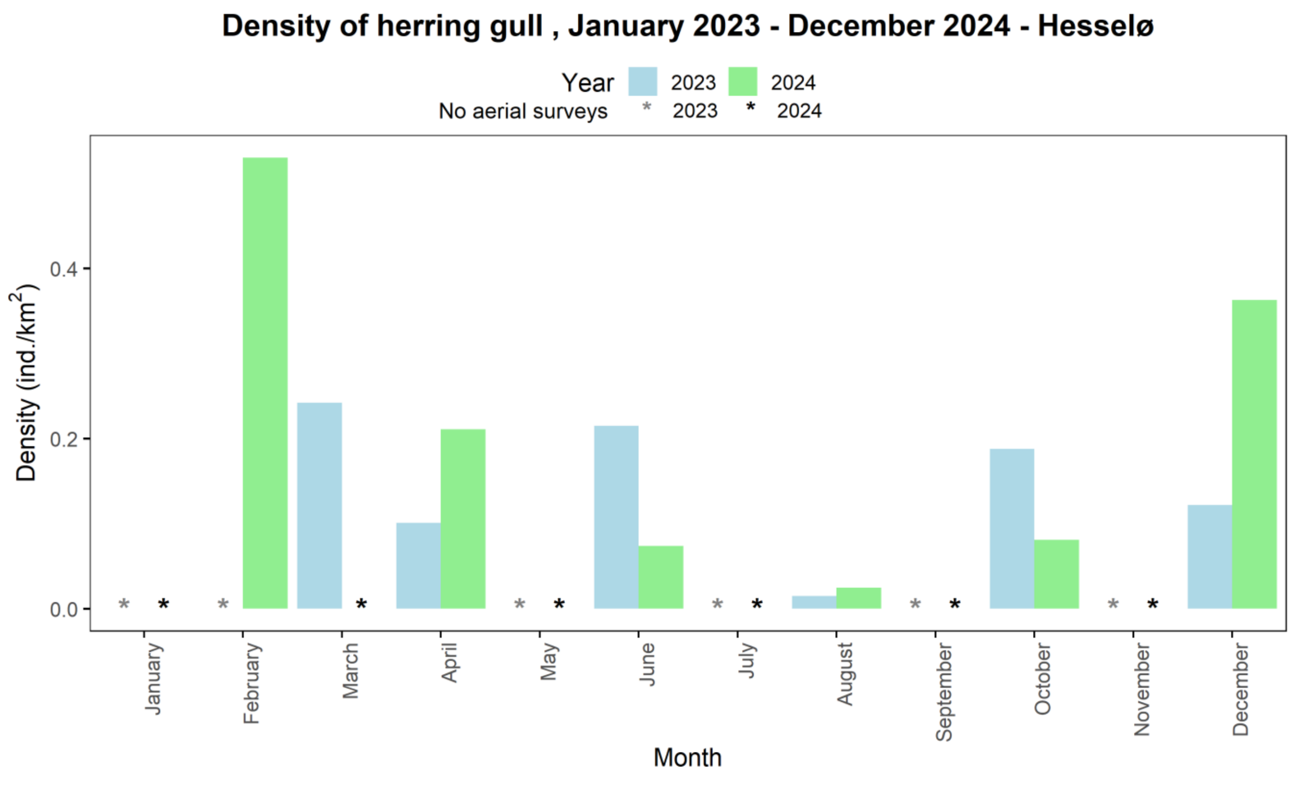


Figure 5.20 Monthly densities of herring gull during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

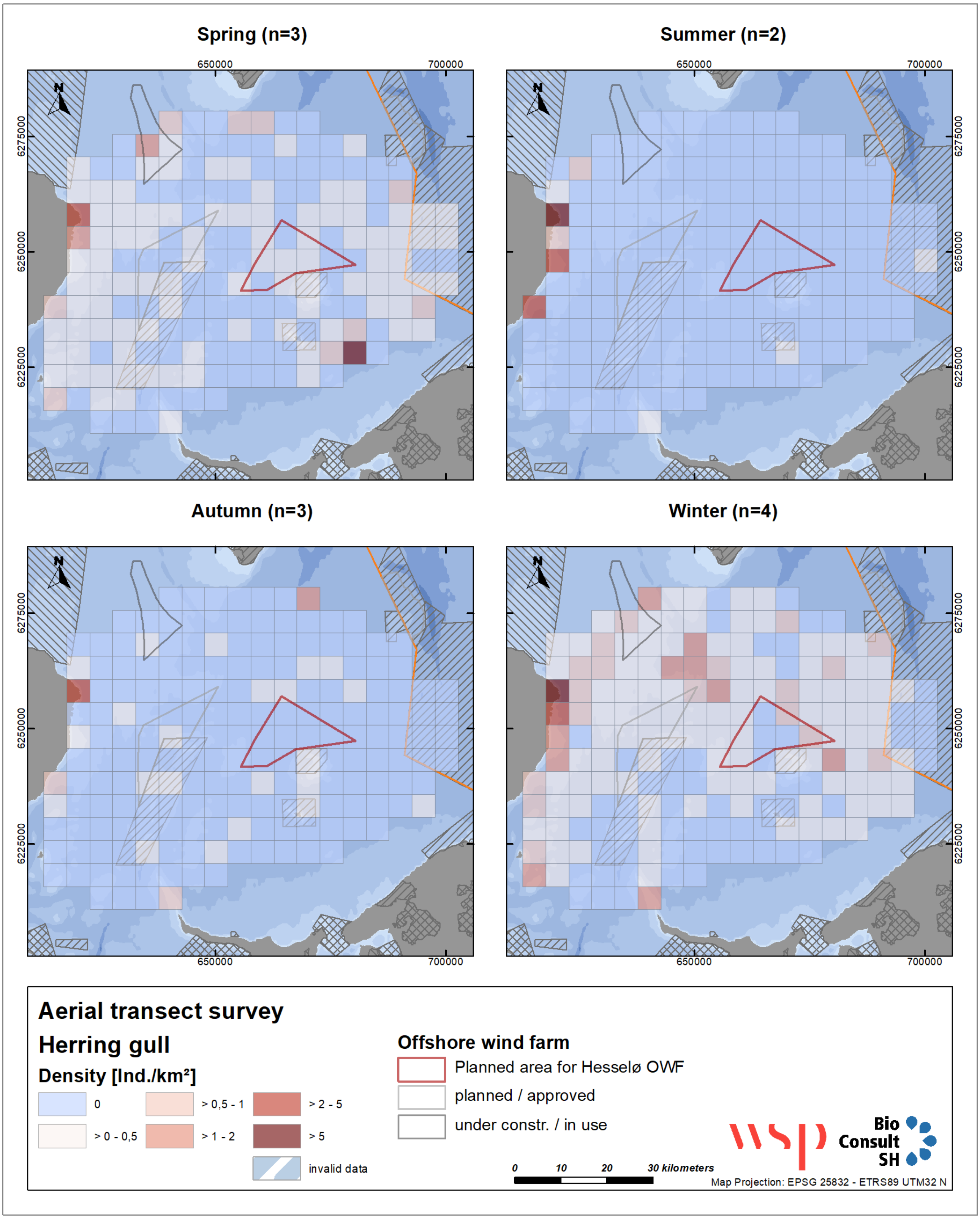


Figure 5.21 Distribution of herring gull in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

GREAT BLACK-BACKED GULL

With 122 individuals, great black-backed gulls represented 1.2% of all resting birds in 2024, a comparable proportion to 2023, where 1.7% (n= 138) of resting birds belonged to this species (Figure 5.2). The temporal distribution varied but the presence of this species was recorded during the two years of baseline monitoring, with the lowest value detected for April 2024, when only a single individual was recorded. The peak of presence was registered in November 2024, with 62 confirmed individuals.

Great black-backed gulls occurred during all flights with densities varying interannually (Figure 5.22). The highest densities were recorded during October 2023 with 0.13 ind./km² and April 2024 with 0.11 ind./km². Seasonally, the lowest densities were found during summer 2024 (<0.01 ind./km²) and autumn 2023 (0.02 ind./km²), while the highest were detected during winter 2023 (0.13 ind./km²) and spring 2024 (0.11 ind./km²).

Great black-backed gulls were sparsely distributed throughout the entire pre-investigation area but were more common and present at higher densities towards coastal regions (summer and autumn). The highest densities were observed in the eastern and southeastern part of the pre-investigation area, close to the Natura 2000 site "Nordvästra Skånes havsområde" (Figure 5.23).

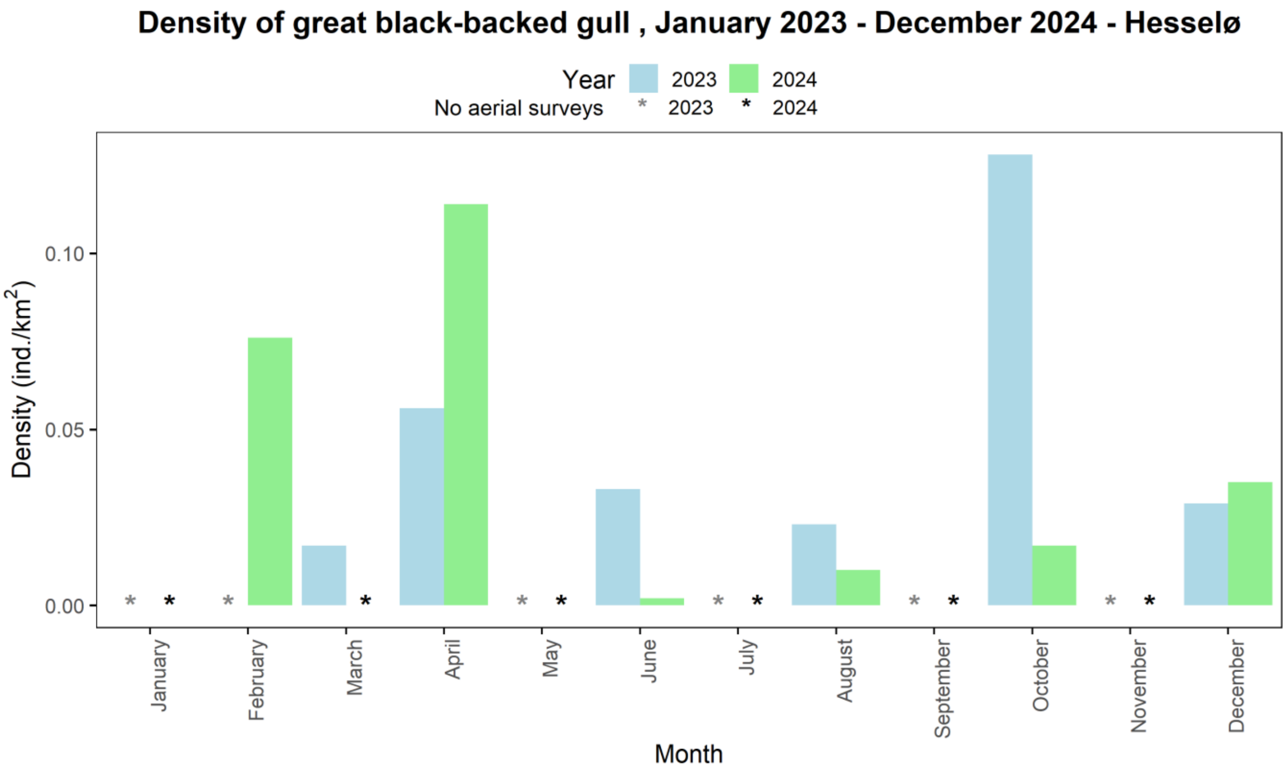


Figure 5.22 Monthly densities of great black-backed gull during digital aerial surveys in the pre-investigation area between January 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

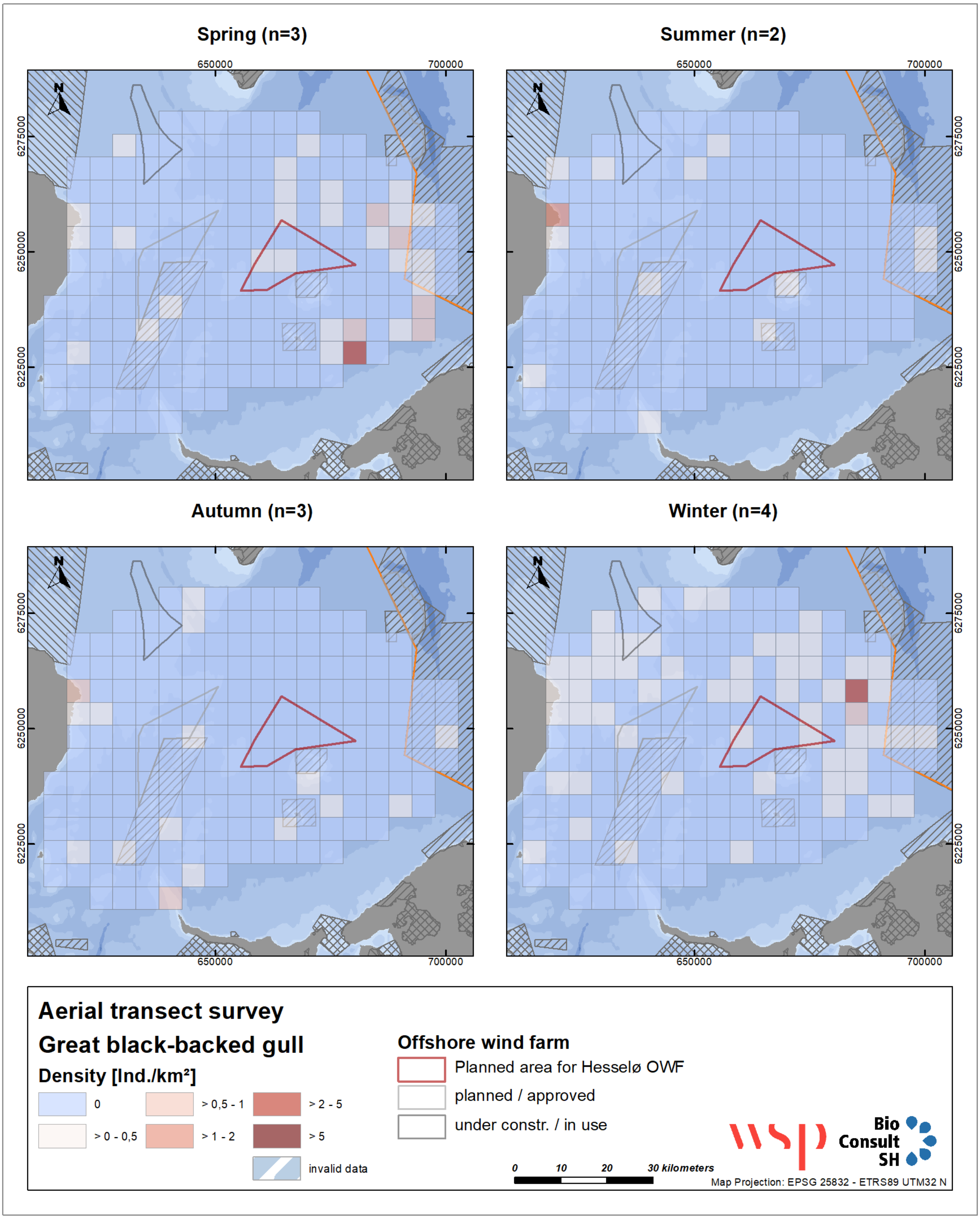


Figure 5.23 Distribution of great black-backed gull in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

BLACK-LEGGED KITTIWAKE

Black-legged kittiwakes represented 3.6% of all resting birds, with an absolute value of 341 individuals recorded. Compared to 2023, the rise in numbers represented an absolute increase of 227.3%, when only 150 individuals (1.9% of all resting birds) were recorded (Figure 5.2). This species was detected during 3 surveys, however 80.3% of sightings occurred during December, a similar pattern as observed in 2023. No individuals were detected between April and September in the studied area.

The density of black-legged kittiwakes was low, except for the autumn and winter months. December 2024 showed the highest density of this species, with 0.50 ind./km², while the recorded density for 2023 was 0.17 ind./km² (Figure 5.24).

Black-legged kittiwakes were distributed throughout the entire pre-investigation area during winter, without any specific geographical pattern (both at offshore locations and towards the coastal parts. During the second year of monitoring, higher concentrations were found within and northwest of the planned OWF (Figure 5.25).

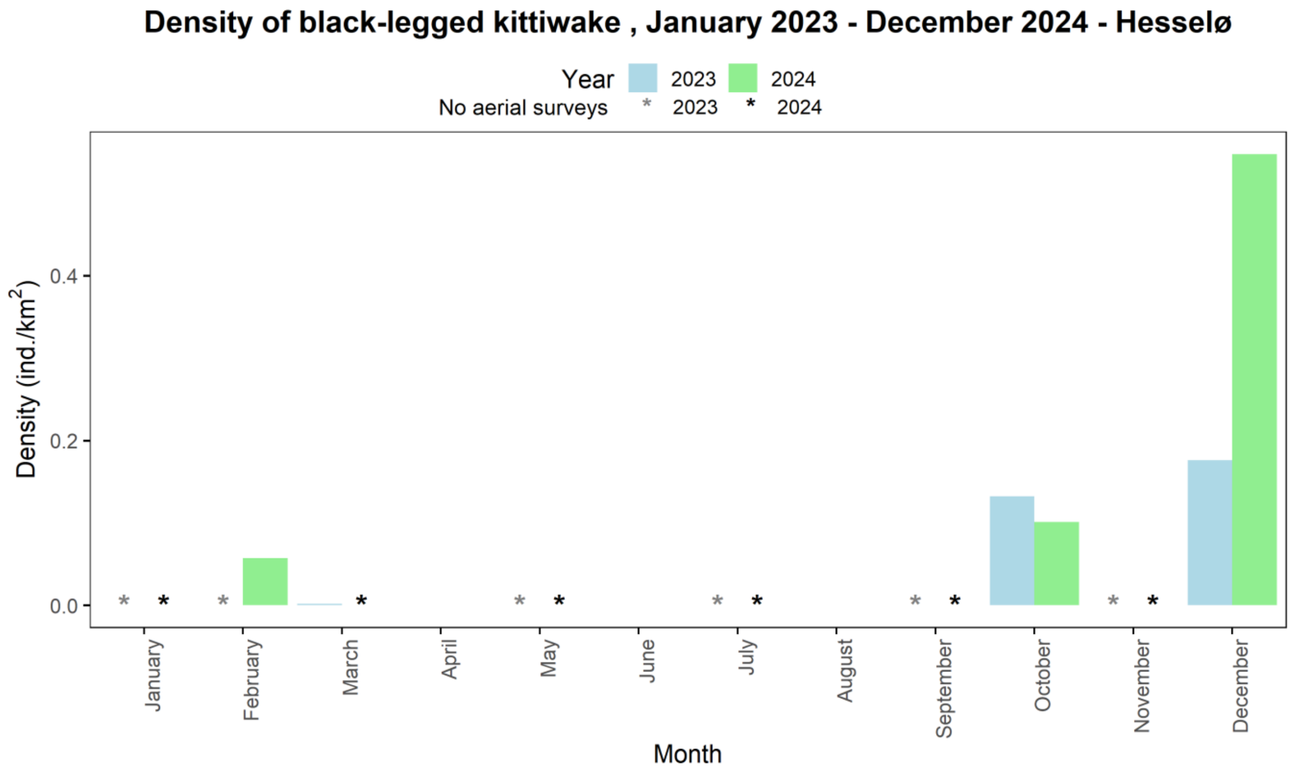


Figure 5.24 Monthly densities of black-legged kittiwake during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

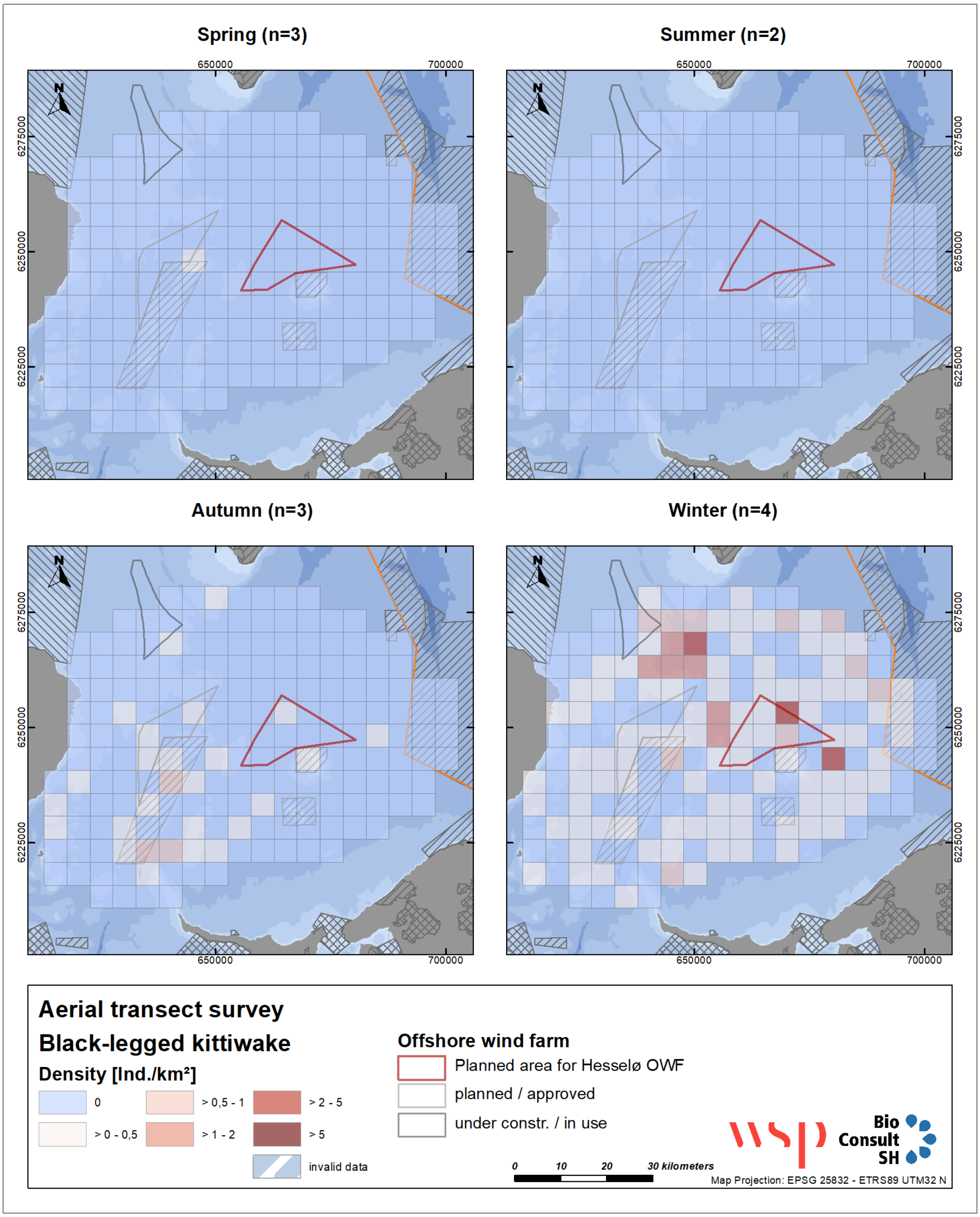


Figure 5.25 Distribution of black-legged kittiwake in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

AUKS

Auks were the most abundant species group in the pre-investigation area for 2024 and altogether represented almost 59.0% (n= 5,666) of all resting birds detected in the area during the six digital aerial surveys. In total, four auk species were detected, of which by far the most abundant one was the common guillemot (49.2%, n= 4,729). The other species in order of abundance were razorbills (3.2%, n= 307), black guillemots (1.5%, n= 139) and three individuals of Atlantic puffin (0.03%). In addition, there were 312 individuals that could not be identified as being common guillemots or razorbills (3.2%) and 176 individuals could not be identified on species level (1.8%).

COMMON GUILLEMOT

A total of 4,729 common guillemots were registered during the observation period; an increase in absolute terms of 54.3% compared to 2023 (n=3,064, Figure 5.2). However, the proportionality among all resting birds increased; from 38.5% in 2023 to 49.3% in 2024. The temporal distribution coincided in both years, with peaks in detection for August and during the winter months. This species was the most sighted during both years of baseline monitoring.

The density of common guillemot was similar in August and December for both years (1.70 ind./km^2 and 2.00 ind./km^2, respectively). However, the highest density was detected during February 2024 (3.30 ind./km^2), although not comparable with the first year of monitoring due to lack of surveillance in February 2023. The season with the lowest detected density was summer, with <0.01 ind./km^2 (Figure 5.26).

Common guillemot occurred throughout the entire 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 prominent, and birds were more widely distributed. High density grid cells (> 5 ind./km^2) were also detected southeast of the planned OWF, near the Natura 2000 site "Nordvästra Skånes havsområde" (Figure 5.27).

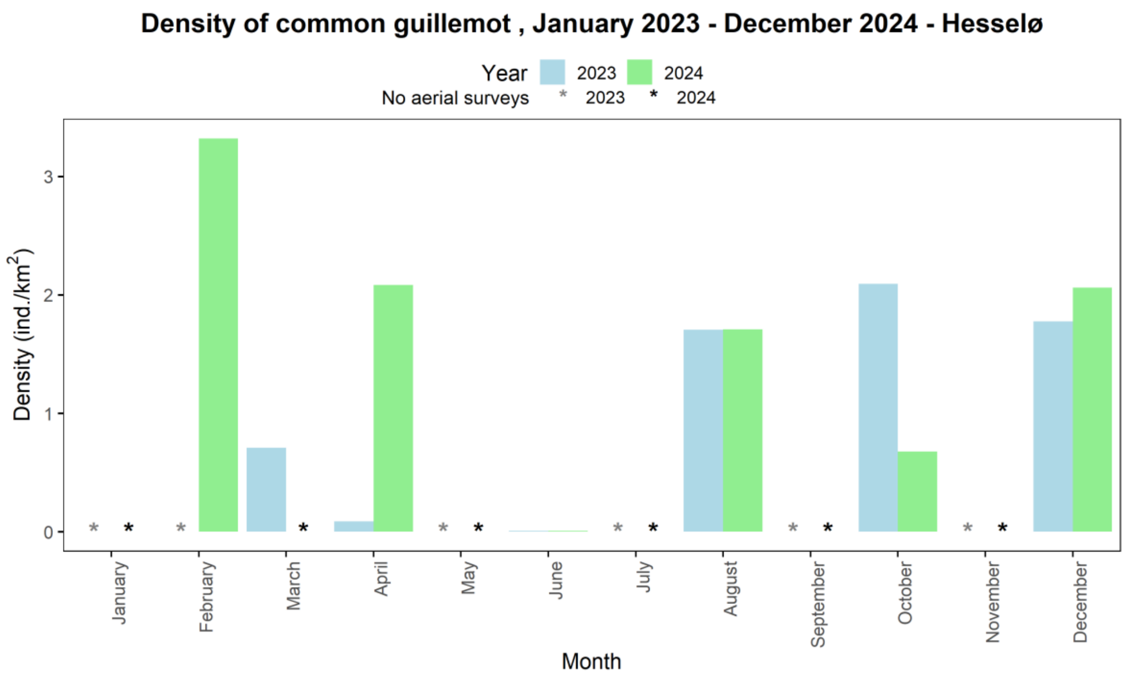


Figure 5.26 Monthly densities of common guillemot during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

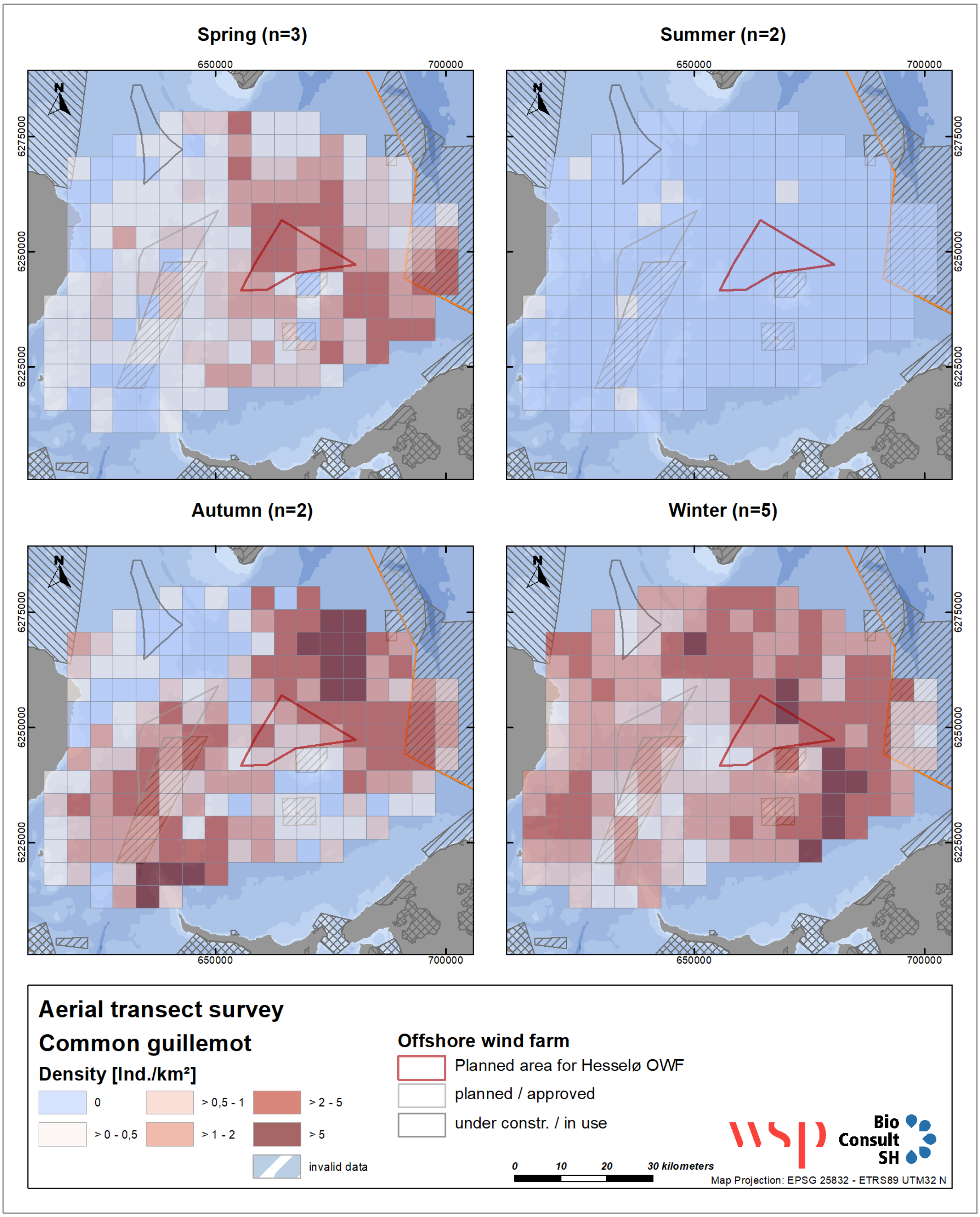


Figure 5.27 Distribution of common guillemot in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

RAZORBILL

The 307 razorbills observed in the area for 2024 represented 3.2% of the total number of resting birds. This represents a decrease of 13.7% in detections when compared in absolute values to 2023 (n=349, Figure 5.2). Both years registered razorbill´s maximum presence during the winter months.

The density was higher during the surveys of October and December during both years (Figure 5.28), and the season with the highest recorded concentration of razorbills was winter, with 0.25 ind./km² and 0.20 ind./km², respectively. June was the only month without any detection for this species, which coincided with the summer season.

Their spatial distribution was similar to the distribution of common guillemot, being predominantly an offshore species. Grid cells of medium density were observed scattered across the area especially in winter when the species was more abundant. Several individuals were also observed within the limits of the planned OWF (Figure 5.29).

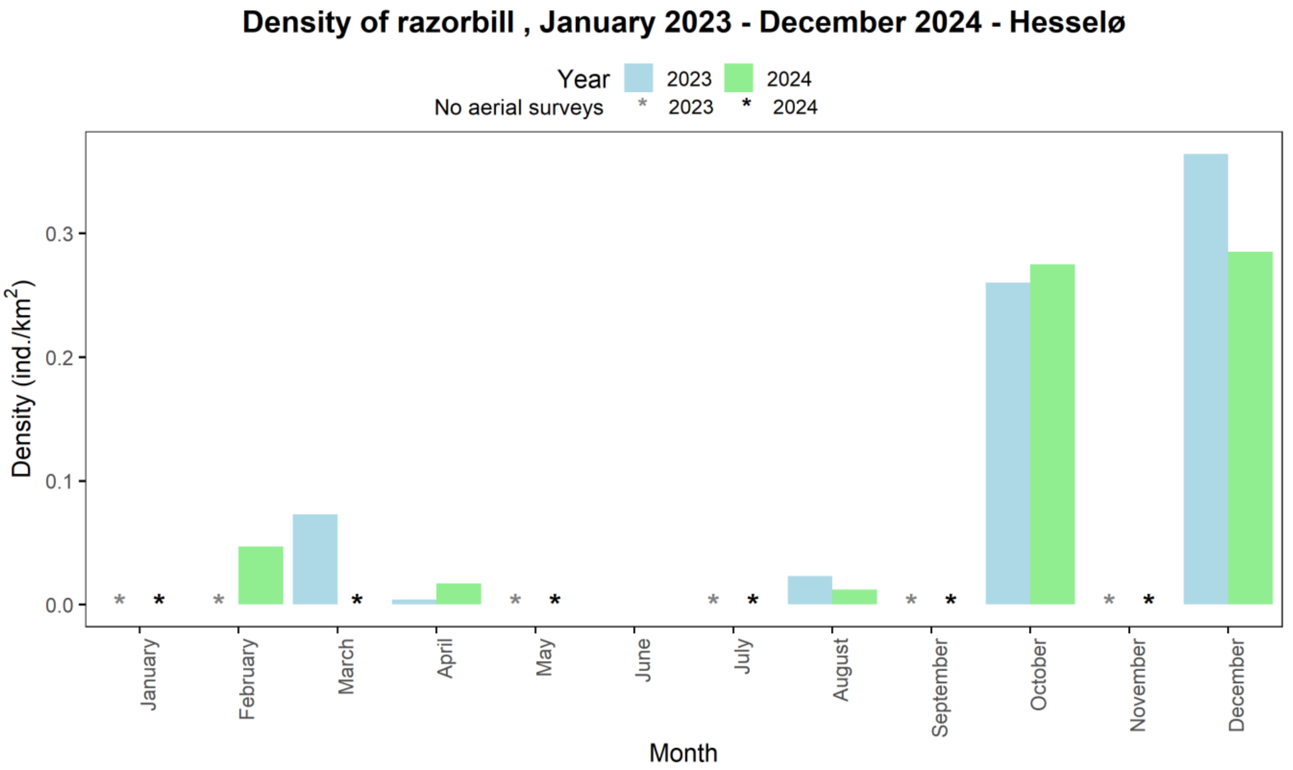


Figure 5.28 Monthly densities of razorbill during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

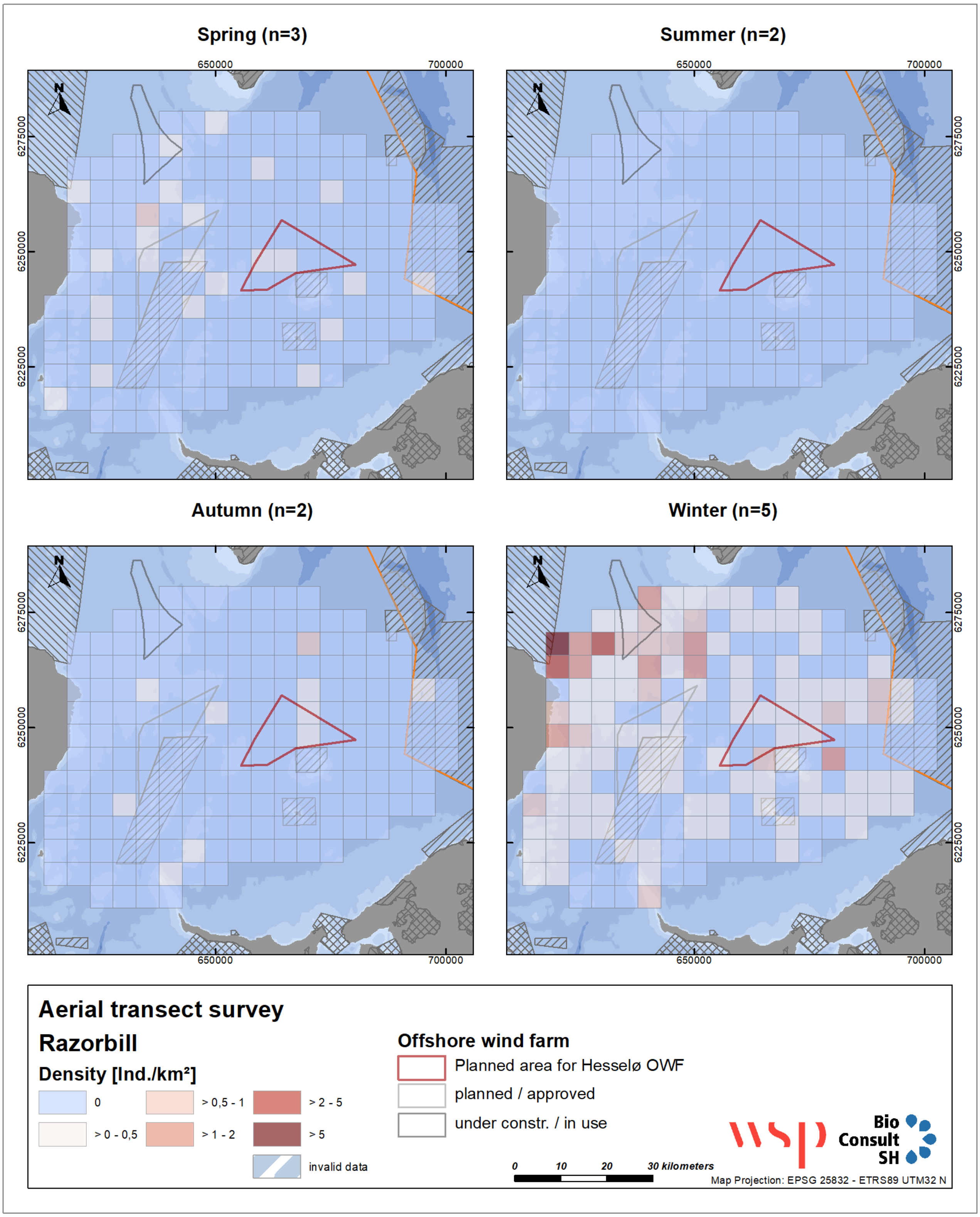


Figure 5.29 Distribution of razorbill in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

BLACK GUILLEMOT

A total of 139 black guillemots were detected throughout the survey period in 2024 in the pre-investigation area, which represents an increase in absolute values of 57.9% in the detection of this species. Although the relative proportion among resting birds remained similar; 1.1% (n= 88) in 2023 and 1.5% in 2024 (Figure 5.2). The temporality of occurrence was marked by the end of the summer as well as the winter months, when peaks were detected in both years.

The density of black guillemots was unevenly distributed along the two years of baseline monitoring, with the highest detections and concentrations registered during winter. December was the month in which black guillemots reached approximately 0.10 ind./km^2 for both years, whereas June returned no observations (Figure 5.30).

Black guillemot numbers were relatively low and they showed no clear 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 5.31).

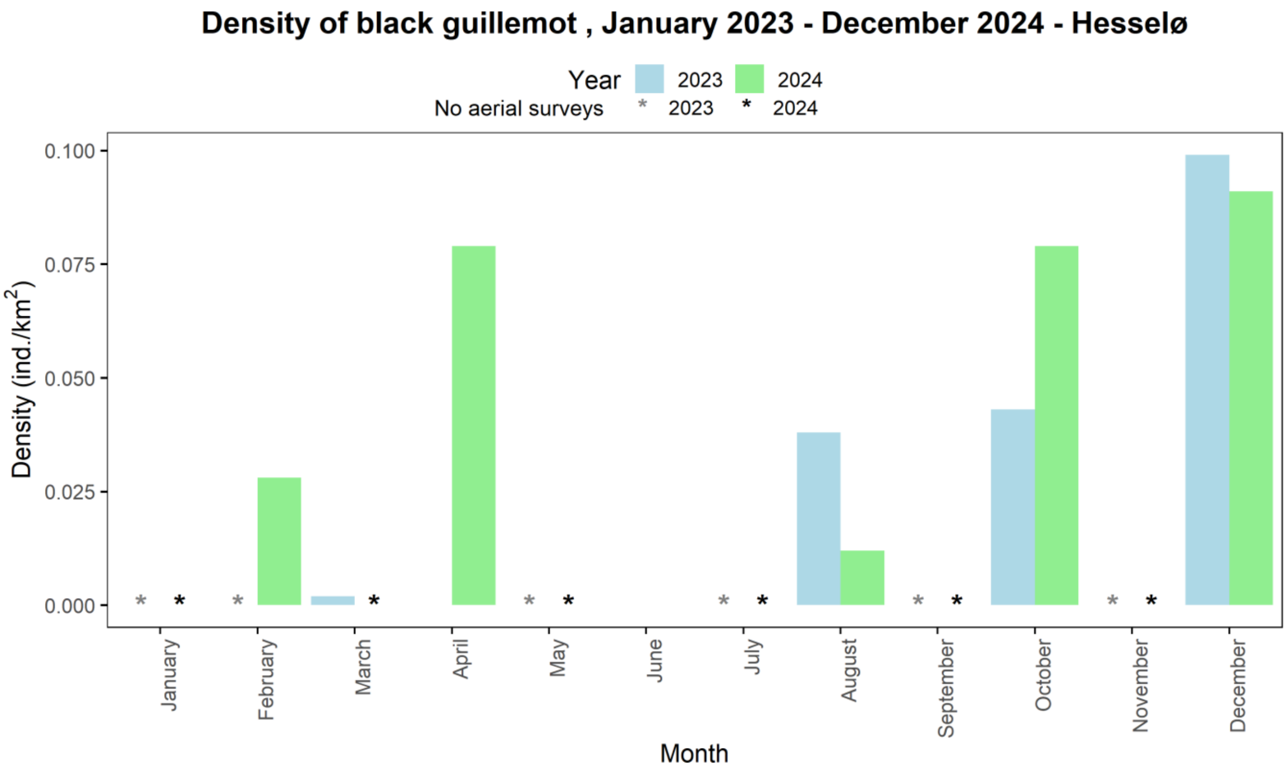


Figure 5.30 Monthly densities of black guillemot during digital aerial surveys in the pre-investigation area between February 2023 and December 2024. Months in which aerial surveys were not conducted are represented by an asterisk *, both for 2023 (grey) and 2024 (black).

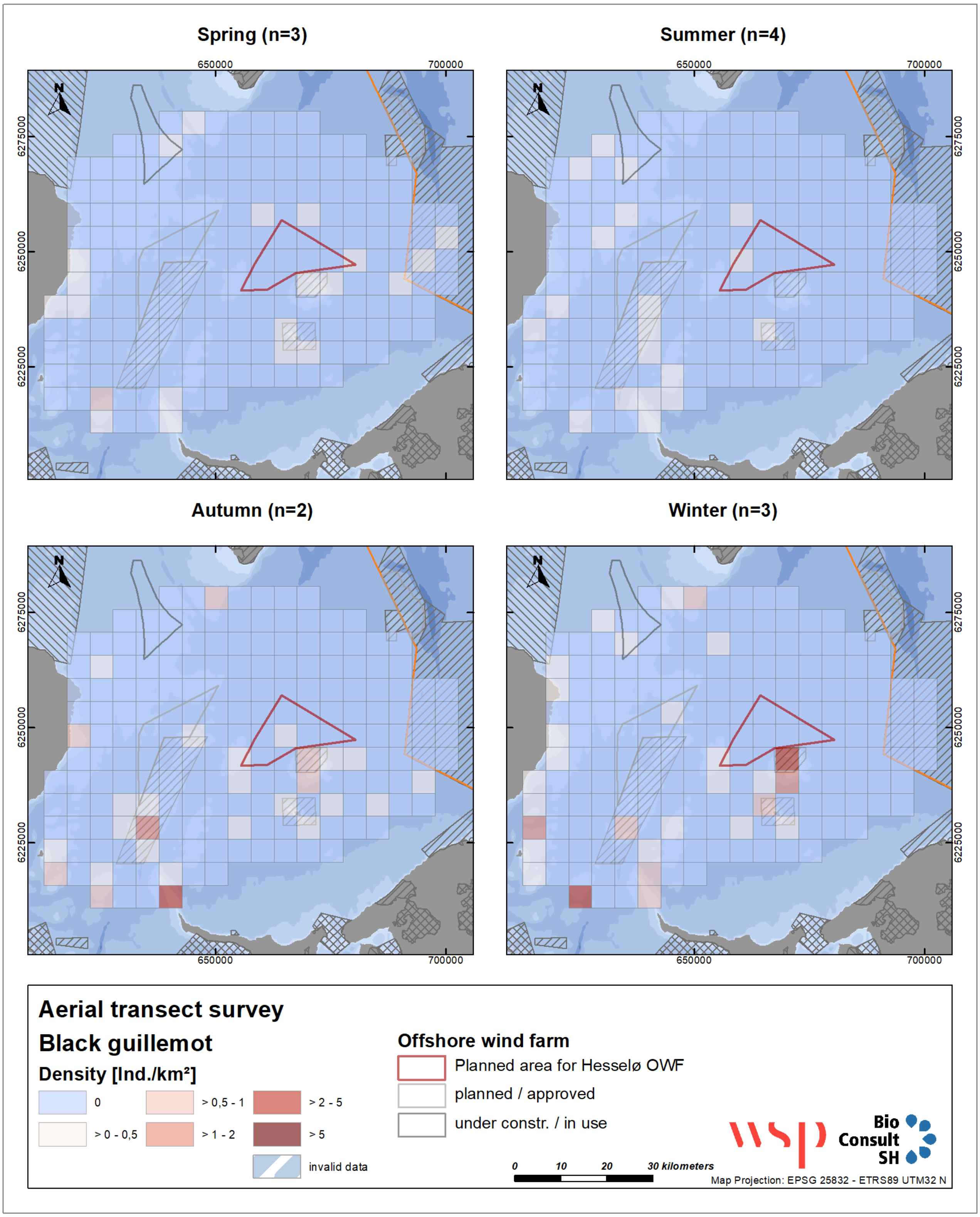


Figure 5.31 Distribution of black guillemot in the pre-investigation area per species specific season during the digital aerial surveys between February 2023 and December 2024. Seasonal classification species-specific according to GARTHE ET AL. (2007). The number of flights per season is given as n.

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. Migration intensity is quantified as migration traffic rate (MTR) defined as the (extrapolated) number of birds (or radar echoes) transiting one square kilometre of airspace within one hour. Analyses are presented for all migrating bird species first and then for relevant species groups (chosen due to their abundance or their inclusion in a conservation category, see next section) of both years of investigations. The appendix (Table A-2 – Table A.4) includes species lists with information on numbers of all individuals observed, taxonomical information and species conservation status.

5.2.1 *OBSERVER-BASED DATA*

ALL SPECIES

DIURNAL MIGRATION (VISUAL OBSERVATIONS)

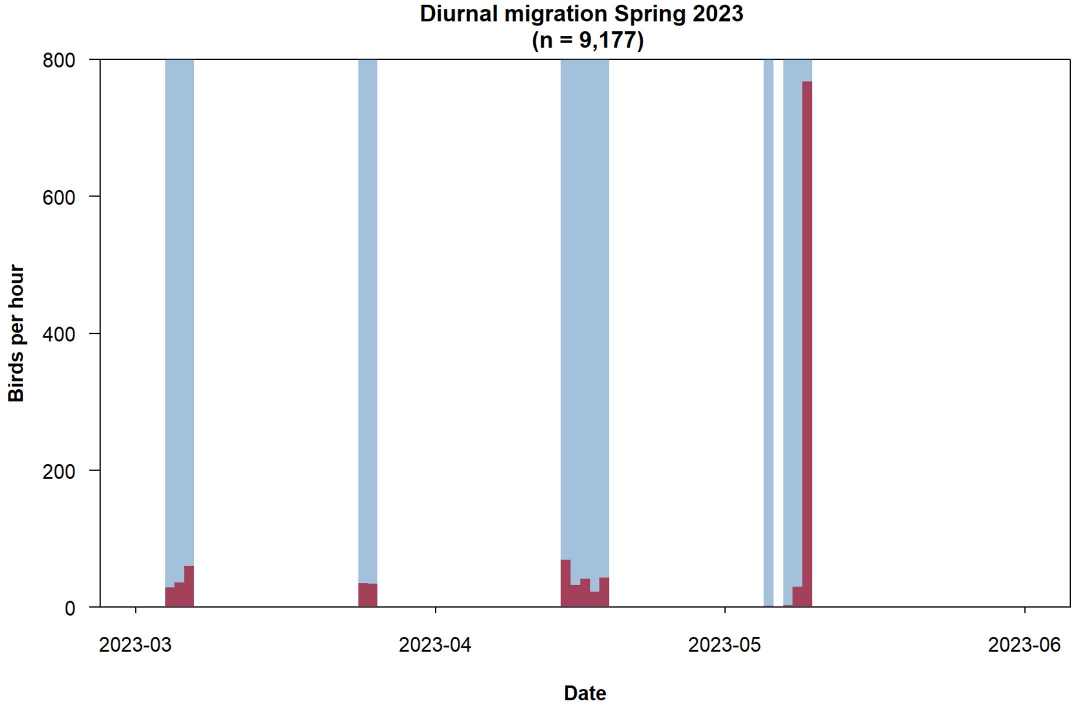
MIGRATION INTENSITY

Spring:

The 14 days of diurnal observations in spring 2023 were evenly spread throughout the season. However, 70% of the migrating birds (n = 6,431, Table 5.3) were observed in May. Mean migration intensity across all bird species in spring was 86.3 ± 197 ind./h with the maximum mean migration occurring in May (200.8 ind./h). On the last date of the surveys, (9th of May 2023) a peak migration event occurred with a maximum of 767.8 ind./h registered (Table 5.3, Figure 5.32). This resulted from a large number of barnacle geese migrating through the area on this specific date (see next section).

Table 5.3 Monthly and seasonal migration rates (ind./h) calculated from visual observations in spring 2023 and spring 2024 in the pre-investigation area. SD = Standard deviation.

Spring	Migration intensity (ind./h)			Number of individuals	Number of survey days
	Mean (± SD)	Median	Maximum value		
March 2023	39.2 (± 12.2)	35.7	60.3	1,219	5
April 2023	41.8 (± 17.3)	41.8	69.0	1,527	5
May 2023	200.8 (± 378.2)	16.7	767.8	6,431	4
Spring 2023	**86.3 (± 197)**	**35.0**	**767.8**	**9,177**	**14**
March 2024	13.8 (± 5.4)	14.0	20.4	301	4
April 2024	51.1 (± 52.1)	28.4	139.1	1,779	5
May 2024	66.1 (± 123)	8.1	285.3	2,726	5
Spring 2024	**45.8 (± 77.4)**	**15.3**	**285.3**	**4,806**	**14**
March combined	27.9 (± 16.2)	29.0	60.3	1,520	9
April combined	46.4 (± 36.9)	37.1	139.1	3,306	10
May combined	125.9 (± 257.4)	8.1	767.8	9,157	9
Spring combined	**66.0 (± 145.6)**	**29.3**	**767.8**	**13,983**	**28**



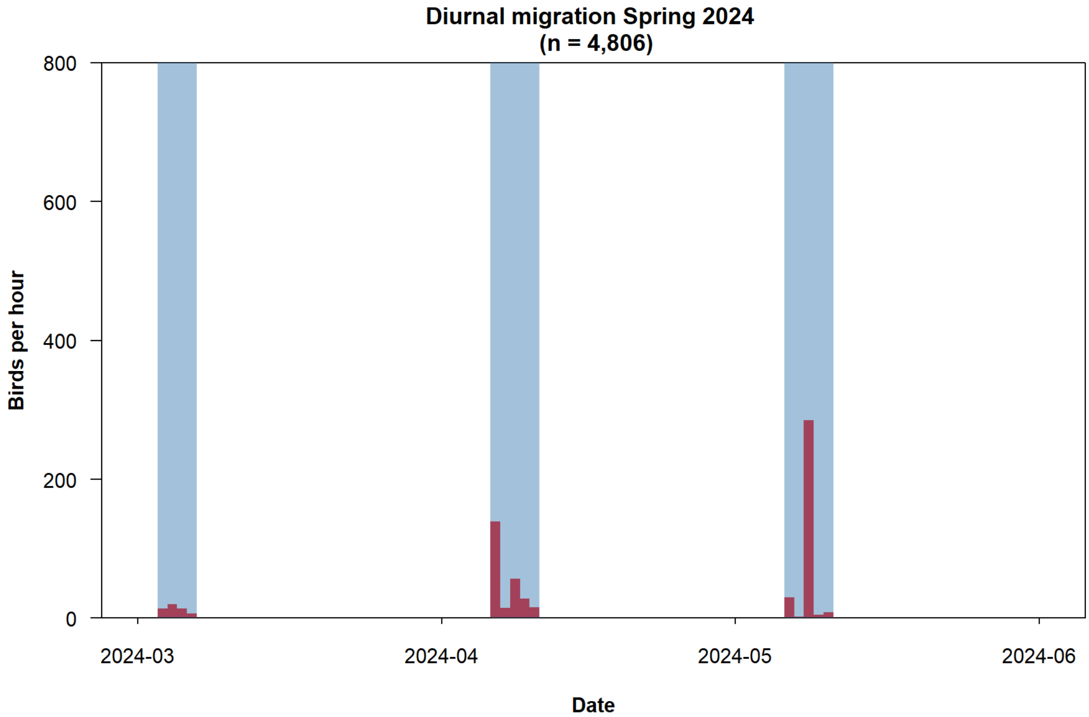


Figure 5.32 Diurnal migration intensity (red bars) derived from visual observations in spring 2023 (top) and spring 2024 (bottom). Light blue shades indicate the dates when surveys took place (14 dates in 2023 and 14 in 2024). Y-axis has been standardized so that a visual comparison of MTR in both years and seasons is easier.

During spring 2024, the mean diurnal migration intensity was about half of the one observed in 2023 (45.8 ± 77.4 ind./h, Table 5.3). Dates of observation were also evenly spread across months. Migration intensity in 2023 was especially high because of a mass migration event observed on the last survey date (9th of May 2023). Mean migration intensity in spring of the second year increased through the season. May was the month with the strongest migration due to a day with strong geese migration (285.3 ind./h observed on May 8th), but the 2024 intensity was much lower in comparison (see above and Table 5.3).

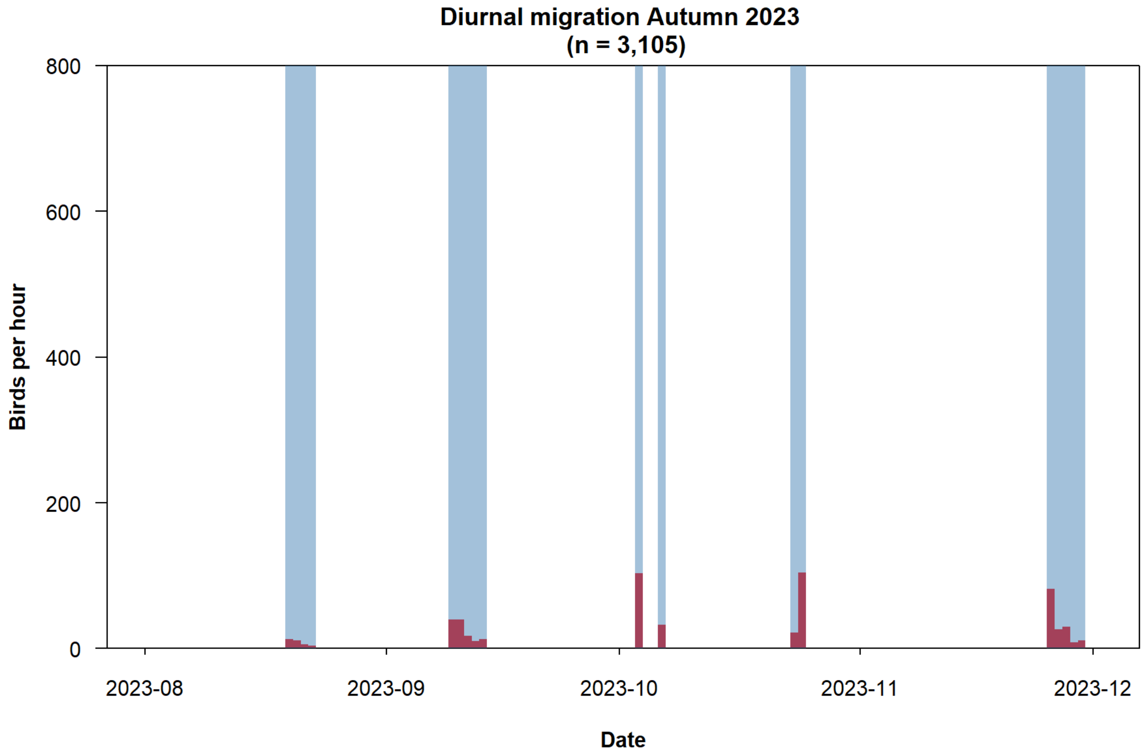
When combining migration intensities of both years, there was a general increase of migration intensity throughout the season. May was the month with the highest average migration intensity but also the month with the greatest variability and with the highest maximum migration values. Results of both years show an average spring migration intensity of 66 ind./h ±145.6 (Table 5.3).

Autumn:

In autumn 2023, the 18 days of diurnal observations were evenly spread throughout the season, with about 4-5 survey days 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 ± 31.9 ind./h with the highest mean migration occurring in October (65.4 ind./h, twice as high as the mean value). There were two dates in October when maximum migration was reached (on the 3rd of October with 103 ind./h and on the 24th of October with 104.2 ind./h; Table 5.4, Figure 5.33). This corresponded to mass migration events of two relevant groups: ducks and geese (see next section).

Table 5.4. Monthly and seasonal migration rates (ind./h) calculated from visual observations in autumn 2023 and autumn 2024 in the pre-investigation area. SD = standard deviation.

Autumn	Migration intensity (ind./h)			Number of individuals	Number of survey days
	Mean (± SD)	Median	Maximal value		
August 2023	8.5 (± 4.3)	8.4	13.3	253	4
September 2023	24.1 (± 14.6)	17.7	40.0	824	5
October 2023	65.4 (± 44.3)	67.9	104.2	1,435	4
November 2023	31.5 (± 29.5)	26.1	81.6	593	5
Autumn 2023	**31.9 (± 31.9)**	**19.7**	**104.2**	**3,105**	**18**
August 2024	65.8 (± 64.9)	35.2	168.9	2,622	5
September 2024	39.3 (± 32.4)	28.3	96.0	1,351	5
October 2024	53.9 (± 12.9)	55.0	66.8	1,182	4
November 2024	29.6 (± 24)	24.3	74.7	800	6
Autumn 2024	**46.0 (± 38.7)**	**32.8**	**168.9**	**5,955**	**20**
August combined	40.3 (± 55)	16.5	168.9	2,875	9
September combined	31.7 (± 25)	24.4	96.0	2,175	10
October combined	59.7 (± 30.8)	55.0	104.2	2,617	8
November combined	30.5 (± 25.2)	26.1	81.6	1,393	11
Autumn	**39.3 (± 35.4)**	**28.7**	**168.9**	**9,060**	**38**



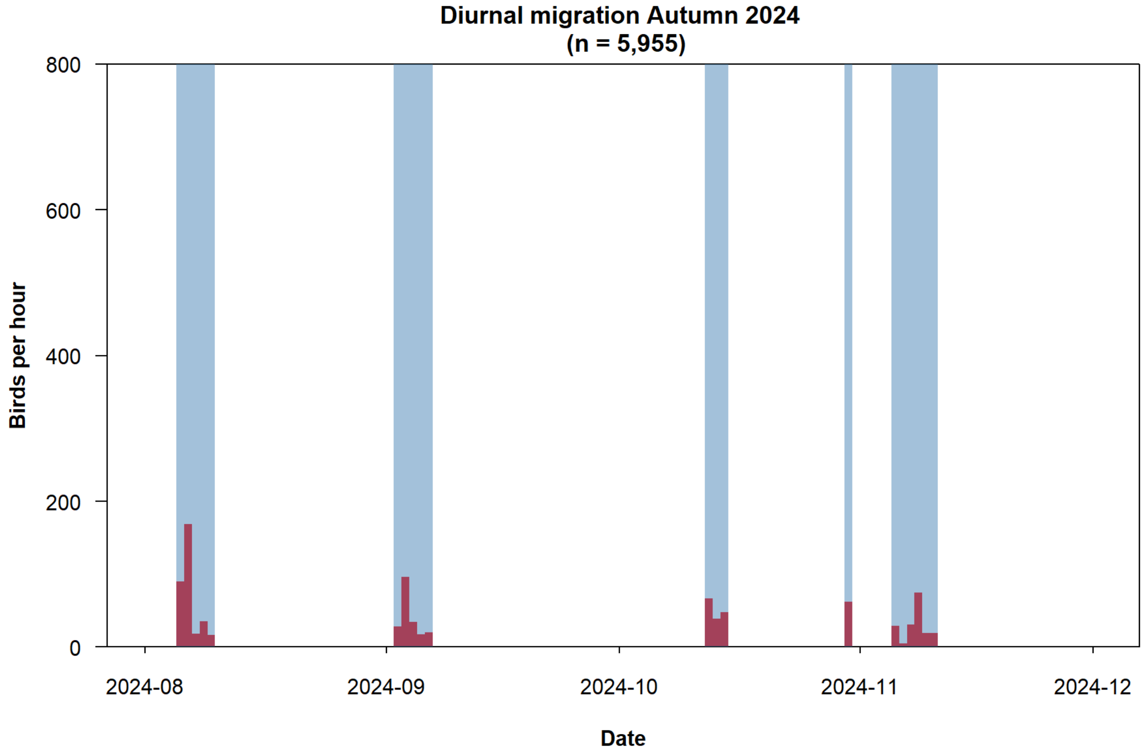


Figure 5.33 Diurnal migration intensity (red bars) derived from visual observations in autumn 2023 (top) and autumn 2024 (bottom). Light blue shades indicate the dates when surveys took place (14 dates in 2023 and 14 in 2024). Y-axis has been standardized, so that a visual comparison of MTR in both years and seasons is easier.

The 20 days of observations were evenly spread during autumn 2024 with 4-6 survey days each month. During this season, mean migration intensity was at a similar level as in the spring, with the mean seasonal value being 46.0

± 38.7 ind./h. However, there was less variation in migration intensity in this season than in spring. Mean migration intensity was highest in August (65.8 ind./h) and varied between ~30 and ~54 ind./h in the other months. Migration intensity was highest in August due to a single date with a mass migration event of common scoters (on 6th of August 2024, when156.2 ind./h of common scoters were registered).

A total of 38 autumn days were surveyed across the two years of investigations. Migration intensity was on average 39.3 ± 35.4 ind./h and much less variable than during spring. Highest mean migration intensity was observed in October with almost 60 ind./h. Average migration intensity was also high in August, but this was mainly due to the scoters peak observed in August 2024 (see above). In 2023, however, August was the month with the least migration.

FLIGHT ALTITUDE

In general, the distribution of flight altitudes was similar in both years and across both seasons, with higher number of birds flying at very low altitudes than at any other altitude layer.

In spring, about 46% of all migrating birds (both years combined) were observed at very low altitudes (0 – 5 m). About 13.4% were migrating at altitudes between 5 and 20 m, and about 37% were observed at altitudes between 20 and 200 m. Only 3.5% of all observed migrants flew at altitudes above 200 m (Figure 5.34).

In autumn, almost two thirds (64.4%) of all migrating birds (both years combined) were observed at very low altitudes (0 – 5 m). About 30% were migrating at altitudes between 5 and 50 m and only a little more than 5% were observed at altitudes above 50 m. About 14% of all birds were flying between 20 and 200 m. Only one single bird was observed flying above 200 m (Figure 5.34).

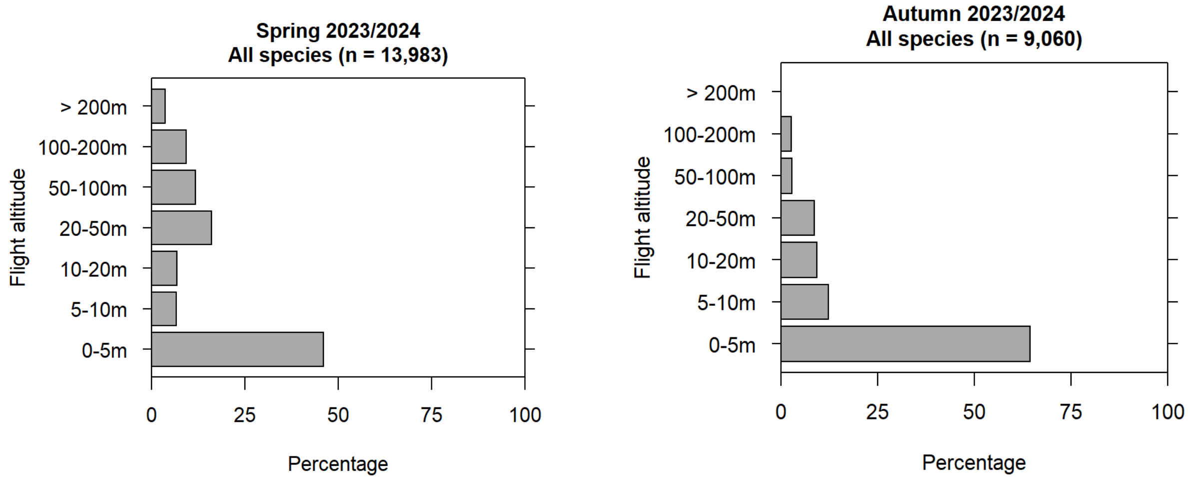


Figure 5.34 Flight altitude distribution of all observed birds during visual observations in spring (left) and autumn (right). Data of both years have been combined: 28 survey dates in spring and 38 survey dates in autumn.

FLIGHT DIRECTION

During spring, the main migration direction of all visually observed birds was NE (70% of all observations, most of them geese, see next section). About 8% of all birds flew to the SE, and these were mainly ducks. A small number of birds flew also to the north (5%) and east (4%) and other directions were less frequent (Figure 5.35). During autumn, there were two main migration directions: 29% of all migrating birds were observed flying towards the NW, whereas 23% were observed flying towards the SW. Around 16% flew to the west. These different migration patterns were more pronounced between years: In 2023, most birds flew towards the SW (29%) and W (23%) and in 2024, over a third of all observed birds flew towards the NW (36%) and 20% towards the SW. Nonetheless, birds were observed flying at all directions, depending on the species/species group with the easterly direction being least frequent (< 2.0%, Figure 5.35).

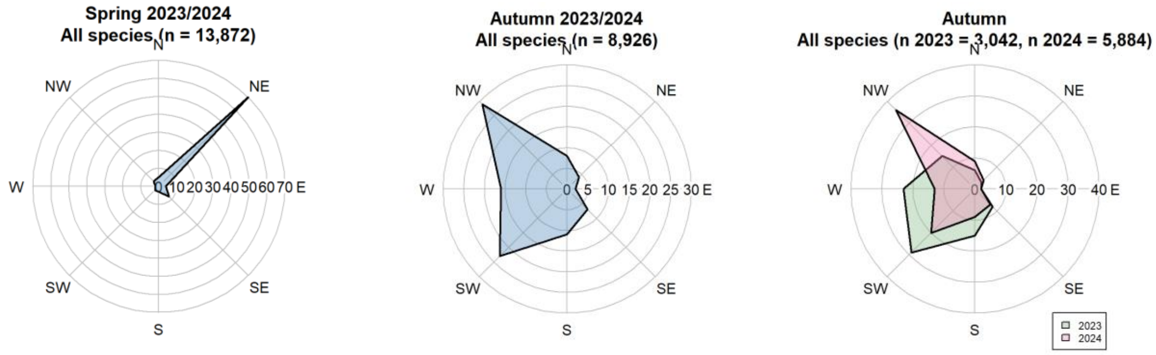


Figure 5.35 Flight directions of all observed birds during visual observations in spring 2023/2024 (left) and autumn 2023/2024 (middle). The plot on the right shows the flight directions during autumn separated by year (as patterns differed between years). Observers estimated the flying direction in 45° increments: N = North, NE = Northeast, E = East, SE = Southeast, S = South, SW = Southwest, W =West, NW = Northwest. Numbers on the axis represent percentages. Data of both years have been combined with 28 survey dates in spring and 38 survey dates in autumn.

DIURNAL PHENOLOGY

Data of both years were combined to present general patterns of temporal variability throughout the observation hours.

During spring migration, the highest migration intensity was observed three hours after the civil morning twilight, when 46% of all birds were detected. In general terms, migration intensity was much 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 (83.8%) than later (Figure 5.36), and this pattern was highly influenced by the most common species observed in spring (barnacle geese, see next section). A low number of birds were observed between the (normalized) 6th and 10th hour of observations (i.e., the afternoon).

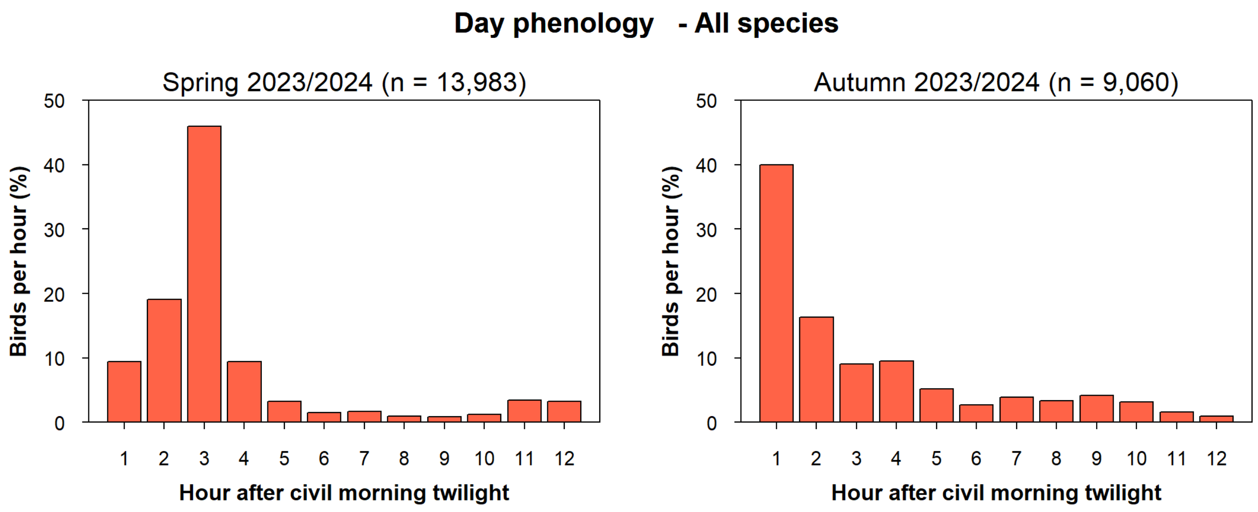


Figure 5.36 Diurnal phenology of all observed birds in spring (left) and autumn (right) 2023. Observations were combined for all observations days during spring, and hours were standardized so that every day would have a 12-hour length, irrespective of the date. Data of both years have been combined: 28 survey dates in spring and 38 survey dates in autumn.

During autumn, the highest bird migration intensity was observed in the early hours of the morning: In the very first hour after civil morning twilight alone, 40% of all birds were observed. In general, almost three quarters or 75% of all birds flew during the first four hours of the day (Figure 5.36), a pattern highly influenced by the most commonly observed species in this season (common scoters, see next section). There was a general decrease in the number of birds observed during migration with the time of the day.

NOCTURNAL MIGRATION (FLIGHT CALLS)

MIGRATION INTENSITY

Spring:

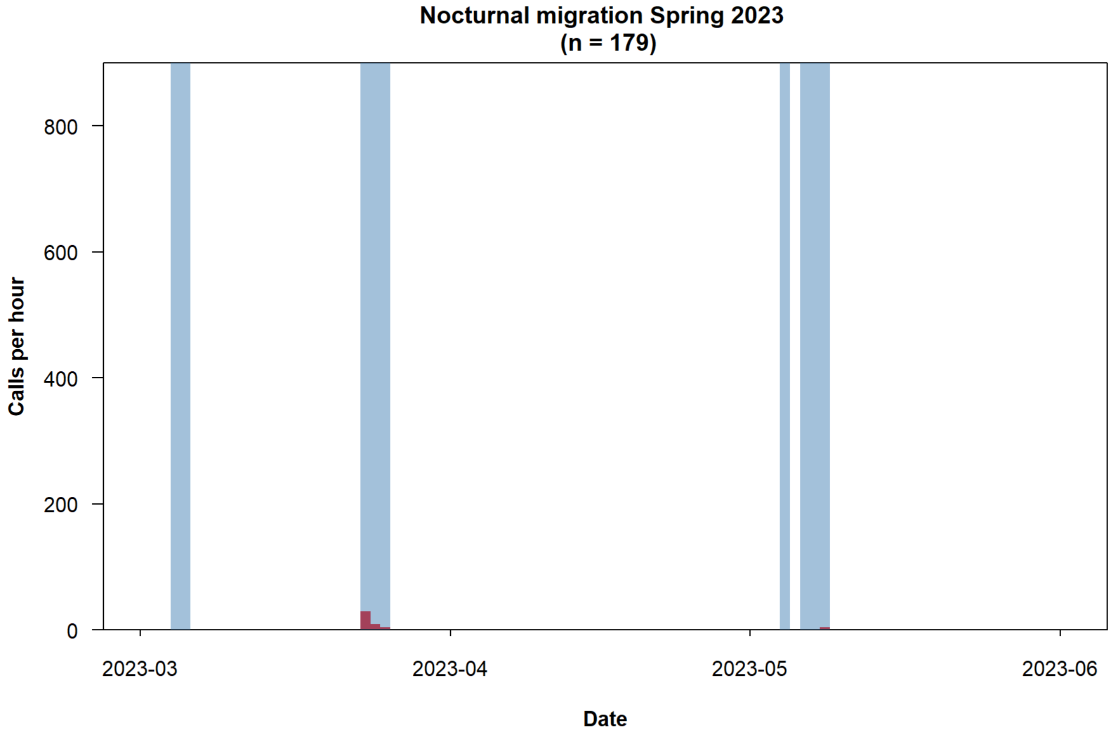
No nocturnal flight calls were registered during the first two nights of the nine spring 2023 survey dates. Nocturnal calls were heard during the other seven nights at different intensities. Most calls were heard in the night of 23rd of March, when the maximum intensity reached 30.2 calls/h (Figure 5.37). In March, the mean migration intensity was 9 ± 12.5 calls/h, whereas in May the mean intensity was just 1.5 ± 1.9 calls/h. There were no survey dates in April. Overall, the mean nocturnal migration intensity reached 5.7 ± 9.8 calls/h in spring 2023 (Table 5.5).

In spring of the following year, however a much higher number of calls were heard during the 15 nights of collection. Survey nights were evenly spread with five consecutive nights for each month. Most calls were registered at the beginning of the survey in March: on the night of the 2nd of March (888.8 calls/h, Figure 5.37). Mean migration intensity decreased throughout the season with a mean intensity in April of 218.1 calls/h and in May of just 3.8 calls/h. Overall, the mean nocturnal migration intensity in spring 2024 was almost 16 times higher than that of spring 2023 (91 ± 228.5 calls/h, Table 5.5).

When averaging findings of both years, mean nocturnal migration intensity for spring was 59.0 ± 183.3 calls/h. Variability was high due to the peak observed in March 2024. The month of April was only surveyed in 2024.

Table 5.5 Monthly and seasonal migration rates (calls/h) calculated from nocturnal flight calls (acoustic observations) in spring 2023 and 2024 in the pre-investigation area. SD = Standard deviation.

Spring	Migration intensity (calls/h)			Number of calls	Number of survey nights
	Mean (± SD)	Median	Maximum value		
March 2023	9 (± 12.5)	5	30.2	159	5
April 2023	0	0	0	0	0
May 2023	1.5 (± 1.9)	0.8	4.3	20	4
Spring 2023	**5.7 (± 9.8)**	**1.2**	**30.2**	**179**	**9**
March 2024	218.1 (± 384.6)	2.5	888.8	6,542	5
April 2024	51.1 (± 55.3)	26.1	143.5	1,119	5
May 2024	3.8 (± 6.0)	1.2	14.5	61	5
Spring 2024	**91 (± 228.5)**	**8**	**888.8**	**7,722**	**15**
March combined	113.5 (± 279.2)	3.8	888.8	6,701	10
April combined	51.1 (± 55.3)	26.1	143.5	1,119	5
May combined	2.8 (± 4.6)	1.2	14.5	81	9
Spring combined	**59.0 (± 183.3)**	**3.4**	**888.8**	**7,901**	**24**



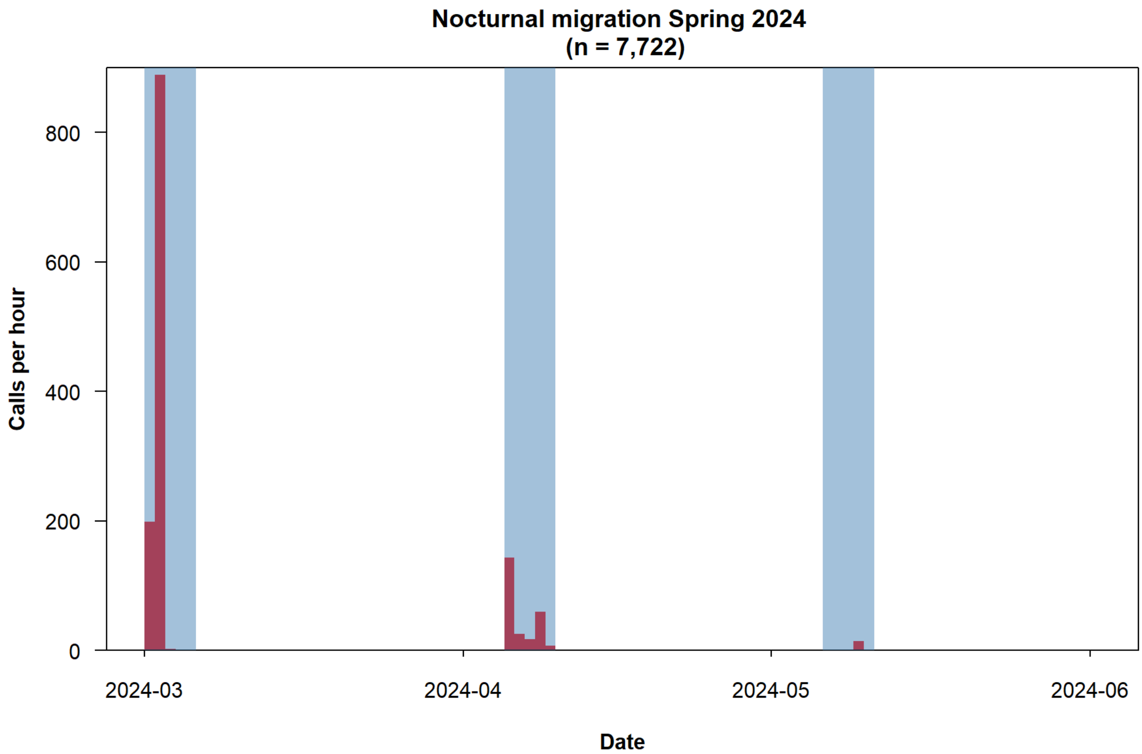


Figure 5.37. Nocturnal migration intensity (red bars) derived from acoustic observations (flight calls) in spring 2023 (top) and spring 2024 (bottom). Light blue shades indicate the dates when surveys took place (9 dates in 2023 and 15 in 2024). Y-axis has been standardized so that a visual comparison of call per hour in both years is easier.

Autumn:

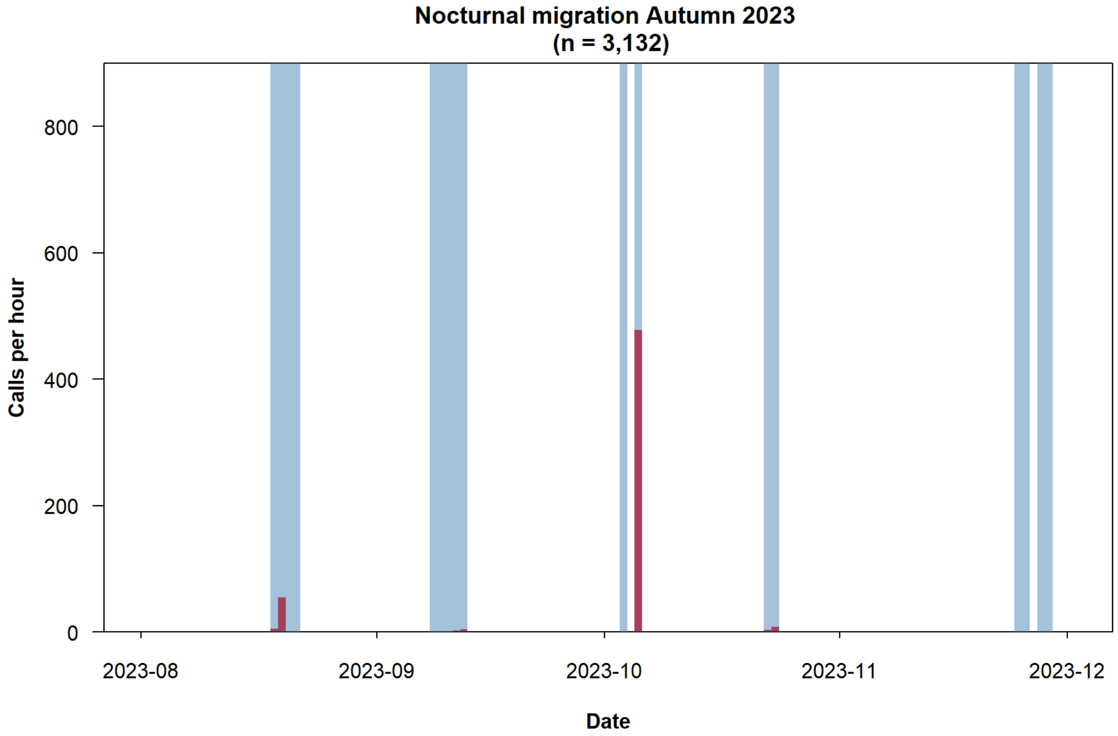
Nocturnal migration intensity was very variable during autumn 2023. Of the total 17 evenly spread survey nights, there were some dates with very low migration intensity and other nights when many bird calls were heard. The mean nocturnal migration intensity reached 33.2 ± 115.4 calls/h in autumn 2023, but the median was much lower because of the extreme variation in migration intensity: 1.3 calls/h (Table 5.6). Most calls were heard on the night of 5th of October (maximum intensity reached then 478.3 calls/h, Figure 5.38). 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).

In contrast, despite a very similar number of calls heard in autumn 2024, the variability was much lower in this season, with mean and median values being very similar for all months. A total of 20 survey nights were conducted and were evenly spread during the autumn 2024 campaign. Mean and median migration intensity increased throughout the season. Migration intensity in August and September was very low (mean < 3.0 calls/h), but increased in October (10.1 calls/h) and reached its maximum in November (67.2 calls/h) when migration of most abundant songbirds took place (e.g., on the 7th of November, 115 calls/h of blackbirds and 54.7 calls/h of redwings were registered, nonetheless these species were also observed at high numbers on the 4th of November and the 9th of November).

When comparing results of both years together, the main difference was found during November. In 2024, most of nocturnal migration occurred during this month whereas in 2023 a very reduced number of calls were detected, despite having four nights of surveys during this month. These survey nights, however, took place by the end of the month. A possible interpretation of these results could be related to the probability that birds had already migrated for 2023. In contrast, in 2024, survey nights for November were at the beginning of the month when large numbers of songbirds were still migrating.

Table 5.6. Monthly and seasonal migration rates (calls/h) calculated from nocturnal flight calls (acoustic observations) in autumn 2023 and 2024 in the pre-investigation area.

Autumn	Migration intensity (calls/h)			Number of calls	Number of survey nights
	Mean (± SD)	Median	Maximum value		
August 2023	15.5 (± 26.6)	3.2	55.2	248	4
September 2023	2.2 (± 1.5)	1.7	4.6	52	5
October 2023	122.5 (± 237.2)	5.8	478.3	2,826	4
November 2023	0.2 (± 0.1)	0.1	0.4	6	4
Autumn 2023	**33.2 (± 115.4)**	**1.3**	**478.3**	**3,132**	**17**
August 2024	1.9 (± 0.9)	2	2.9	31	5
September 2024	2.5 (± 2.9)	0.9	6.5	60	5
October 2024	10.1 (± 6.9)	10.2	18.3	249	4
November 2024	67.2 (± 73)	46.9	190.9	2,822	6
Autumn 2024	**23.3 (± 47.9)**	**4.7**	**190.9**	**3,162**	**20**
August	7.9 (± 17.8)	2	55.2	279	9
September	2.4 (± 2.2)	1.5	6.5	112	10
October	66.3 (± 166.5)	8.5	478.3	3,075	8
November	40.4 (± 64.5)	5.9	190.9	2,828	10
Autumn	**27.8 (± 84.6)**	**2.7**	**478.3**	**6,294**	**37**



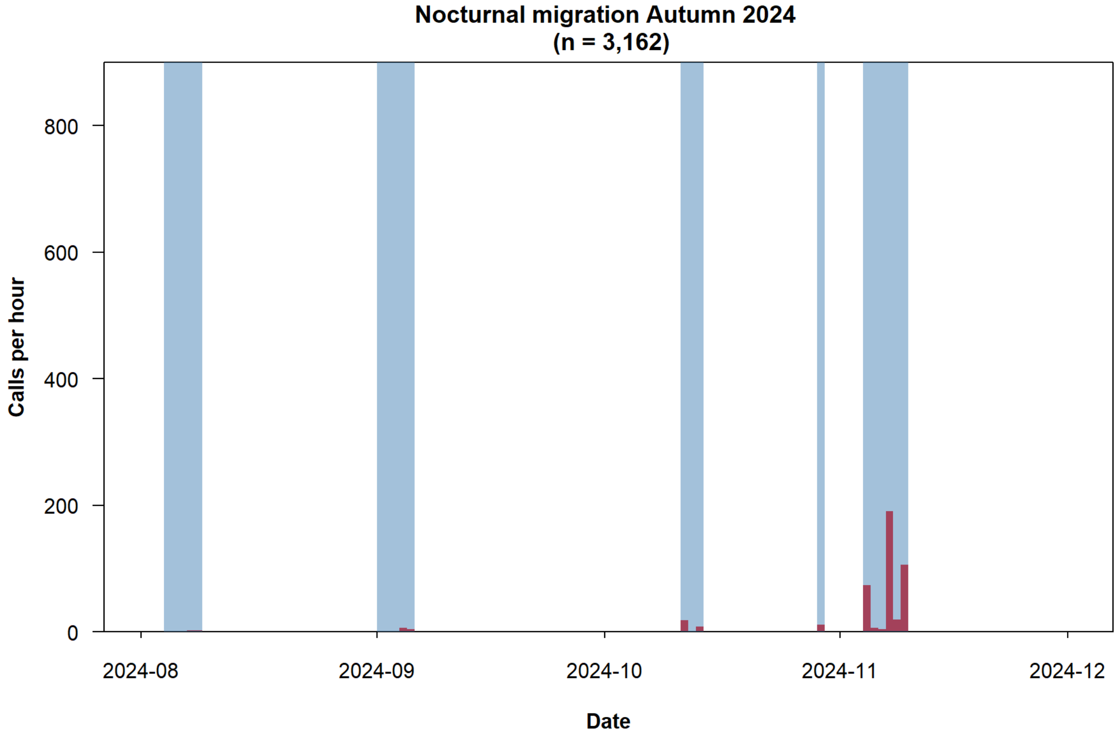


Figure 5.38 Nocturnal migration intensity (red bars) derived from acoustic observations (flight calls) in autumn 2023 (top) and autumn 2024 (bottom). Light blue shades indicate the dates when surveys took place (17 dates in 2023 and 20 in 2024). Y-axis has been standardized so that a visual comparison of call per hour in both years is easier.

NOCTURNAL PHENOLOGY

During spring migration, highest call intensities were recorded late in the night (from the ninth hour after evening civil twilight onwards, 67% of all migration was recorded in these last 4 standardised hours). The overall highest migration intensity occurred at 10 hours after civil evening twilight (Figure 5.39).

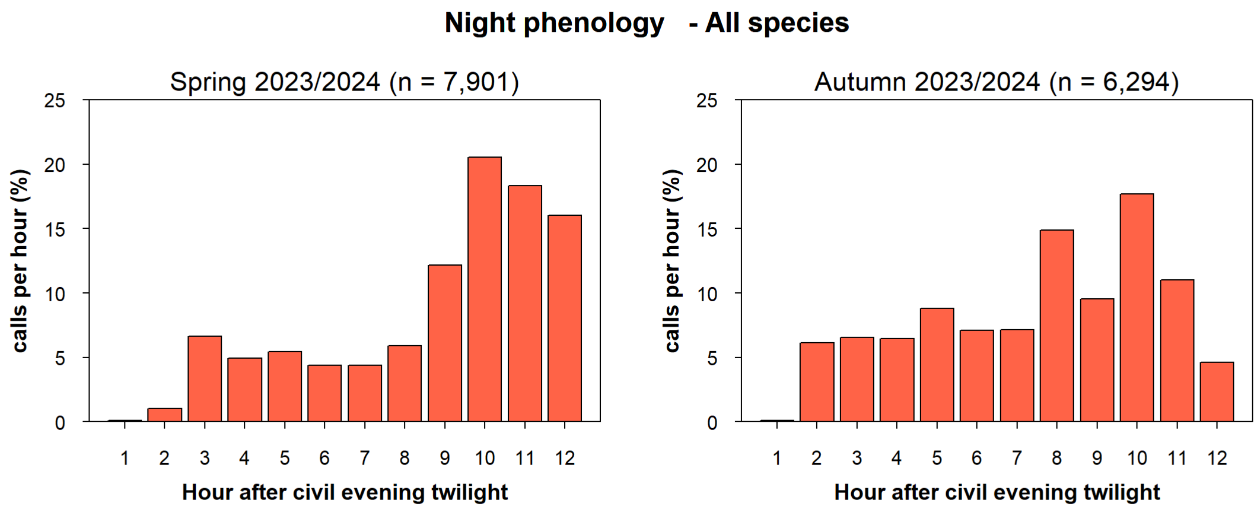


Figure 5.39 Nocturnal phenology of all observed birds in spring (left) and autumn (right) 2023. Observations were combined for all observations days during spring, and hours were standardized so that every day would have a 12-hour length, irrespective of the date. Data of both years have been combined: 24 survey dates in spring and 37 survey dates in autumn.

During autumn migration, call intensities remained more or less constant between the second and 7th hour after civil evening twilight (6-8% of all calls in each hour) and there were two hours at which most calls were heard (8 and 10 standardized hours after civil evening twilight). In general, 58% of all migration was recorded in the last five standardized hours after civil evening twilight (Figure 5.39).

PER SPECIES GROUPS

DIURNAL MIGRATION (VISUAL OBSERVATIONS)

SPECIES COMPOSITION

Spring:

A total of 9,177 birds, of which 94.6% were identified to 67 species, were registered in the Kattegat study area during the 14 days of diurnal observations in spring 2023 (Table 5.7). Of the total number of migrating birds observed, 71.6% were geese (n=6,568, Table 5.8), most of them being barnacle geese (67.9%), and greylag geese (1.7%). The second most abundant group of migrating birds observed during the survey period were ducks (13.2%, n = 1,210, Table 5.8), mainly common scoter (10.7%) and, to a smaller extent, other sea ducks such as common eider (0.9%), velvet scoter (0.5%) and long-tailed duck (0.4%). A large number of migrating passerine species made up the third most abundant group of migrating birds in spring 2023 (songbirds, 6.1%). Cormorants, gulls and waders each represented less than 3% of all migrating birds in the area during spring 2023 (Figure 5.40). Of waders (1.4%), the most abundant species was the Eurasian curlew, whereas common gull was the most abundant species of gulls (0.7%).

Table 5.7 Total number of birds and species observed during spring and autumn 2023 and 2024 in the pre-investigation area. Summed data from both years has been added.

Season/Year	Number of survey days	Number of individuals	Number of species	Number of species > 250 individuals	Number of species < 10 individuals	Number of species under conservation category (Appendix)
Spring 2023	14	9,177	67	2	37	28
Autumn 2023	18	3,105	75	3	45	29
All year2023	**32**	**12,282**	**103**	**3**	**60**	**41**
Spring 2024	14	4,806	53	2	34	20
Autumn 2024	20	5,955	64	1	35	29
All year 2024	**34**	**10,761**	**84**	**2**	**50**	**37**
Spring	28	13,983	83	2	50	**34**
Autumn	38	9,060	93	5	56	37
Both years	**66**	**23,043**	**122**	**10**	**72**	**49**

Table 5.8 Number of individuals and species of diurnally migrating birds observed in the pre-investigation area. Numbers in parenthesis in the headings represent the number of survey days for each season and year. Species groups that are further described are highlighted in bold.

Species groups	Spring (Kattegat)			Autumn (Hesselø)			Total	N species (sp. conserv.)
	2023 (14)	2024 (14)	Total (28)	2023 (18)	2024 (20)	Total (38)		
Divers	**59**	**19**	**78**	**24**	**83**	**107**	**185**	**3 (3)**
Grebes	4	4	8	0	2	2	10	1 (1)
Tubenoses	0	2	2	3	5	8	10	2 (1)
Gannets	**27**	**53**	**80**	**124**	**51**	**175**	**255**	**1 (0)**
Cormorants	180	57	237	68	96	164	**401**	1 (0)
Herons	1	2	3	5	13	18	21	1 (0)
Swans	**28**	**0**	**28**	**109**	**66**	**175**	**203**	**2 (1)**
Geese	**6,568**	**2,747**	**9,315**	**440**	**448**	**888**	**10,203**	**7 (2)**
Ducks	**1,210**	**1,234**	**2,444**	**1,566**	**4,226**	**5,792**	**8,236**	**12 (8)**
Birds of prey	14	2	16	4	21	25	41	9 (4)
Cranes	**56**	**7**	**63**	**0**	**0**	**0**	**63**	**1 (1)**
Waders	**131**	**221**	**352**	**52**	**40**	**92**	**444**	**15 (10)**
Skuas	2	1	3	5	1	6	9	2 (1)
Gulls	**209**	**230**	**439**	**253**	**275**	**528**	**967**	**8 (6)**
Terns	**37**	**9**	**46**	**4**	**69**	**73**	**119**	**3 (3)**
Auks	**87**	**60**	**147**	**198**	**54**	**252**	**399**	**5 (2)**
Pigeons	1	1	2	1	2	3	5	2 (0)
Owls	0	1	1	0	2	2	3	1 (1)
Nightjars	0	1	1	0	0	0	1	1 (1)
Swifts	3	0	3	1	4	5	8	1 (1)
Songbirds	**560**	**155**	**715**	**248**	**497**	**745**	**1,460**	**43 (3)**
All	**9,177**	**4,806**	**13,983**	**3,105**	**5,955**	**9,060**	**23,043**	**122 (49)**

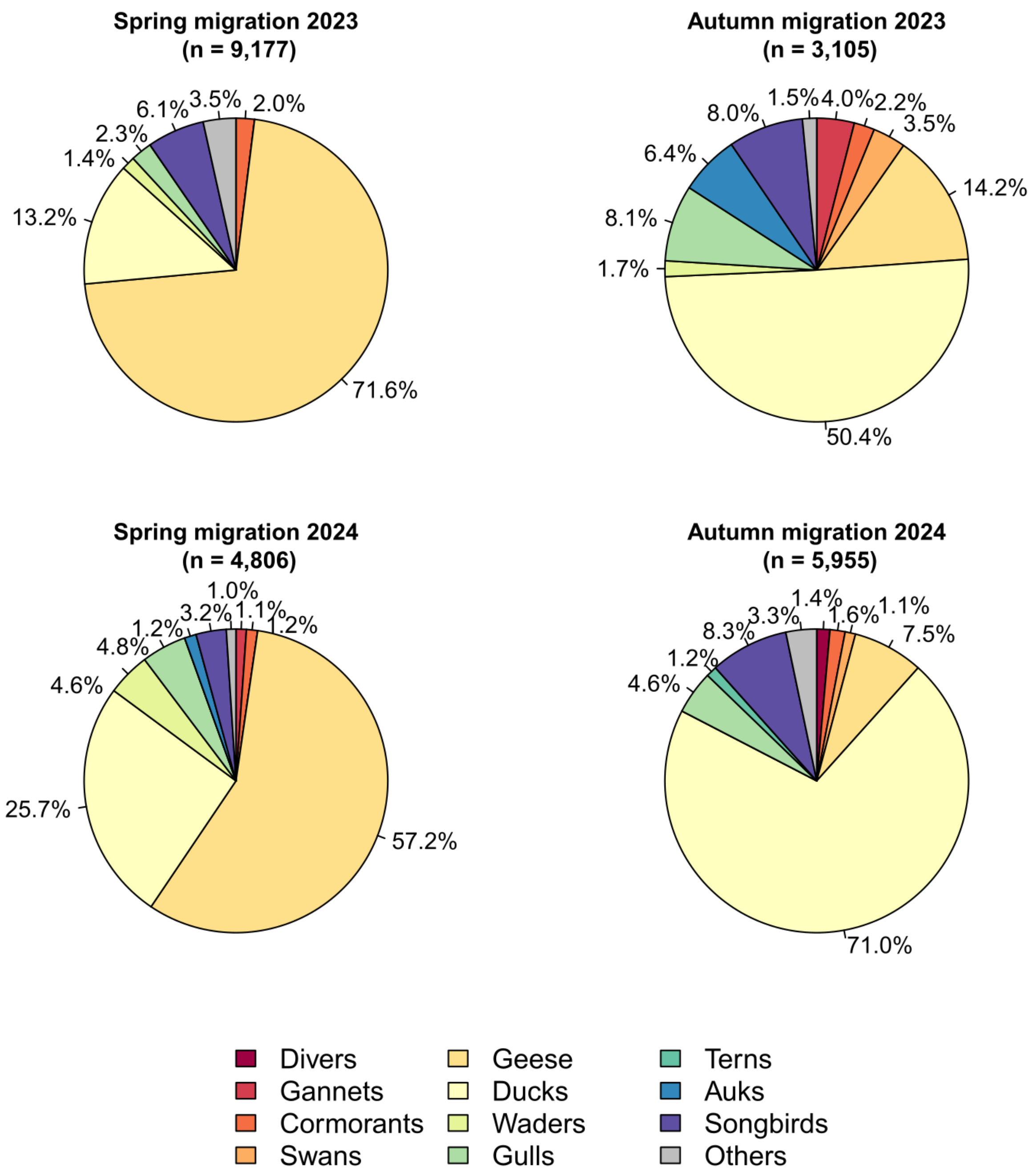


Figure 5.40 Percentage of observed diurnal migratory species in spring and autumn of the first and second years of baseline study (2023 and 2024, top and bottom plots, respectively) in the pre-investigation area, grouped at taxonomic family level. All species groups, whose abundance represent at least 1% of the total number of birds in each season 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 < 1%. Survey days for spring were 14, whereas in autumn 2023 and 2024, 18 and 20 days of observation were conducted, respectively.

In spring 2024, a total of 4,806 birds (only half of the 2023 total, 9177 birds, Table 5.7) belonging to 53 species were registered during the 14 days of diurnal observations in the pre-investigation area of Kattegat. Similar to the previous year, the most abundant group of registered birds was geese (57.2%, n=2,747, Table 5.8), predominantly barnacle geese (55% of the total migrating birds). Greylag geese occurred less frequently (0.7% vs. 1.7%). The second most abundant group of birds was ducks, as in 2023, and it represented over a quarter of all migrating birds (25.7%, n=1,234, Table 5.8) with common scoter being more often observed (22.7% of all migrating birds). Other duck species such as velvet scoter (1.0%) or common eider (0.6%) were less frequently observed. Gulls (4.8%), waders (4.6%) and songbirds (3.2%) were the next groups in abundance. Three species of gulls were most commonly seen: lesser black-backed gull and herring gull (each 1.6% of all migrating birds) as well as great black-backed gull (0.8%) Most waders observed were European golden plovers (4.2%). The most commonly observed songbirds were meadow pipit (0.9%) and white/pied wagtail (0.6%). Other groups that occurred in smaller numbers were cormorants, gannets and auks (1.1 – 1.2%, Figure 5.40).

Overall, a total of 13,983 birds grouped into 83 species of 21 taxonomic groups were recorded during spring of both seasons (28 survey dates of both years combined, Table 5.7). Of the total number of migrating birds observed during both springs, two thirds were geese (66.6%, n=9,315, Table 5.8), most of them being barnacle goose (63.5%). The second most abundant group of migrating birds observed during the survey period were ducks (17.5%, n=2,444, Table 5.8) and these were mainly composed of common scoter (14.8%). A large number of migrating passerine species comprised the third most abundant migrating group of birds in spring (songbirds, 5.1%, n=715, Table 5.8) whereas cormorants, gulls and waders represented each 3% or less of all migrating birds in the area during spring. A total of 34 species (41%, Table 5.7) are considered under one or more of four conservation categories (see Appendix for details).

Autumn:

A total of 3,105 birds (of which 2,828 birds, 91.1%, were identified to 75 species, Table 5.7) were registered during the 18 days of diurnal observations in autumn 2023 in the pre-investigation area. Of the total number of migrating birds observed in this season, half were ducks (n=1,566, Table 5.8), most of which were common scoter (28.6%) and Eurasian wigeon (10.9%). The second most abundant group of migrating birds observed during the survey period were geese (14.2%, n=440) of which barnacle goose were the most abundant species (11.6%). Gulls (8.1%), songbirds (8.0%) and auks (6.4%) followed in terms of abundance (Figure 5.40). Other groups and species like gannet (4%), swans (3.5%), cormorant (2.2%) and waders (1.7%), were less abundant.

In autumn 2024, 5,955 birds (almost double of the 2023 total) of 64 species were observed during the 20 days of observations (Table 5.7). Ducks were by far the most abundant group representing 71% of all birds observed (n=4,226, Table 5.8). They were mainly represented by common scoters (62.6% of all birds), followed by velvet scoters (3.0%) and common eiders (2.7%), which occurred in smaller numbers. Moreover, songbirds (8.3%), geese (7.5%) and gulls (4.6%) followed in abundance (Table 5.8, Figure 5.40). Of these, the most common species were common starling (3.7%) and chaffinch (1.3%), barnacle and greylag geese (2.5-2.6%) and lesser black-backed gull (1.7%), black-legged kittiwake (1.1%) and common gull (0.8%). Other groups and species such as divers, gannet, cormorant, and auks represented less than 1.8% of all observed birds.

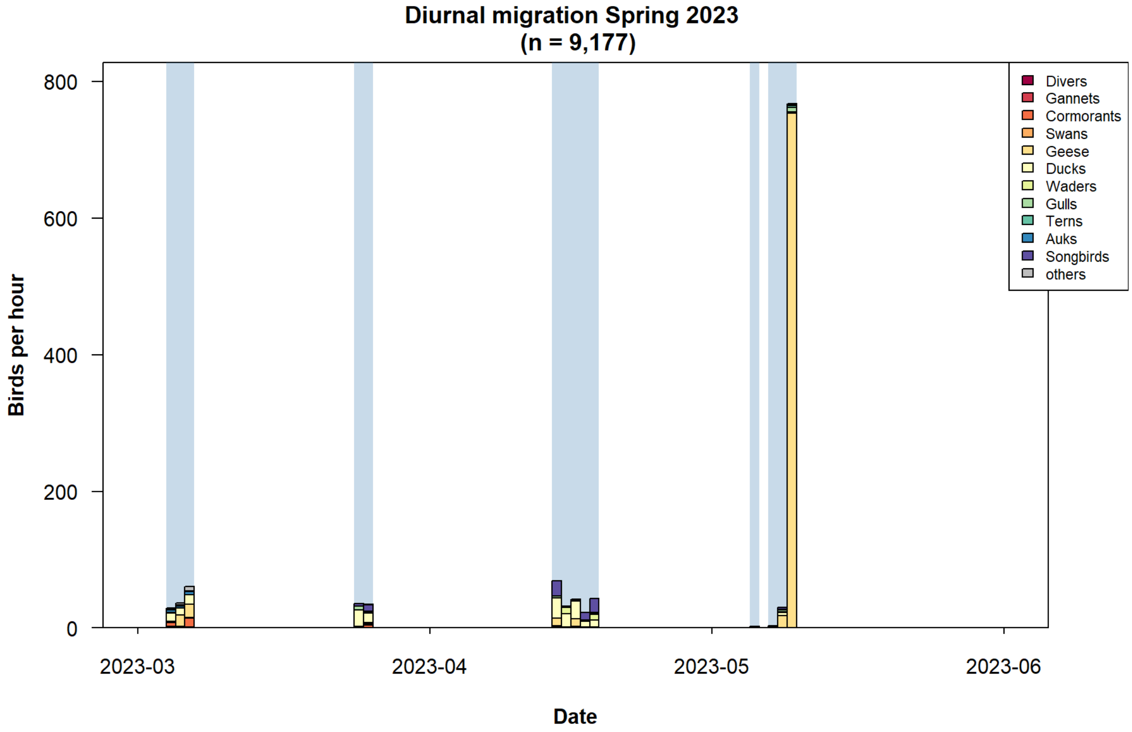
Over the two autumn seasons, a total of 9,060 diurnally migrating birds grouped into 93 species (belonging to 19 taxonomic groups) were recorded over 38 days of surveys. Almost two thirds of all birds (64%, n=5,792, Table 5.8) were ducks, most of which were common scoter (50.9%) and Eurasian wigeon (4.3%). The second most abundant group of migrating birds observed during the survey periods were geese (9.8%, n=888, Table 5.8) of which barnacle goose were the most abundant species (5.7%). After these, songbirds (8.2%), gulls (5.8%) and auks (2.8%) followed in terms of abundance. Species considered under a conservation category were also in a similar proportion (37 species, 40%).

MIGRATION INTENSITY

The following graphs present patterns previously shown across seasons but with coloured bars indicating species groups. The same colours used for species groups in Figure 5.40 have been used in all figures for diurnal migration whereas colours used in Figure 5.43 have been used for graphs of nocturnal migration. These graphs just serve as a quick overview of how the most common species groups were registered throughout the season. Summary graphs of migration intensity per month are shown for relevant species group (see below).

As Figure 5.40 already showed, the most common species group in spring 2023 was geese, and most of them occurred on the last survey date (Figure 5.41). Songbirds were most common in the middle of the season, whereas ducks were commonly migrating throughout the season (Figure 5.41). In spring 2024, geese were also more abundant by the end of the season (May), whereas the largest migration of ducks took place in the middle of the season. Waders were most common also in May (Figure 5.41).

In autumn, mainly ducks were migrating in large numbers at the beginning of the season. Geese started to migrate in September but were more common in October and November. Auks and swans were also more common at the end of the season whereas songbirds were mostly migrating in October and beginning of November (Figure 5.42).



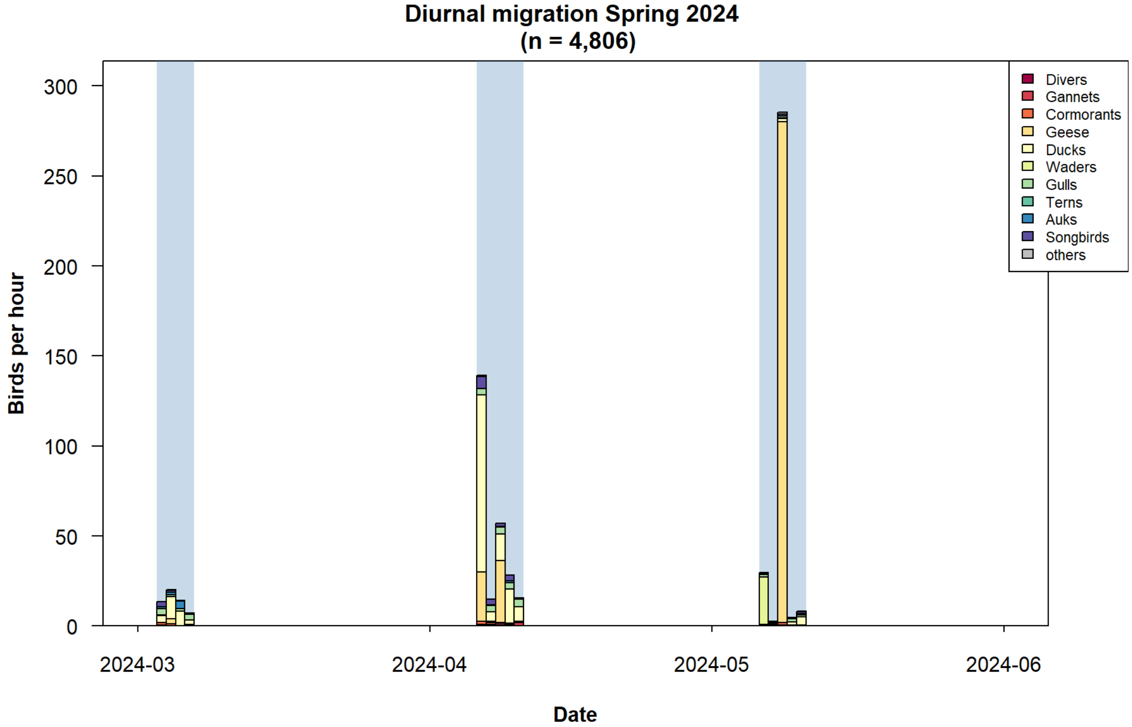
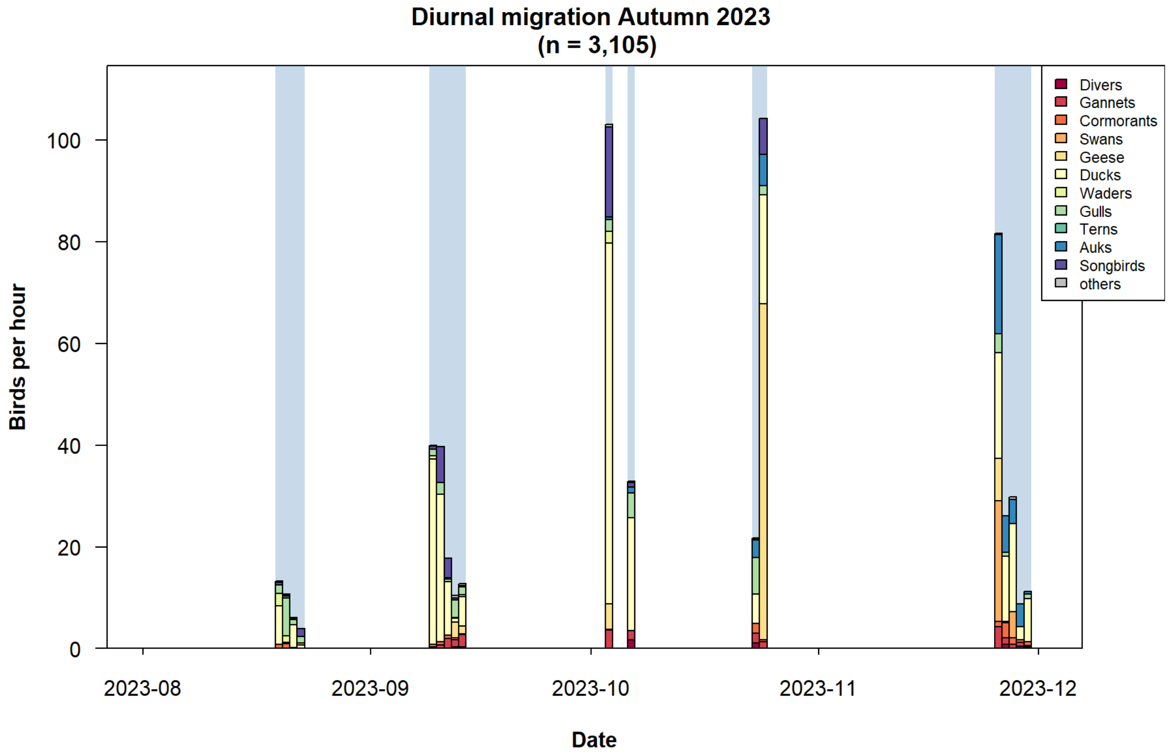


Figure 5.41 Diurnal migration intensity derived from visual observations in spring 2023 (top) and spring 2024 (14 dates, each). Bar colours indicate birds/h for each species group. The same colours have been used as in Figure 5.8.



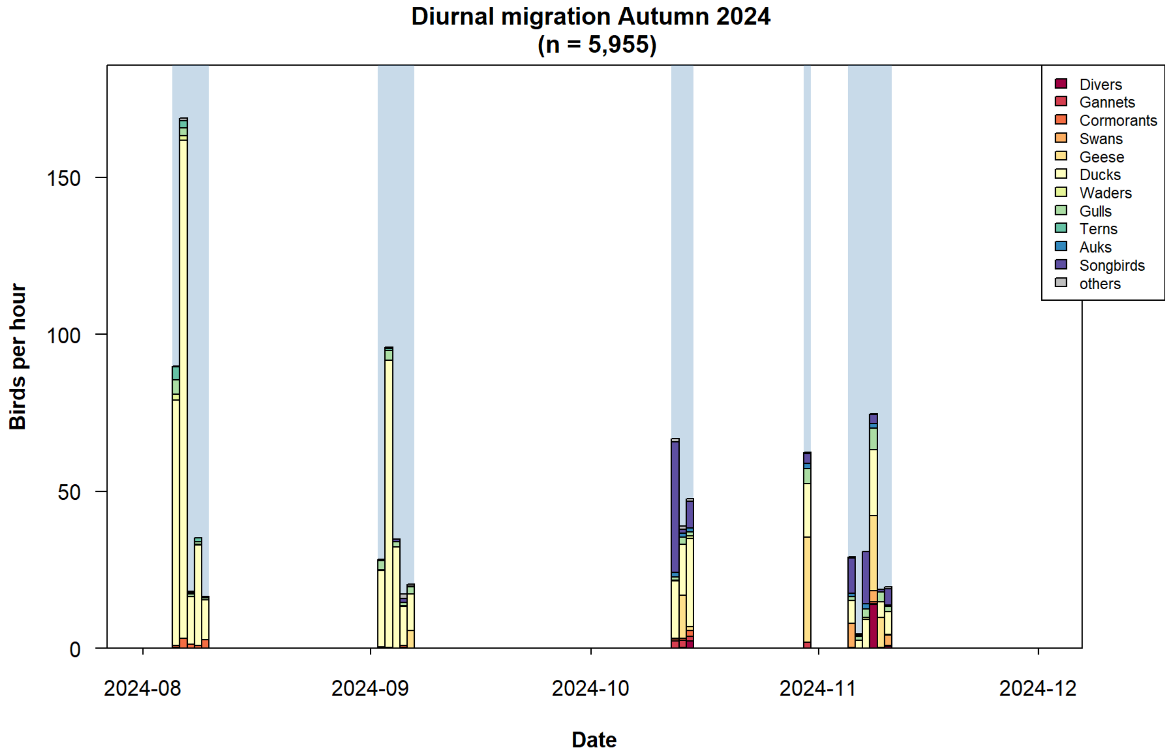


Figure 5.42 Diurnal migration intensity derived from visual observations in autumn 2023 (top, 18 dates) and autumn 2024 (bottom, 20 dates). Bar colours show birds/h for each species group. Colours as in Figure 5.8.

SPECIES COMPOSITION

Spring:

In general, there were only few bird calls registered during the nine nights of survey in spring 2023. Out of a total of 179 bird calls, 162 calls (91%) could be identified to species level (14 species in total). Most of the birds heard during night belonged to songbirds: 50% were thrushes (*Turdus* spp., among which redwings were most abundant) and 39% belonged to other songbird species (e.g. European robins, common chiffchaffs, etc.). Other species worth mentioning were barnacle goose, oystercatcher, common sandpipers and gulls (Figure 5.43).

Table 5.9. Total number of bird calls and species heard during spring and autumn 2023 and 2024 in the pre-investigation area. Data of both years has been added too.

Season/Year	Number of survey nights	Number of bird calls	Number of species	Number of species > 250 bird calls	Number of species < 10 bird calls	Number of species under conservation category (Appendix)
Spring 2023	9	179	14	0	9	2
Autumn 2023	17	3,132	18	2	8	4
All year2023	**26**	**3,311**	**26**	**2**	**14**	**5**
Spring 2024	15	7,722	30	4	10	11
Autumn 2024	20	3,162	16	3	7	5
All year 2024	**35**	**10,884**	**37**	**4**	**13**	**14**
Spring	24	7,901	33	4	11	12
Autumn	37	6,294	26	4	11	8
Both years	**61**	**14,195**	**45**	**5**	**16**	**17**

Table 5.10 Number of individuals and species of nocturnally migrating birds observed in the pre-investigation area. Numbers in parenthesis in the headings represent the survey dates for each season and year. Species further described are highlighted in bold.

Species groups	Spring (Kattegat)			Autumn (Hesselø)			Total	N species (sp. conserv.)
	2023 (12)	2024 (14)	Total (28)	2023 (23)	2024 (20)	Total (38)		
Divers	0	0	0	0	15	15	**15**	1 (1)
Herons	0	17	17	1	0	1	**18**	1 (0)
Geese	12	4	16	0	0	0	**16**	2 (1)
Ducks	0	77	77	0	0	0	**77**	2 (1)
Waders	**6**	**241**	**247**	**159**	**21**	**180**	**427**	**11 (6)**
Gulls	**3**	**91**	**94**	**20**	**7**	**27**	**121**	**6 (5)**
Terns	0	0	0	0	13	13	**13**	1 (0)
Pigeons	0	11	11	0	0	0	**11**	1 (0)
Songbirds	**69**	**1642**	**1711**	**212**	**401**	**613**	**2,324**	**43 (3)**
Thrushes	**89**	**5639**	**5728**	**2740**	**2705**	**5445**	**11,173**	**19 (1)**
All	**179**	**7,722**	**7,901**	**3,132**	**3,162**	**6,294**	**14,195**	**45 (17)**

In contrast, during spring 2024, there was a large number of bird calls registered in the 15 survey nights (n= 7,722) from a total of 30 species. Most calls were from songbirds (73% of thrushes and 21% of all other songbirds). The most common thrushes were common blackbirds (59% of all calls heard) and redwings (12%) while sky larks (13%) and European robins (6%) were two other songbirds commonly recorded. Waders produced 3% of all calls heard with two species being most common: Northern lapwing (1.3%) and Eurasian oystercatcher (1.2%). Gulls represented only 1.2% of all calls heard in spring with the common gull as the most common gull in the season (0.8%). Calls of two species of ducks were heard in April 2024: Common scoters and Eurasian wigeons made together 1.0% of all calls in that season.

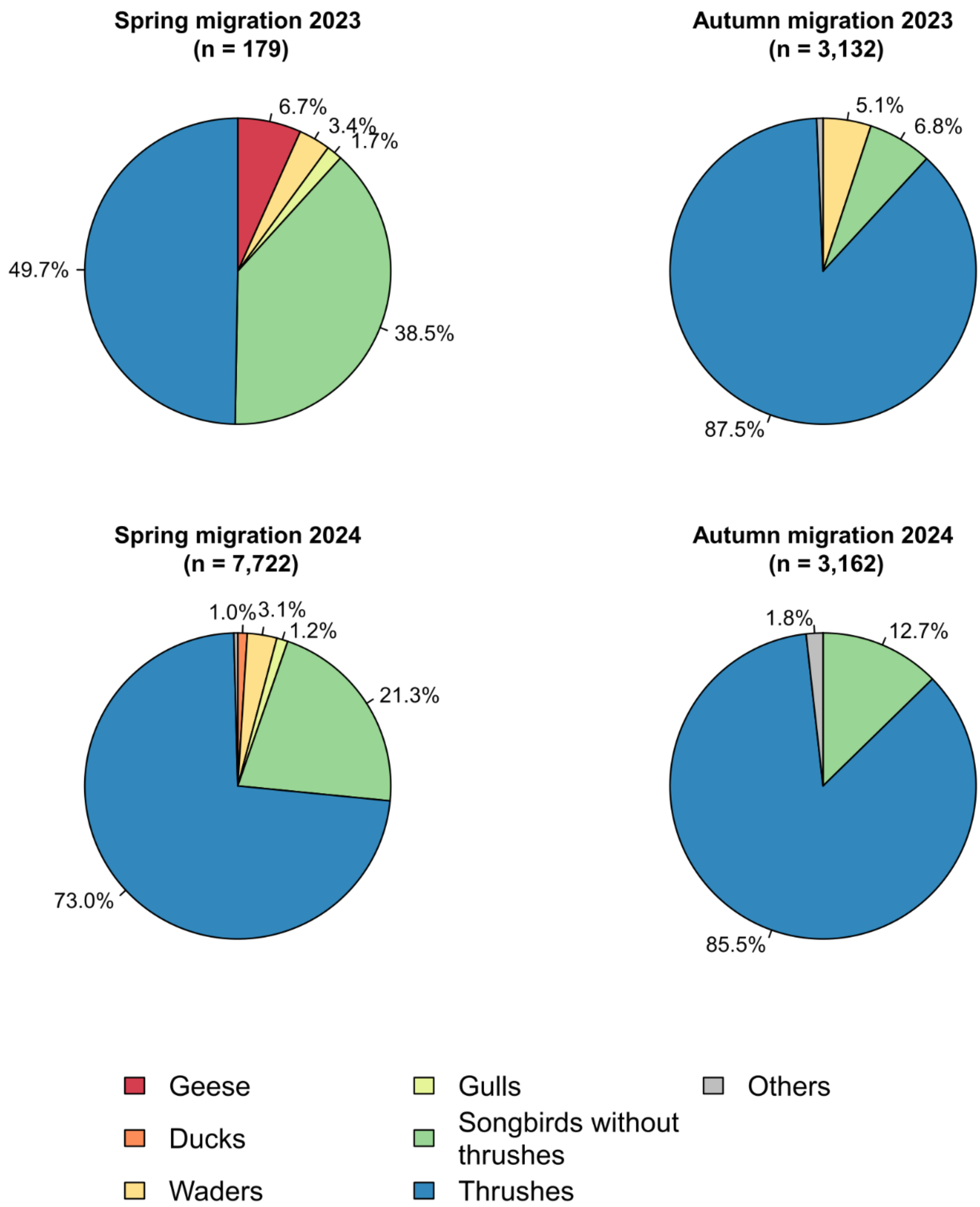


Figure 5.43 Percentage of nocturnal migratory species (based on acoustic observations) in spring and autumn of 2023 (top figures) and 2024 (bottom figures) in the pre-investigation area, grouped into high-category taxa. See Figure 5.40 for more details. In spring 2023, nine survey nights were conducted whereas in spring 2024, a total of 15 nights were surveyed. In autumn, 17 and 20 nights were surveyed in 2023 and 2024, respectively.

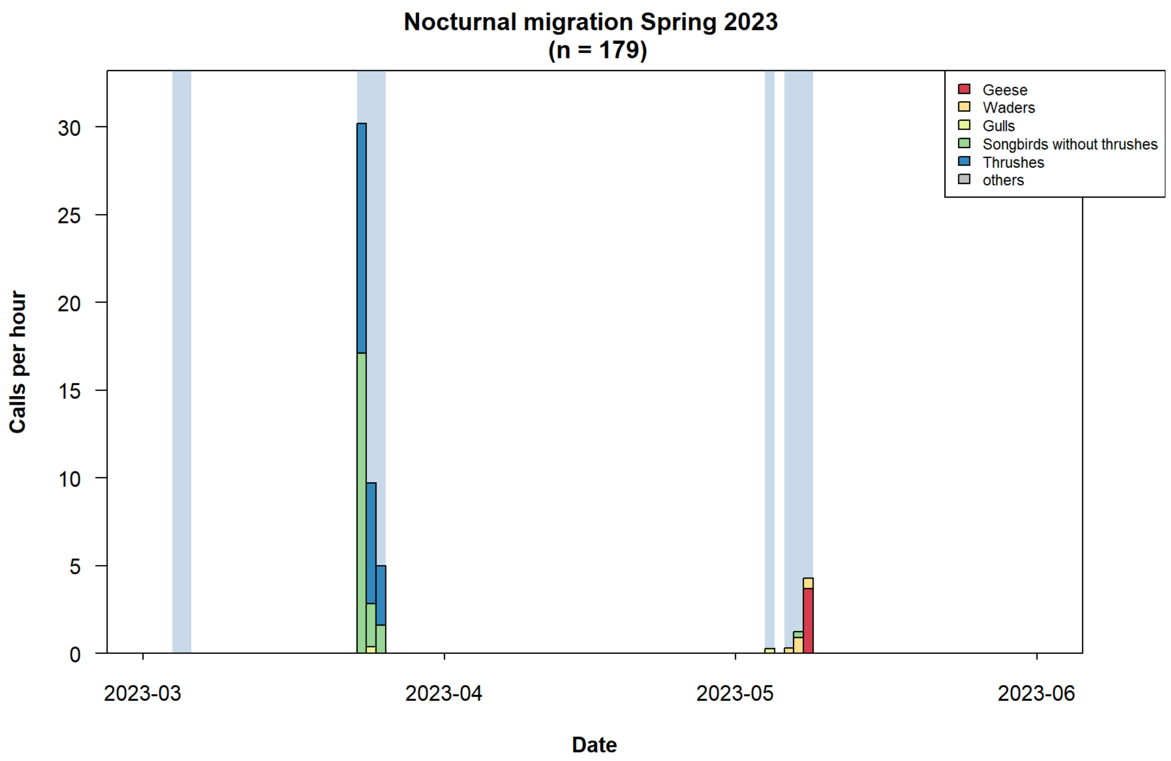
Autumn:

During the autumn migration in the pre-investigation area in 2023, 17 nights were surveyed. Out of a total of 3,132 bird calls, 3,111 calls (99%) 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: 88% (*Turdus* spp., among which song thrush was the most abundant) and only 7% belonged to other songbird species (e.g. robins, etc.). The only other group that was relatively common was waders (5%, Figure 5.43).

During the 20 nights of survey monitoring in autumn 2024, a very similar number of calls were heard as in the previous autumn: 3,162. These corresponded to 16 species. Songbirds were heard most, with other groups representing less than 1% of all calls in that season. Thrushes represented 86% of all calls and were mainly composed of common blackbirds (49%) and redwings (34%) whereas European robins were the most common other songbird species (11% of all calls). Calls of divers, waders, gulls and terns were also heard but at very low numbers and are then shown under the category “others” (Figure 5.43).

MIGRATION INTENSITY

During nocturnal migration, most songbirds calls (both thrushes and non-thrushes) were heard mostly at the beginning of the spring season (March, beginning of April, Figure 5.44) whereas in autumn, they were mostly heard from October till the end of the season (Figure 5.45).



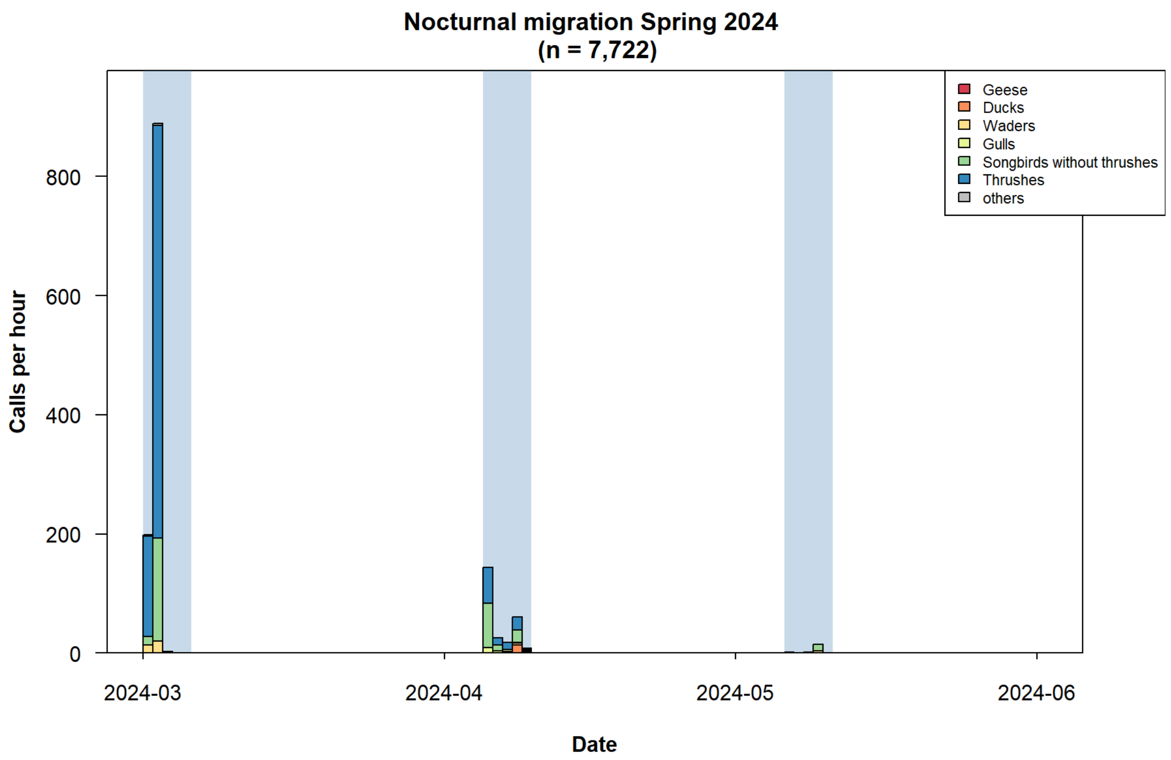
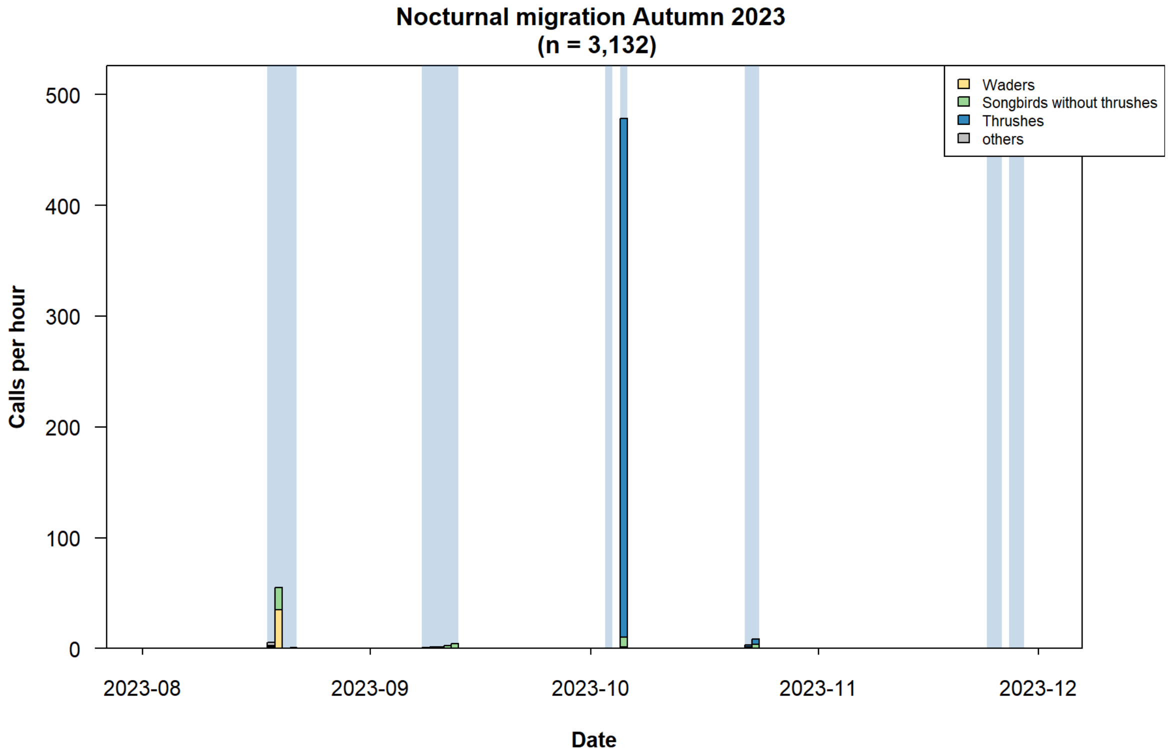


Figure 5.44 Nocturnal migration intensity derived from visual observations in spring 2023 (top) and 2024 (bottom). Bar colours indicate calls/h for each species group. The same colours have been used as in Figure 5.43.



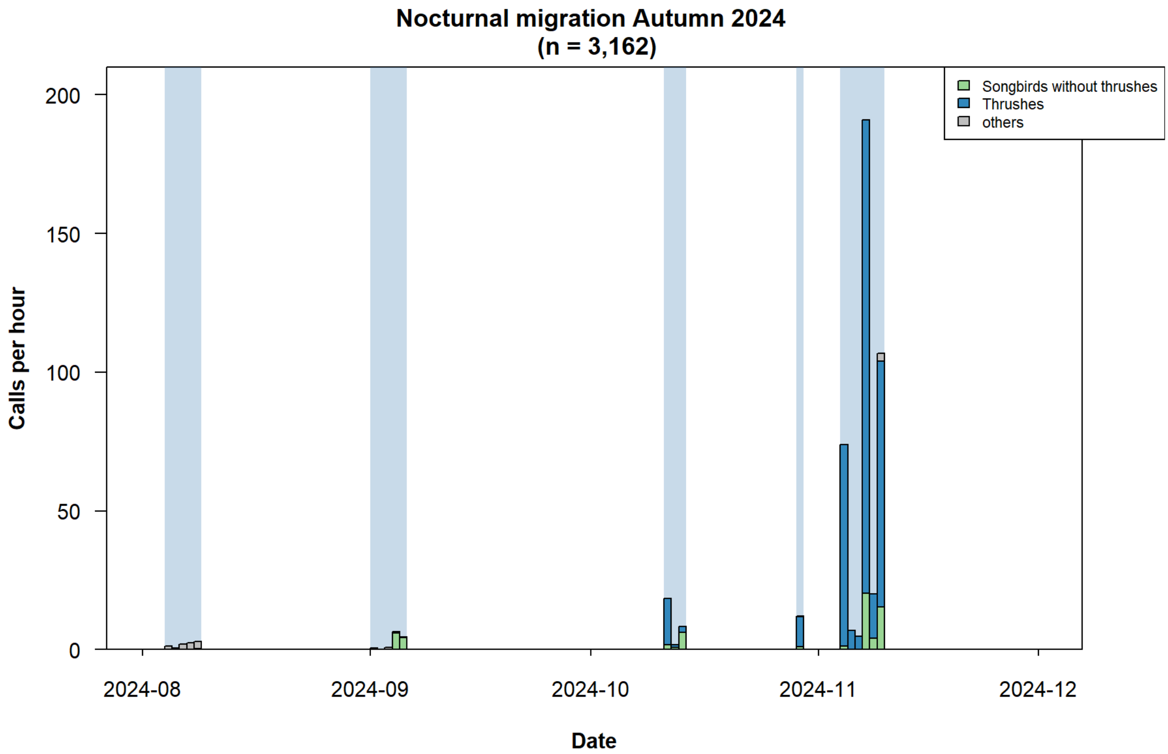


Figure 5.45 Nocturnal migration intensity derived from visual observations in autumn 2023 (top) and 2024 (bottom). Bar colours indicate calls/h for each species group. The same colours have been used as in Figure 5.43.

RELEVANT SPECIES GROUP

In the following paragraphs, migration patterns are summarized for the most relevant species groups. A species group was selected as relevant if at least 100 individuals were observed over the two years of surveys. If any group occurred in lower numbers but is known to hold a large number of species that are considered threatened (listed under any of the conservation categories, see Appendix tables for more detail and Table 5.8), it was also included as relevant. For each of these groups, mean, maximum daily/monthly diurnal and nocturnal (whenever it applies) migration rates are also shown as well as altitudinal and flight direction patterns (combined data of both years is shown whenever possible). In addition, the appendix shows migration intensities along the survey dates for all relevant groups.

DIVERS

Divers were observed in all seasons and in both years. They were frequently registered in low numbers both in spring and autumn. For autumn 2024, divers represented over 1% of all migrating birds seen in the season (Figure 5.40). Up to three species were identified, the most common one was the red-throated diver (Gavia stellata, which accounted for 50% of all divers seen during both years). Black-throated divers were less common and only one individual white-billed diver was registered in spring 2023. However, 75 individuals (40.5% of all divers seen in both years) could not be identified to species level. In general, migration traffic rates remained at a maximum of < 2.4 ind./h, except for a single date in autumn 2024 (8th of November in which up to 14 ind./h were registered, Table 5.11).

Table 5.11 Main migration patterns of divers in spring and autumn 2023 and 2024 during visual observations in the pre-investigation area. Number of individuals (and species), mean, median and maximum migration rates (ind./h) and dates of maximum migration are provided. Frequency of occurrence (how often they were surveyed over how many dates) is also shown. The total number of survey days is provided under the denominator in the column "Freq. of occurrence" (i.e., total survey days in each season and year). SD = Standard deviation.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq of occurrence	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq of occurrence	Mean MTR (± SD)	Median	Max. MTR (date)
2023	59 (3)	13/14	0.63 (± 0.60)	0.42	1.83 (04.03)	24 (1)	7/18	0.28 (± 0.50)	0	1.68 (06.10)
2024	19 (2)	11/14	0.20 (± 0.20)	0.15	0.57 (08.04)	83 (1)	6/20	0.88 (± 3.10)	0	14.0 (08.11)
2023/ 2024	78 (3)	24/28	0.42 (± 0.47)	0.19	1.83 (04.03)	107 (1)	13/38	0.6 (± 2.29)	0	14.0 (08.11.)

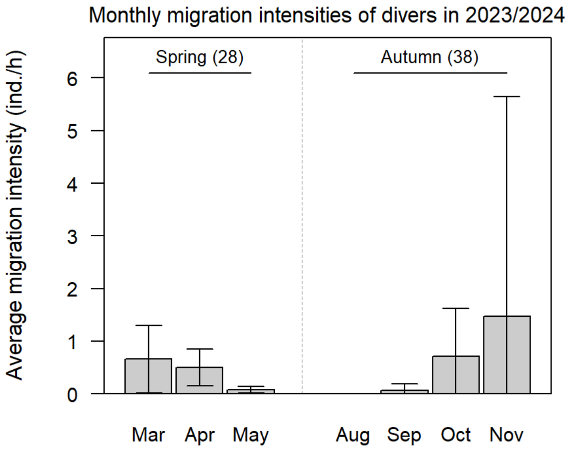


Figure 5.46 Average (mean) monthly diurnal migration intensity of divers in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

Overall, mean monthly intensities decreased from March to May and increased from September to November. Variability was large in November due to a migration peak observed on the 8th of November (14 ind./h, Table 5.11 and Figure 5.46)

The altitudinal distribution of divers did not differ very much between years, and the data is therefore shown combined for both years. In general, two thirds of all divers flying in spring were observed below 20 m, whereas 32% were observed flying between 20 and 50 m and only one individual above 50 m. In autumn, there was a slight difference between years in the distribution of individuals across altitudes, with over 75% of the individuals of 2023 flying in the lowest altitude layer (0-5 m), and during 2024, about 50% of all individuals were flying between 20-50 m, when looking at the combined data. However, 36% of all divers seen during both years were flying very close to the surface (0-5 m), almost 20% between 5 and 10 m, < 2% between 10 and 20 m but 43% between 20 and 50 m (Figure 5.47).

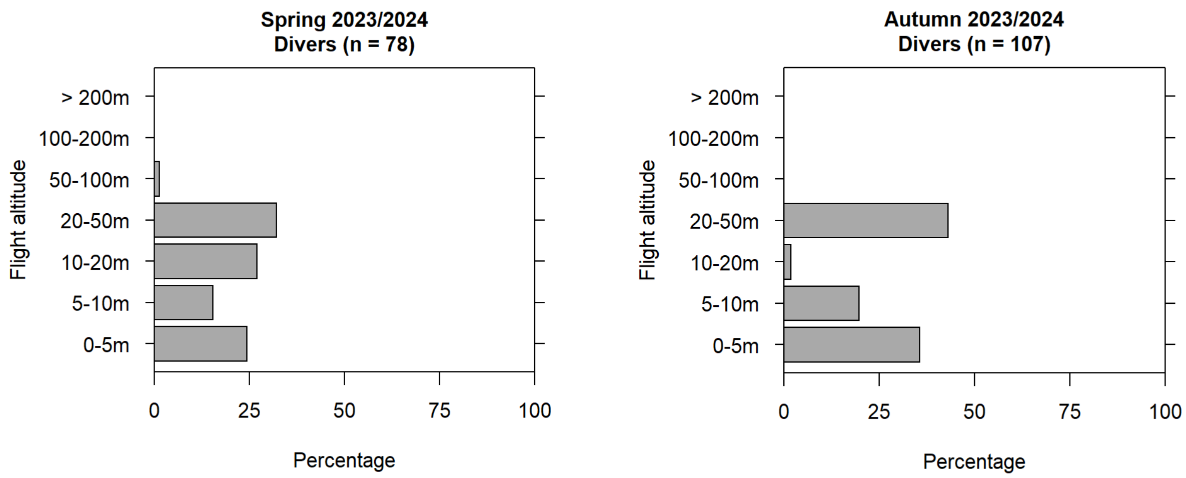


Figure 5.47 Flight altitude distribution of divers during visual observations in spring (left) autumn (right) of both years. Altitudinal data has been combined. See Figure 5.34 for details.

Flight directions of divers differed between years, so they are shown separately for each year. In general, divers flew in all directions in spring, including the N, but they preferred mostly southern directions (> 50% of all divers in both years flew to a southern direction: SW, S, SE), compared to about 32% flying to any northern direction. However, in 2023, most divers flew to SE (25%) or S (22%) whereas in 2024, two opposite southern directions predominated: 32% flew to the SW and 21% flew to the SE. In autumn, also two main directions were observed and these differed between years. In 2023, however, there were very few individuals to confidently detect a tendency. Nonetheless, 8 individuals (a third of all individuals observed in that year) flew towards the SW while during 2024, over half of all individuals were observed flying towards the NW (53%, Figure 5.48).

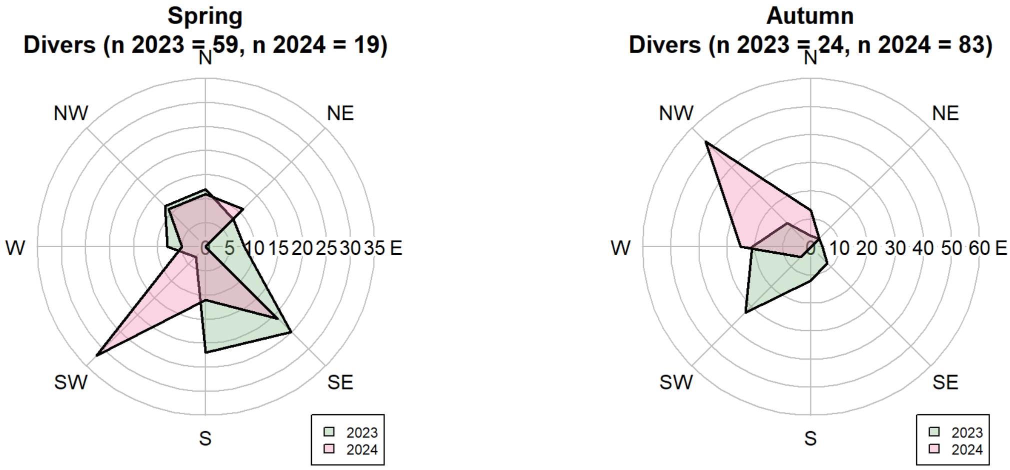


Figure 5.48 Flight directions of divers during visual observations in spring (left) and autumn (right) of both years in the pre-investigation area. Data is shown separately for each year since main migration directions differ between years. See Figure 5.35 for details.

Divers were also heard during a single night in autumn 2024 (November 9th, 2024). In total 15 calls of red-throated divers could be registered.

GANNETS

Gannet (*Morus bassanus*) was not very abundant but still observed in many surveys. In spring 2023, only 27 individuals were seen, and these represented only 0.3% of all birds in the season, whereas in autumn of the same year 124 individuals were seen and these represented 4% of all migrating birds. In 2024, about the same number of individuals were seen in spring and autumn and these represented around 1% of all migrating birds in each season (Table 5.12).

In spring, mean monthly migration rates varied between approximately 0.2 ind./h (March and May) and 1 ind./h (April). In autumn, monthly migration intensities were larger and the month with most observations was also in the middle of the season (October, > 2 ind./h, Figure 5.49).

Table 5.12 Main migration patterns of gannets in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq of occurrence	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq of occurrence	Mean MTR (± SD)	Median	Max. MTR(date)
2023	27 (1)	9/14	0.28 (± 0.29)	0.29	0.8 (24.03)	124 (1)	14/18	1.28 (± 1.25)	1.07	4.27 (25.11)
2024	53 (1)	13/14	0.54 (± 0.44)	0.42	1.69 (10.04)	51 (1)	9/20	0.46 (± 0.81)	0	2.26 (12.10)
2023/ 2024	80 (1)	22/28	0.41 (± 0.39)	0.35	1.69 (10.04)	175 (1)	23/38	0.85 (± 1.11)	0.26	4.27 (25.11)

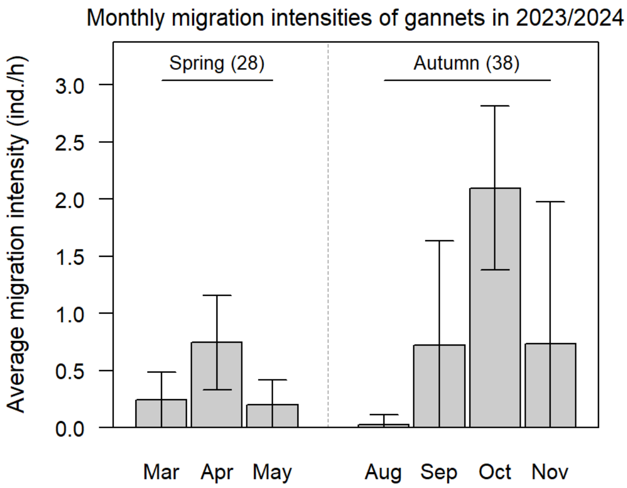


Figure 5.49 Average (mean) monthly diurnal migration intensity of gannets in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

Gannet had a similar altitude distribution in spring and autumn with most birds flying between sea level and up to 50 m. Only 2.5% and 5% of all gannets flew above 50 m in spring and autumn respectively. In spring, slightly more individuals were observed flying at very low altitudes (0-5 m, 39%), whereas in autumn, 31% were observed flying between 10-20 m. Nonetheless, in both seasons almost 80% of all migrating gannets were observed below 20 m (Figure 5.50).

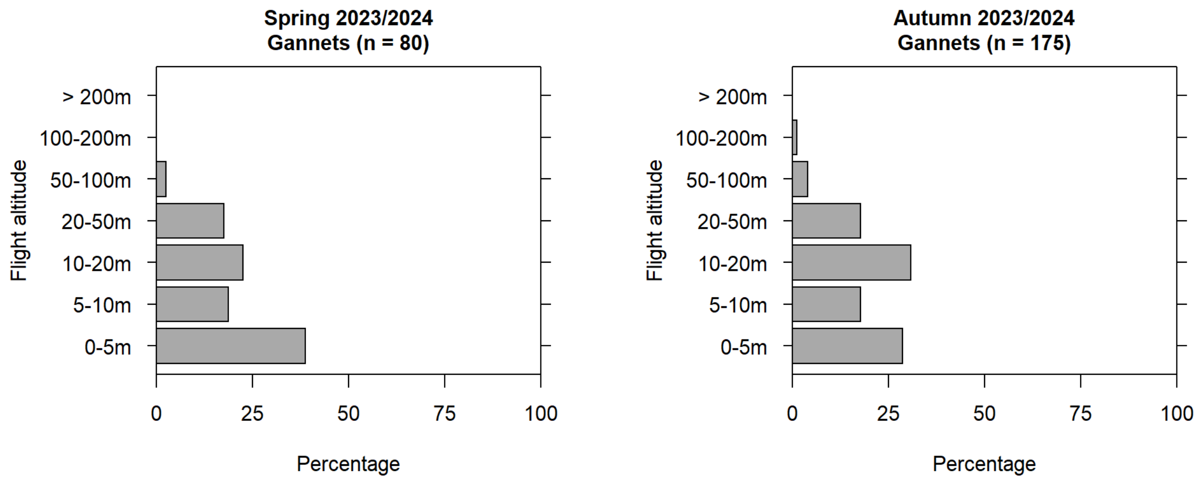


Figure 5.50 Flight altitude distribution of gannets during visual observations in spring (left) autumn (right) 2023. See Figure 5.34 for details.

Gannets flew at almost all directions in all seasons with no specific patterns. In spring 2023, most birds were seen flying to the N (25%) with the next common directions being the NW and the W (21% and 17%). In spring of 2024, most birds flew to the W (31%) but many still flew to the SW, NW and N (15-17%, each). In autumn 2023, most birds flew directly to the north (22%) but still many flew to the south or to the NW (18%). In the following autumn, birds did not show a preferred direction (17% flew to the SW and varying proportion between 9 and 15% flew in other directions (Figure 5.51).

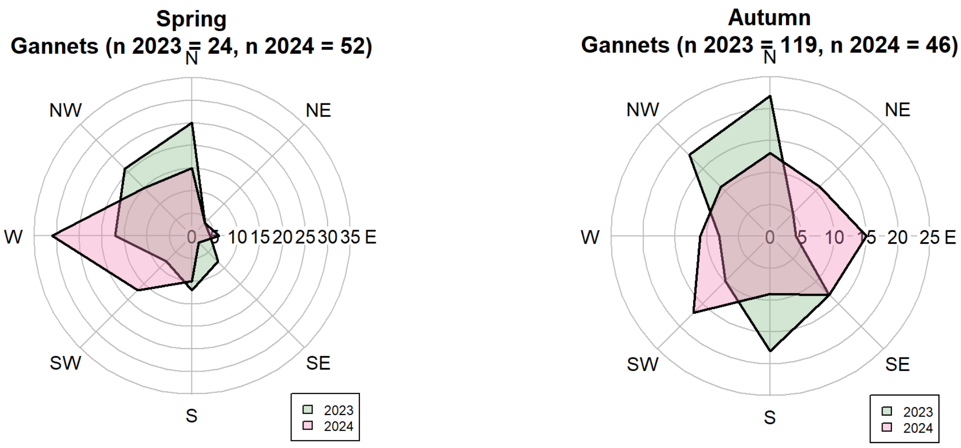


Figure 5.51 Flight direction of gannets during visual observations in spring (left) and autumn (right) 2023. See Figure 5.35 for details.

CORMORANTS

Cormorants, represented by only one species, the great cormorant (*Phalacrocorax carbo*), though not very abundant, were frequently observed in almost all surveys. In 2023, almost 100 more individuals were seen when compared to 2024. They represented approximately 2% of all migrating birds in spring and autumn, whereas in 2024, they represented 1.1% of all birds in spring and 1.6% of all birds in autumn. The highest daily maximum migration intensity (12.5 ind./h) was registered on March 6th, 2023. During this date, double as many cormorants migrated as in any other survey date of that spring. No other survey date (in any other season) registered such a high number of cormorants (Table 5.13).

Table 5.13 Main migration patterns of cormorants in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	180 (1)	11/14	2.02 (± 3.5)	0.62	12.5 (06.03)	68 (1)	16/18	0.74 (± 0.70)	0.57	2.93 (26.11)
2024	57 (1)	12/14	0.60 (± 0.60)	0.34	1.58 (08.05)	96 (1)	13/20	0.68 (± 0.90)	0.40	3.12 (06.08)
2023/ 2024	237 (1)	23/28	1.31 (± 2.55)	0.42	12.5 (06.03)	164 (1)	29/38	0.71 (± 0.83)	0.52	3.12 (06.08)

The high migration intensity in March 2023 contributed to the highest mean migration (~3 ind./h) and the highest variability, with migration intensity decreasing towards the rest of the season (mean monthly values of April and May were < 0.7 ind./h, Figure 5.52). In autumn, migration rate was on average lower than in spring and the month with the highest intensity was August (Figure 5.52).

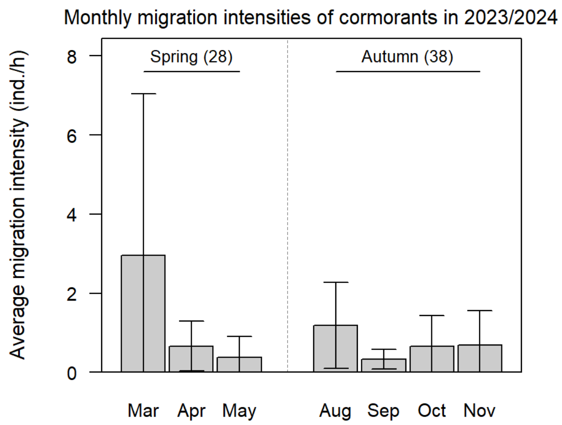


Figure 5.52 Average (mean) monthly diurnal migration intensity of cormorant in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

The cormorant showed a very similar altitude distribution pattern for spring and autumn with 28-32% of individuals flying at very low altitudes (0-5 m) and another third flying between 20 and 50 m (34% in spring and 30% in autumn). In general, 58% in spring and 69% of all cormorants in autumn flew below 20 m. In addition, in spring, 8% of all cormorants flew also between 50 and 100 m whereas in autumn only one individual was seen flying between 100 and 200 m (Figure 5.53).

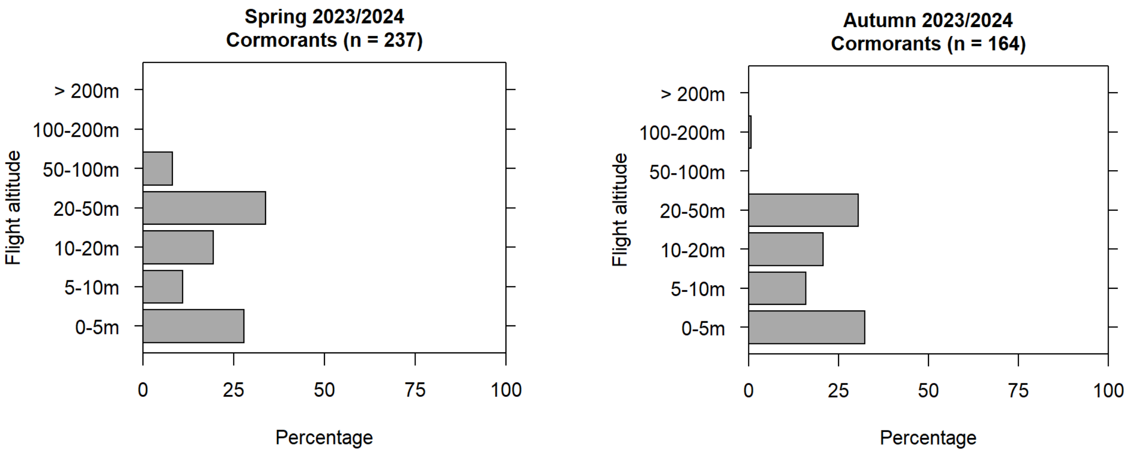


Figure 5.53 Flight altitude distribution of cormorants during visual observations in spring (left) and autumn (right) 2023. See Figure 5.34 for details.

Very similar flying patterns were observed during spring of both years. The main flying direction was NE (35%) followed by north (22%). In autumn, the main flying directions differed between years with over a third of all cormorants flying towards the south in 2023 (34%). In contrast, 37.5% of all cormorants in autumn 2024 were found flying towards the north. A relatively large number of individuals flew to opposite directions as the preferred one in each year: 18% flew towards the NW in 2023 and 19% to the south in 2024 (Figure 5.54).

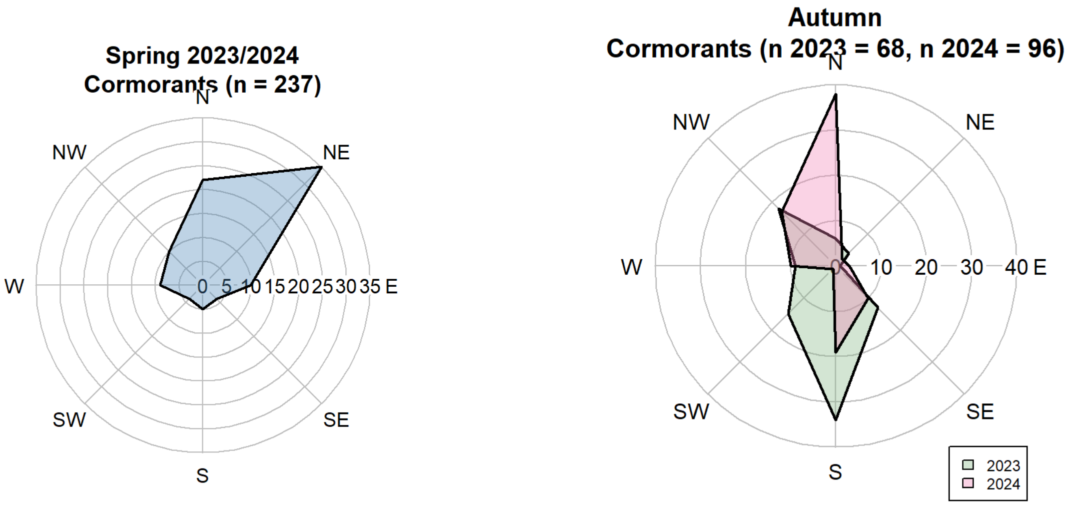


Figure 5.54 Flight directions of cormorants during visual observations in spring (left) and autumn (right) 2023. See Figure 5.35 for details.

SWANS

Swans were neither abundant nor frequent (Table 5.14 and Figure 5.55). In spring, there were only 28 individuals recorded, all from the first year of surveys, whereas most individuals were recorded from autumn. Most swans (81% of all the individuals) were identified as whooper swans, whereas only two individuals observed in spring 2023 were mute swans. The rest were unidentified swans (18% of the total 203 individuals of swans registered during both years of data collection). Swans 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 (Table 5.14). In autumn, they were more abundant, but they did not appear frequently, and all observations occurred in November. The maximum daily migration rate was on the 25th of November 2023 (23.7 ind./h, Table 5.14).

Table 5.14 Main migration patterns of swans in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq of occurrence	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq of occurrence	Mean MTR (± SD)	Median	Max. MTR (date)
2023	28 (2)	4/14	0.31 (± 0.58)	0	1.50 (06.03)	109 (1)	3/18	1.61 (± 5.65)	0	23.73 (25.11)
2024	0	0/14	-	-	-	66 (1)	3/20	0.73 (± 1.97)	0	7.78 (05.11)
2023/ 2024	28 (2)	4/28	0.16 (± 0.43)	0	1.50 (06.03)	175 (1)	6/38	1.15 (± 4.1)	0	23.73 (25.11)

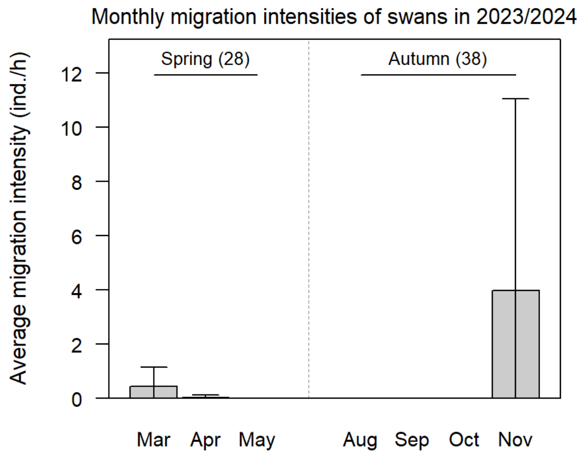
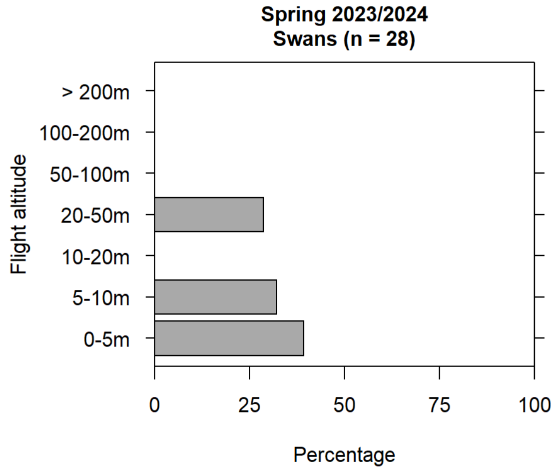


Figure 5.55 Average (mean) monthly diurnal migration intensity of swans in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

In spring, most swans flew at low altitudes (< 10 m, 71%, n=20), but > 28% flew between 20 and 50 m of altitude (Figure 5.56). In autumn, almost half of all individuals were observed flying at very low altitudes whereas approximately a quarter were seen flying between 20 and 50 m (27%), but they were also observed at lower and higher altitudes (e.g., 14% flew at 100-200 m, Figure 5.56).



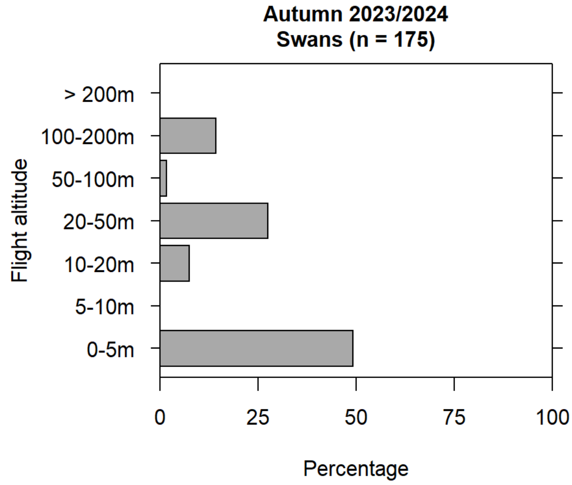
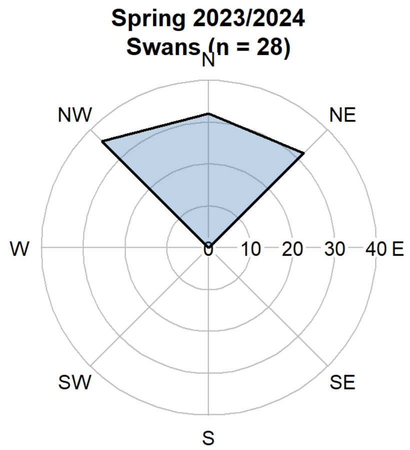


Figure 5.56 Flight altitude distribution of swans during visual observations in spring (left) and autumn (right) 2023. See Figure 5.34 for details.

In spring, swans flew to the NW, NE and N, with similar proportions (36%, 32% and 32%, respectively, Figure 5.57). In autumn 2023, they flew in a SW (31%), S (28%) and to a lesser extent to the SW and SE direction (20% and 17%, respectively, Figure 5.57). In autumn 2024, most birds flew to the W (36%) and SW (26%) and fewer to the NW (18%). Other directions were less frequent, and N and NE were not observed (Figure 5.57).



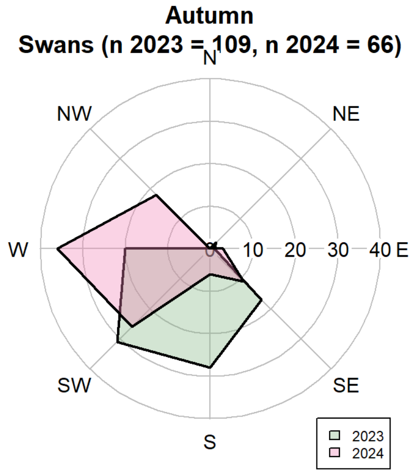


Figure 5.57 Flight direction of swans during visual observations in spring (left) and autumn (right) 2023. See Figure 5.35 for details.

GEESE

Geese were, by far, the most abundant taxonomic group observed during diurnal migrations in spring of both years (71.6% and 57.7% of all migrating birds in 2023 and 2024, respectively). Whereas they were not very abundant in autumn, they were still the second most abundant species group in this season after ducks (see Figure 5.40). They were however not very frequent, occurring in high numbers but in few survey dates (Table 5.15).

A total of seven species were identified but only one was very abundant (barnacle goose, *Branta leucopsis* which represented 92% of all geese observed during both years; n= 10,203). Other species were greylag goose (3.6% of all geese) and Brent goose (1.1% of all geese). Other species were less common: Canada goose, bean goose, greater white-fronted goose and common shelduck (see Appendix). About 2.3% (or 239 individuals) remained unidentified.

Combining data of both years, about 91% of all geese were observed in spring (regardless of the year, although this percentage was larger in 2023 than in 2024) and barnacle goose was very dominant. In spring, migration intensities increased consistently throughout the season and most birds were observed in May. During both years, migration peaks occurred on very similar dates (9th of May 2023, and 8th of May 2024 and the night of May 8th of 2023, nocturnal migration, see below). The maximum diurnal daily migration intensity of geese was 752.4 birds/h in 2023 and 278.1 ind./h in 2024 (both in May).

In autumn, similar number of geese were detected in both years but maximum values were larger in 2023 (66.1 vs. 33.4 ind./h). Migration peaks occurred in October.

Table 5.15 Main migration patterns of geese in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	6,568 (5)	11/14	59.45 (± 199.6)	1.69	752.38 (09.05)	440 (4)	5/18	4.66 (± 15.5)	0	66.10 (24.10)
2024	2747 (4)	6/14	24.53 (± 73.8)	0	278.06 (08.05)	448 (5)	9/20	4.42 (± 9.2)	0	33.40 (30.10)
2023/ 2024	9,315 (5)	17/28	41.99 (± 148.72)	0.51	752.38 (09.05)	888 (5)	14/38	4.53 (± 12.4)	0	66.10 (24.10)

Migration patterns were, in general, similar for geese. Monthly migration intensities increased throughout the season in spring with maximum values occurring in May (when migration peaks took place). Variability was also larger in this month. In autumn, the averages were lower but the tendencies were similar in both years with most migration occurring in October and no birds being registered in August (Figure 5.58).

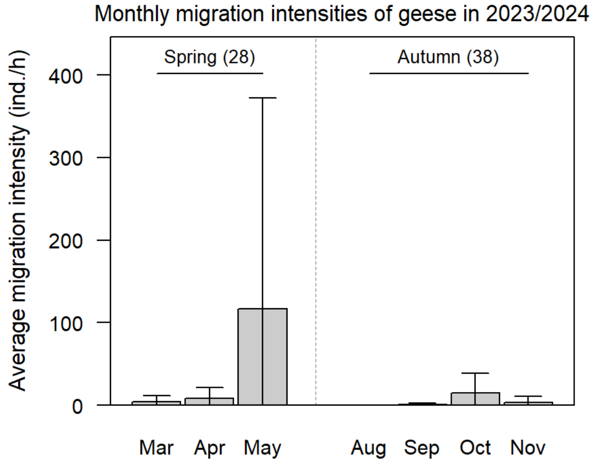


Figure 5.58 Average (mean) monthly diurnal migration intensity of geese in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

In spring, a large proportion of the geese (37%) were observed flying at low altitudes (< 5m), roughly 9% of all individuals were observed flying at altitudes between 5-20 m whereas almost 50% of the birds flew at altitudes between 20-200m (Figure 5.59). In autumn, there was a difference in the altitude distribution of geese between years. Where in 2023, most geese (72.5%) were observed flying at high altitudes (50-200 m), and comparatively fewer flew below this range, in 2024, almost 75% flew below 20 m, and a little above 25% flew in the range between 20 and 50 m. When data is combined for both years, the pattern revealed indicated that 50% of geese flew up to 50 m and another 50% flew above this level (Figure 5.59).

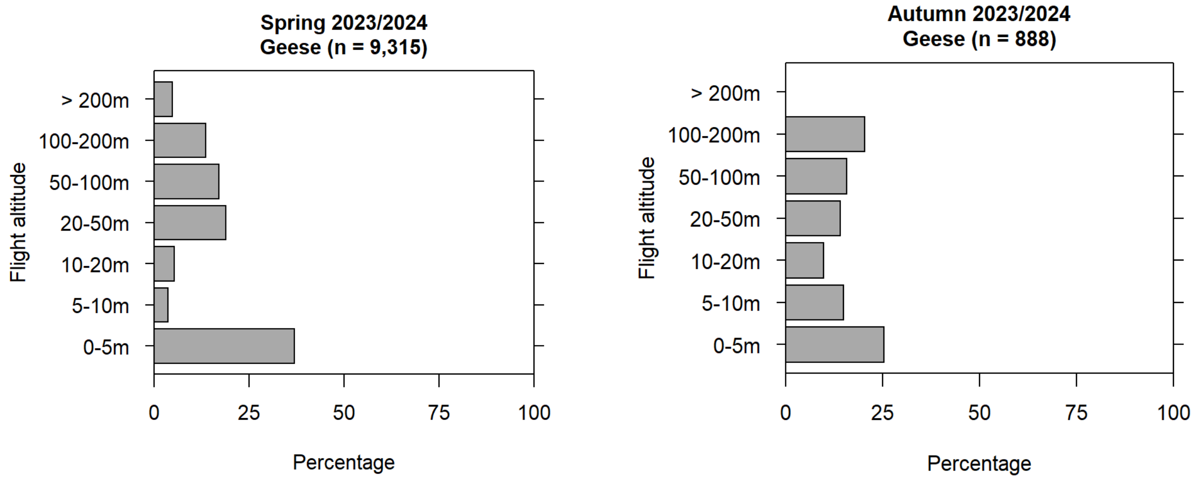


Figure 5.59 Flight altitude distribution of geese during visual observations in spring (left) and autumn (right) in the pre-investigation area. See Figure 5.34 for details.

The migration direction in spring was very clear: 94% of all geese migrated towards the NE and less than 2% of all geese migrated towards the NW or the N (Figure 5.60). In autumn, however, migration directions differed between years. In 2023, two thirds of the birds flew to the west while in 2024, 41% flew to the SW, but still 28% flew to the NE and 22% to the south (Figure 5.60).

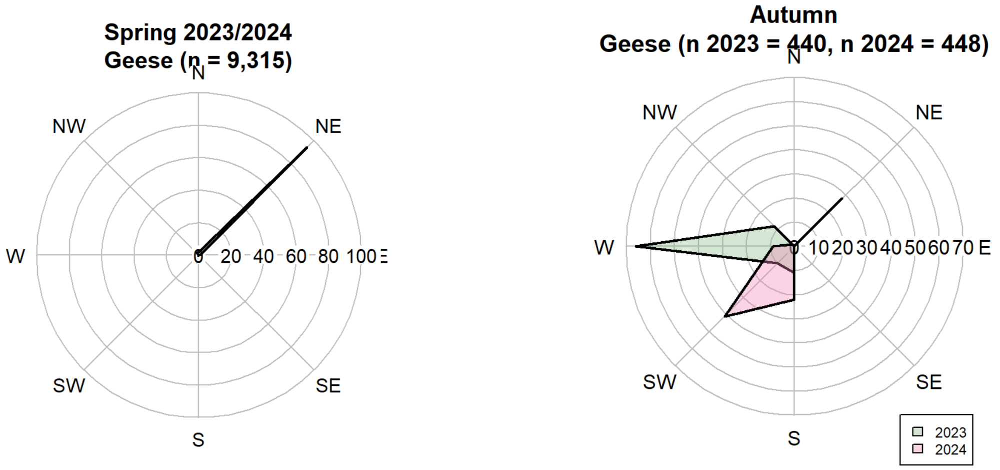


Figure 5.60 Flight directions of geese during visual observations in spring (left) and autumn (right) of both years in the pre-investigation area. See Figure 5.35 for details.

Geese were also registered during nocturnal migration, but in very low frequency and numbers and only during spring. In 2023, 12 calls of barnacle goose were heard on the night of 8th of May 2023 (3.7 calls/h) whereas in 2024, four calls of common shelduck were heard on the night of 1st of March (0.7 calls/h).

DUCKS

A total of 1,210 ducks were observed during spring migration in 2023. The most common species was common scoter (*Melanitta nigra*) which comprised 10.7% of all migrating birds observed in the season. Other species that occurred at much lower frequencies were common eider (0.92%), velvet scoter (0.54%) and long-tailed duck (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, Table 5.16). In May, their migration intensity decreased (an average of 1.93 birds/h, in comparison to a mean of 15.05 ind./h in March and 18.62 ind./h in April (Figure 5.61).

Table 5.16 Main migration patterns of ducks in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	1,210 (7)	14/14	12.58 (± 9.3)	11.39	29.0 (14.04)	1,566 (10)	18/18	15.42 (± 17.3)	9.55	70.83 (03.10)
2024	1,234 (7)	13/14	12.96 (± 25.3)	4.82	98.57 (06.04)	4226 (8)	20/20	30.08 (± 37.9)	16.59	158.62 (06.08)
2023/2024	2,444 (9)	27/28	12.77 (± 18.7)	8.29	98.57 (06.04)	5,792 (11)	38/38	23.14 (± 30.48)	13.96	158.62 (06.08)

In spring 2024, a very similar number of ducks was observed (1,234), and ducks represented over a quarter of all migrating birds in that season (25.7%, Figure 5.40). The most common species was also common scoter (22.7%), followed by velvet scoter (1.0%) and common eider (0.6%). Daily diurnal migration rates remained at below 20 ind./h, with the exception of one date in which almost 100 ind./h were registered (6th of April, Table 5.16). This peak migration date increased the overall monthly migration rate; thus, April was the month with most ducks being observed (Figure 5.61).

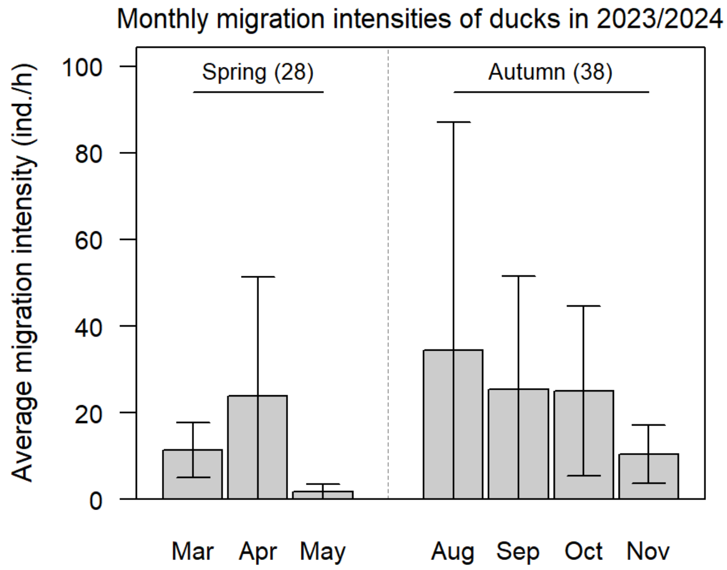


Figure 5.61 Average (mean) monthly diurnal migration intensity of ducks in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28

in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

In autumn 2023, 1,566 ducks belonging to 10 species were observed. Considering that in autumn more survey dates were carried out than in spring, a comparative similar number of ducks were registered. However, ducks made up over half of all migrating birds seen in the season because geese were not as dominant as during spring. Common scoter, the most common species represented 28.6% of all migrating birds in the season. Other common species were Eurasian wigeon (10.9%), common eider (2.5%) and velvet scoter (2.4%). Only three individuals of long-tailed duck 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, Table 5.16).

In the following year, higher number of ducks were registered (4,266) and these represented 71% of all migrating birds in the season (i.e. almost 3 out of 4 birds observed were ducks). The most common species was common scoter (62.6%). Other species relatively common were velvet scoter (3%), common eider (2.8%) and Eurasian wigeon (0.9%). Migration rates were higher in August, also when the maximum migration rate was registered and progressively decreased through the season (Figure 5.61).

Altitudinal migrating patterns were very similar for spring and autumn. When combining the data of both years, ducks flew mainly at very low altitudes (~75% of them flew at altitudes up to 5 m). whereas 96% and > 94% of all ducks were observed flying up to 20 m height in spring and autumn respectively (Figure 5.62).

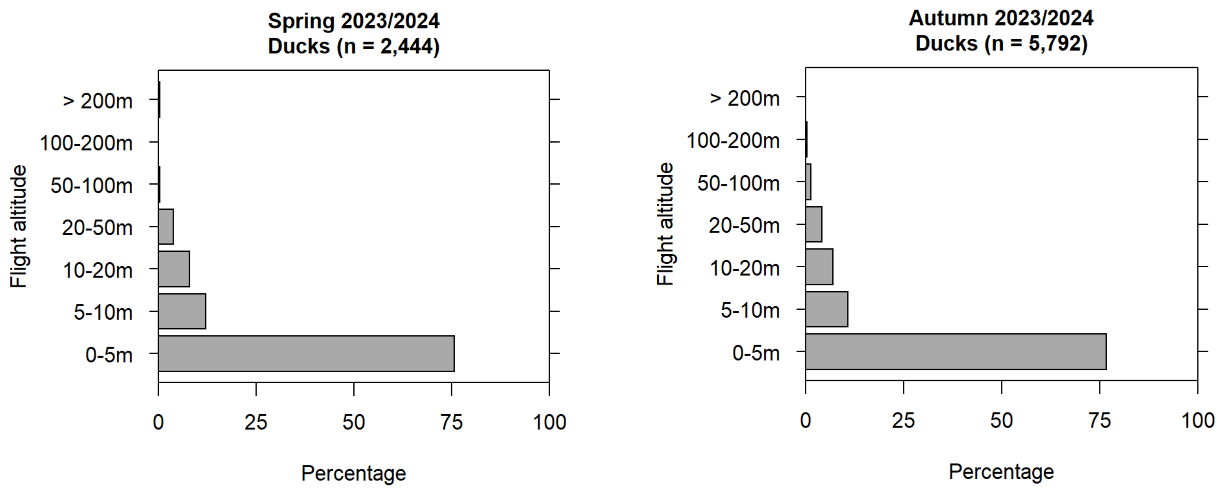


Figure 5.62 Flight altitude distribution of ducks during visual observations in spring (left) and autumn (right) 2023. See Figure 5.34 for details.

In spring 2023, ducks flew in different directions (depending on the species, but also the date). However most, flew in SE direction (21%, Figure 5.63). In spring 2024, however most ducks were seen flying to the SE (56%). Whereas all other directions were also registered, they were not that frequent. In autumn 2023, they flew mainly at a SW direction (36%), but NW and W were also commonly observed directions of flight for ducks (~20% each, Figure 5.63). In autumn 2024, most ducks were observed flying at the opposite direction than in spring (NW, 47%). Other directions less frequently chosen were SW, W and N (varying between 11 – 13% each).

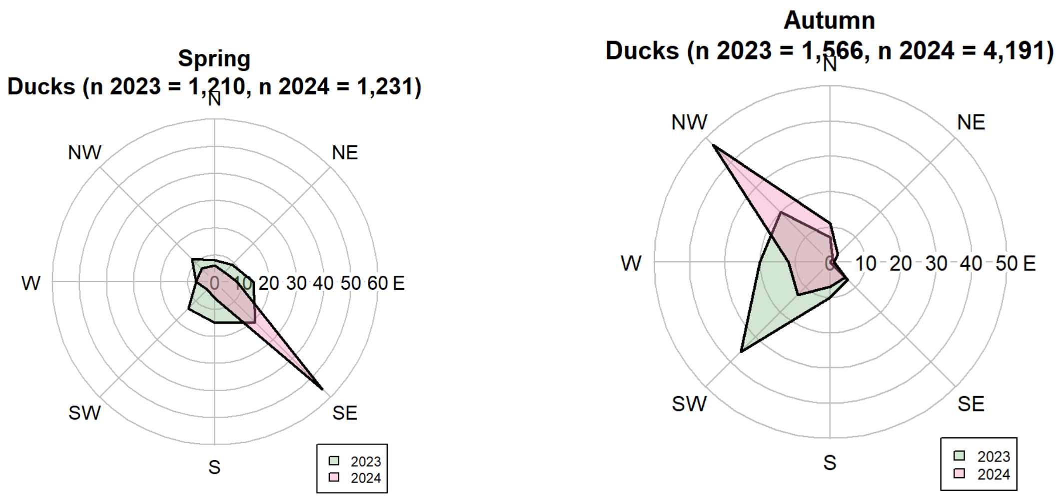


Figure 5.63 Flight direction of ducks during visual observations in spring (left) and autumn (right). See Figure 5.35 for details.

Ducks were also heard during nights but only in spring 2024 during mid-April. Then, 44 calls of common scoters and 33 calls of Eurasian wigeons were heard between the nights of 7th – 9th of April, with the maximum intensity being recorded on the 8th of April (13.3 calls/h).

CRANES

Cranes (represented by one species, *Grus grus*) were neither abundant nor frequent and is the only group included here in addition to those that were relatively common because it is a species that often flies at altitudes coinciding with turbine rotor heights, and thus being potentially vulnerable to collisions with OWF and in addition is under Annex I of the Birds Directive. It was only present in low numbers in spring, and many more individuals were registered during the first year than during the second year (Table 5.17). The maximum migration rate overall was registered in March 2023 (6.5 ind./h, Table 5.17).

Table 5.17 Main migration patterns of cranes in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	56 (1)	3/14	0.66 (± 1.82)	0	6.50 (06.03)	0	0/18			
2024	7 (1)	1/14	0.06 (± 0.23)	0	0.85 (08.05)	0	0/20			
2023/2024	63 (1)	4/28	0.36 (± 1.31)	0	6.50 (06.03)	0				

Most cranes flew at high altitudes: 98% of all registered individuals in both years flew above 100 m of altitude). Only one single bird was observed flying between 10 and 20 m of altitude (Figure 5.64). Cranes flew mainly to the NE (75% of all individuals) with about 25% of all individuals flying to the E (Figure 5.64).

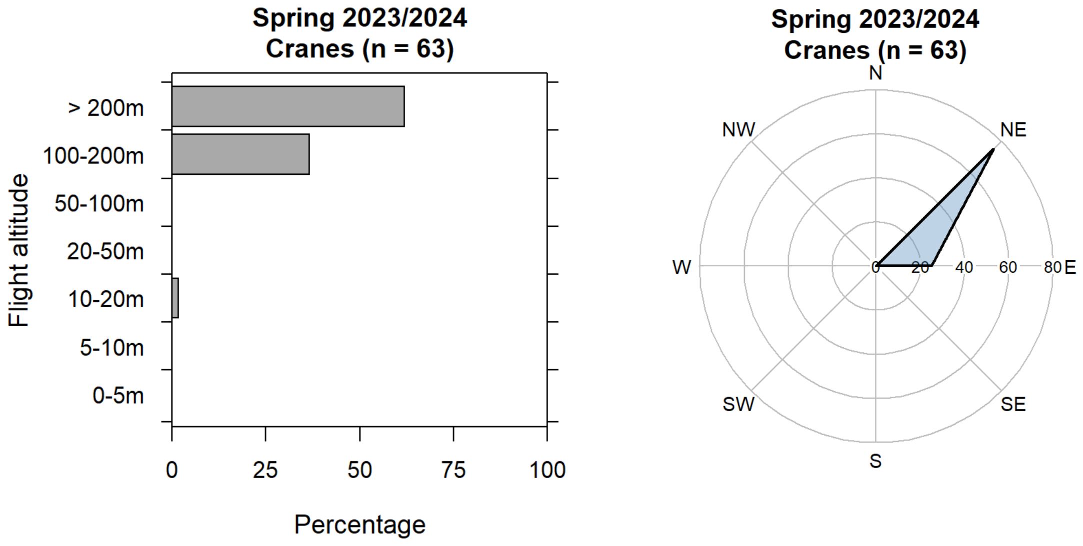


Figure 5.64 Flight altitude distribution (left) and flight directions (rights) of cranes during visual observations in spring 2023/2024. See Figure 5.34 and Figure 5.35 for details.

WADERS

Waders were neither abundant nor frequent but represented 1.4% of all migrating birds during diurnal observations in spring 2023. In this migrating period, 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 ind./h (Table 5.18). During spring 2024, waders were not frequently seen but at a single date many European golden plovers (200 individuals) were registered (May 6th, 2024). Only three species were observed during the whole season, but golden plovers were the most common and represented 4.2% of all migrating birds in the season. The second most common species (whimbrels) represented < 0.4% of all migrating birds but was also observed in that same date of May.

Table 5.18 Main migration patterns of waders in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	131 (3)	3/14	1.25 (± 3.2)	0	9.66 (15.04)	52 (7)	7/18	0.42 (± 0.8)	0	2.4 (19.08, 03.10)
2024	221 (3)	4/14	1.92 (± 7)	0	26.3 (06.05)	40 (6)	8/20	0.28 (± 0.5)	0	1.88 (05.08, 06.08)
2023/2024	352 (6)	7/28	1.58 (± 5.36)	0	26.3 (06.05)	92 (11)	15/38	0.34 (± 0.66)	0	2.4 (19.08, 03.10)

In autumn, waders occurred more frequently but were less numerous. Nonetheless, a larger number of species were sighted. In autumn 2023, waders 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 ringed plover (0.5% of all migrating birds), followed by golden plover, red knot and 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, waders were observed at low migration intensities (varying from 0.1 ind./h to 2.4 ind./h).

In autumn 2024, 40 individuals of 6 species were observed, and they only represented 0.7% of all migrating birds. The most common species were European golden plover and bar-tailed godwit (< 0.3% of all migrating birds each). Maximum migration rates were observed at the beginning of the season (5-6th August, < 1.9 ind./h, Table 5.18) and much lower numbers were surveyed afterwards. Nonetheless, a similar tendency was observed between both years with more birds being registered in August, than in October and fewer in September/November (Figure 5.65).

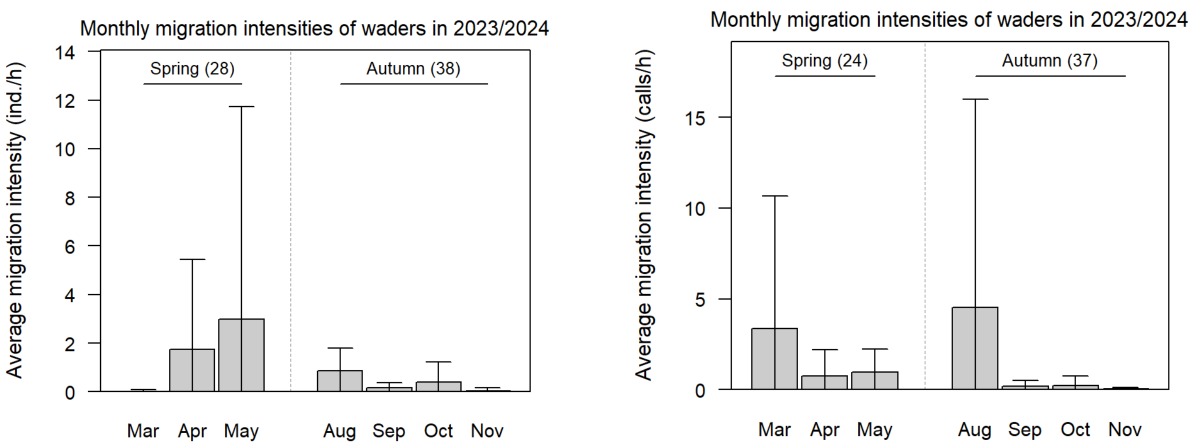


Figure 5.65 Average (mean) monthly diurnal(left) and nocturnal (right) migration intensity of waders in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days/nights in each season (28 days in spring) and 38 days in autumn (diurnal migration) and 24 nights in spring and 37 nights in autumn (nocturnal migration).

Table 5.19 Main migration patterns of waders in spring and autumn of both years during acoustic observations at night in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	6 (2)	3/9	0.21 (± 0.3)	0	0.92 (07.05)	159 (6)	6/17	2.29 (± 8.4)	0	35 (19.08)
2024	241 (7)	7/15	2.95 (± 5.9)	0	20.5 (02.03)	21 (3)	6/20	0.28 (± 0.6)	0	2.29 (08.08)

2023/2024	248 (7)	10/24	1.92 (± 4.84)	0	20.5 (02.03)	180 (8)	12/37	1.2 (± 5.74)	0	35 (19.08)

Whereas waders were not particularly abundant during days, they were relatively common during night migration, typically representing between 3 and 5% of all calls heard during nights, thereby being the most common groups after songbirds (Figure 5.43). In spring 2023, very few calls were heard (mean of 0.9 calls/h, but represented 3.4% of all migrating bird calls in the season), most of them on May 7th, 2023 (Table 5.19). These few calls belonged mainly to Eurasian oystercatchers (1.7%) and common sandpipers (1.1%).

In spring 2024, waders made up for 3.1% of all calls and two species were more common: northern lapwings (1.3%) and oystercatchers (1.2%). In 2024, most wader calls were heard at the beginning of the season (2nd of March) during a night of high migration (maximum migration rate 20.5 calls/h, Table 5.19). Overall, monthly migration intensities of waders during nights were higher in March than in the two other spring months (Figure 5.65).

In autumn, waders were the only taxonomic group after songbirds that occurred at relatively high numbers at night (Figure 5.43). In 2023, a total of 159 calls belonging to six species were heard during night migrations. Most of them were Eurasian oystercatcher (1.9%). Ringed plover (1.3%) and common sandpiper (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, Table 5.18, Table 5.19). 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 October 5th. In 2024, there were very few calls of waders heard, with only one species being relatively common and representing 0.5% of all migrating calls in that season (common sandpiper). Migration rates were larger in August and decreased towards the end of the season (Figure 5.65).

In spring, most waders (>95%) were observed flying at very low altitudes (< 10 m) whereas in autumn this percentage was lower but still above 75% (Figure 5.66). In spring, only 4% of all individuals were observed flying above 20 m of altitude, in autumn this proportion was a bit higher but also low (8%, Figure 5.66).

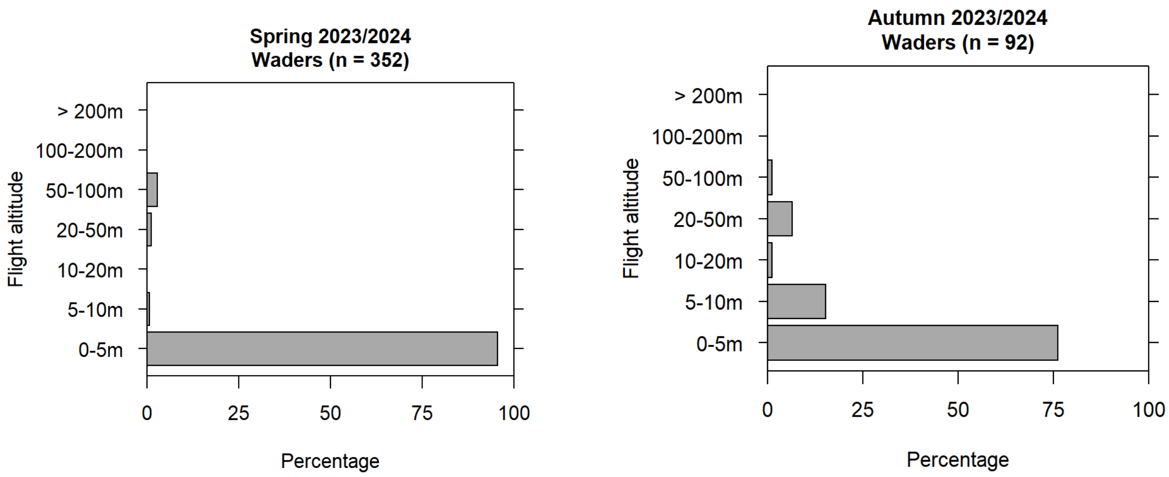
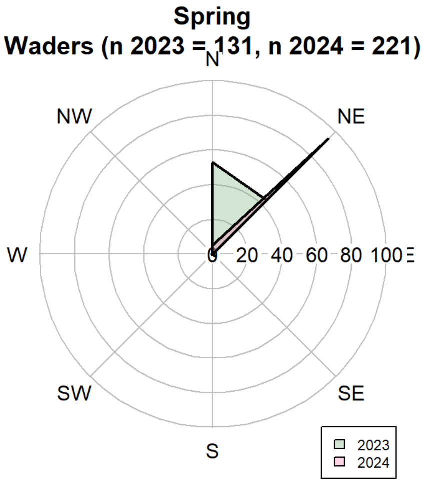


Figure 5.66 Flight altitude distribution of waders during visual observations in spring(left) and autumn (right) 2023. See Figure 5.34 and Figure 5.35 for details.

In spring 2023, most waders flew to the N (53%) and NE (44%) while in spring 2024 they mainly flew to the NE (94%). In autumn, the main direction of flight for both years was SW (2023: 85%, 2024: 49%). Nonetheless, in

2024 many waders flew also to the south (26%, Figure 5.67). Other directions were less frequent.



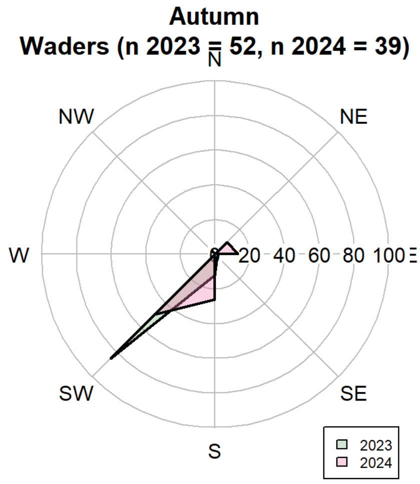


Figure 5.67 Flight directions of waders during visual observations in spring (left) and autumn (right) 2023. See Figure 5.35 for details.

GULLS

Gulls were frequently observed at similar numbers in both seasons and years, which resulted in comparatively similar migration rates. In spring 2023, gulls made up 2.3% of all migrating birds during diurnal observations (Figure 5.40). In this season, four species were common: common gull (0.68%), lesser black-backed gull (0.58%), herring gull (0.47%) and black-headed gull (0.33%). Diurnal migration intensity was larger in May with the last day of surveys (9th of May.2023) registering most migrating gulls (6.9 ind./h, Table 5.20). In spring 2024, gulls made up 4.8% of all migrating birds (Figure 5.40). The three most common species were lesser black-backed gull and herring gull (each representing 1.6% of all migrating birds) and great black-backed gull (0.8%). Gulls were observed throughout the season at more or less similar rates, but most were seen in April, also when the maximum daily migration rate occurred (Figure 5.68).

Table 5.20 Main migration patterns of gulls in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	209 (6)	14/14	2.02 (± 1.9)	1.36	6.88 (09.05)	253 (6)	16/18	2.36 (± 2.2)	1.65	7.45 (20.08, 23.10)
2024	230 (6)	14/14	2.43 (± 1.2)	2.36	4.15 (10.04)	275 (7)	20/20	2.32 (± 1.6)	1.93	6.89 (08.11)
2023/2024	439 (7)	28/28	2.22 (± 1.6)	1.64	6.88 (09.05)	528 (7)	36/38	2.34 (± 1.89)	1.67	7.45 (20.08, 23.10)

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 kittiwake (1.4%). Gulls were frequently observed during the season at relatively medium migration intensities (0.6 ind./h to 7.4 ind./h). In autumn 2024, similar numbers and rates were observed. In this season, gulls represented 4.6% of all migrating birds and the most commonly identified species were lesser black-backed gull (1.8%), black-legged kittiwake (1.1%) and common gull (0.8%). In general, monthly migration rates of gulls in autumn were at similar levels but the mean was slightly larger in October (Figure 5.68).

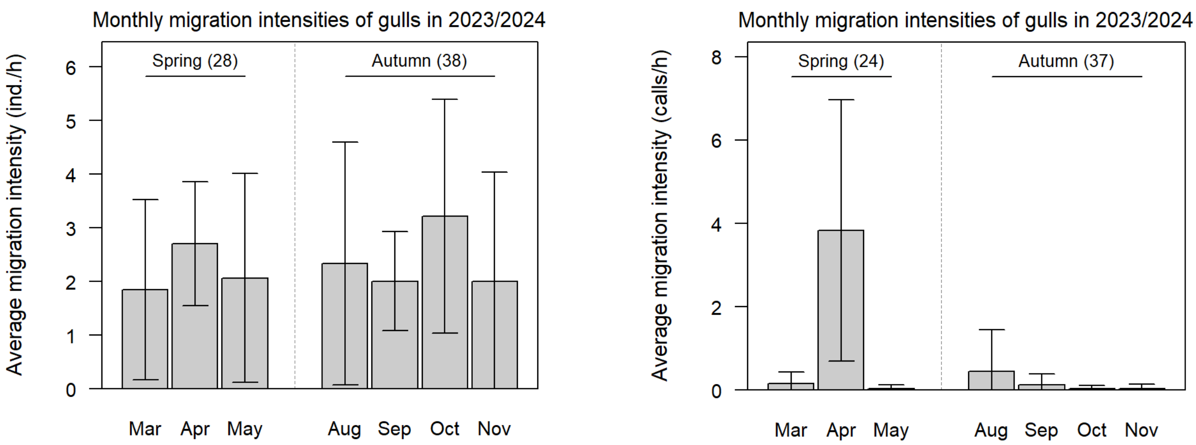


Figure 5.68 Average (mean) monthly diurnal(left) and nocturnal (right) migration intensity of gulls in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring and 38 in autumn, diurnal migration, and 24 nights in spring and 37 nights in autumn during nocturnal migration).

Table 5.21 Main migration patterns of gulls in spring and autumn of both years during acoustic observations at night in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	3 (1)	2/9	0.07 (± 0.2)	0	0.38 (24.03)	20 (2)	6/17	0.27 (± 0.7)	0	3 (18.08)
2024	91 (4)	7/15	1.35 (± 2.5)	0	9.18 (05.04)	7 (2)	4/20	0.08 (± 0.2)	0	0.86 (06.08)
2023/2024	94 (4)	9/24	0.87 (± 2.04)	0	9.18 (05.04)	27 (3)	10/37	0.17 (± 0.52)	0	3 (18.08)

Gulls were also registered during night migrations, but with low number of calls making up > 1% of all heard calls in spring and < 1% in autumn (Figure 5.43). During night observations in spring, calls of common gull were the most commonly heard, whereas in 2024 they flew mainly on a single date in April which contributed to the high monthly intensity of April (Figure 5.68). In autumn, a few gulls were heard, and, in both years, their highest migration rates were in August (Table 5.21).

Gulls show a similar altitude distribution in both seasons. They were observed in similar proportions up to altitudes of 50 m. In spring, 31% of all birds were observed flying very low while 67% of all birds were observed flying below 20 m. About 31% of birds flew in the fourth category (20-50 m). Only 2.5% were observed flying above 50 m. In autumn, the pattern was very similar with 29% flying close to the water surface, but a total of 73% flew below 20 m. About 22% flew between 25 and 50 m and only 4% above 50 m (Figure 5.69).

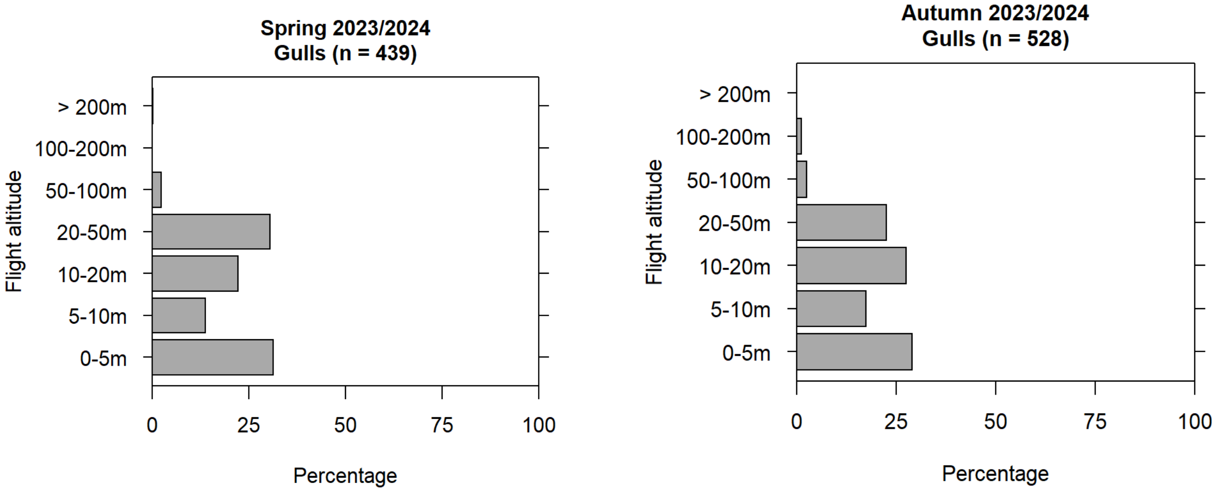


Figure 5.69 Flight altitude distribution of gulls during visual observations in spring and autumn 2023. See Figure 5.34 for details.

Gulls flew in many directions. In spring 2023, most gulls flew in a NE direction (40%) with some flying to the east, and fewer in other directions (SE, S, W, Figure 5.70). In spring 2024, however, while some individuals flew to the NE (15.5%), other directions like S (22%) and W (16%) were more common.

In autumn 2023, 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 5.70). In autumn 2024, gulls were seen flying in many directions too with NW, SE and SW being almost equally common.

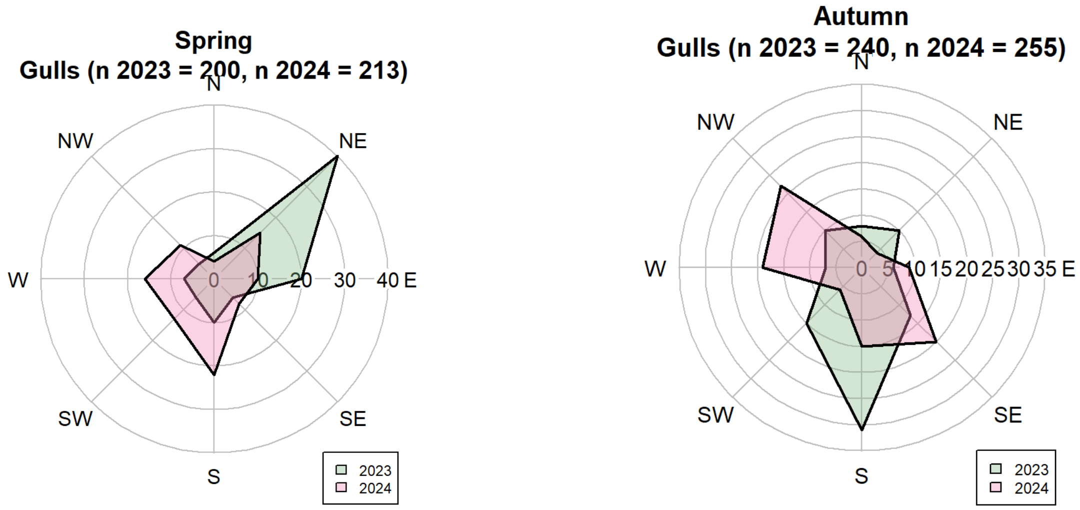


Figure 5.70 Flight directions of gulls during visual observations in spring and autumn 2023. See Figure 5.35 for details.

TERNS

Terns were neither abundant nor frequent, but in autumn 2024, they made up > 1% of all migrating birds (Figure 5.40). In spring of both years most observed individuals of terns were unidentified, and the few individuals that were identified were Sandwich terns and common terns. In autumn 2024, most sighted terns were also identified as these two species. Nonetheless, terns were observed on only few dates (Table 5.22).

Table 5.22 Main migration patterns of terns in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	37 (2)	4/14	0.33 (± 0.90)	0	3.12 (09.05)	4 (2)	2/18	0.03 (± 0.1)	0	0.41 (20.08)
2024	9 (1/2)	2/14	0.08 (± 0.21)	0	0.73 (10.05)	69 (2)	6/20	0.44 (± 1.04)	0	4.12 (05.08)
2023/2024	46 (2)	6/28	0.2 (± 0.63)	0	3.12 (09.05)	73 (3)	8/38	0.24 (± 0.77)	0	4.12 (05.08)

In spring, their maximum migration intensities were in May (3.1 ind./h in 2023 and 0.7 ind./h in 2024, Table 5.22, Figure 5.71), whereas in autumn they were mainly seen in August with a much larger number of individuals observed in 2024 than in 2023 (Figure 5.71, Table 5.22).

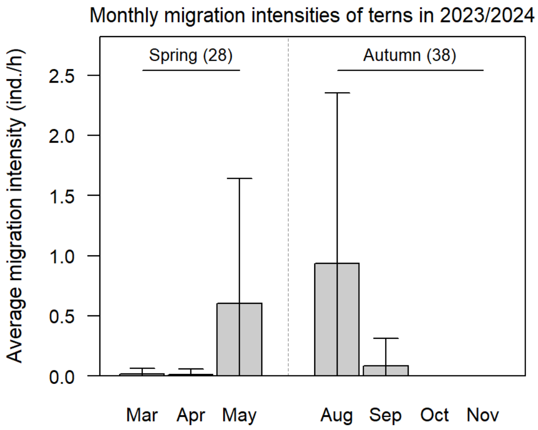


Figure 5.71 Average (mean) monthly diurnal migration intensity of terns in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

During nights they were also only heard in autumn 2024. A total of 13 calls of common tern were heard during three nights between the 6th and 8th of August with the maximum intensity being registered on the night of 7th of August 2024 (2.5 calls/h).

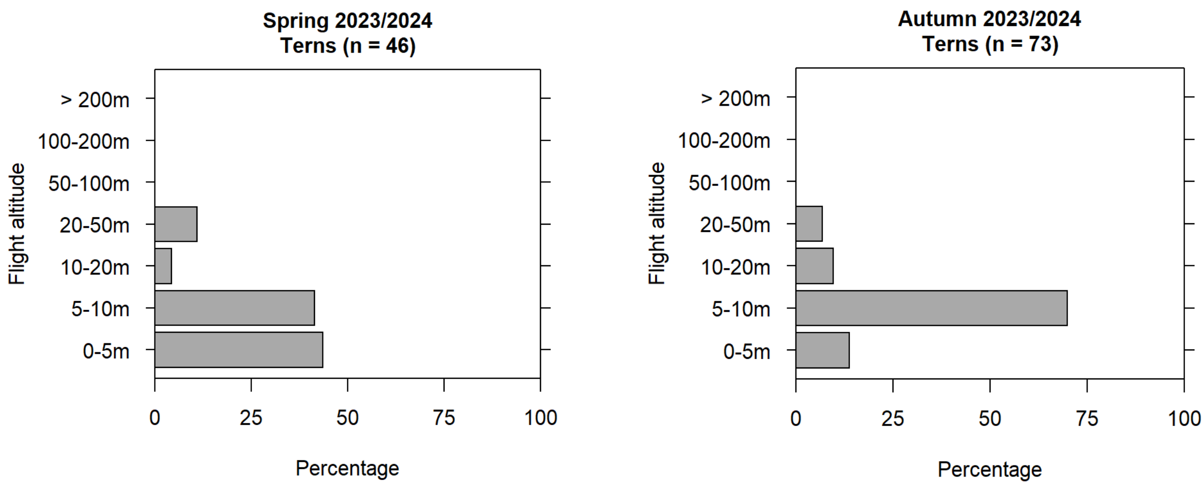


Figure 5.72 Flight altitude distribution of terns during visual observations in spring and autumn 2023. See Figure 5.34 for details.

Most terns flew in the first ten meters above sea level (~85%). Only about 10% and 7% of all terns seen in spring and autumn, respectively were observed flying above 20 m, and none was registered flying above 50 m of altitude (Figure 5.72).

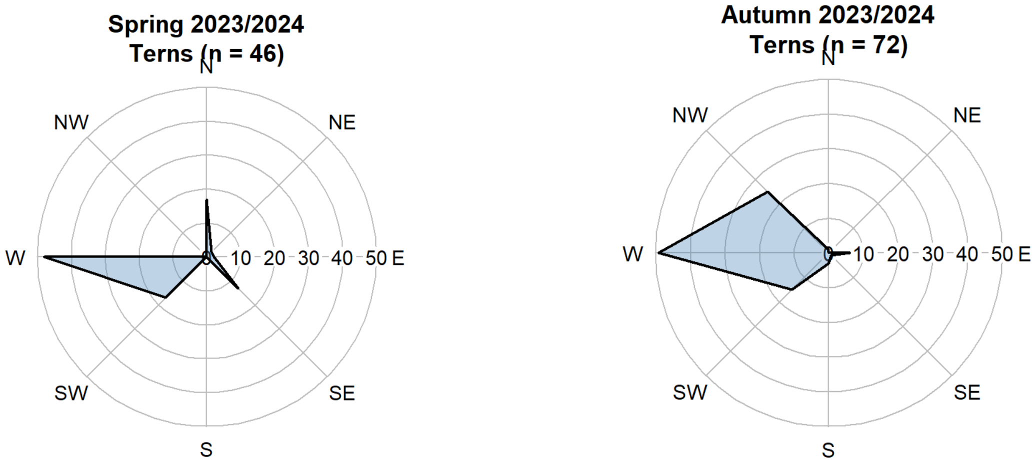


Figure 5.73 Flight directions of terns during visual observations in spring and autumn 2023. See Figure 5.35 for details.

In spring and autumn almost 48% of all terns seen flew to the west. In addition, during spring about 17% flew to the north and to the SW and some flew to the SE (13%) whereas in autumn about 25% flew to the NW and 16% to the SW (Figure 5.73).

AUKS

Auks were not very abundant, but they were observed relatively frequent (Table 5.23). In spring, they represented 0.94% and 1.25% of all diurnally migrating birds in 2023 and 2024, respectively (Figure 5.40). Of the four species registered in spring 2023, razorbill was the most common one (0.62% of all migrating birds). Other species were common guillemot (0.13%), black guillemot (0.1%) and one individual of Atlantic puffin. In spring 2024, common guillemot (0.5%) and razorbill (0.4%) were more common and only one individual of black guillemot was surveyed. Most auks were observed at the beginning of the migrating season (beginning of March in both years) and the maximum migration intensity was similar in both years 4.3-4.4 ind./h (Table 5.23).

Table 5.23 Main migration patterns of auks in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023	87 (4)	8/14	1.0 (± 1.60)	0.13	4.33 (04.03)	198 (4)	10/18	2.66 (± 4.8)	0.32	19.47 (25.11)
2024	60 (3)	11/14	0.73 (± 1.10)	0.29	4.38 (05.03)	54 (4)	10/20	0.53 (± 0.7)	0.06	1.8 (30.10)
2023/2024	147 (4)	19/28	0.87 (± 1.38)	0.25	4.38 (05.03)	252 (4)	20/38	1.54 (± 3.48)	0.13	19.47 (25.11)

In autumn 2023, auks represented 6.4% of all migrating birds (Figure 5.40). A total of four species of auks were identified, the most common ones were common guillemot (2.2%) and razorbill (2.1%). In addition, 1.2% of all birds were grouped as common guillemot/razorbill. A few black guillemots (0.4%) were also present during the autumn migration. In autumn 2024, they just represented 0.9% of all migrating birds and most common species were common guillemot (0.4%) and razorbill (0.3%). Few individuals of black guillemot and a single individual of little auk were also observed. In contrast to waders, auks started to appear at larger numbers late in autumn. In 2023, the maximum migration was observed in late November (19.5 ind./h) whereas in 2024, maximum migration was in late October (30th of October, Table 5.23). Thus, migration intensity of auks increased towards the end of autumn (Figure 5.74).

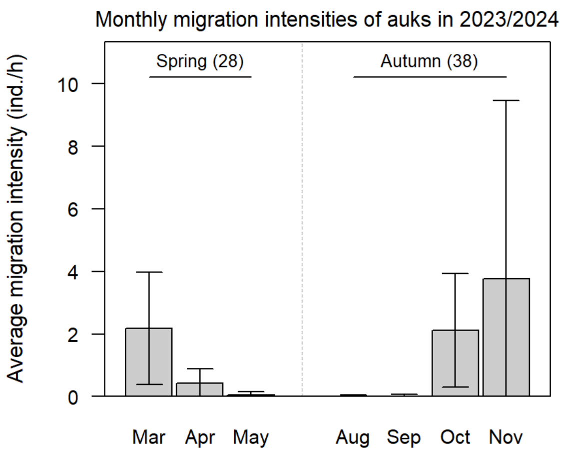


Figure 5.74 Average (mean) monthly diurnal migration intensity of auks in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

Most auks were observed at low flying altitudes (< 10 m, 92% and 88% in spring and autumn, respectively), and only very few of them were observed flying at higher altitudes (mostly below 20 m, Figure 5.75). Less than 1% of all auks were observed flying above this altitude.

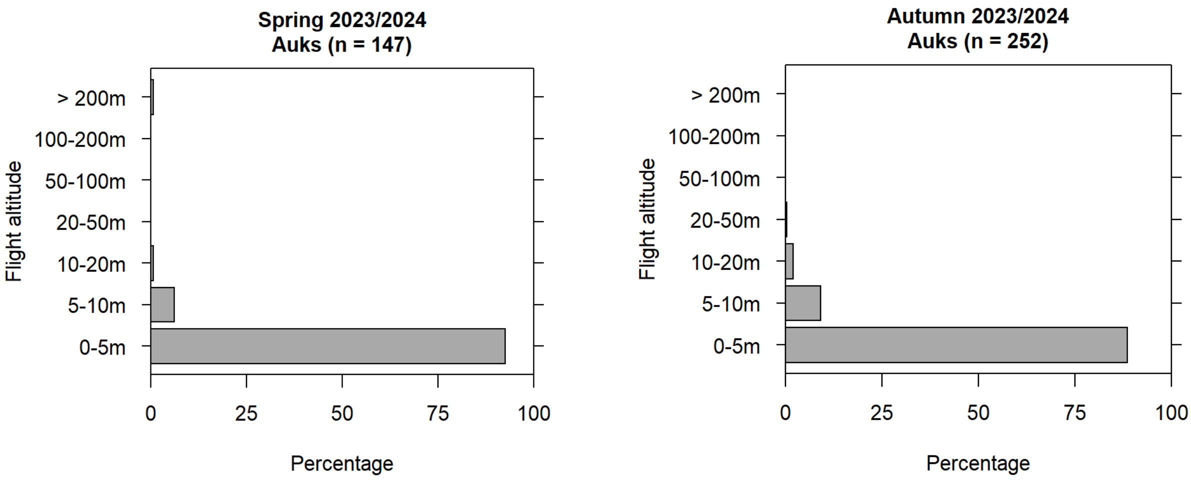


Figure 5.75 Flight altitude distribution of auks during visual observations in spring and autumn 2023. See Figure 5.34 for details.

Flying directions of auks were very variable in both years and seasons. In spring 2023, a large proportion of auks were migrating towards the S, NW and N, while in spring 2024 most observed flying directions were SE, N and S. In autumn, also all directions of flight were observed. However, the main directions were SW, NW and W in autumn (this last direction of flight was more dominant in 2024, Figure 5.76).

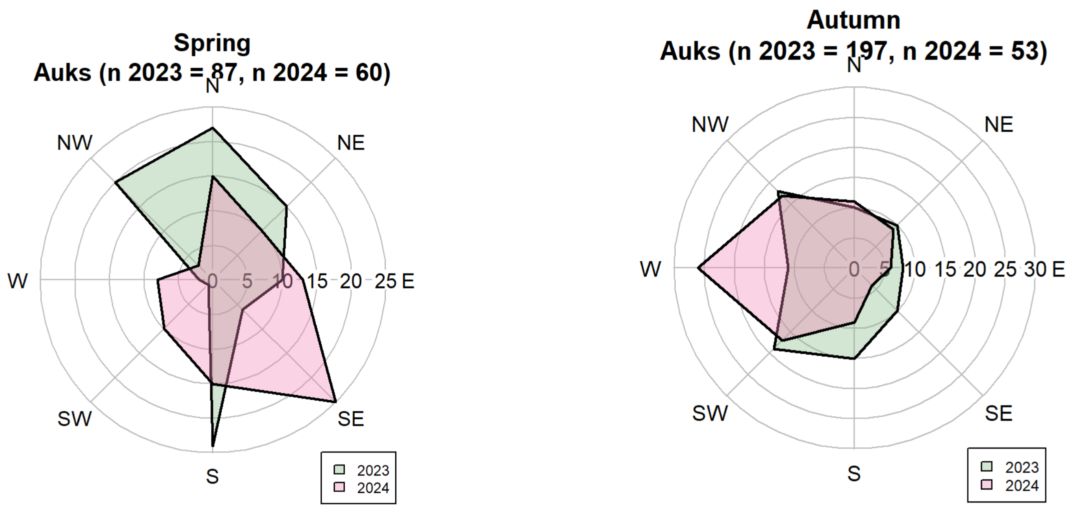


Figure 5.76 Flight directions of auks during visual observations in spring and autumn 2023. See Figure 5.35 for details.

SONGBIRDS

Songbirds comprise a diverse group of migrating birds. During days they occurred frequently, but they were very abundant during nights when their calls made up for the most numerous calls heard during both spring and autumn (Figure 5.40, Figure 5.43, Table 5.24).

During diurnal migration in spring 2023, songbirds were the most common group of birds registered after geese and ducks (6.1%, Figure 5.40). The most common species were meadow pipit, Eurasian jackdaw, barn swallow and brambling, but none of them made up > 0.9% of abundance. Migration intensity was higher in April (mean of 10.9 ind./h, compared to 3.6 ind./h in March and 1.2 ind./h in May. The maximum migration intensity was observed on the 14th of April 2023 (21.9 ind./h, Table 5.24). In spring 2024, songbirds represented about 3.2% of all migrating birds (Figure 5.40). The most common species in the season were meadow pipit and white/pied wagtail (< 1.0%, each). Maximum migration intensities were also registered in the middle of the season in April (Figure 5.77).

Table 5.24 Main migration patterns of songbirds in spring and autumn of both years during visual observations in the pre-investigation area. For details see heading of Table 5.11.

Year	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR	Median	Max. MTR (date)
2023	560 (23)	14/14	5.52 (± 7.4)	1.84	21.86 (14.04)	248 (29)	13/18	2.24 (± 4.5)	0.35	17.67 (03.10)

2024	155 (16)	13/14	1.60 (± 1.8)	0.97	6.57 (06.04)	497 (14)	17/20	4.74 (± 9.8)	0.84	41.57 (12.10)
2023/2024	715 (28)	27/28	3.56 (± 5.62)	1.39	21.86 (14.04)	745 (31)	30/38	3.56 (± 7.72)	0.48	41.57 (12.10)

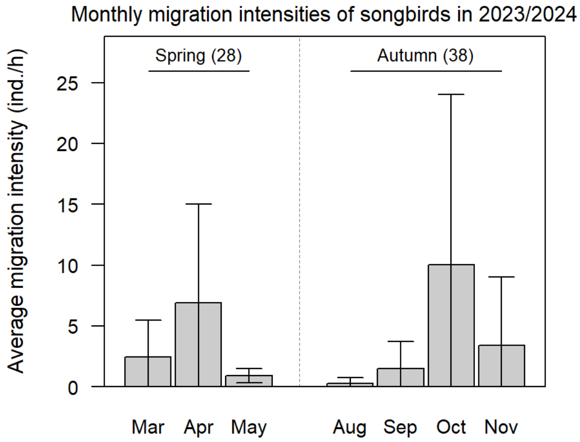


Figure 5.77 Average (mean) monthly diurnal migration intensity of songbirds in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey days in each season (28 in spring: 14 days in 2023 and 14 days in 2024) and 38 days in autumn (18 in 2023 and 20 in 2024).

In autumn songbirds made up about 8% of all migrating birds. During autumn 2023, several species of songbirds were identified (29 species). The most commonly occurring species were Eurasian siskin (1.2% of all migrating birds), white wagtail/pied wagtail (1%), meadow pipit (0.9%) and yellow wagtail (0.7%).

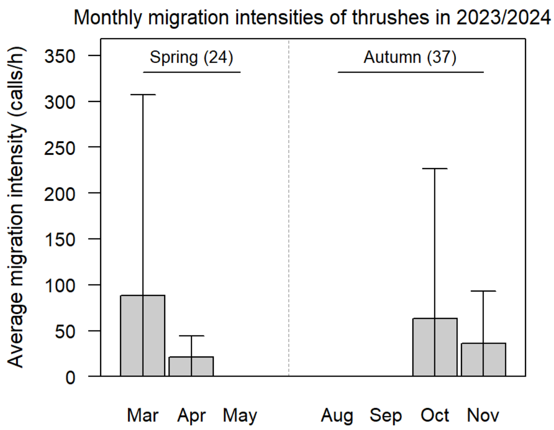
Migration intensity was variable, but the mean value was 2.2 ind./h. Maximum migration intensity occurred at the middle of the season on the 3rd of October (17.7 ind./h, Table 5.24). Songbirds were not registered in November. In autumn 2024, two species were commonly seen: starlings (3.7%) and chaffinch (1.3%). Maximum intensity was also registered in October (41.6 ind./h on the 12th of October, Table 5.24, Figure 5.77).

During nocturnal migration, songbirds were the most frequently registered birds, representing between 88% and 98% of all birds heard (see Figure 5.43). During nocturnal migration, songbird calls are divided into two groups: those belonging to thrushes, *Turdus* spp. and those of all other songbirds. Thrushes were more commonly heard than the other songbirds, varying between almost 50% and 87.5% (spring and autumn 2023, see Figure 5.43).

In spring 2023, the most common thrush 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 (Table 5.25). In spring 2024, the most common species of thrush registered was the common blackbird (59% of all calls) and the redwing (12.4%). Other songbirds that were commonly heard in this season were the sky lark (12.5%) and the European robin (6.3%). Many more calls were registered in 2024 than in 2023, but in both cases the maximum number of calls were heard in March (Figure 5.78). The maximum migration intensity for both type of songbird calls was registered at the beginning of March (March 2nd, 2024) which was also considered a peak acoustic migration date: this night registered 865 calls/h of songbirds, Table 5.25).

Table 5.25 Main migration patterns of songbirds in spring and autumn of both years during acoustic observations in the pre-investigation area. For details see heading of Table 5.11.

Year (Group)	Spring migration					Autumn migration				
	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)	No ind. (spp.)	Freq. of occur.	Mean MTR (± SD)	Median	Max. MTR (date)
2023 (Thrushes)	89 (3)	3/9	2.59 (± 4.6)	0	13.09 (23.03)	2740 (5)	12/17	28.00 (± 113.4)	0.21	467.83 (05.10)
2024 (Thrushes)	5,639 (4)	9/15	64.57 (± 179.2)	0.67	692.33 (02.03)	2705 (4)	11/20	19.51 (± 43.1)	0.63	170.57 (07.11)
2023/2024 (Thrushes)	5,728 (4)	12/24	41.33 (± 143.15)	0.08	692.33 (02.03)	5,445 (5)	23/37	23.41 (± 81.91)	0.22	467.83 (05.10)
2023 (All others)	69 (7)	4/9	2.39 (± 5.6)	0	17.09 (23.03)	212 (4)	11/17	2.6 (± 5)	0.63	20.00 (19.08)
2024 (All others)	1,642 (10)	12/15	20.61 (± 46.3)	1	173.00 (02.03)	401 (4)	12/20	3.12 (± 5.5)	0.75	20.29 (07.11)
2023/2024 (All others)	1,711 (12)	16/24	13.78 (± 37.35)	0.79	173.00 (02.03)	613 (7)	23/37	2.88 (± 5.22)	0.67	20.29 (07.11)



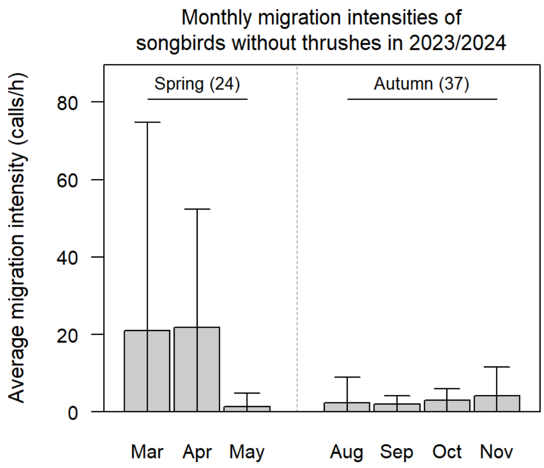


Figure 5.78 Average (mean) monthly nocturnal migration intensity of thrushes (left) and other songbirds (right) in both years (data combined). Variability is represented by standard deviations. Numbers in brackets indicate the number of survey nights in each season (24 in spring: 9 nights in 2023 and 15 nights in 2024) and 37 days in autumn (17 in 2023 and 20 in 2024).

In autumn 2023, 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 other songbirds the most common species were the European robin (3%). Other species occurred in smaller numbers. The migration intensity of the group of songbirds, excluding thrushes, was low 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 19th of August. Thrushes were heard during the whole season but at very low intensities (often < 1 call/h). Only on the night of October 5th, there was a peak migration event when nocturnal migration intensity reached 467.8 calls/h (Table 5.25). In autumn 2024, the most common thrushes observed were the same as in spring: common blackbird (49% of all calls) and redwing (34.3%) Of the other songbirds, the most common species was the European robin (11%). No skylarks were registered in autumn. Migration intensities increased towards the end of the season with most songbird calls heard on the night of 7th of November (Table 5.25). Overall, thrushes were mainly heard in October and November while all other songbird calls were constantly heard during the whole season (Figure 5.78).

In spring, 82.5% of all birds were observed at altitudes below 20m. In autumn, flying altitude of diurnally migrating songbirds differed a bit between 2023 and 2024. In 2023, flying altitude decreased progressively with altitude, with most of the migration occurring in altitudes up to 20 m (81%), and comparatively fewer songbirds being detected at very low altitudes: < 40% while in 2024, many more songbirds were observed flying close to the sea surface: 73%. Nonetheless, the proportion of birds being observed above 20 m was similar in both years (~15-18%, Figure 5.79).

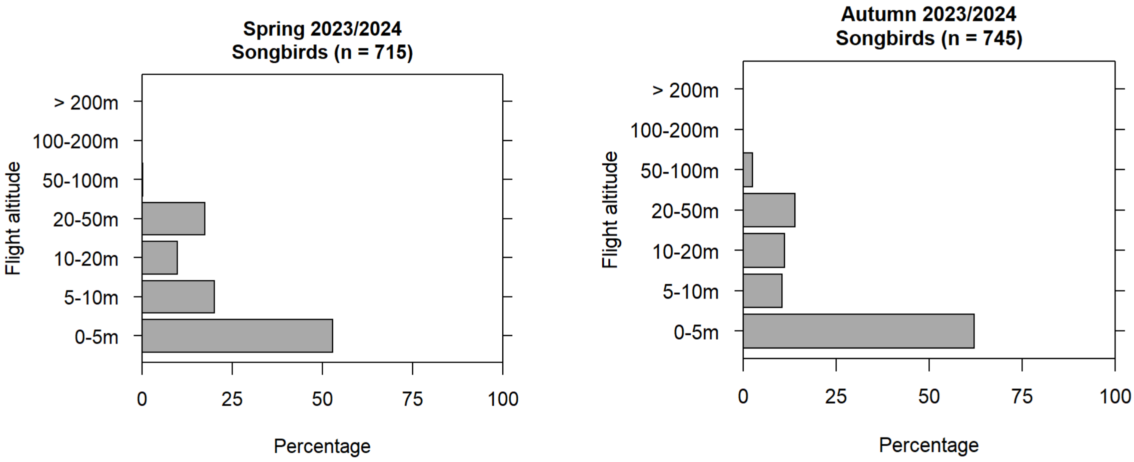
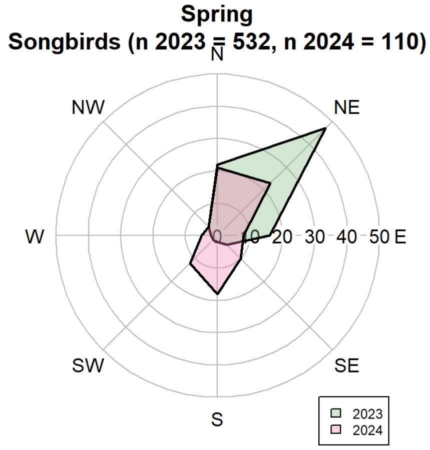


Figure 5.79 Flight altitude distribution of songbirds during visual observations in spring and autumn 2023. See Figure 5.34 for details.

In spring 2023, most birds were flying at a NE direction, and in general > 85% of all birds flew in a N, NE, E direction (Figure 5.80). In the following year, flying directions divided into the N, NE direction (44%) and a southern direction (S, SW and SE, made up about 40% of all the directions) In autumn 2023, most birds were observed flying at a SW direction (38%), but about 40% flew also to the S and SE. In autumn 2024, most birds flew directly to the SW (70%) and fewer to the SE and W (Figure 5.80).



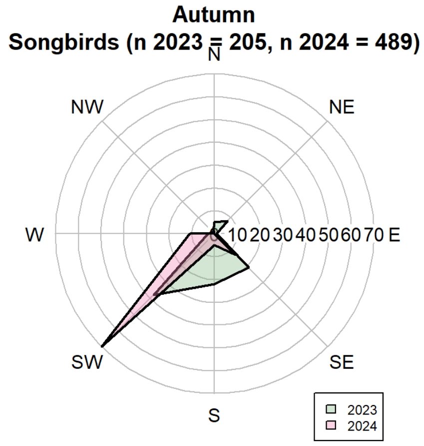


Figure 5.80 Flight directions of songbirds during visual observations in spring and autumn 2023. See Figure 5.35 for details.

5.2.2 HORIZONTAL AND VERTICAL RADAR

MIGRATION INTENSITY

Vertical radar was reanalysed for both years, since part of the data of 2023 was calculated with a different setting than usual (see Methods). The recalculation of 2023 gives slightly higher migration rates than those provided in the previous report, nonetheless the same patterns were found.

Surveyed days:
A total of 39 days and 33 nights contained vertical radar signals in 2023. For the calculations of migration intensity, data from days and nights with scarce hours of collection due to weather (rain, fog, wind >7 Bft) or sea state (< 70% of day length or night length) were discarded. 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 5.26 and Table 5.27).

For the year 2024, radar signals were available from a total of 42 days and 36 nights. Nonetheless, some of these dates produced very few signals and are thus not used for the calculations of migration intensity. In the end, 34 days (81% of all dates) and 34 nights (94%) were used to calculate average migration intensities.

Spring
In spring 2023, mean migration intensity during daytime was 25.8 MTR (signals/(km*h) and 445.3 MTR during nights (Table 5.26). During days, migration intensity was higher in the middle of the season with the highest mean migration taking place in April (33.3 MTR), due to a peak of migration on the 14th of April (82.7 MTR, Table 5.26, Figure 5.81). Mean nocturnal migration intensity was higher towards the end of the season. In May, the mean value was 740.7, mainly due to a peak migration event taking place on the night of the 7th of May (2231.2 MTR, Figure 5.82).

Table 5.26. Monthly and seasonal diurnal and nocturnal migration rates (MTR) calculated from vertical radar in spring 2023 in the pre-investigation area.

Spring	Diurnal migration (MTR)				Nocturnal migration (MTR)			
	Mean (± SD)	Median	Maximum	Number of days	Mean (± SE)	Median	Maximum	Number of nights
March 2023	23.5 (±15.2)	19.3	49.9	5	123.1 (±159.1)	69.6	346.3	4
April 2023	33.3 (±28.8)	26.5	82.7	5	398.3 (±383.3)	266.6	954.9	4
May 2023	20.5 (±18.9)	13.7	52.6	5	740.7 (±929.2)	344.8	2231.2	5
Spring 2023 *	**25.8 (±20.9)**	**20.7**	**82.7**	**15**	**445.3 (±634.5)**	**194.7**	**2231.2**	**13**
March 2024	13 (±4.9)	10.3	21.5	5	76.9 (±76.8)	71.2	157.2	4
April 2024	51.8 (±29.2)	55.5	80.9	5	495.1 (±279.7)	549.3	805.6	5
May 2024	19.7 (±7.9)	22.4	29.3	5	147.9 (±101.1)	136.0	317.3	5
Spring 2024	**28.2 (±24)**	**21.5**	**80.9**	**15**	**251.6 (±254.8)**	**138.6**	**805.6**	**14**
March	18.3 (±12)	14.9	49.9	10	100 (±118.2)	71.2	346.3	8
April	42.5 (±29)	27.1	82.7	10	452.1 (±311.1)	371.1	954.9	9
May	20.1 (±13.7)	18.4	52.6	10	444.3 (±697.1)	138.6	2231.2	10
Spring	**27.0 (±22.1)**	**20.8**	**82.7**	**30**	**344.9 (±477.5)**	**141.2**	**2231.2**	**27**

* The values of the first study year, 2023, were re-analysed due to a faulty radar setting and may now deviate somewhat from last year's report. This deviation, however, had no impact on last year's overall findings.

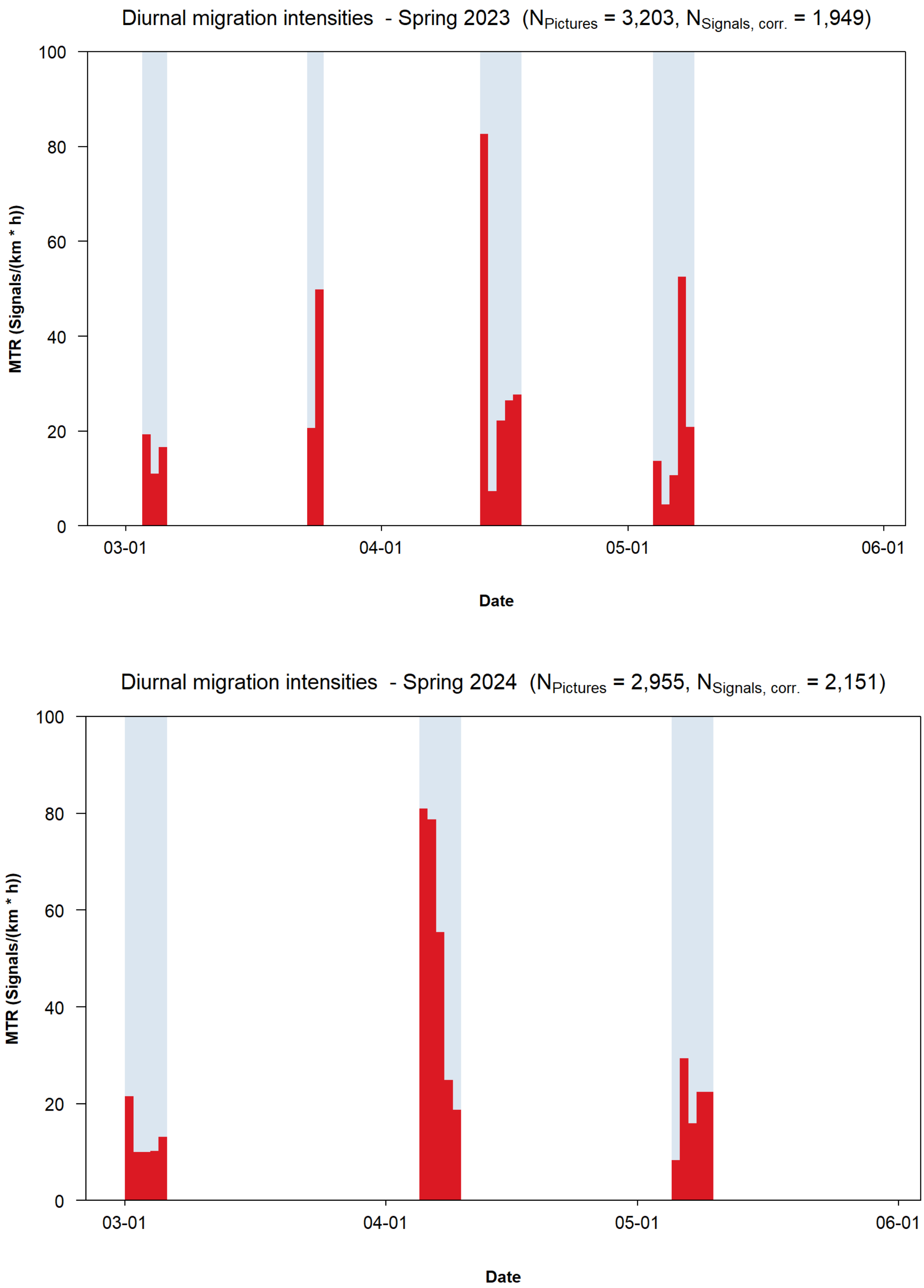
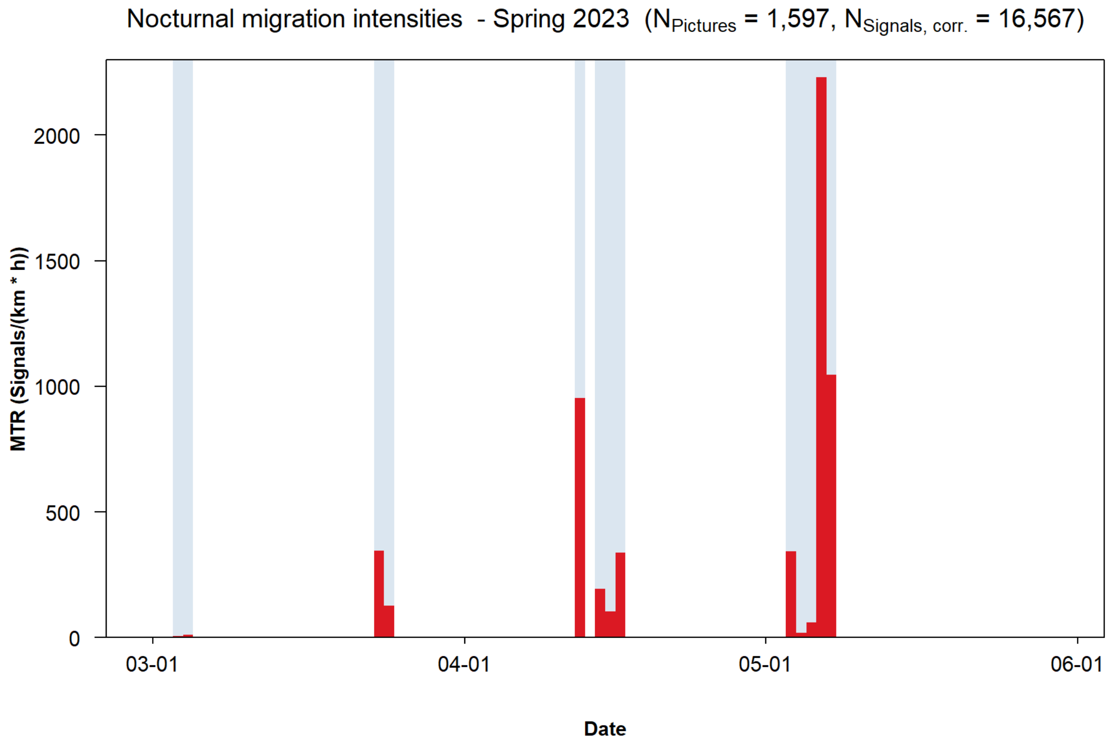


Figure 5.81 Diurnal migration intensity in spring 2023 (top) and 2024 (bottom) based on daily migration traffic rates (MTR) calculated from the vertical radar. MTR is specified as radar signals per km and hour (up to 1,000 m altitude). Areas highlighted in light grey indicate the survey days. For comparison, the scale of the y-axis was kept identical.



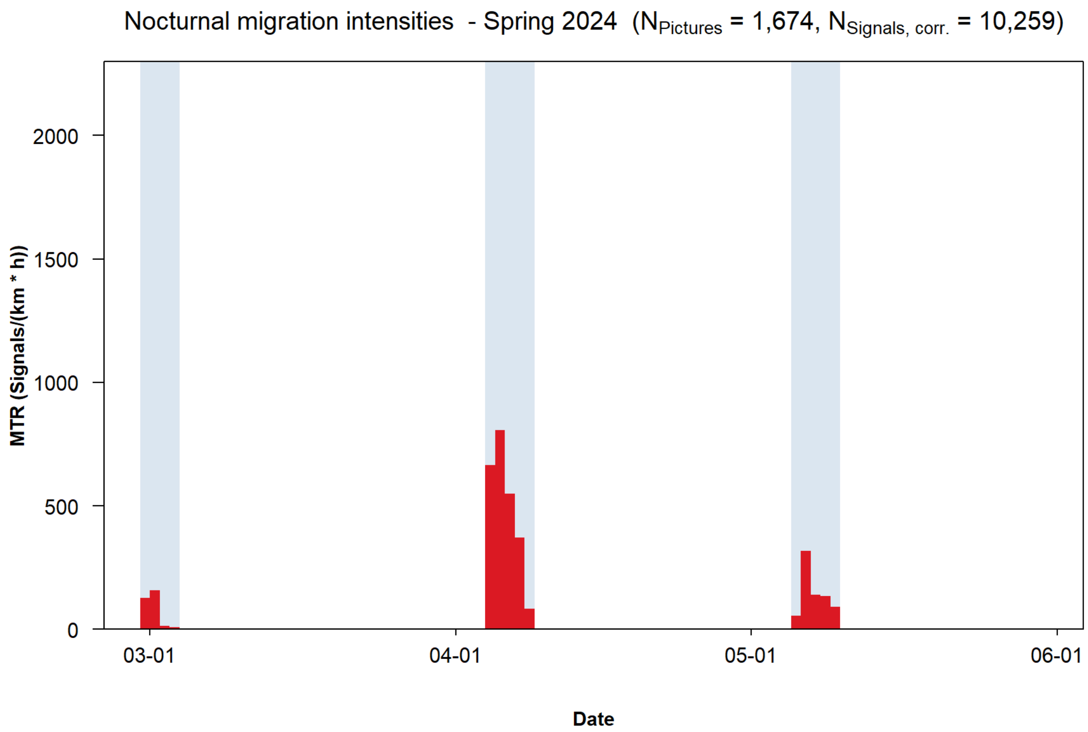


Figure 5.82 Nocturnal migration intensity in spring 2023 (top) and 2024 (bottom) based on daily migration traffic rates (MTR) calculated from the vertical radar. MTR is specified as radar signals per km and hour (up to 1,000 m altitude). Areas highlighted in light grey indicate the survey days. For comparison, the scale of the y-axis was kept identical.

In spring 2024, mean migration intensity was 28.2 MTR during daytime, a value that was a little higher than that of the previous year. Also in this year, the highest migration was observed in April (mean: 51.8 MTR). In this month, the maximum migration intensity was registered too (80.9 MTR on 6th of April 2024). During nights, mean migration intensity was much higher on average (252 MTR) with most of migration also taking place in April. Here, also a large migration peak was registered (805.6 MTR on the same date as when the major peak migration during days was registered: 6th of April 2024).

Autumn

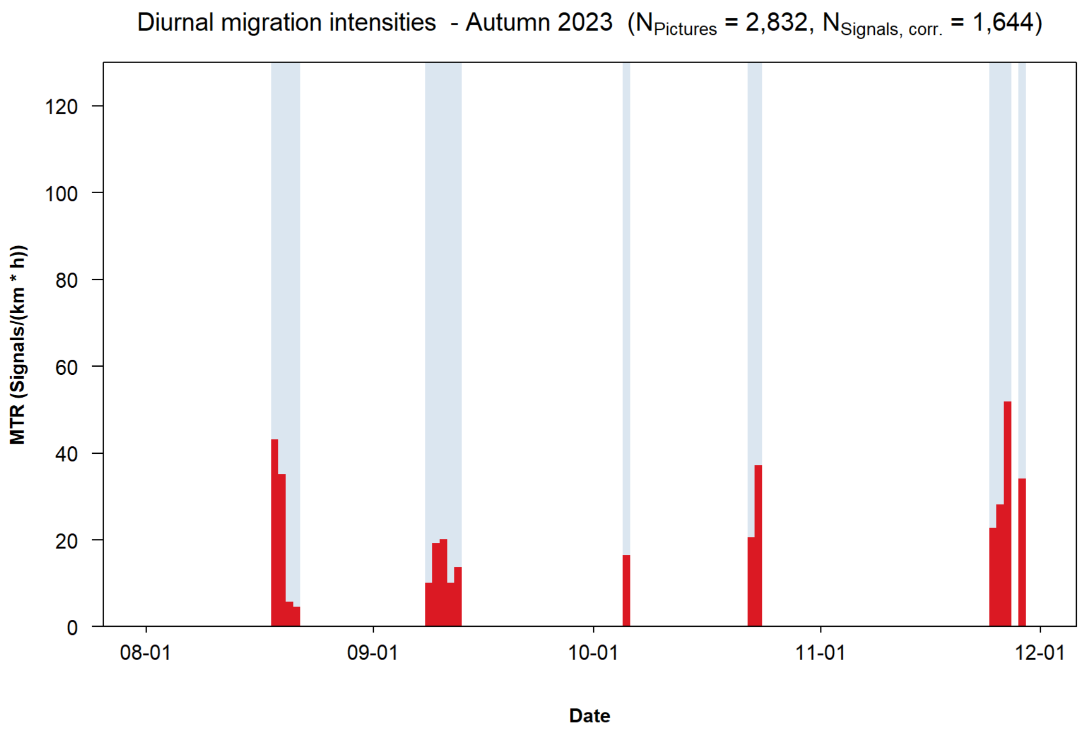
In autumn 2023, mean migration intensity during daylight was 22.9 MTR with the maximum migration taking place in November (40.1 MTR) when the maximum value occurred on the 27th of November (60.3 MTR, Table 5.27, Figure 5.83). Mean migration intensity during nights was also larger, but not as large as 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 5.84).

In autumn 2024, mean diurnal migration intensity was almost as double as that of the previous year (41.8 MTR, Table 5.27). The maximum intensity was registered at the beginning of the season (8th of August 2024, Figure 5.83). During nights, mean nocturnal migration was also more than double than during 2023 (265.8 MTR). There were two nights with many radar signals at the end of the season (>1400 MTR, 13th of October and the maximum on the 7th of November, 2024, Table 5.27, Figure 5.84).

Table 5.27. Monthly and seasonal diurnal and nocturnal migration rates (MTR) calculated from vertical radar in autumn 2023 in the pre-investigation area.

Autumn	Diurnal migration (MTR)				Nocturnal migration (MTR)			
	Mean (± SD)	Median	Maximum	Number of days	Mean (± SE)	Median	Maximum	Number of nights
August 2023	22.2 (±19.9)	20.4	43.2	4	141.2 (±224.6)	12.1	400.6	3
September 2023	14.7 (±4.8)	13.8	20.2	5	32.4 (±20.6)	37.3	56.4	5
October 2023	24.8 (±10.9)	20.6	37.1	3	351.3 (±388)	189.5	794.0	3
November 2023	34.2 (±12.7)	31.1	51.9	4	26 (±12.4)	25.2	38.8	3
Autumn 2023 *	**23.3 (±13.8)**	**20.4**	**51.9**	**16**	**122.7 (±220.3)**	**38.1**	**794.0**	**14**
August 2024	51 (±50.7)	30.9	125.9	4	159 (±132.8)	206.5	329.1	5
September 2024	38.3 (±12.3)	41.2	51.3	5	183.6 (±60.3)	203.6	260.7	5
October 2024	33.7 (±25.4)	31.0	66.8	4	401.8 (±677.9)	85.8	1417.4	4
November 2024	43.9 (±24)	32.9	83.0	6	332.8 (±568.5)	126.7	1485.4	6
Autumn 2024	**41.8 (±27.7)**	**36.0**	**125.9**	**19**	**265.8 (±415)**	**148.2**	**1485.4**	**20**
August	36.6 (±38.8)	29.6	125.9	8	152.3 (±156.8)	119.5	400.6	8
September	26.5 (±15.3)	21.0	51.3	10	108 (±90.3)	81.0	260.7	10
October	29.9 (±19.6)	25.3	66.8	7	380.2 (±529.8)	103.3	1417.4	7
November	40 (±19.9)	32.0	83.0	10	230.5 (±474.9)	44.2	1485.4	9
Autumn	**33.4 (±24)**	**28.1**	**125.9**	**35**	**206.9 (±351.2)**	**85.1**	**1485.4**	**34**

* The values of the first study year, 2023, were re-analysed due to a faulty radar setting and may now deviate somewhat from last year's report. This deviation, however, had no impact on last year's overall findings.



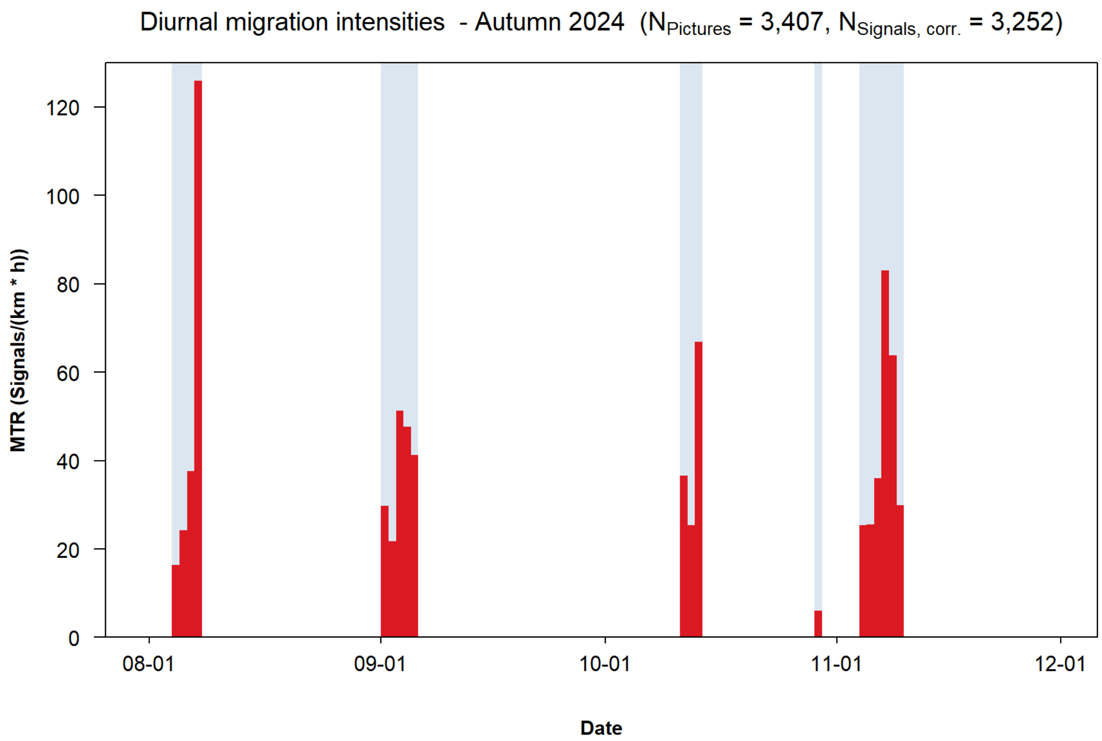
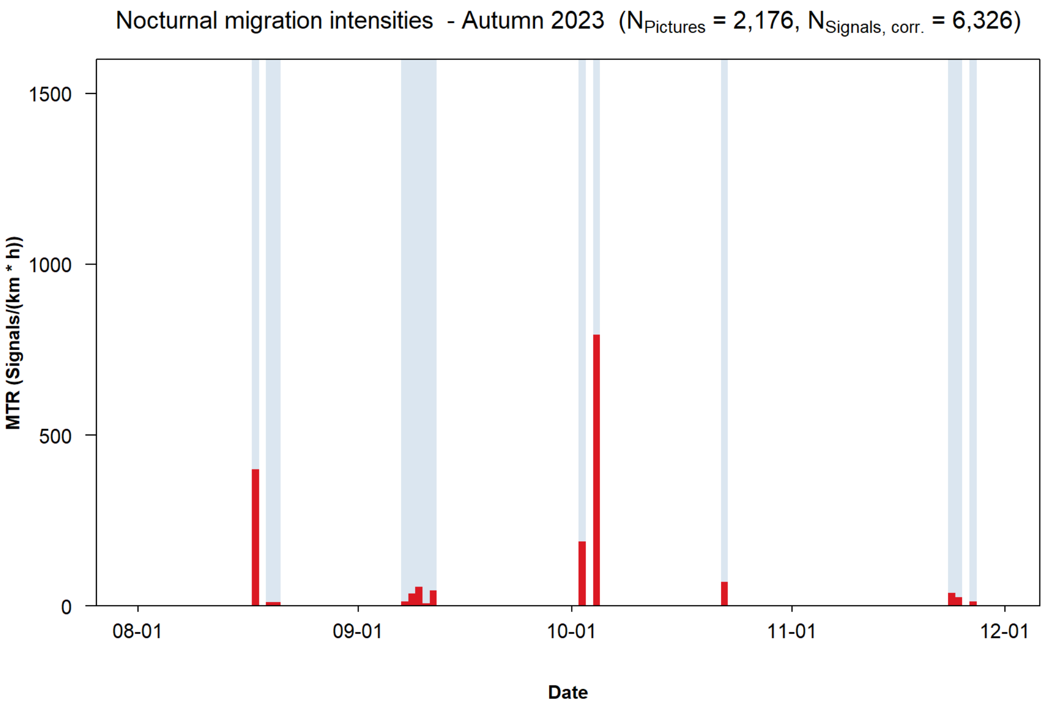


Figure 5.83 Diurnal migration intensity in autumn 2023 (top) and 2024 (bottom) based on daily migration traffic rates (MTR) calculated from the vertical radar. MTR is specified as radar signals per km and hour (up to 1,000 m altitude). Areas highlighted in light grey indicate the survey days. For comparison, the scale of the y-axis was kept identical.



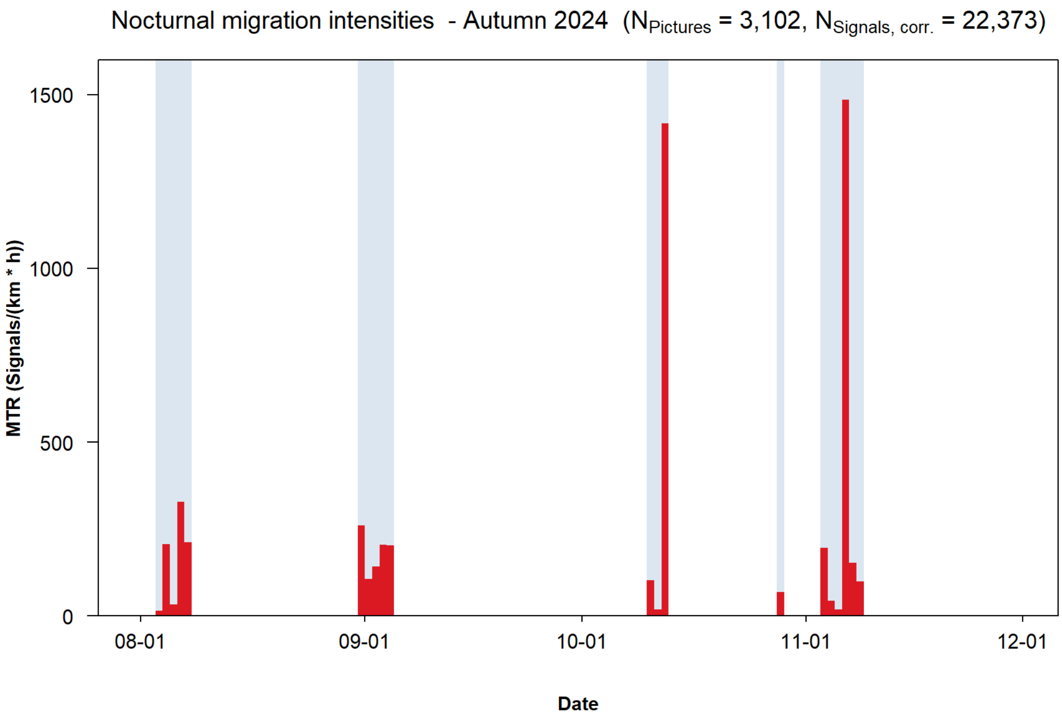


Figure 5.84 Nocturnal migration intensity in autumn 2023 (top) and 2024 (bottom) based on daily migration traffic rates (MTR) calculated from the vertical radar. MTR is specified as radar signals per km and hour (up to 1,000 m altitude). Areas highlighted in light grey indicate the survey days. For comparison, the scale of the y-axis was kept identical.

FLIGHT ALTITUDE

For the plotting of altitude distribution, all vertical radar signals of both years were combined to generate average altitude distribution plots. General patterns were similar for both years, and when differences were observed, comments are added along this report. Bird signals obtained from vertical radar data (up to 1,000 m altitude), showed a different vertical distribution between diurnal and nocturnal migration (Figure 5.85, Figure 5.86).

During daytime, the majority of signals (31% and 42% in spring and autumn, respectively) were 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 13% of signals at 100-200 m (in spring and autumn, respectively) to 5-6% at 900-1,000 m altitude. Nocturnally detected bird signals were more evenly spread over the whole altitude range in spring. This pattern was stronger when considering only nights with high migration intensity (Figure 5.87). In general, the proportion of signals at the bottom layer in spring was also larger: 16.5% of signals occurred at the very first 100 m of altitude. But then proportions varied between 7% at the most upper layer to 11% at the layer 300-400 m (Figure 5.85). In autumn, however, there was a relatively large number of radar signals occurring at the two top layers, and this was observed in 2024 and was mainly driven by the nights with high migration intensity (Figure 5.88). Here, the proportion of signals varied between 16 and 18%, coming close to the 21% of signals observed at the very bottom layer (0-100 m).Otherwise, the altitude distribution resembled that of diurnal migration with a slight decrease of signals with altitude (from 9% to about 4%, between 200 and 700 m, Figure 5.86).

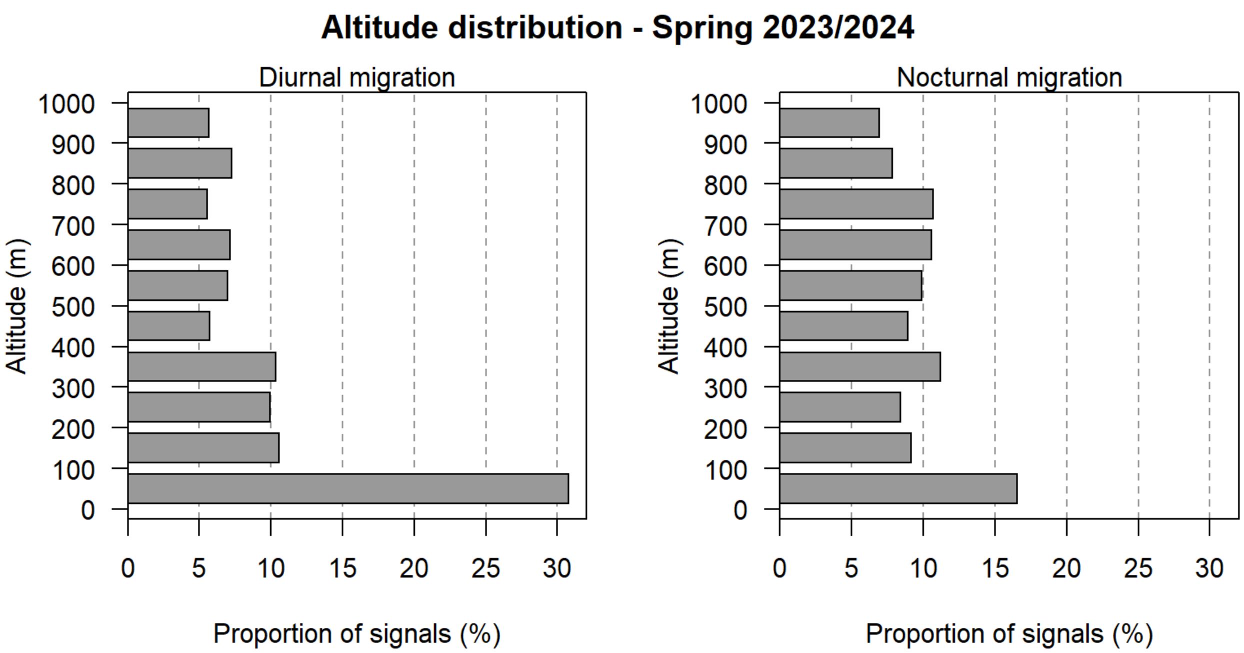


Figure 5.85 Flight altitude distribution from vertical radar data during spring in the pre-investigation area. Depicted is the relative appearance of signals up to 1,000 m height in 100 m increments. The graph on the left shows the altitude distribution of birds during the daylight phase, the right graph during the night.

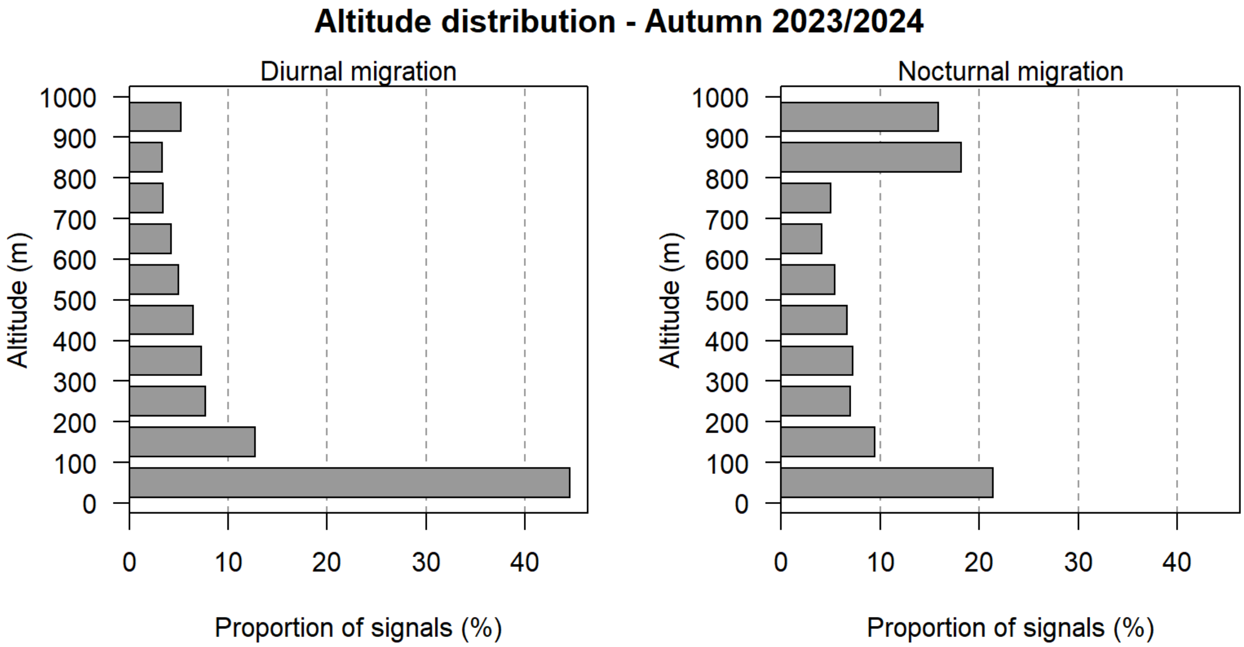


Figure 5.86 Flight altitude distribution from vertical radar data during autumn in the pre-investigation area. Depicted is the relative appearance of signals up to 1,000 m height in 100 m increments. The graph on the left shows the altitude distribution of birds during the daylight phase, the right graph during the night.

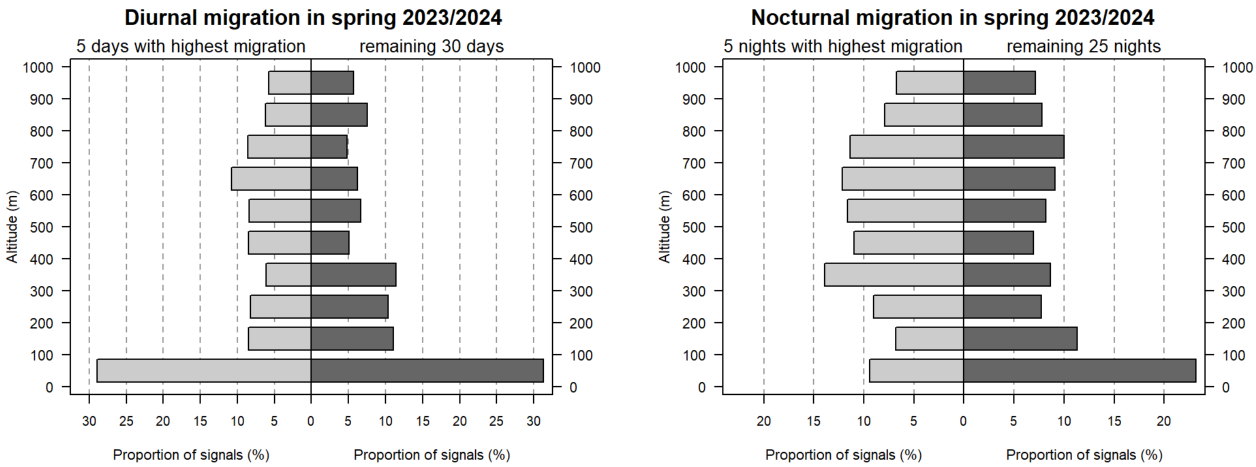


Figure 5.87 Flight altitude distribution from vertical radar data during spring (2023 and 2024 combined) in the pre-investigation area divided according to the 5 da with highest migration intensity (light grey) and all other days (dark grey). Depicted is the relative appearance of signals up to 1,000 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.

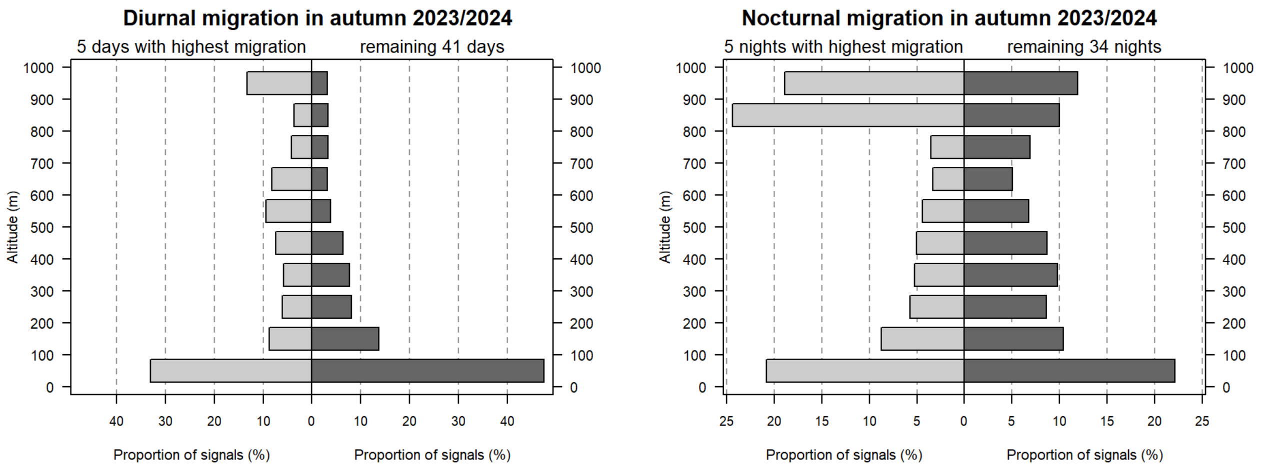


Figure 5.88 Flight altitude distribution from vertical radar data during autumn (2023 and 2024 combined) in the pre-investigation area divided according to the 5 days with highest migration intensity (light grey) and all other days (dark grey). Depicted is the relative appearance of signals up to 1,000 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 and autumn (Figure 5.89). 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 there was stronger migration during the first two hours of the night. The migration remained relatively moderate until midnight and then slowly decreased. The main difference between temporal patterns of spring and autumn was that in spring strong migration (> 300 MTR) was detected during most of the night (except the two hours before sunrise) and in autumn strong migration was only seen during the first two hours after sunset.

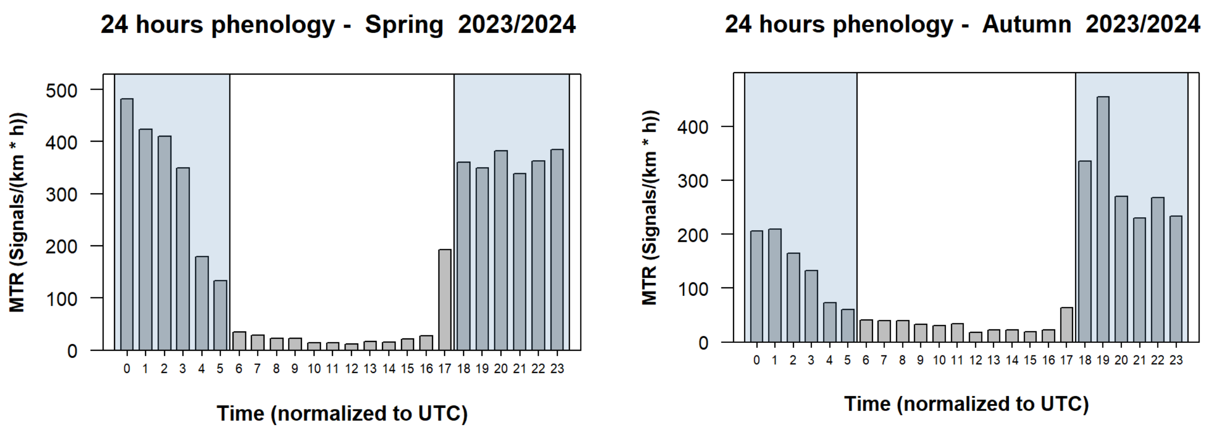


Figure 5.89 24 h migration intensity from vertical radar data in spring and autumn in the pre-investigation area. As daylength varies over the year, nocturnal (blue shaded) and diurnal observations of the single survey days are depicted stretched/compressed to a "normalised" length of 12 hours each. Time data in UTC (minus one hour compared to MET/ two hours to MEST).

FLIGHT DIRECTIONS

Few bird signals were recorded with the horizontal radar. In spring, signals were detected at different directions of flight during diurnal migration and mostly NW and NE (a northern direction was chosen as the mean direction). During nocturnal migration, signals indicated a NEE direction of flight (Figure 5.90).

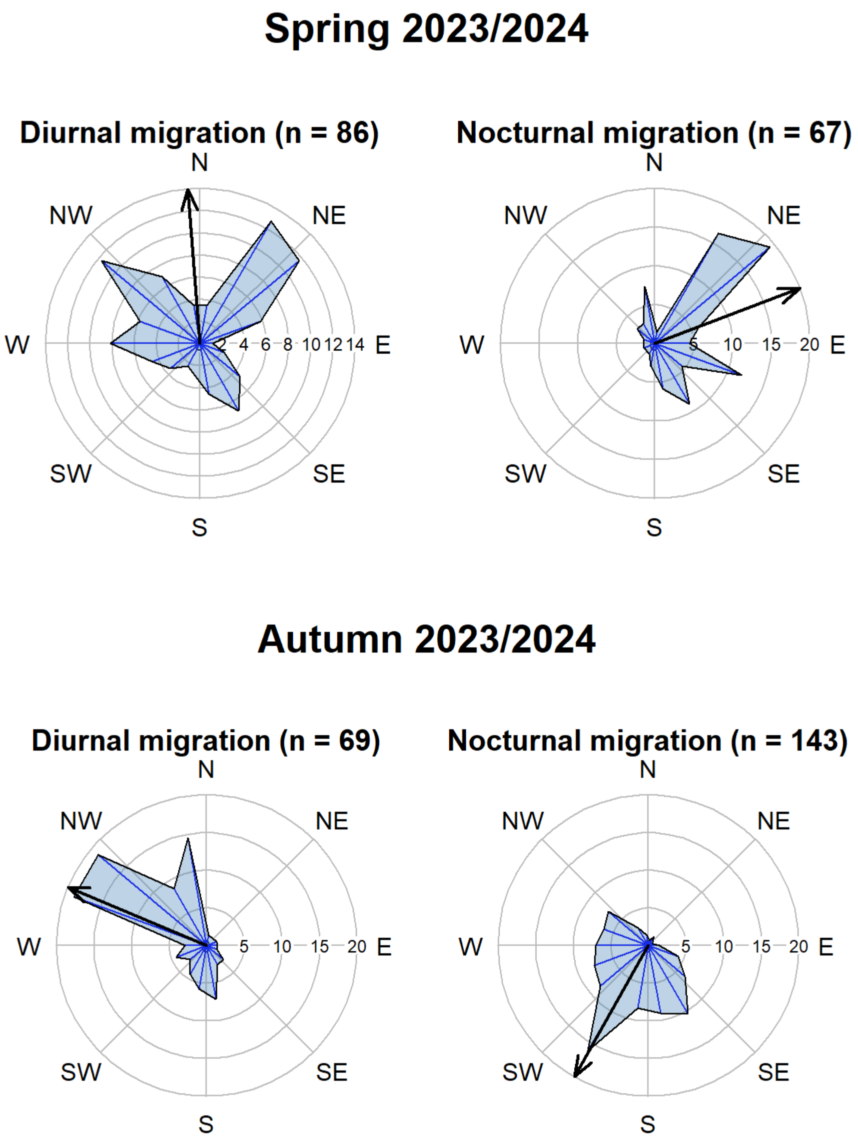


Figure 5.90 Flight direction of bird signals according to the horizontal radar shown in percentage (%) during diurnal and nocturnal migration in spring (top) and autumn (bottom) of both years in the pre-investigation area. For plotting purposes, flight directions were grouped into groups of 20° increments. 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, there were fewer bird signals during diurnal migration than during nocturnal migration. In general, there was a large difference in the migration directions registered during days (NWW) than during nights (SSW) in (Figure 5.90).

6 STATUS AND DISCUSSION

6.1 RESTING BIRDS

In the following section, findings from the results of the resting bird surveys will be assessed regarding the importance of the pre-investigation area for the relevant species. Furthermore, the results will be compared with existing data from the area. During the twelve digital aerial surveys conducted over two monitoring years, a total of 7,956 resting birds belonging to 23 species were observed in 2023, while 9,610 resting birds belonging to 26 different species were recorded during the 2024 campaign.

Common guillemot was the most common species, with 3,064 and 4,729 individuals recorded in total, for 2023 and 2024 respectively. The second most common species was the common scoter with 1,087 individuals during 2023. However, during the second year of monitoring, red-throated diver was the second most common species with 660 observations. Among sea ducks, the decline in observations was higher for common scoters while common eiders were present at similar proportions during both years, representing approximately 6% of all resting birds detected.

For divers, according to PETERSEN ET AL. (2021), the highest number of birds in the pre-investigation area is reached between December and April, during winter and early spring. The observed patterns in this study are consistent with the phenology of the species, which returns to the Baltic Sea before heading towards their breeding grounds from April onwards (SKOV et al. 2011). The second year of monitoring presented the highest recorded density during February with 0.77 ind./km² (no survey conducted in March for 2024). The recorded densities of divers were higher than comparable studies around the Kattegat area, in which mean densities from 0.05 to 0.07 ind./km^2 have been found (PETERSEN & NIELSEN 2011; SKOV et al. 2011).

Generally, the Kattegat-Hesselø area is not considered as an important habitat for divers, with emphasis on red-throated divers, as their main wintering and moulting area as well as migratory routes are located south of the planned OWF, within the Great Belt Sea and the Kiel Bay (KLEINSCHMIDT ET AL.,2022). However, this study shows that higher numbers than expected can occur in the pre-investigation area during some years.

Northern gannets were rarely observed in the pre-investigation area; however, a notable increase in sightings was observed during the 2024 monitoring campaign. The highest densities were found near the northwest tip of the Sjællands Odde. In the former Hesselø planned OWF, PETERSEN ET AL. (2021) did register northern gannet sightings with a peak of presence during April in areas with depths of 20-32 m. The presence of this species has been increasing during winter periods in the Kattegat area and Western Baltic Sea (GARTHE et al. 2024).

In the current study, common scoters were present in high numbers only during one survey in April 2023. Usually, winter and spring are the periods when the highest densities are reached, but common scoters can also be present in summer, which is also the beginning of their moulting season (PETERSEN & NIELSEN 2011). In this study, only very small numbers were found during August in the pre-investigation area. The number of common scoters was much lower in 2024, compared to 2023, specially during spring, which could be due to interannual variations and temporary distribution shifts, for example due to lack of available prey or disturbances from human activities like fisheries or marine traffic (KAISER et al. 2006; VAN DE WOLFSHAAR et al. 2023).

Similar variations were found by Petersen et al. (2021), with winter counts that ranged from 0 to > 74,000 individuals observed during the surveys. The area northwest of the planned Hesselø OWF is where the highest densities of common scoters are regularly found, in the Natura 2000 protected area Nordvestlige Kattegat (DK00FC371), in which previous studies have detected a mean winter density of 4.03 ind./km^2 (SKOV et al. 2011). In our study, the highest density was located near the northwestern tip of Sjælland Odde, during spring 2023, with 2.10 ind./km^2. Based on this study and previous studies, the pre-investigation area does not seem to be a key area for common scoters.

Gulls were the third most common species group during both years of baseline monitoring in the pre-investigation area, although their detected presence slightly increased during the second year. The most abundant species was the herring gull, followed by common gull and lesser black-backed gull. Similar to the findings by PETERSEN ET AL. (2021), gulls were spread widely across the pre-investigation area, however with some local concentrations by the coast. PETERSEN ET AL. (2021) identified black-legged kittiwakes as one of the important species in the area, mainly north and south of the planned OWF. In this study, only small numbers were found in the first year, mostly during winter and spring. However, in the second year, higher densities were found in the central part of the pre-investigation area during winter. In general, there was a high interannual variability and some gull species showed a two to threefold increase in their presence in the area. In previous studies, no high concentrations were found for the pre-investigation area. The highest densities were located in coastal areas. However, kittiwakes were found in previous studies in the eastern and northwestern part of the pre-investigation area (PETERSEN et al. 2021).

Common guillemots were the most abundant resting bird species and reached the highest densities found in the planned OWF, especially during autumn and winter in the northeastern and southwestern part of the pre-investigation area, and partly also in the Natura 2000 protected areas of Stora Middelgrund och Röde bank (SE0510186), Store Middelgrund (DK00VA250) and Nordvästra Skånes havsområde (SE0420360), outside of the studied area. However, none of these Natura 2000 protected areas recognise common guillemots as a species of interest or in need of special protective measures, except for Nordvästra Skånes havsområde regarding razorbills, a species within the same group of birds and similar behaviour and phenology in that area of the Baltic Sea. It is known that guillemots/razorbills usually occur in some distance from shore and in deeper waters (PETERSEN & NIELSEN 2011), specially within the Skagerrak and northern Kattegat areas with average densities of > 10 ind./km^2 (SKOV et al. 1992). In the area of studies, average densities for this species have been found at 1 – 10 ind. /km^2 (SKOV et al. 1992), which matches the observed patterns in this study. The seasonal occurrence of the highest densities ranged from end of summer until spring, a similar pattern as in Petersen et al. (2021). This study´s findings suggest the importance of the area for guillemots as they were detected in medium within the limits and in close vicinity of the planned OWF.

6.2 MIGRATING BIRDS

6.2.1 DIURNAL MIGRATION

MOST COMMON SPECIES

After two years of data collection on migrating birds in the pre-investigation area, several generalities were observed. Results of the second year, for example, confirm findings of the first year in terms of the most common species and their migration patterns in the area. In the following, the findings of both seasons (spring and autumn) and both years (2023 and 2024) are discussed.

Spring

In spring, the same number of survey days were conducted in both years (n = 14), but in 2023, almost twice as many birds were registered than in the following year (n = 9,177 vs. 4,806). Nonetheless, the same patterns were observed between the years. The most numerous taxon was geese, representing almost 72% and 58% of all migrating birds observed in spring of each year, respectively. In both years combined, a total of 9,315 geese were observed. When considering both years together, two out of three migrating birds observed were geese. Most geese could be identified and belonged to a single species: barnacle goose, which represented over 95% of all geese seen in spring.

The second most common species group observed in spring were (sea) ducks. Almost the same number of individuals were registered in spring 2023 and 2024 (1,210 vs. 1,234) representing 13% and 26% of all migrating birds, respectively (in 2023 twice as many migrating birds were observed). The common scoter was the most common sea duck observed (representing 81% and 89% of all ducks in the respective years). Common eider and velvet scoter were less abundant.

Autumn

Since the autumn migration season is a month longer (August – November), more survey days were planned for this season. A total of 18 days were surveyed in 2023, and in 2024, surveys were conducted for two more days. In 2023, 3,105 birds were observed, whereas 5,955 migrants were recorded during the 20 survey dates in 2024. In autumn, ducks replaced geese as the most abundant group (50% and 71% of all migrating birds in 2023 and 2024, respectively) while geese came in second (14% and 7.5% of all observed autumn migrants in each year, respectively). The common scoter was the most abundant species and represented 28.6% and 62.6% of all autumn migrants in each year, respectively. Eurasian wigeon (10.9%) was recorded frequently only in the autumn of 2023, whereas only a few dozen wigeons were observed in the autumn of 2024. Common eiders and velvet scoters represented each ~<3% of all migrating birds in each autumn. Of geese, the most common species was the barnacle goose which represented 11.6% of all migrating birds in autumn 2023 and 2.5% of all birds in autumn 2024 and 58% of all geese surveyed in both autumns. Greylag geese were common only in the autumn of 2024 constituting some 35.0% of the 448 geese sighted.

The most abundant species overall was the barnacle goose (*Branta leucopsis*) of which three long-distance migratory populations exist in the Western Palearctic that migrate in spring to their breeding locations in Russia, Svalbard and Greenland. The pre-investigation area is located 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 is estimated to consist of 1,400,000 individuals according to the Waterbirds Populations Portal (http://wpe.wetlands.org, accessed on 16.05.2025) and has steadily increased in numbers since the 1980s (e.g., NILSSON & KAMPE-PERSSON 2020). The recently established breeding populations in the Baltic Sea and along the North Sea Coast (see FEIGE et al. 2008; VAN DER JEUGD et al. 2009) may originally be derived from the Russian population (established through a feral population of Stockholm Zoo). These central-European breeding populations of barnacle geese have then become more or less sedentary, and they share wintering grounds with the migrating Arctic populations. Russian and Baltic Sea populations are expected to occur in large numbers in the study area.

The common scoter (*Melanitta nigra*) was the most abundant duck species and the most common species in autumn. 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 almost year-round, but in particularly high numbers in winter (MENDEL et al. 2008). The main wintering areas are located in the Baltic Sea, the 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 (from June onwards, cf. FOX et al. 2025). The pre-investigation area itself does not constitute an important resting area for these ducks (see section of resting birds), since its waters appear to be too deep for foraging. However, the study area is a transit area for these birds during autumn migration for individuals going towards the northern Kattegat as well as towards southern resting areas. About 25-30 years ago, the northern Kattegat was supposed to have held about 38% of the wintering European population of these birds (DURINCK et al.

1994). This highlights the (former) potential of the habitat as well as the decline of its importance as wintering grounds for these species.

Eurasian wigeons were seen in high numbers only in 2023 and 82% of all wigeons were observed on a single day (October 3rd, 46 ind./h). They were mostly flying towards the southwest and at low 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 eider and velvet scoter) represented together ~ 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 surveys, but also mid-October). The northern Kattegat is known as an important wintering area for several duck species, including common eiders and velvet scoters (DURINCK et al. 1994), it is expected that the pre-investigation area is crossed by them during migration towards the Kattegat.

When combining data of both years, songbirds were the third most abundant taxon after geese and ducks during diurnal migration in spring (5.1%, both years combined) and during autumn (8.2%, both years combined) and they were also the most diverse group: many species were detected in both years (in spring, 30 and in autumn 31). Songbirds were frequently observed in both seasons, but no single species occurred at > 1% of abundance in spring. In autumn, Eurasian siskins (1.2%) wagtails (white and yellow) and meadow pipits were most common in 2023, whereas in 2024, common starlings (3.7%) and chaffinches (1.3%) were most common.

Of other relatively common migrant taxa such as gulls, auks and waders, only gulls occurred frequently and throughout both seasons during diurnal migrations. Three to four species were common in spring: lesser black-backed gull, herring gull and common gull. In addition, relatively many great black-backed gulls were recorded in 2024. Two species were common in autumn: lesser black-backed gull and black-legged kittiwake, whereas common gull and herring gull were less common, even though they occurred regularly. Black-legged kittiwake populations have been declining in the last three decades, and this decline is expected to continue so that the species is considered vulnerable by the IUCN. These species have very different migration patterns. Lesser black-backed gull and herring gull were observed mostly between August and September, whereas kittiwake and common gull were mostly seen between October and November. Migrational directions and altitudes also differed: Lesser black-backed gull flew to the south-southeast, whereas many black-legged kittiwakes and common gulls flew to the northwest. Middelgrunden in the northern Kattegat area is an important bird wintering area for the kittiwake (DURINCK et al. 1994), and the observed direction of flight could coincide with these birds heading to a wintering location nearby.

Few wader species were occasionally common, especially on spring passage. While waders in general were not seen often, many species are considered threatened, because breeding populations in Europe have been declining in the last decades.

Auks is the last group of migrants worth mentioning here. Common guillemot and razorbill were the most common auk species seen in the area, and in autumn 2023, these species represented > 5% of all migrating birds of the season. Spring migrants usually were seen early in the season (March), whereas autumn migrants were seen towards the end of the season (October and November). Flight directions varied considerably, so it may be possible that the auks remain in the area during winter. Previous surveys of the inner Danish waters showed that many auks are present in large numbers in winter in parts of the central Kattegat between Nordsjælland, Anholt, and Læsø with water depths of 20-40 m (PETERSEN & NIELSEN 2011).

Altogether, these six groups of migrants (i.e., geese, ducks, songbirds, gulls, waders, and auks) represented the bulk of migrating birds (>90%) during diurnal migration. Nonetheless, two other species groups need to be mentioned, because they require attention and conservation measurements. Birds of prey, which are of great concern regarding their potential for collision with wind turbines, were only seen rarely (18 individuals in 2023 and 23 individuals in 2024). Cranes (*Grus grus*) may also be at a potential risk to collide with wind turbines during migration as they tend to migrate at rotor height (THERKILDSEN et al. 2012, and see results). In both years of data collection, 63 cranes were observed flying on migration in spring (mainly in March) through the study area heading northeast. Studies conducted further south (Kriegers Flak area, ELLIS & WARBERG BECKER 2015; SKOV et al. 2015) where larger number of cranes might be migrating have nevertheless shown a relatively low risk for collision and comparatively low mortality even when assuming a very low avoidance rate (e.g., 0.69, see Skov et al 2015). A most recent study close to Kriegers Flak and Bornholm using tagged cranes and visual observations from anchored vessels has provided data showing that cranes may show even a stronger avoidance rate (> 0.98) which suggests a much lower risk of collision. Whereas cranes do not seem to avoid passing through the turbines they do seem to be able to modify their flight behaviour with regards to the operating status of the wind turbines (WSP & BIOCONSULT SH 2024). These results agree with the results from another study conducted on an onshore wind farm with cranes exhibiting high avoidance despite flying through the wind farms (DRACHMANN et al. 2021). Nonetheless, collision risk might be higher with unfavourable weather conditions and low visibility, and the possible influence of cumulative impacts when several OWF are built on the migration route of cranes must be considered.

MIGRATION INTENSITIES

Bird migration can be highly variable, and strong variation may be found even if all days were sampled. In cases with strong variation (i.e., high peaks), the use of median values may be more suitable for comparing data than the arithmetic mean, since the median is less sensitive to outliers (MCCLUSKEY & LALHKEN 2007). For example, the daily mean migration intensity obtained from visual observations during spring 2024 was about half of the spring 2023 result (45.8 ind./h vs. 86.3 ind./h). In comparison, the equivalent median intensity rate in spring 2023 was 35.0 ind./h whereas in the following year intensity was much lower (15.3 ind./h). As mentioned previously, peak migration events of geese contributed considerably to this difference: > 752 ind./h were registered on a single date in May 2023, whereas in 2024 the peak migration of geese registered was considerably lower (278 ind./h). Data of both years combined result in a combined median diurnal migration rate of 29.3 ind./h. In the following, this discussion focusses on the three most abundant taxa – geese, ducks, and songbirds – that constituted the predominant part of the observed daytime migration in the study area.

In autumn, many more common scoters were registered during the second year, so migration intensity increased in 2024 from a median of 19.7 in 2023 to 32.8 in 2024. Maximum daily migration rates were also higher in the second year (169 ind./h in August 2024, vs. 104 ind./h in October 2023). Combining data of both years, the median autumn migration was then 28.7 ind./h resulting in similar median values for spring and autumn in the investigation area.

When comparing the migration intensities found in the pre-investigation area with those of other studies, certain patterns can be deduced. There were, in general, lower migration intensities and less variability among daily migration rates in the North Sea area N-7.2 than in the Baltic Sea area. Median spring migration varied between 25 ind./h (in 2019) and 23 ind./h (in 2020) in the N-7.2 area (IBL UMWELTPLANUNG et al. 2021). The Baltic Sea area O-1.3 which is located between the island of Rügen (Germany) and southern Sweden, showed more variable migration intensities as well as the presence of high peak migration events. Median values for spring 2016 were 9.3 but reached 35.4 ind./h in the following spring. When comparing median values from this study with those obtained in the pre-investigation area in Kattegat, the ranges are more similar. Nonetheless, a high migration intensity in spring in the pre-investigation area can be explained by the mass migration events of barnacle geese whose magnitude and occurrence may also vary from year to year.

In autumn, median migration intensities in the North Sea area N-7.2 were 23 ind./h in 2018 and 15.6 ind./h in 2019, whereas the autumn migration intensities in the O-1.3 area were higher (33 ind./h in 2016 and 38.5 ind./h in 2017 (BIOCONSULT SH et al. 2020). Median autumn migration intensities in the Kattegat pre-investigation area varied between 19.7 and 32.8 ind./h in 2023 and 2024, respectively.

Migration intensities and flight patterns of the most important groups varied as well. Barnacle geese were registered on a few dates from the end of March onwards but were mostly seen at the end of the spring season (especially on May 9th, 2023), when a mass migration event occurred with a migration intensity of 752 ind./h was registered. A study using GLS (global location sensor) 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 heading 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 high migration intensities. Indeed, in the second year of investigation, most geese were observed flying on almost the exact date (271 ind./h on the 8th of May 2024). In autumn 2023, most barnacle geese were observed on one date (October 24th, 2023) when intensities of 65 ind./h were observed. In the following year, a maximum of 23.8 ind./h of barnacle geese were registered later in the season (November 8th, 2024).

Whereas geese mostly occurred in May and on relatively few dates, ducks were observed almost on every survey day in the study area (see Results and Appendix). In 2023, there was no mass migration event of ducks, but they were seen at daily intensities varying between 10 ind./h in March to almost 30 ind./h in April. In May, < 5 ind./h were seen. In 2024, a high number of ducks was registered on the 6th of April (98 ind./h), most of them being common scoters, some of them possibly local birds moving about.

In autumn, ducks were abundant, especially common scoter. The species was frequently observed and present on almost all survey dates. In 2023, most birds were observed flying on September 9th and 10th (34 and 29 ind./h) whereas in 2024, many common scoters were surveyed on the 6th of August (156 ind./h) but also a month later on the 3rd of September (91 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 wigeon were only registered in autumn and was only numerous in 2023. Birds were seen in September, October and November. Over 82% of all individuals in 2023 were observed on October 3rd (46 ind./h), in 2024, the maximum migration rate was 4.8 ind./h and observed on September 4th. Thus, the species possibly use the area for resting but also on its migration route.

Songbirds were frequently observed in both seasons, but (daily) migration intensities were larger in autumn compared to spring. In spring, maximum migration intensities of songbirds occurred in April but were larger in 2023 than in 2024 (> 20 ind./h vs. 6 ind./h). In autumn, maximum migration intensities in 2023 occurred on October 3rd at 17.7 ind./h and no songbirds were seen or heard in the last week of November. November survey dates of 2024 took place in the first week of November and registered large amounts of songbirds both during days and nights. Maximum migration rates of songbirds in 2024 also occurred in mid-October (>41.6 ind./h on October 12th).

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, whereas unfavourable weather conditions for longer periods will often lead to mass migration events with high migration intensities once the weather turns favourable.

Migration intensities according to the vertical radar during daytime were of similar levels in the spring (median MTR of 20.7 and 20.5 in 2023 and 2024, respectively) and autumn 2023 (median MTR of 20.4). The median values were only in autumn 2024 larger reaching 36 MTR. Whereas vertical radar data cannot be directly compared to results obtained from observer-based data, certain congruence especially in the phenology can be observed. Nonetheless, vertical radar did not detect any of the strong (geese) migration events in May (9th and 8th of May). This could 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 large birds like geese (several kilometres). In addition, the resolution of the radar data can cause this 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 thus causing a large difference between the number of sighted individuals and the number of radar echoes. This clearly illustrates the advantages of combining the two methodologies (radar and observer-based surveys).

FLIGHT DIRECTIONS

During spring, the main migration direction of all visually observed birds was clearly northeast, as expected. This overall direction was mostly influenced by the direction of flight shown by the most common species, e.g., barnacle goose. Other species groups moved only partially to the northeast (e.g., ducks, songbirds, gulls, cormorants) with some noteworthy differences in flight directions in some important groups. Ducks flew to the southeast mainly in 2024 but in the previous year only 21% flew in that direction and the rest of the ducks were seen flying in all other directions at similar proportions. This might indicate that some of these ducks were only commuting between resting or foraging sites. The clear northeasterly direction observed in most migrating birds, however, met the expectations of birds crossing the central Kattegat on the shortest possible route across the sea when moving between the wintering areas in southern Europe and the breeding areas in northern Scandinavia and Russia. Very few bird signals were available from horizontal radar in 2023, and when adding horizontal radar data from 2024, main directions were northeast and northwest. Nonetheless, the migration direction of signals during nocturnal migration is in accordance with the main direction of migration observed during the observer-based surveys.

Flight directions obtained from horizontal radar signals recorded during diurnal and nocturnal migration differed especially in autumn. During daytime, most of radar signals indicated a north-westerly and northerly direction, whereas at night the signals were mainly showing birds flying towards SW and SE. Although there appears to be a mismatch, the results of the radar are in accordance with the observer-based data. The radar signals analysed belonged to data from August and September, as most other data were not analysable (see Methods). Hence, during nocturnal migration, the data portray mostly passerine migration and its directions, which according to the literature fly to the SW, and - to a lesser extent - towards the SE.

FLIGHT ALTITUDES

Given the differences in species composition observed during the seasons, comparatively many more birds were flying at higher altitudes in spring than in autumn. Almost 60% of bird flights visually observed in the pre-investigation area during spring occurred at altitudes between 0 and 20 m, with most (46%) occurring at very low altitudes (0-5 m). However, in autumn this proportion was much higher: 85% of all migrating birds in the season flew below 20 m of altitude. While in spring, ~25% of all birds flew at higher altitude classes (> 50 m), in autumn only 5% of all birds flew at these high altitudes. Looking at the group-specific altitudinal data, these differences were largely influenced by the flying behaviour of the most common species in each season. In spring, a significant proportion of the migrating geese were flying at altitudes potentially coinciding with rotor height (> 20 m, 54%). In autumn, they also flew high, but in comparison, geese were not that numerous. 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).

In autumn, most observed birds (> 85%) flew below 20 m of altitude. These were mainly ducks, auks, most passerines and a large number of gulls and other groups. Ducks, as the most numerous group seen in autumn, flew very low: 95% of all ducks observed in spring and autumn flew below 20 m. The only species groups seen migrating at higher altitudes were geese and swans (50% of geese and 43% of swans flew between 50 – 200 m).

It should be mentioned that the flight height distribution based on visible observation at higher altitudes is limited to larger birds (such as geese or ducks) that can still 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 necessary in addition.

Data from vertical radar provide altitude distributions up to 1000 m with the advantage that this can also be done during night. The diurnal distribution of altitude from vertical radar data supports the findings of observers, that, in general, a larger proportion of birds were observed in the lowest altitude layer and that the proportion of birds flying at lower altitudes in autumn was larger than in spring. The density of bird signals decreased with increasing altitude but remained at 10% up to 400 m in spring and then remained at 6-7% for each subsequent altitude layer. In autumn, however, the proportion of bird signals reached only in the second altitude layer (100-200 m) approx. 13% and then decreased constantly with altitude. At the top layer the density increased slightly, probably because during nocturnal migration also in autumn there was a larger proportion of birds flying in the top layers (see below).

TEMPORAL PATTERNS

Despite its high degree of variability, bird migration displays some temporal patterns throughout the migration seasons and through the daily cycle that are important to note. In general, nocturnal migration is far more intense than diurnal, and autumn migration is stronger than spring migration. The former effect can be explained by the species-specific composition of migrants and the latter by their age-specific composition. Songbirds are the most abundant breeding birds in the subarctic and – possibly to avoid predators – prefer to migrate in darkness. Furthermore, depending on the annual breeding success, their autumn numbers can swell by the factor 2 to 4, compared to spring. This population increase is usually reduced by subsequent mortality on migration or in the wintering areas.

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 third 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 were 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. In autumn, 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.

6.2.2 NOCTURNAL MIGRATION

Many species of nocturnally migrating birds produce species-specific flight calls during the migration. Such calls are thought to serve different functions, such as flock maintenance, orientation and stimulation of migration activity (FARNSWORTH 2005). Because direct observations of nocturnal migrants are almost impossible to obtain, the recording of flight calls is often used to study nocturnal migration as the only method that provides taxonomic information on the migrating species (WELCKER & VILELA 2018). The analysis of flight calls recorded in the study area showed that songbirds were the most abundant group during nocturnal migration (considering 2023 and 2024 together, songbirds represented 94% of all calls in spring and 96% in autumn), with other groups such as geese, wader and gulls occurring less often.

It is well known that the bulk of migration movements occurs at night (ALERSTAM 1990) and that such night movements are 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 to number about 200-300 million in spring to cross the western Baltic Sea and the Kattegat (BELLEBAUM et al. 2010a).

Since not all bird species vocalise during migration, results obtained from the analysis of flight calls provides only additional information on species composition and relative frequency of their abundances as well as the temporal activity pattern. However, call rates (i.e., calls per hour) are compared with migration rates (i.e., MTR as individuals per hour and kilometre), since flight calls may be affected by time of the day and atmospheric conditions among others (FARNSWORTH 2005; HÜPPOP & HILGERLOH 2012). However, it is impossible to know whether calls may be produced by different individuals or the same individual.

The number of nocturnal calls recorded in spring of both years was extremely variable, possibly reflecting migrational altitudes due to predominant weather. Whereas in the first spring only 179 flight calls were heard, in the following year 7,722 flight calls were registered. This can partly be explained by the fact that in 2024, many more survey nights were available. Nevertheless, it shows that the number of nocturnal calls does not necessarily relate to the intensity of bird migration during those nights. However, the identification of bird taxa most commonly heard can still provide an indication of some species-specific proportions of nocturnal migrants and their passage times.

When combining data of all four migration seasons (i.e., spring 2023 till autumn 2024), about four out of five flight calls came from thrushes. Thrushes are mainly represented by five species and were early in spring and late in autumn more common than any other songbird family. In spring, the most common thrushes were blackbird (only found in 2024) and redwing which represented about 61% and 14% of all calls heard in both years in spring, respectively. Calls of sky larks and European robins were also frequent (13% and 7%). In 2023, most songbirds were heard migrating at the beginning of the spring (March) because 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). In 2024, three five-night survey periods were conducted during spring, one at the beginning of each month. Nonetheless, again most nocturnal songbirds were heard at the beginning of March and not in April. There was a progressive decrease of perceived calls heard throughout the season. At the North Sea island of Heligoland, which lies some 230 km southwest of the study area on the migratory flyway of many songbirds, the mean spring migration passage dates for redwing, European robin and song thrush have been estimated to take place at April 6th, 16th and 20th, respectively, whereas that of blackbird is estimated to be the 26th of March (HAEST et al. 2018).

The number of nocturnal flight calls in autumn was almost identical in both years. In 2023, 3,132 calls were heard and 3,162 calls in 2024. Thrushes were again very abundant, although the proportions of each species in each year differed. For example, song thrushes were much more common than blackbirds in 2023, but in 2024, the opposite was true. When combining both years, song thrush was the most numerous species, representing 41% of all calls. Blackbird and redwing represented about 26% and 23% of all songbirds calls during that season. Robin was the only species that was relatively common (7% of all songbirds calls of both years). In 2023, most of audible 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). In 2024, however, most calls of thrushes and robins were heard on the 7th of November, when > 190 calls/h of songbirds were heard. Comparatively fewer songbird calls were heard during the survey of October which took place a month earlier, and closer to the date at which most calls were heard in the previous year.

Results of the vertical radar confirmed that there often is a high migration intensity during nights. Migration intensity detected with vertical radars during night was between three (in autumn) and seven times (in spring) stronger than during daylight, when comparing the median intensities of both years. Nonetheless, the migration intensities recorded by vertical radar and nocturnal calls heard by observers do not correlate well. In 2023, there appeared to be a good match of the calls heard with the results of vertical radar, but the proportions did not coincide. Vertical radar indicated a much larger activity in April than it was estimated from the observer data.

One must, however, keep in mind that the radar is able to detect signals that extend much higher into the vertical space (up to 1000 m of altitude), whereas calls might be able to accurately be heard when they are relatively close to the ship and not much higher. Nonetheless, there were also some coincidences with the radar data in autumn. The night of October 5th, 2023 provided the highest number of calls heard as well as the strongest migration intensity registered by vertical radar. Similarly, during the night of 7th of November 2024 strong signals were also detected by the vertical radar and peak calling activity. Nonetheless, a peak in October was not detected as a night with high numbers of calls by the observers. This again emphasizes the fact that most nocturnal migration may be missed when only using night calls to detect it and that a great proportion of nocturnal migration occurs at very high altitudes. Flight directions detected by the horizontal radar coincided with the expected direction taken by most songbirds, the group that is most numerous at nights and thus, probably most commonly detected by the radar.

7 DATA AND KNOWLEDGE GAPS

Resting birds:

The present study indicates that there is already a comprehensive understanding of the bird species that regularly occur within the pre-investigation area of the proposed Hesselø OWF. Moreover, the analysis of data collected in the field between February 2023 and December 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. This information is of utmost importance in order to make a strong assessment of the potential environmental impacts of Hesselø´s OWF development.

In this study, a total twelve digital aerial surveys were conducted covering an area of 4,120.7 km² with an approximated 11.7 % of coverage of the targeted area. 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 "snapshot" method since the distribution of seabirds is only observed during the specific and relatively short 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, the results from the surveys of resting birds in the Hesselø area are in accordance with the existing knowledge but can also depict much more precise details on the presence of birds inside and outside the proposed OWF area. 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 to be able to draw better conclusions about seasonal and spatial distribution patterns.

Migrating birds:

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 provides 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. Results of the second year of analysis between March and November 2024 have made it possible to get a better understanding of the annual variability in abundances and distribution patterns but nonetheless have validated the results of the first year of investigation strengthening the conclusions of this study. Nonetheless, results have also pointed out to the possibility of missing critical migration periods, due to a lack of predictability for peak migration events. Also, it is possible to overlook less conspicuous species as well as vulnerable and endangered species which may be rarely detected and need a much longer study period. Our study also cannot assess cumulative effects along migration routes and how further development of OWF may affect bird migration. In addition, changes in migration time and routes due to climate change may increase over time and are still not fully understood.

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 species 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 and common eiders being the most frequently observed species, which mostly aggregated at the tip of Sjællands Odde.

However, a noticeable decrease in common scoters´s detection during the second year of monitoring could have revealed interannual spatial variability for this species. 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 when compared to existing data. The same applies to common guillemots, which were present in large numbers across the entire pre-investigation area, particularly in winter.

The results showed that the observed distribution patterns and abundances of recorded species were mostly in line with already published data, thus confirming described patterns, but also showing higher than expected densities for divers and guillemots. The study provides information on specific seasonal distributions and abundances at a finer temporal and spatial level than previous work.

Migrating birds:

Results of the second year of investigations confirmed the major findings and despite the expected variability of bird migration, the main patterns observed in the first year also hold for the second year of investigation. 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 (mainly common scoters) were frequently observed. These two species dominated migration during daytime, occurring in high numbers, especially 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 all altitudes including higher altitudes well above 50 m.

Especially in spring, most geese were registered on a single migration day (09.05. in 2023 and 08.05. in 2024), 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).

Very few cranes were registered and only during spring migration, most of them in the first year during two days at the beginning of spring 2023 (56 individuals) and at the end of the spring 2024 (only 7 individuals). Cranes were flying in the expected NE direction, however, the number of individuals registered (63 in total), 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 preferred flying height (potentially putting them at risk with wind turbines collision) and their status as a protected species, it is worth mentioning that some crane migration was observed in the pre-investigation area. On the other hand, very few birds of prey were observed, both in the first (18 individuals) and second (23 individuals) year and mainly in autumn.

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, especially in the first year due to a large migration event in May. 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. In addition, in autumn 2024, strong nocturnal migration was registered in the very upper altitude classes (> 800 m). 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 scoter.

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10 APPENDIX

10.1 RESTING BIRDS

Table A 1. Species list of all birds detected during the six digital aerial surveys between February and December 2024 in the pre-investigation areas Kattegat II/Hesselø. 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	660	I	LC	LC	B 2e
	Black-throated diver	Sortstrubet lom	Gavia arctica	R/M	14	I	LC	LC	B 2c
	Great northern diver	Islom	Gavia immer	R/M	1	I	LC	LC	A 1c
	unidentified diver	NA	Gavia sp.	R/M	15	NA	NA	NA	NA
Grebes	Great crested grebe	Toppet lappedykker	Podiceps cristatus	R/M	23	NA	LC	LC	C 1
	Red-necked grebe	Gråstrubet lappedykker	Podiceps grisegena	R/M	1	NA	VU	VU	A 3c
	Slavonian grebe	Nordisk lappedykker	Podiceps auritus	R/M	12	I	NT	VU	A 1b 1c
	Red-necked grebe / Great crested grebe	Na	Podiceps grisegena/Podiceps cristatus	R/M	1	NA	NA	NA	NA
	unidentified grebe	Na	Podicipedidae sp.	R/M	7	NA	NA	NA	NA
Tubenose	Northern fulmar	Mallemuk	Fulmarus glacialis	R/M	3	NA	VU	EN	NA
Gannets	Northern gannet	Sule	Morus bassanus	R/M	59	NA	LC	LC	C 1
Cormorants	Great cormorant	Skarv	Phalacrocorax carbo	R/M	403	NA	LC	LC	C 1
Herons	Grey heron	Fiskehejre	Ardea cinerea	M	2	NA	LC	LC	C 1
Swans	Whooper swan	Sangsvane	Cygnus cygnus	M	2	I	LC	LC	C 1
Grebes	Greylag goose	Grågås	Anser anser	M	5	NA	LC	LC	C 1 / B 1
	Barnacle goose	Bramgås	Branta leucopsis	M	33	I	LC	LC	C 1
	Brent goose	Knortegås	Branta bernicla	M	1	NA	LC	LC	NA
	Common shelduck	Gravand	Tadorna tadorna	M	1	NA	LC	LC	B 2a
Ducks	Common eider	Ederfugl	Somateria mollissima	R/M	548	NA	EN	VU	A 4

Species groups	Common names in		Scientific names	Resting / Migratory	Number of ind.	Conservation/Protection categories			
	English	Danish				Birds Dir	UICN	EU Cat 28	AEWA
	Long-tailed duck	Havlit	Clangula hyemalis	R/M	21	NA	LC	LC	A 1b
	Common scoter	Sortand	Melanitta nigra	R/M	138	NA	LC	N/A	B 2a
	Velvet scoter	Fløjlsand	Melanitta fusca	R/M	13	NA	VU	VU	A 1b
	Common goldeneye	Hvinand	Bucephala clangula	M	1	NA	LC	LC	B 2c
	Red-breasted merganser	Toppet skallesluger	Mergus serrator	M	144	NA	NT	NT	B 2c
	Unidentified duck	Na	Anatinae sp.	M	13	NA	NA	NA	NA
Birds of prey	European honey-buzzard	Hvepsevåge	Pernis apivorus	M	1	I	LC	LC	NA
	Eurasian marsh harrier	Rørhøg	Circus aeruginosus	M	2	I	LC	LC	NA
	Eurasian sparrowhawk	Spurvehøg	Accipiter nisus	M	11	I *	LC	LC	NA
	Common kestrel	Tårnfalk	Falco tinnunculus	M	2	NA	LC	LC	NA
	Merlin	Dværgfalk	Falco columbarius	M	1	I	VU	VU	NA
Waders	European golden plover	Hjejle	Pluvialis apricaria	M	1	I	LC	LC	C 1
	unidentified wader	Na	Limicolae	M	16	NA	NA	NA	NA
Skuas	Great skua	Storkjove	Stercorarius skua	R/M	1	NA	LC	LC	B 1
	Arctic / Pomarine skua	Na	Stercorarius parasiticus/Stercorarius pomarinus	R/M	1	NA	NA	NA	NA
Gulls	Little gull	Dværgmåge	Hydrocoloeus minutus	R/M	2	I	LC	LC	A (3c 3e)
	Black-headed gull	Hættemåge	Chroicocephalus ridibundus	R/M	95	NA	LC	VU	B 2c
	Common gull	Stormmåge	Larus canus	R/M	503	NA	LC	LC	B 2c
	Unidentified small gull	Na	Larus small sp.	R/M	30	NA	NA	NA	NA
	Lesser black-backed gull	Sildemåge	Larus fuscus	R/M	235	NA	LC	LC	A 3c / B 2e / C1
	Herring gull	Sølvmåge	Larus argentatus	R/M	614	NA	LC	VU	B 2c 2e /C1
	Great black-backed gull	Svartbag	Larus marinus	R/M	122	NA	LC	NT	B 2c

Species groups	Common names in		Scientific names	Resting / Migratory	Number of ind.	Conservation/Protection categories			
	English	Danish				Birds Dir	UICN	EU Cat 28	AEWA
	Common gull / Herring gull	Na	Larus argentatus/Larus canus	R/M	12	NA	NA	NA	NA
	Unidentified large gull	Na	Larus (magnus) sp.	R/M	17	NA	NA	NA	NA
	Great black-backed gull / Lesser black-backed gull	Na	Larus fuscus/Larus marinus	R/M	3	NA	NA	NA	NA
	Unidentified Larus gull	Na	Larus sp.	R/M	3	NA	NA	NA	NA
	Black-legged kittiwake	Ride	Rissa tridactyla	R/M	341	NA	VU	EN	A 1b
	Unidentified gull	Na	Laridae sp.	R/M	33	NA	NA	NA	NA
Terns	Sandwich tern	Splitterne	Thalasseus sandvicensis	R/M	1	I	LC	LC	C 1
	Common tern / Arctic tern	Na	Sterna hirundo/Sterna paradisaea	R/M	12	I	NA	NA	C 1
Auks	Common guillemot	Lomvie	Uria aalge	R/M	4729	I *	LC	LC	C 1 / B 1
	Common guillemot / razorbill	Na	Uria aalge / Alca torda	R/M	312	NA	NA	NA	NA
	Razorbill	Alk	Alca torda	R/M	307	NA	LC	LC	C 1
	Black guillemot	Tejst	Cepphus grylle	R/M	139	NA	LC	LC	B 1
	Atlantic puffin	Lunde	Fratercula arctica	R/M	3	NA	EN	LC	A 1b
	unidentified auk	Na	Alcidae sp.	R/M	176	NA	NA	NA	NA
Pigeons	Feral pigeon	Na	Columba livia domestica	M	1	NA	NA	NA	NA
	Stock pigeon	Huldue	Columba oenas	M	2	NA	LC	LC	NA
	Common wood pigeon	Ringdue	Columba palumbus	M	56	I *	LC	LC	NA
Songbirds	Grey wagtail	Bjergvipstjert	Motacilla cinerea	M	2	NA	LC	LC	NA
	Chaffinch	Bogfinke	Fringilla coelebs	M	13	I *	LC	LC	NA
	Brambling	Kvækerfinke	Fringilla montifringilla	M	3	NA	LC	LC	NA
	Common redpoll	Stor gråsisken	Acanthis flammea	M	7	NA	LC	LC	NA
	Unidentified bird	Na	Aves sp	M	121	NA	NA	NA	NA
	Unidentified songbird	Na	Passerine sp	M	377	NA	NA	NA	NA

Species groups	Common names in		Scientific names	Resting / Migratory	Number of ind.	Conservation/Protection categories			
	English	Danish				Birds Dir	UICN	EU Cat 28	AEWA
-	No animal sighting	Na	No animal sighting	M	93	NA	NA	NA	NA
Total					10,428				

10.2 MIGRATING BIRDS

Table A-2: Species list of all migrating birds observed (diurnal migration, visual observations) during the surveys in spring and autumn 2023 and 2024 in the pre-investigation area Kattegat and Hesselø. The table also indicates if a species is listed under one of the four conservation categories of Table A-4 (Annex I of the Bird Directive, EN, VU or NT of the IUCN and Birdlife categories and category A of the AEWA convention)

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Divers	Red-throated diver	x	12	12	24	18	51	69
Divers	Black-throated diver	x	14	2	16	0	0	0
Divers	White-billed diver	x	1	0	1	0	0	0
Divers	unidentified diver		32	5	37	6	32	38
Grebes	Great crested grebe		0	3	3	0	0	0
Grebes	Red-necked grebe	x	1	1	2	0	1	1
Grebes	unidentified grebe		3	0	3	0	1	1
Tubenoses	Northern fulmar	x	0	2	2	3	4	7
Tubenoses	Sooty shearwater		0	0	0	0	1	1
Gannets	Northern gannet		27	53	80	124	51	175
Cormorants	Great cormorant		180	57	237	68	96	164
Herons	Grey heron		1	2	3	5	13	18
Swans	Mute swan		2	0	2	0	0	0
Swans	Whooper swan	x	9	0	9	109	46	155
Swans	unidentified swan		17	0	17	0	20	20
Geese	unidentified goose		68	67	135	30	74	104
Geese	Bean goose	x	25	0	25	0	0	0

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Geese	Greater white-fronted goose	?	0	0	0	0	10	10
Geese	Greylag goose		155	35	190	17	157	174
Geese	Canada goose		0	0	0	13	40	53
Geese	Barnacle goose	x	6,235	2,642	8,877	361	151	512
Geese	Brent goose		80	2	82	19	16	35
Geese	Common shelduck		5	1	6	0	0	0
Ducks	Eurasian wigeon	x	0	0	0	337	54	391
Ducks	Eurasian teal		1	0	1	0	2	2
Ducks	Mallard		0	2	2	2	3	5
Ducks	Northern pintail	x	0	0	0	18	8	26
Ducks	Northern shoveler	x	0	2	2	0	0	0
Ducks	Greater scaup	x	0	0	0	25	0	25
Ducks	Common eider	x	84	28	112	78	164	242
Ducks	Long-tailed duck	x	36	1	37	3	0	3
Ducks	Common scoter		981	1,093	2,074	887	3,728	4,615
Ducks	Common scoter / velvet scoter		0	13	13	0	48	48
Ducks	Velvet scoter	x	50	48	98	76	177	253
Ducks	Common goldeneye		0	0	0	3	0	3
Ducks	Red-breasted merganser	x	14	15	29	1	0	1
Ducks	unidentified merganser / goosander		0	1	1	0	0	0
Ducks	unidentified duck		44	31	75	136	42	178

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Birds of prey	European honey-buzzard	x	2	0	2	0	0	0
Birds of prey	Red kite		0	1	1	0	0	0
Birds of prey	Western marsh harrier	x	0	0	0	2	1	3
Birds of prey	Hen harrier	x	1	0	1	1	1	2
Birds of prey	unidentified harrier		0	0	0	0	2	2
Birds of prey	Eurasian sparrowhawk		6	1	7	0	6	6
Birds of prey	Common buzzard		0	0	0	0	2	2
Birds of prey	unidentified Buteo buzzard		1	0	1	0	0	0
Birds of prey	unidentified bird of prey		1	0	1	0	1	1
Birds of prey	Common kestrel		2	0	2	0	6	6
Birds of prey	Merlin	x	1	0	1	1	1	2
Birds of prey	Eurasian hobby		0	0	0	0	1	1
Cranes	Common crane	x	56	7	63	0	0	0
Waders	Eurasian oystercatcher	x	0	2	2	0	0	0
Waders	Ringed plover		0	0	0	17	0	17
Waders	European golden plover	x	0	200	200	10	16	26
Waders	Grey plover		0	0	0	1	0	1

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Waders	Red knot	x	0	0	0	8	0	8
Waders	Sanderling		1	0	1	0	0	0
Waders	Purple sandpiper	x	0	0	0	0	2	2
Waders	Dunlin	x	0	0	0	7	0	7
Waders	Ruff	x	0	0	0	2	0	2
Waders	Snipe	x	0	0	0	0	4	4
Waders	Bar-tailed godwit	x	0	0	0	0	13	13
Waders	Whimbrel		0	18	18	7	1	8
Waders	Eurasian curlew	x	128	0	128	0	0	0
Waders	Common redshank	x	2	0	2	0	0	0
Waders	Common sandpiper		0	0	0	0	1	1
Waders	unidentified wader		0	1	1	0	3	3
Skuas	Arctic skua	x	2	0	2	1	1	2
Skuas	Great skua		0	0	0	4	0	4
Skuas	unidentified skua		0	1	1	0	0	0
Gulls	Little gull	x	2	0	2	0	1	1
Gulls	Black-headed gull	x	30	3	33	3	17	20
Gulls	Common gull		62	20	82	17	48	65
Gulls	Lesser black-backed gull	x	53	79	132	152	104	256
Gulls	Herring gull	x	43	79	122	16	28	44
Gulls	Caspian gull		0	1	1	0	0	0
Gulls	Great black-backed gull	x	10	40	50	13	12	25

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Gulls	unidentified large gull		0	1	1	0	0	0
Gulls	Black-legged kittiwake	x	0	0	0	45	64	109
Gulls	unidentified gull		9	7	16	7	1	8
Terns	Sandwich tern	x	7	0	7	3	18	21
Terns	Common tern	x	2	0	2	0	29	29
Terns	Common tern / Arctic tern	x	28	0	28	0	0	0
Terns	Black tern	x	0	0	0	1	0	1
Terns	unidentified tern		0	9	9	0	22	22
Auks	Common guillemot		12	22	34	69	21	90
Auks	Common guillemot / razorbill		5	15	20	36	10	46
Auks	Razorbill		57	20	77	66	16	82
Auks	Black guillemot		10	1	11	12	2	14
Auks	Little auk	x	0	0	0	1	1	2
Auks	Atlantic puffin	x	1	0	1	0	0	0
Auks	unidentified auk		2	2	4	14	4	18
Pigeons	Feral pigeon		0	0	0	1	0	1
Pigeons	Common wood pigeon		1	1	2	0	2	2
Owls	Short-eared owl	x	0	1	1	0	2	2
Nightjars	European nightjar	x	0	1	1	0	0	0
Swifts	Common swift	x	3	0	3	1	4	5
Songbirds	Sky lark		10	7	17	2	19	21

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Songbirds	Sand martin		0	1	1	0	0	0
Songbirds	Barn swallow		24	8	32	5	2	7
Songbirds	unidentified swallow / martin		6	1	7	3	0	3
Songbirds	Olive-backed pipit		0	0	0	2	0	2
Songbirds	Tree pipit		0	1	1	6	0	6
Songbirds	Meadow pipit		82	44	126	27	2	29
Songbirds	unidentified pipit		3	2	5	0	0	0
Songbirds	Yellow wagtail		0	0	0	21	8	29
Songbirds	Grey wagtail		0	1	1	0	0	0
Songbirds	White wagtail / pied wagtail		7	30	37	31	5	36
Songbirds	Winter wren		2	2	4	3	1	4
Songbirds	Hedge accentor		1	0	1	0	0	0
Songbirds	European robin		0	1	1	3	0	3
Songbirds	Common redstart		0	0	0	4	0	4
Songbirds	Northern wheatear	x	0	0	0	1	0	1
Songbirds	Common blackbird		0	1	1	1	0	1
Songbirds	Song thrush		1	0	1	0	0	0
Songbirds	Redwing		3	0	3	2	0	2
Songbirds	unidentified thrush		1	0	1	0	0	0
Songbirds	Icterine warbler		0	0	0	1	0	1
Songbirds	Lesser whitethroat		0	0	0	2	0	2
Songbirds	Garden warbler		0	0	0	1	0	1
Songbirds	Blackcap		0	0	0	2	0	2

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Songbirds	Common chiffchaff		4	5	9	5	0	5
Songbirds	unidentified leaf warbler		1	0	1	0	0	0
Songbirds	Goldcrest		0	0	0	10	1	11
Songbirds	Pied flycatcher		0	0	0	1	0	1
Songbirds	Blue tit		0	0	0	7	0	7
Songbirds	Eurasian jackdaw		48	0	48	0	0	0
Songbirds	Rook	x	3	3	6	0	0	0
Songbirds	Crow		2	0	2	0	0	0
Songbirds	Carrion Crow		1	0	1	0	0	0
Songbirds	Hooded crow		7	0	7	0	0	0
Songbirds	Common raven		2	0	2	0	0	0
Songbirds	unidentified crow		5	1	6	0	1	1
Songbirds	Common starling		17	6	23	14	220	234
Songbirds	Chaffinch		7	0	7	3	78	81
Songbirds	Brambling		22	3	25	5	2	7
Songbirds	unidentified *Fringilla* finch		39	0	39	0	138	138
Songbirds	European serin		0	0	0	0	1	1
Songbirds	European greenfinch		0	0	0	1	0	1
Songbirds	European goldfinch		3	3	6	0	0	0
Songbirds	Eurasian siskin		13	0	13	37	1	38
Songbirds	Common linnet		1	6	7	1	0	1
Songbirds	Twite	x	0	0	0	0	4	4

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Songbirds	Lesser redpoll		0	0	0	1	0	1
Songbirds	unidentified *Carduelis* finch		17	0	17	0	0	0
Songbirds	Snow bunting		9	0	9	0	0	0
Songbirds	Reed bunting		6	0	6	1	1	2
Songbirds	unidentified songbird		213	29	242	45	13	58
TOTAL			9,177	4,806	13,983	3,105	5,955	9,060

Table A-3: Species list of all migrating birds heard (nocturnal migration, flight calls) during the surveys in spring and autumn 2023 and 2024 in the pre-investigation area Kattegat and Hesselø.

Species groups	English names	Conservation category	Spring (Kattegat)			Autumn (Hesselø)		
			2023	2024	Total	2023	2024	Total
Divers	Red-throated diver	x	0	0	0	0	15	15
Herons	Grey heron		0	17	17	1	0	1
Geese	Barnacle goose	x	12	0	12	0	0	0
Geese	Common shelduck		0	4	4	0	0	0
Ducks	Eurasian wigeon	x	0	34	34	0	0	0
Ducks	Common scoter		0	43	43	0	0	0
Waders	Eurasian oystercatcher	x	3	96	99	60	0	60
Waders	Ringed plover		0	0	0	41	0	41

Waders	European golden plover	x	0	6	6	0	2	2
Waders	Grey plover		0	0	0	2	0	2
Waders	Northern lapwing	x	0	98	98	0	0	0
Waders	Dunlin	x	0	1	1	0	0	0
Waders	Snipe	x	0	0	0	13	0	13
Waders	Eurasian woodcock		0	0	0	0	1	1
Waders	Eurasian curlew	x	0	15	15	0	0	0
Waders	Common greenshank		0	0	0	3	0	3
Waders	Wood sandpiper	x	0	3	3	0	0	0
Waders	Common sandpiper		2	18	20	37	16	53
Waders	unidentified wader		1	4	5	3	2	5
Gulls	Black-headed gull	x	0	10	10	0	0	0
Gulls	Common gull		2	65	67	0	0	0
Gulls	Lesser black-backed gull	x	0	0	0	10	0	10
Gulls	Herring gull	x	0	14	14	9	1	10
Gulls	Great black-backed gull	x	0	1	1	0	0	0
Gulls	Black-legged kittiwake	x	0	0	0	0	2	2
Gulls	unidentified gull		1	1	2	1	4	5
Terns	Common tern	x	0	0	0	0	13	13
Pigeons	Common wood pigeon		0	11	11	0	0	0
Songbirds without thrushes	Sky lark		3	964	967	0	0	0

Songbirds without thrushes	Tree pipit		0	30	30	15	0	15
Songbirds without thrushes	Meadow pipit		2	1	3	0	3	3
Songbirds without thrushes	Yellow wagtail		0	0	0	0	21	21
Songbirds without thrushes	Hedge accentor		0	0	0	1	0	1
Songbirds without thrushes	European robin		28	489	517	95	348	443
Songbirds without thrushes	Northern wheatear	x	0	1	1	0	0	0
Thrushes	Common blackbird		0	4,563	4,563	13	1,558	1,571
Thrushes	Fieldfare		0	0	0	5	4	9
Thrushes	Song thrush		12	63	75	2,419	57	2,476
Thrushes	Redwing		71	960	1,031	300	1,085	1,385
Thrushes	Mistle thrush		5	44	49	2	1	3
Thrushes	unidentified thrush		1	9	10	1	0	1
Songbirds without thrushes	Common chiffchaff		10	47	57	0	0	0
Songbirds without thrushes	unidentified leaf warbler		1	0	1	0	0	0
Songbirds without thrushes	Goldcrest		1	0	1	0	0	0
Songbirds without thrushes	Great tit		0	1	1	0	0	0

Songbirds without thrushes	Common starling		0	96	96	0	0	0
Songbirds without thrushes	Chaffinch		7	6	13	0	0	0
Songbirds without thrushes	Brambling		0	1	1	4	0	4
Songbirds without thrushes	Reed bunting		3	0	3	0	13	13
Songbirds without thrushes	unidentified songbird		14	6	20	97	16	113
TOTAL			179	7,722	7,901	3,132	3,162	6,294

Table A-4: Species list of all migrating birds observed (diurnal migration, visual observations) and heard (nocturnal migration, flight calls) during the surveys in spring 2023 in the pre-investigation area Kattegat and Hesselø. 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.

Species groups	Common names in		Scientific names	Conservation/Protection categories				Investigation area		Type of data	
	English	Danish		Birds Dir	UICN	EU Cat 27 + UK	AEWA	Spring (Kat)	Autumn (Hes)	Visual obs.	Night calls
Divers	Red-throated diver	Rødstrubet Lom	*Gavia stellata*	I	LC	LC	B 2e	x	x	x	x
Divers	Black-throated diver	Sortstrubet Lom	*Gavia arctica*	I	LC	LC	B 2c	x		x	
Divers	White-billed diver	Hvidnæbbet Lom	*Gavia adamsii*		N/A	VU	A 1c	x		x	
Grebes	Great crested grebe	Toppet Lappedykker	*Podiceps cristatus*		LC	LC	C 1	x		x	
Grebes	Red-necked grebe	Gråstrubet Lappedykker	*Podiceps grisegena*		VU	VU	A 3c	x	x	x	
Tubenoses	Northern fulmar	Mallemuk	*Fulmarus glacialis*		VU	EN		x	x	x	
Tubenoses	Sooty Shearwater	Sodfarvet Skråpe	*Ardenna grisea*						x	x	
Gannets	Northern gannet	Sule	*Morus bassanus*		LC	LC	C 1	x	x	x	
Cormorants	Great cormorant	Skarv	*Phalacrocorax carbo*		LC	LC	C 1	x	x	x	
Herons	Grey heron	Fiskehejre	*Ardea cinerea*		LC	LC	C 1	x	x	x	x

Swans	Mute swan	Knopsvane	*Cygnus olor*		LC	LC	C 1	x		x	
Swans	Whooper swan	Sangsvane	*Cygnus cygnus*	I	LC	LC	C 1	x	x	x	
Geese	Bean goose	Tajgasædgås	*Anser fabalis*		VU	LC	A 3c*	x		x	
Geese	Greater white-fronted goose	Blisgås	*Anser albifrons*	I *	LC	LC	C 1		x	x	
Geese	Greylag goose	Grågås	*Anser anser*		LC	LC	C 1 / B 1	x	x	x	
Geese	Canada goose	Canadagås	*Branta canadensis*		LC	N/A			x	x	
Geese	Barnacle goose	Bramgås	*Branta leucopsis*	I	LC	LC	C 1	x	x	x	x
Geese	Brent goose	Knortegås	*Branta bernicla*		LC	LC		x	x	x	
Ducks	Common shelduck	Gravand	*Tadorna tadorna*		LC	LC	B 2a	x		x	x
Ducks	Eurasian wigeon	Pibeand	*Mareca penelope*		LC	VU	B 2c	x	x	x	x
Ducks	Eurasian teal	Krikand/Amerikansk Krikand	*Anas crecca*		LC	LC	C 1	x	x	x	
Ducks	Mallard	Gråand	*Anas platyrhynchos*		LC	LC	C 1	x	x	x	
Ducks	Northern pintail	Spidsand	*Anas acuta*		VU	EN	B 1		x	x	
Ducks	Northern shoveler	Skeand	*Spatula clypeata*		LC	NT	B 1	x		x	

Ducks	Greater scaup	Bjergand	*Aythya marila*		LC	EN	C 1		x	x	
Ducks	Common eider	Ederfugl	*Somateria mollissima*		VU	EN	A 4	x	x	x	
Ducks	Long-tailed duck	Havlit	*Clangula hyemalis*		LC	LC	A 1b	x	x	x	
Ducks	Common scoter	Sortand	*Melanitta nigra*		N/A	LC	B 2a	x	x	x	x
Ducks	Velvet scoter	Fløjlsand	*Melanitta fusca*		VU	VU	A 1b	x	x	x	
Ducks	Common Goldeneye	Hvinand	*Bucephala clangula*		LC	LC	B 2c		x	x	
Ducks	Red-breasted merganser	Toppet Skallesluger	*Mergus serrator*		NT	NT	B 2c	x	x	x	
Birds of prey	European honey-buzzard	Hvepsevåge	*Pernis apivorus*	I	LC	LC		x		x	
Birds of prey	Red kite	Rød Glente	*Milvus milvus*	I	LC	LC		x		x	
Birds of prey	Western marsh-harrier	Rørhøg	*Circus aeruginosus*	I	LC	LC			x	x	
Birds of prey	Hen harrier	Blå Kærhøg	*Circus cyaneus*	I	VU	LC		x	x	x	
Birds of prey	Eurasian sparrowhawk	Spurvehøg	*Accipiter nisus*	I * (granti)	LC	LC		x	x	x	

Birds of prey	Eurasian buzzard	Musvåge	*Buteo buteo*		LC	LC			x	x	
Birds of prey	Common kestrel	Tårnfalk	*Falco tinnunculus*		LC	LC		x	x	x	
Birds of prey	Merlin	Dværgfalk	*Falco columbarius*	I	VU	VU		x	x	x	
Birds of prey	Eurasian hobby	Lærkefalk	*Falco subbuteo*		LC	LC			x	x	
Cranes	Common crane	Trane	*Grus grus*	I	LC	LC	C 1	x		x	
Waders	Eurasian oystercatcher	Strandskade	*Haematopus ostralegus*		VU	VU	A 4	x	x	x	x
Waders	Common ringed plover	Stor Præstekrave	*Charadrius hiaticula*		LC	LC	B 1		x	x	x
Waders	Eurasian golden plover	Hjejle	*Pluvialis apricaria*	I	LC	LC	C 1	x	x	x	x
Waders	Grey plover	Strandhjejle	*Pluvialis squatarola*		LC	LC	B 2e		x	x	x
Waders	Northern lapwing	Vibe	*Vanellus vanellus*		VU	VU	A 4	x			x
Waders	Red knot	Islandsk Ryle	*Calidris canutus*		LC	LC	A 4		x	x	
Waders	Sanderling	Sandløber	*Calidris alba*		LC	LC	C 1	x		x	

Waders	Purple sandpiper	Sortgrå Ryle	*Calidris maritima*		LC	NT	B 1		x	x	
Waders	Dunlin	Almindelig Ryle	*Calidris alpina*	I *	LC	LC	C1	x	x	x	x
Waders	Ruff	Brushane	*Calidris pugnax*	I	NT	NT	B 2c		x	x	
Waders	Common snipe	Dobbeltbekkasin	*Gallinago gallinago*		VU	LC	B 2c		x	x	x
Waders	Eurasian woodcock	Skovsneppe	*Scolopax rusticola*		LC	LC	B 2c		x		x
Waders	Bar-tailed godwit	Lille Kobbersneppe	*Limosa lapponica*	I	LC	LC	A 4		x	x	
Waders	Eurasian whimbrel	Småspove	*Numenius phaeopus*		LC	LC	C 1	x	x	x	
Waders	Eurasian curlew	Storspove	*Numenius arquata*		NT	NT	A 4	x		x	x
Waders	Common redshank	Rødben	*Tringa tetanus*		VU	VU	B 2c / C 1	x		x	
Waders	Common greenshank	Hvidklire	*Tringa nebularia*		LC	LC	C 1		x		x
Waders	Wood sandpiper	Tinksmed	*Tringa glareola*	I	LC	LC	C 1	x			x
Waders	Common sandpiper	Mudderklire	*Actitis hypoleucos*		LC	LC	B 2c	x	x	x	x
Skuas	Arctic skua	Almindelig Kjove	*Stercorarius parasiticus*		EN	EN			x	x	
Skuas	Great skua	Storkjove	*Stercorarius skua*		LC	LC	B 1	x		x	

Gulls	Little gull	Dværgmåge	*Hydrocoloeus minutus*	I	LC	LC	A (3c 3e)	x	x	x	
Larus gulls	Black-headed gull	Hættemåge	*Chroicocephalus ridibundus*		VU	LC	B 2c	x	x	x	x
Larus gulls	Common gull	Stormmåge	*Larus canus*		LC	LC	B 2c	x	x	x	x
Larus gulls	Lesser black-backed gull	Sildemåge	*Larus fuscus*		LC	LC	A 3c / B 2e / C1	x	x	x	x
Larus gulls	Herring gull	Sølvmåge	*Larus argentatus*		VU	LC	B 2c 2e /C1	x	x	x	x
Larus gulls	Caspian gull	Kaspisk Måge	*Larus cachinnans*		LC	LC	C 1	x		x	
Larus gulls	Great black-backed gull	Svartbag	*Larus marinus*		NT	LC	B 2c	x	x	x	x
Gulls	Black-legged kittiwake	Ride	*Rissa tridactyla*		VU	EN	A 1b		x	x	x
Terns	Sandwich tern	Splitterne	*Thalasseus sandvicensis*	I	LC	LC	C 1	x	x	x	
Terns	Common tern	Fjordterne	*Sterna hirundo*	I	LC	LC	C 1	x	x	x	x
Terns	Common tern / Arctic tern		*Sterna hirundo/Sterna paradisaea*	I			C 1	x		x	

Terns	Black tern	Sortterne	*Chlidonias niger*	I	LC	LC	B 2c		x	x	
Auks	Common guillemot	Lomvie	*Uria aalge*	I * (iberica)	LC	LC	C 1 / B 1	x	x	x	
Auks	Razorbill	Alk	*Alca torda*		LC	LC	C 1	x	x	x	
Auks	Black guillemot	Tejst	*Cepphus grylle*		LC	LC	B 1	x	x	x	
Auks	Little Auk	Søkonge	*Alle alle*		LC	NE	C (1)		x	x	
Auks	Atlantic puffin	Lunde	*Fratercula arctica*		LC	EN	A 1b	x		x	
Pigeons	Feral pigeon	NA	*Columba livia domestica*						x	x	
Pigeons	Common wood pigeon	Ringdue	*Columba palumbus*	I * (azorica)	LC	LC		x	x	x	x
Owls	Short-eared owl	Mosehornugle	*Asio flammeus*	I	LC	LC		x	x	x	
Nightjars	European nightjar	Natravn	*Caprimulgus europaeus*	I	LC	LC		x		x	
Swifts	Common swift	Mursejler	*Apus apus*		NT	NT		x	x	x	
Songbirds	Sky lark	Sanglærke	*Alauda arvensis*		LC	LC		x	x	x	x

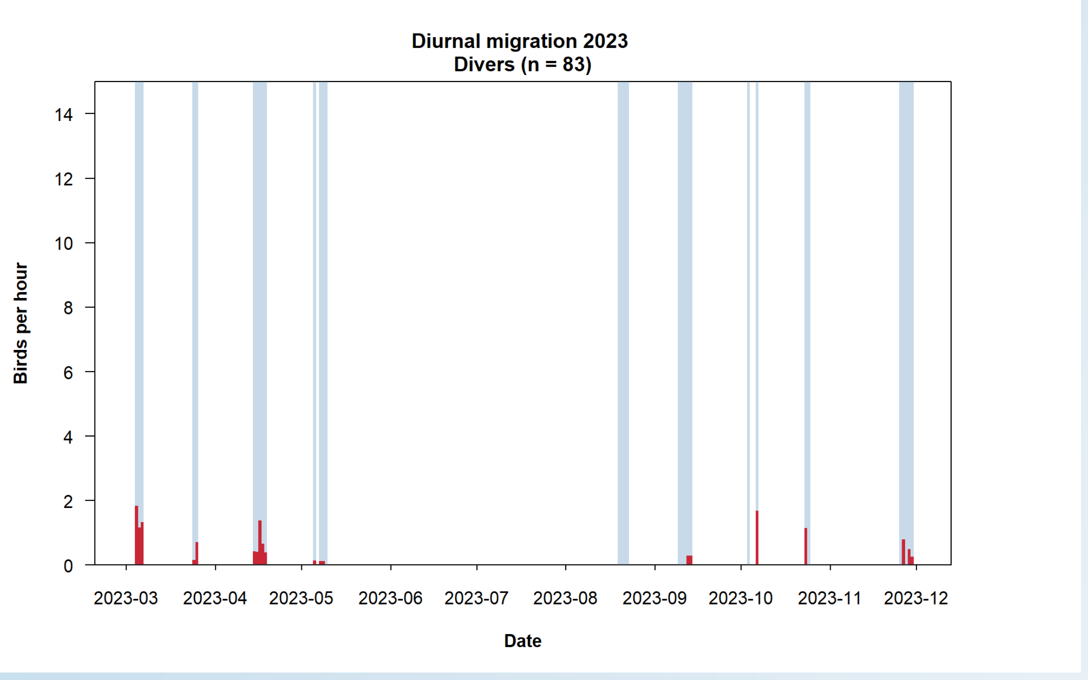
Songbirds	Sand martin	Digesvale	*Riparia riparia*		LC	LC	Bank Swallo w	x		x	
Songbirds	Barn swallow	Landsvale	*Hirundo rustica*		LC	LC		x	x	x	
Songbirds	Olive-backed pipit	Tajgapiber	*Anthus hodgsoni*		LC	N/A			x	x	
Songbirds	Tree pipit	Skovpiber	*Anthus trivialis*		LC	LC		x	x	x	x
Songbirds	Meadow pipit	Engpiber	*Anthus pratensis*		LC	LC		x	x	x	x
Songbirds	Western yellow wagtail	Gul Vipstjert	*Motacilla flava*		LC	LC			x	x	x
Songbirds	Grey wagtail	Bjergvipstjert	*Motacilla cinerea*		LC	LC		x		x	
Songbirds	White wagtail / pied wagtail	Hvid Vipstjert	*Motacilla alba*		LC	LC		x	x	x	
Songbirds	Winter wren	Gærdesmutte	*Troglodytes troglodytes*	I * (fridariensis)	LC	LC		x	x	x	
Songbirds	Hedge accentor	Jernspurv	*Prunella modularis*		LC	LC		x	x	x	x
Songbirds	European robin	Rødhals	*Erithacus rubecula*		LC	LC		x	x	x	x
Songbirds	Common redstart	Rødstjert	*Phoenicurus phoenicurus*		LC	LC			x	x	

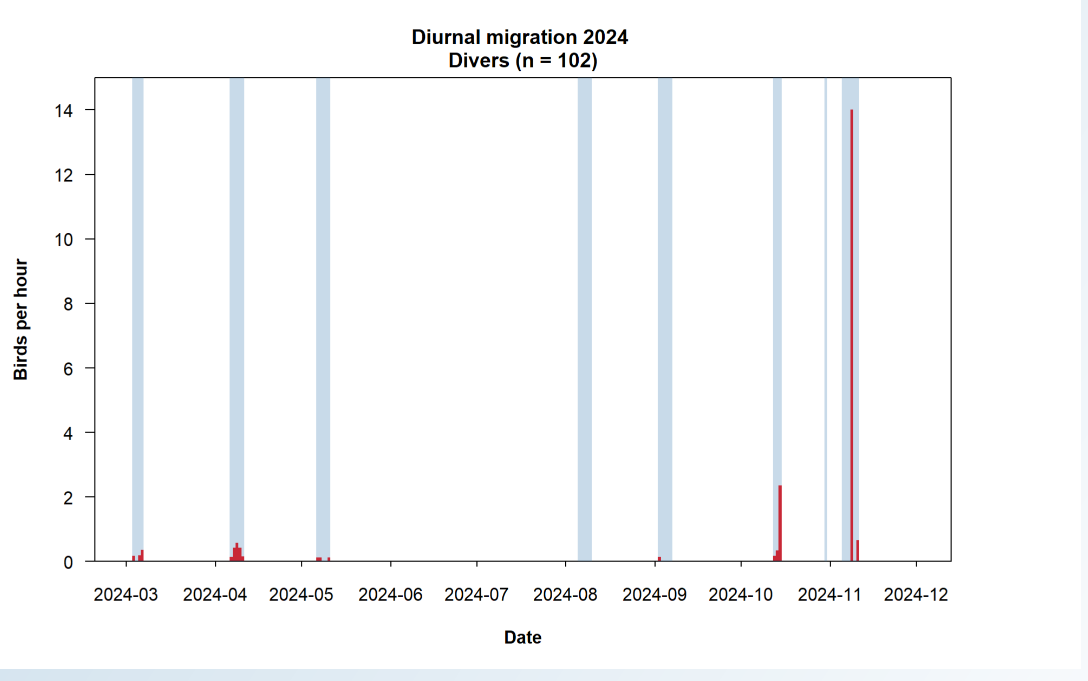
Songbirds	Northern wheatear	Stenpikker	*Oenanthe oenanthe*		LC	NT		x	x	x	x
Songbirds	Common blackbird	Solsort	*Turdus merula*		LC	LC		x	x	x	x
Songbirds	Fieldfare	Sjagger	*Turdus pilaris*		LC	LC			x		x
Songbirds	Song thrush	Sangdrossel	*Turdus philomelos*		LC	LC		x	x	x	x
Songbirds	Redwing	Vindrossel	*Turdus iliacus*		LC	LC		x	x	x	x
Songbirds	Mistle thrush	Misteldrossel	*Turdus viscivorus*		LC	LC		x	x		x
Songbirds	Icterine warbler	Gulbug	*Hippolais icterina*		LC	LC			x	x	
Songbirds	Lesser whitethroat	Gærdesanger	*Curruca curruca*		LC	N/A			x	x	
Songbirds	Garden warbler	Havesanger	*Sylvia borin*		LC	LC			x	x	
Songbirds	Eurasian blackcap	Munk	*Sylvia atricapilla*		LC	LC			x	x	
Songbirds	Common chiffchaff	Gransanger	*Phylloscopus collybita*		N/A	LC		x	x	x	x
Songbirds	Goldcrest	Fuglekonge	*Regulus regulus*		LC	LC		x	x	x	x
Songbirds	Pied flycatcher	Broget fluesnapper	*Ficedula hypoleuca*		LC	LC			x	x	
Songbirds	Eurasian blue tit	Blåmejse	*Cyanistes caeruleus*		LC	N/A			x	x	
Songbirds	Great tit	Musvit	*Parus major*		LC	LC		x			x

Songbirds	Eurasian jackdaw	Allike	*Coloeus monedula*		LC	LC		x		x	
Songbirds	Rook	Råge	*Corvus frugilegus*		LC	VU		x		x	
Songbirds	Crow	Sortkrage	*Corvus corone*		LC	LC		x		x	
Songbirds	Hooded crow	Gråkrage	*Corvus cornix*					x		x	
Songbirds	Common raven	Ravn	*Corvus corax*		LC	LC		x		x	
Songbirds	Common starling	Stær	*Sturnus vulgaris*		LC	LC		x	x	x	x
Songbirds	Chaffinch	Bogfinke	*Fringilla coelebs*	I * (ombriosa)	LC	LC		x	x	x	x
Songbirds	Brambling	Kvækerfinke	*Fringilla montifringilla*		LC	LC		x	x	x	x
Songbirds	European serin	Gulirisk	*Serinus serinus*		LC	LC			x	x	
Songbirds	European greenfinch	Grønirisk	*Chloris chloris*		LC	LC			x	x	
Songbirds	European goldfinch	Stillits	*Carduelis carduelis*		LC	LC		x		x	
Songbirds	Eurasian siskin	Grønsisken	*Spinus spinus*		LC	LC		x	x	x	
Songbirds	Common linnet	Tornirisk	*Linaria cannabina*		LC	LC		x	x	x	
Songbirds	Twite	Bjergirisk	*Linaria flavirostris*		LC	VU			x	x	

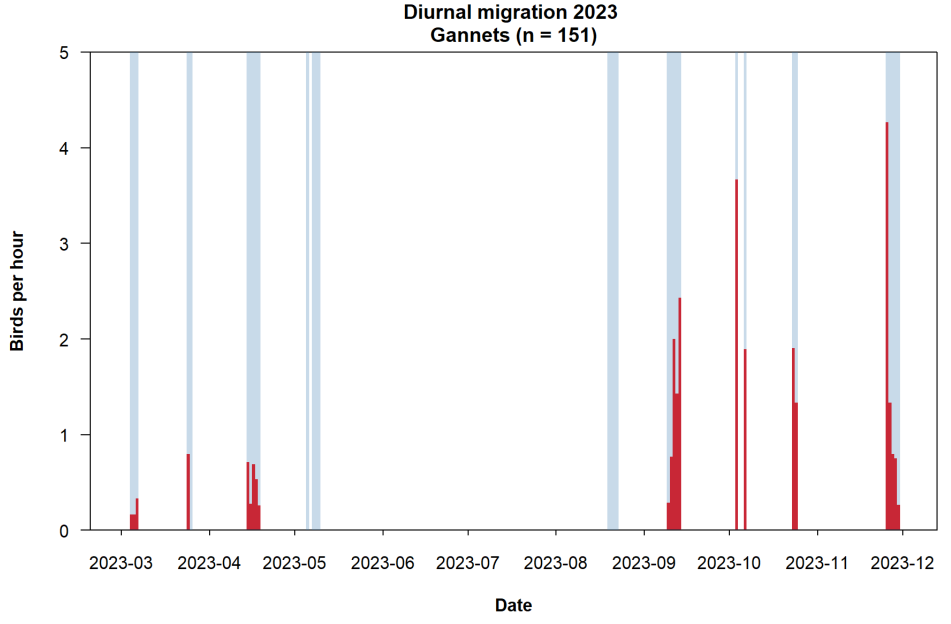
Songbirds	Common redpoll	Stor Gråsisken	*Acanthis flammea*		LC	LC			x	x	
Songbirds	Snow bunting	Snespurv	*Plectrophenax nivalis*		LC	LC		x		x	
Songbirds	Reed bunting	Rørspurv	*Emberiza schoeniclus*		LC	LC		x	x	x	x
Total								**13,983**	**9,060**	**7,901**	**6,294**

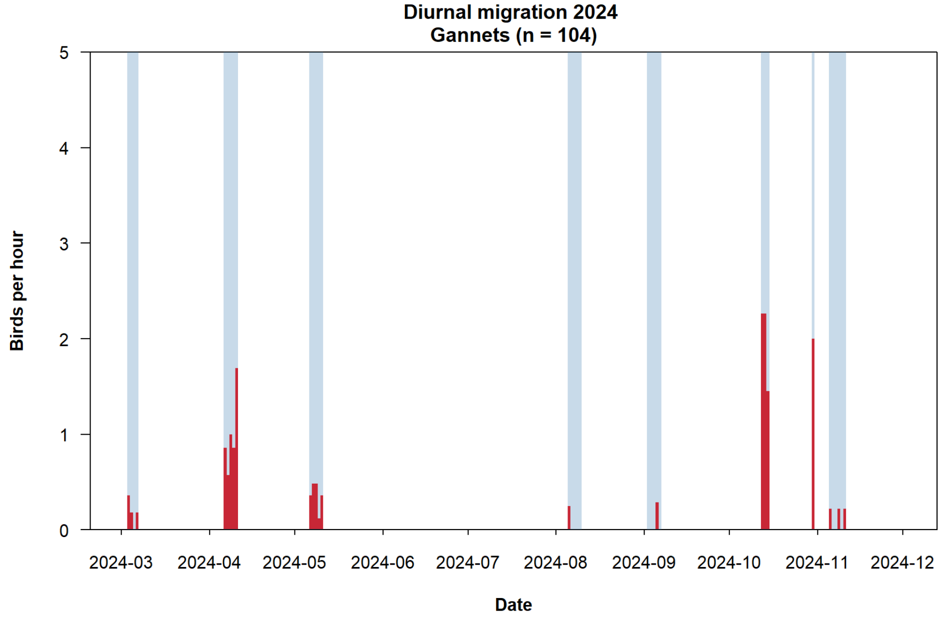
10.2.1 DIVERS


Diurnal migration 2023
Divers (n = 83)
Birds per hour
0
2
4
6
8
10
12
14
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date

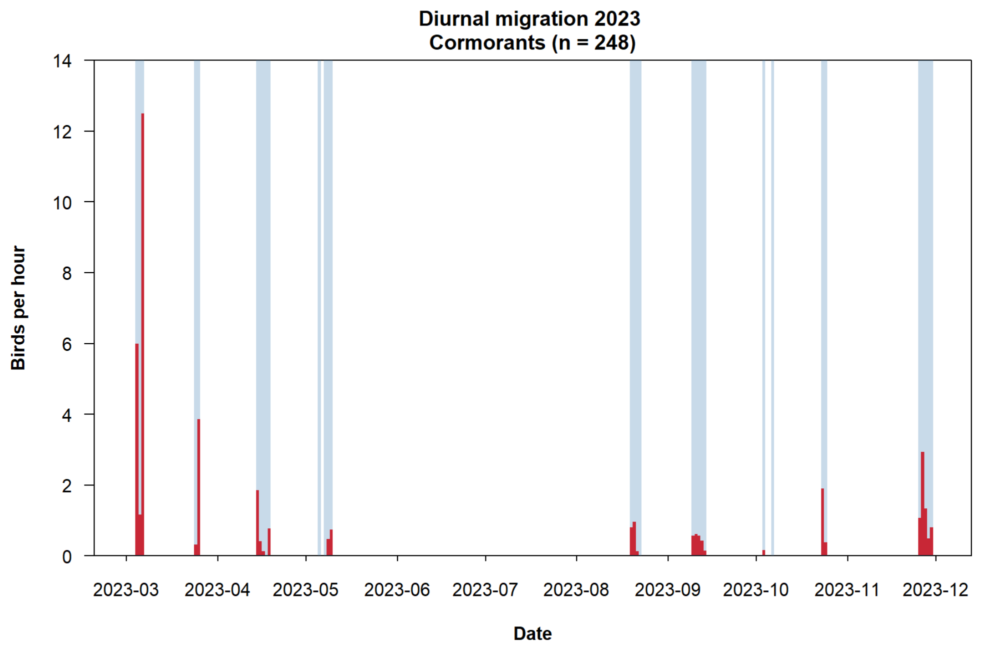

Diurnal migration 2024
Divers (n = 102)
Birds per hour
0
2
4
6
8
10
12
14
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

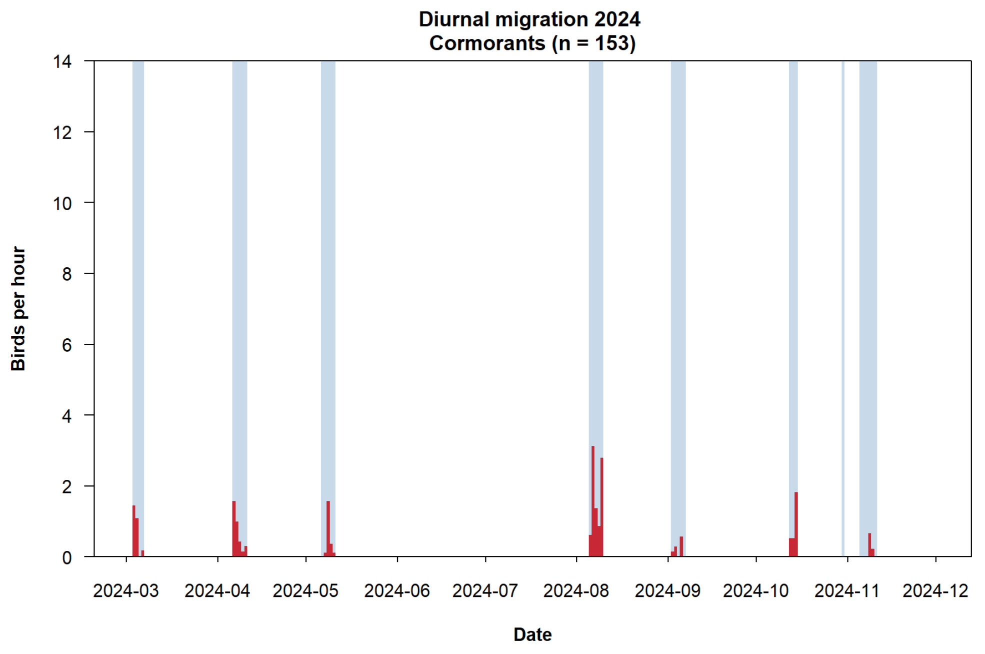
10.2.2 GANNETS



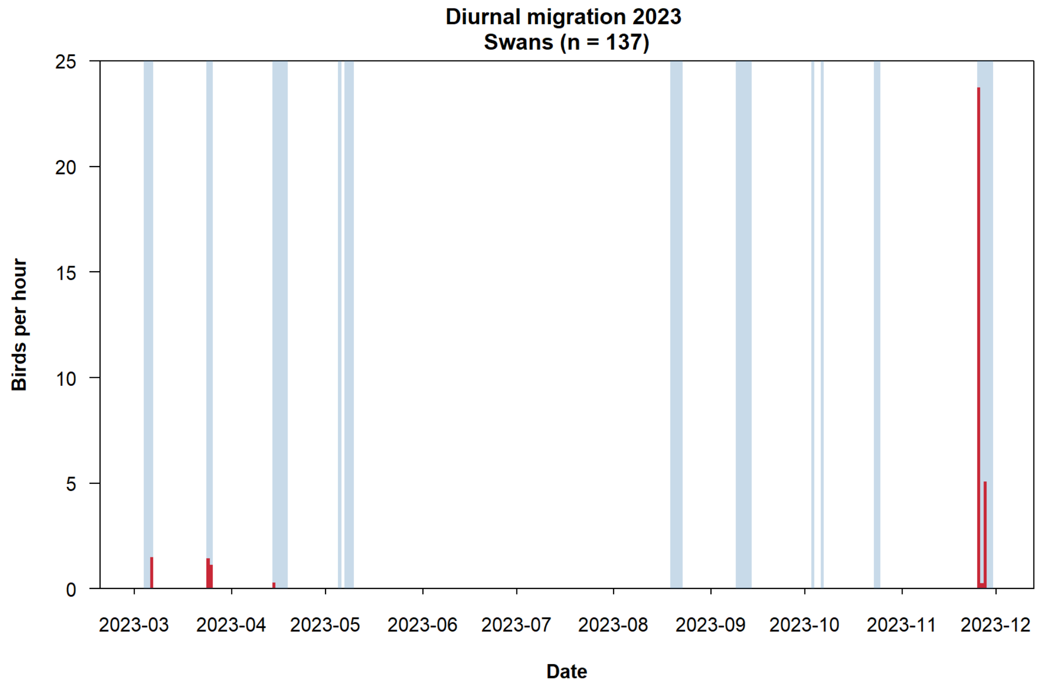


10.2.3 CORMORANTS

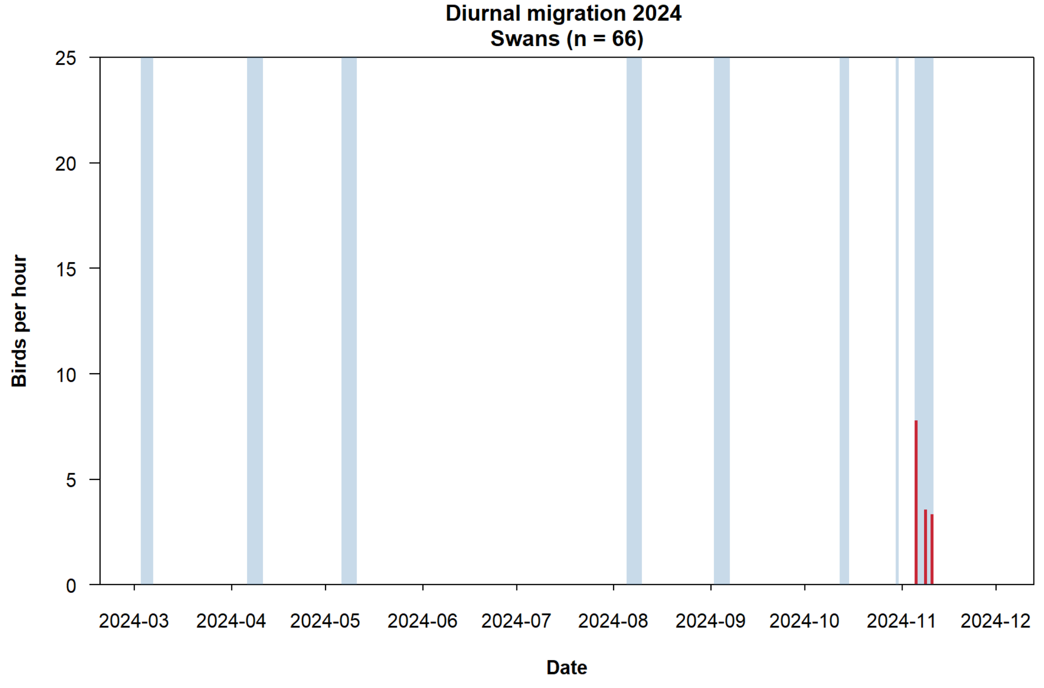




10.2.4 SWANS

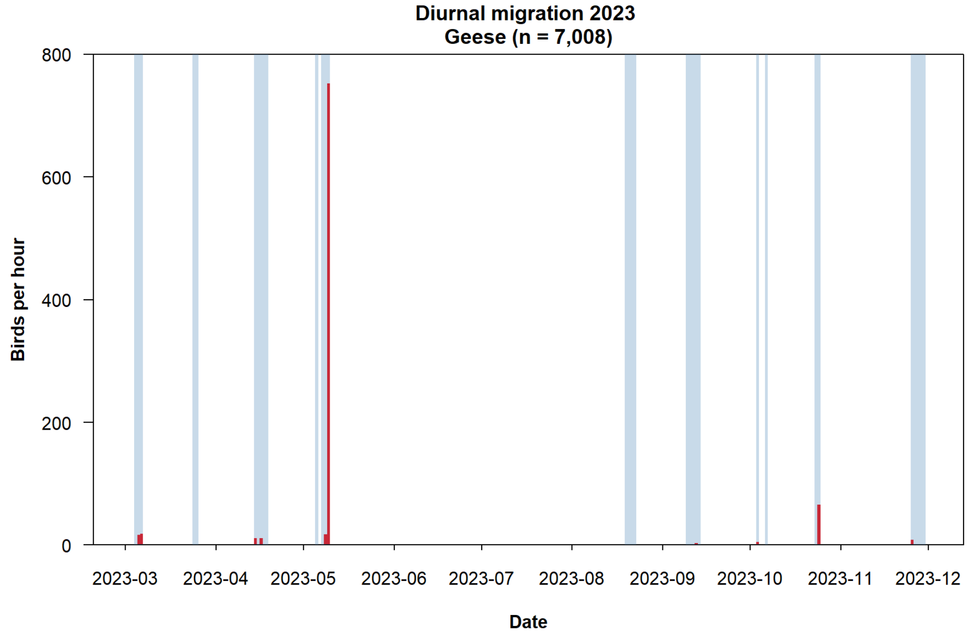


Diurnal migration 2023
Swans (n = 137)
Birds per hour
0
5
10
15
20
25
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date

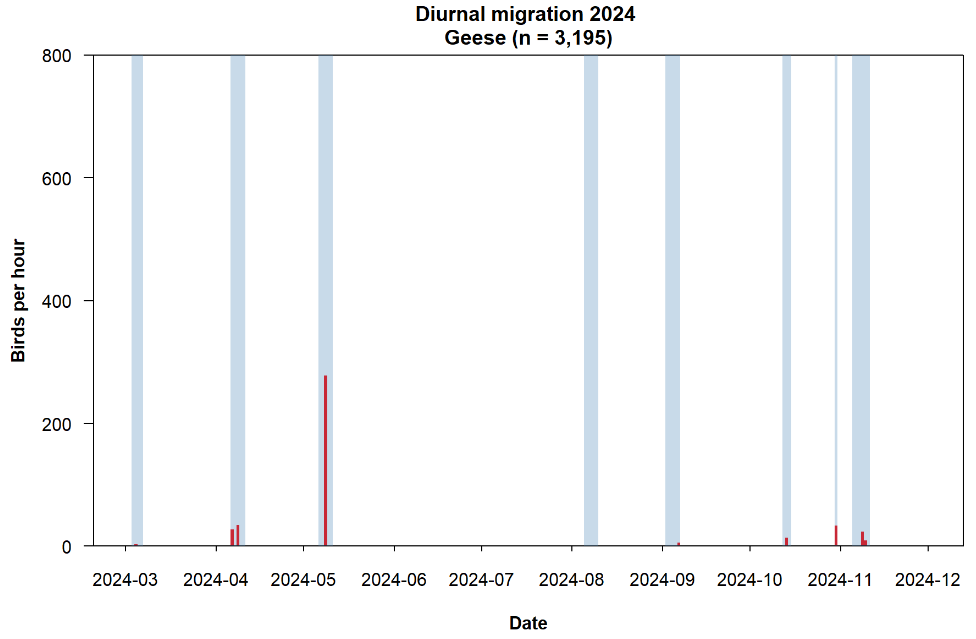


Diurnal migration 2024
Swans (n = 66)
Birds per hour
0
5
10
15
20
25
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

10.2.5 GEESE

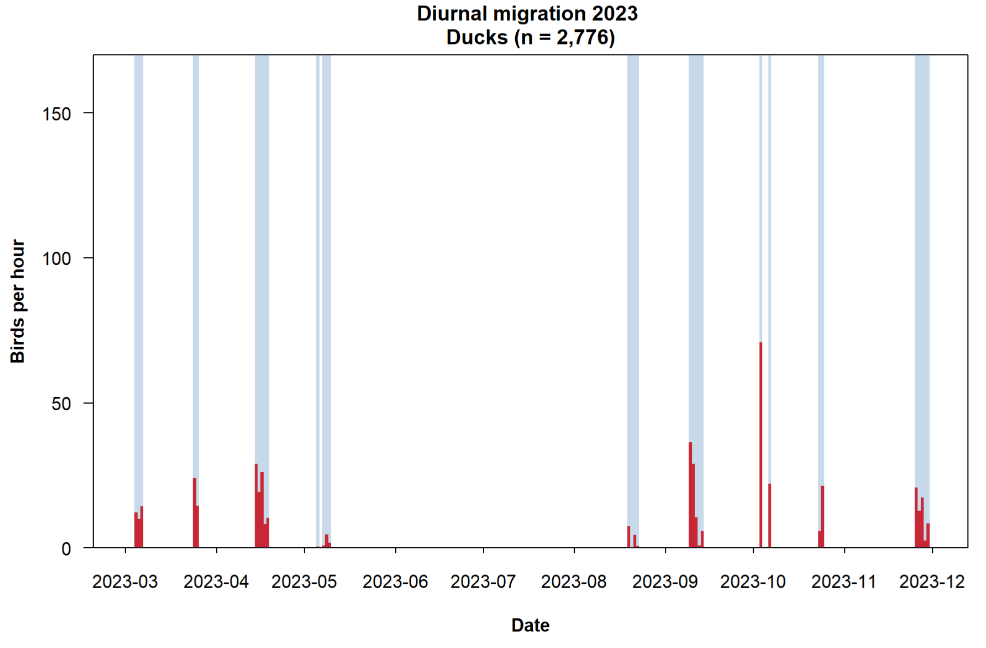


Diurnal migration 2023
Geese (n = 7,008)
800
600
400
200
0
Birds per hour
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date

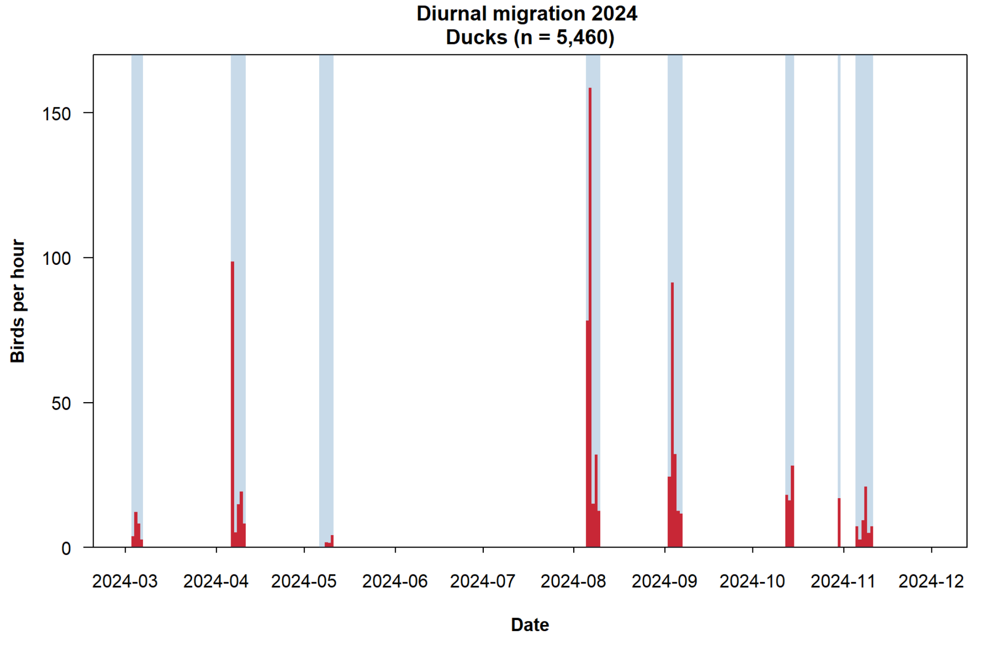


Diurnal migration 2024
Geese (n = 3,195)
800
600
400
200
0
Birds per hour
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

10.2.6 DUCKS

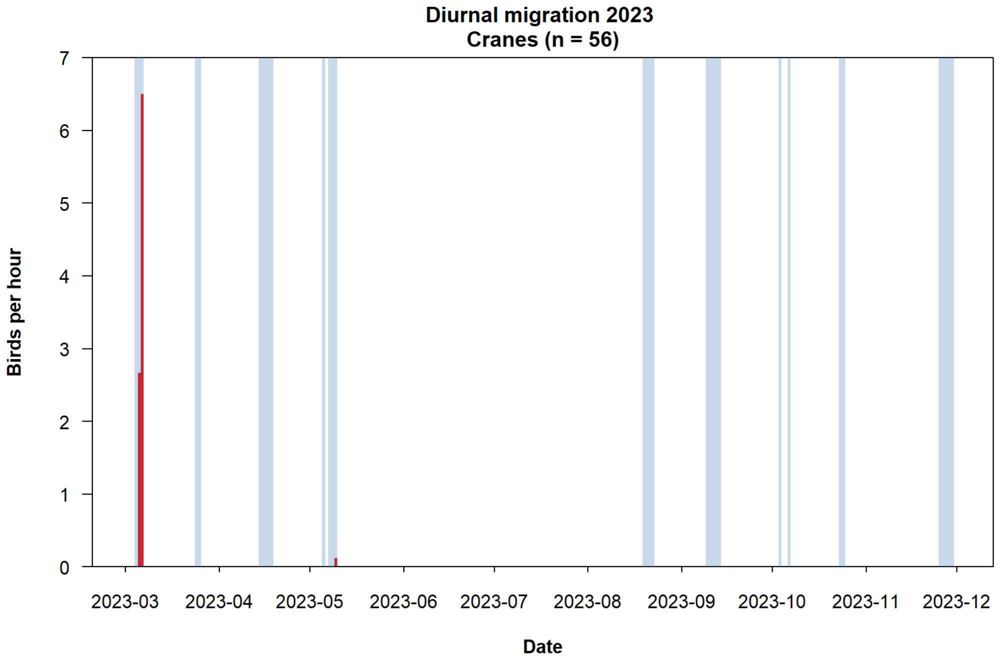


Diurnal migration 2023
Ducks (n = 2,776)
Birds per hour
0
50
100
150
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date

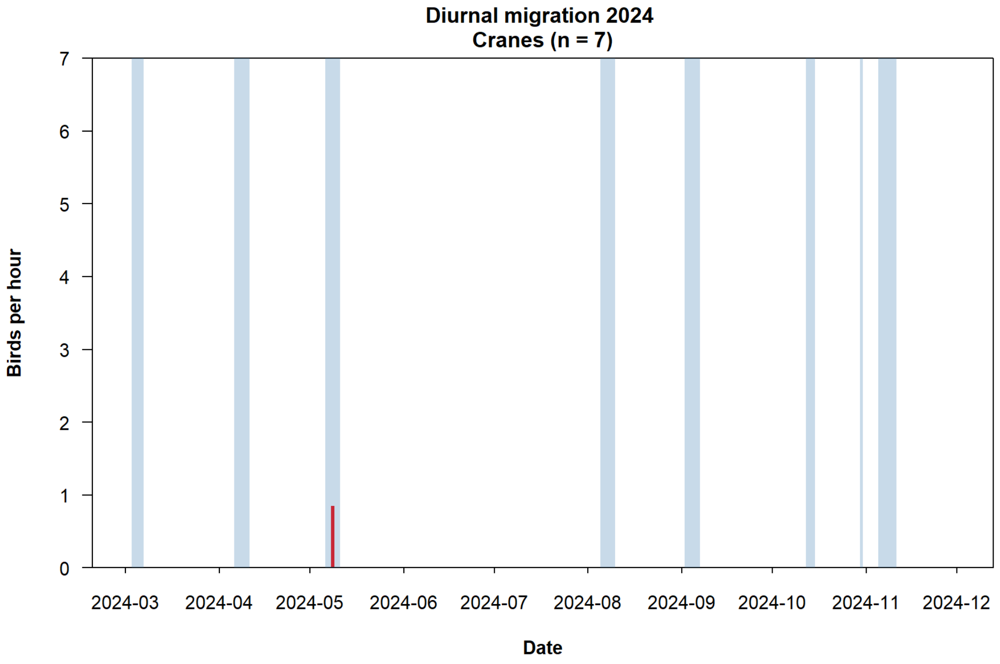


Diurnal migration 2024
Ducks (n = 5,460)
Birds per hour
0
50
100
150
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

10.2.7 CRANES

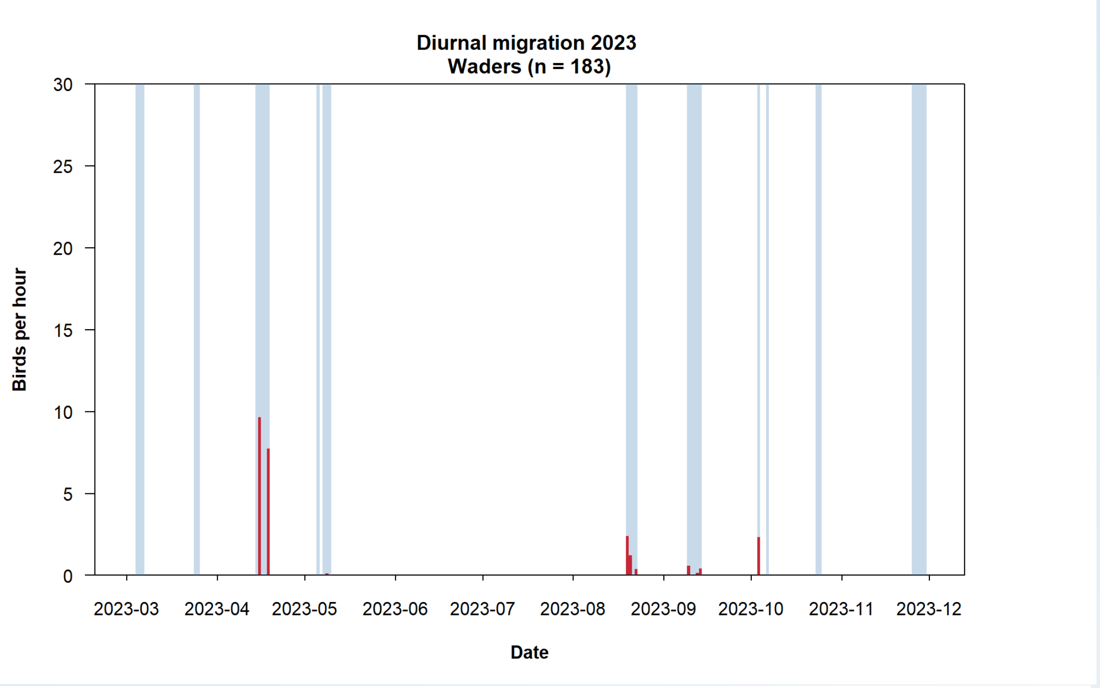


Diurnal migration 2023
Cranes (n = 56)
Birds per hour
0
1
2
3
4
5
6
7
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date

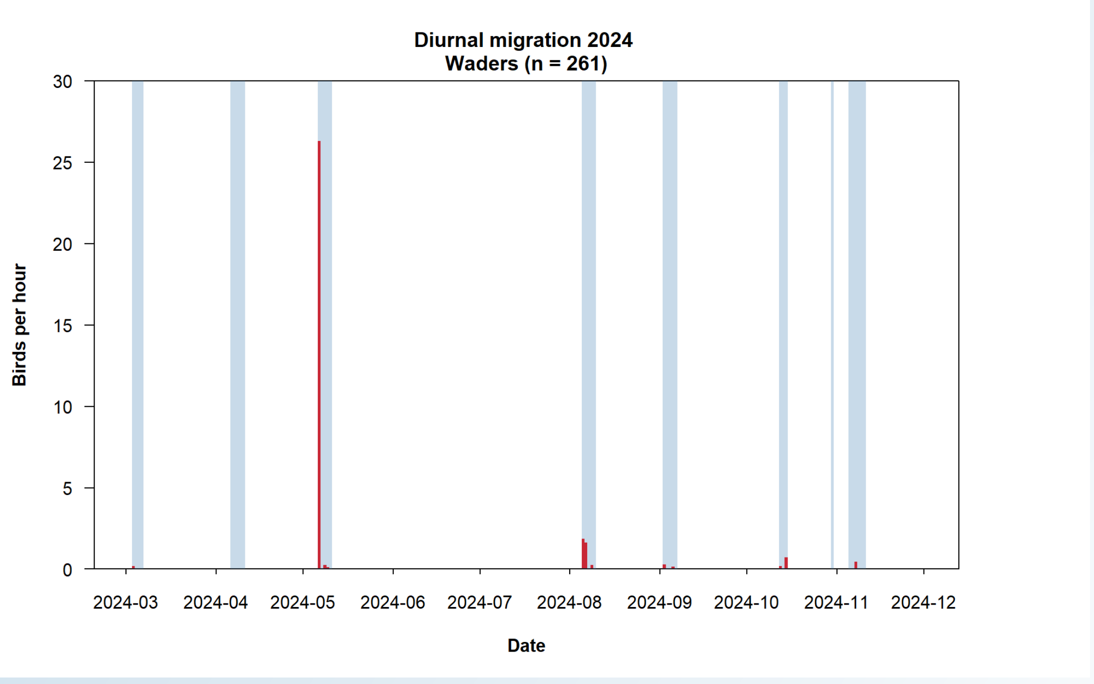


Diurnal migration 2024
Cranes (n = 7)
Birds per hour
0
1
2
3
4
5
6
7
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

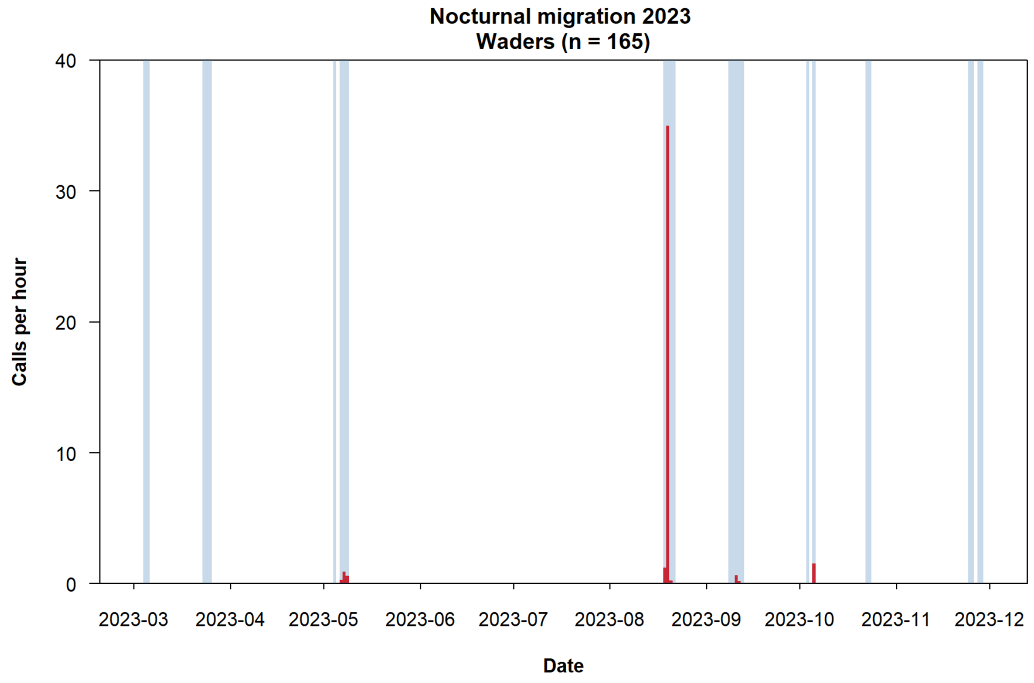
10.2.8 WADERS

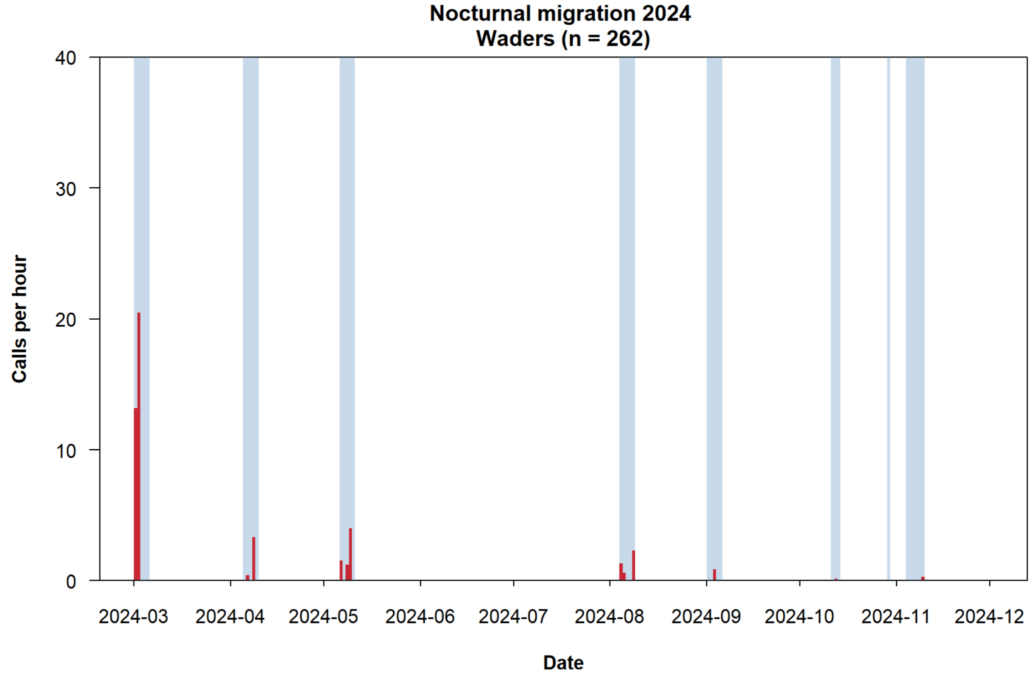


Diurnal migration 2023
Waders (n = 183)
Birds per hour
30
25
20
15
10
5
0
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date

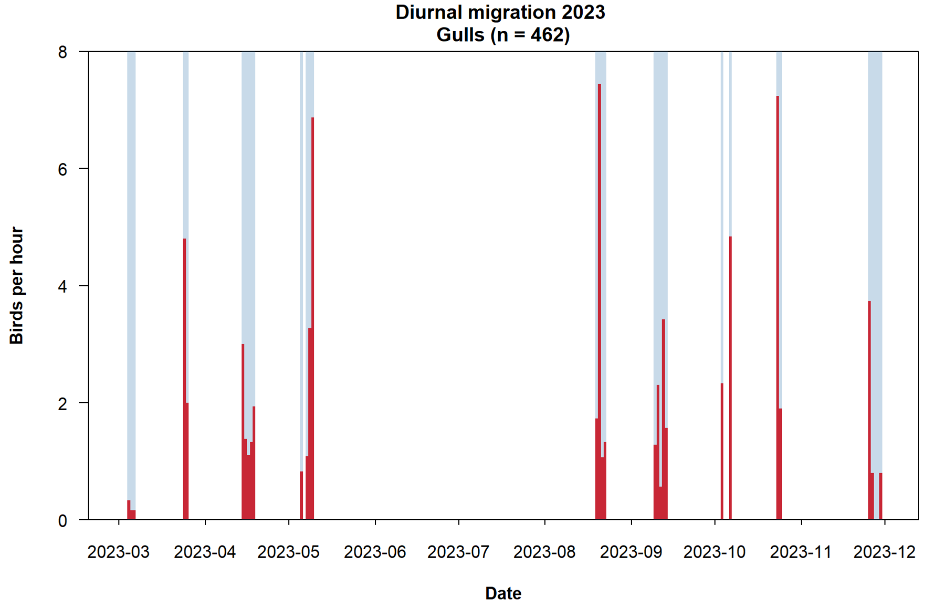


Diurnal migration 2024
Waders (n = 261)
Birds per hour
30
25
20
15
10
5
0
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

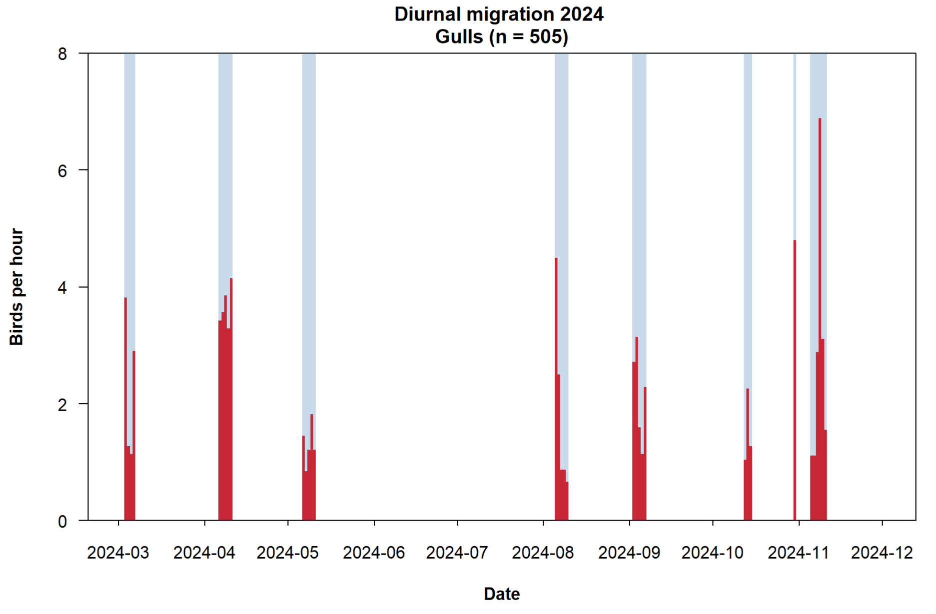

Nocturnal migration 2023
Waders (n = 165)
Calls per hour
0
10
20
30
40
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date


Nocturnal migration 2024
Waders (n = 262)
Calls per hour
0
10
20
30
40
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

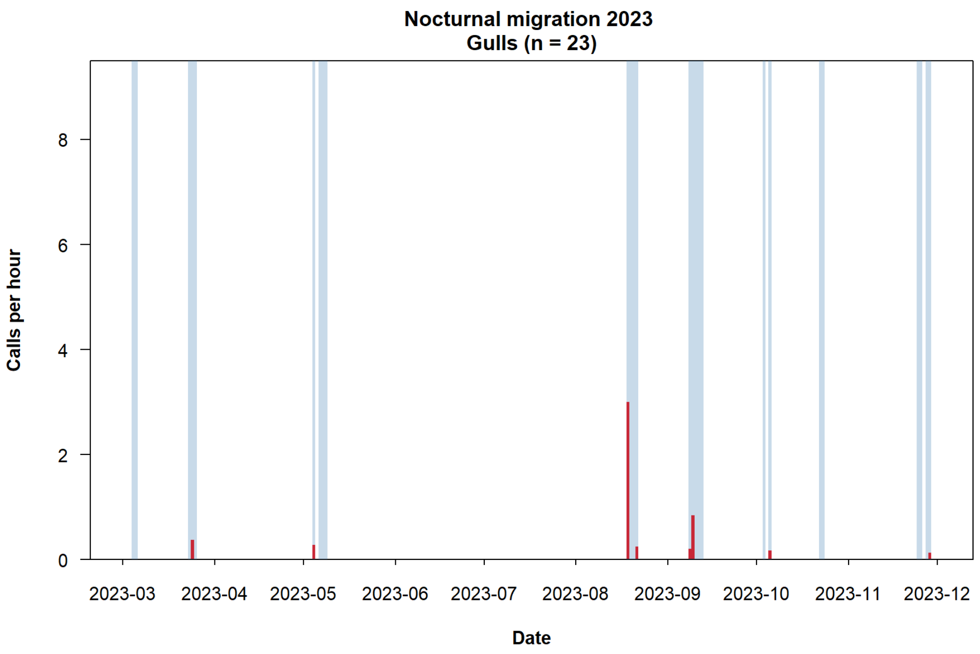
10.2.9 GULLS



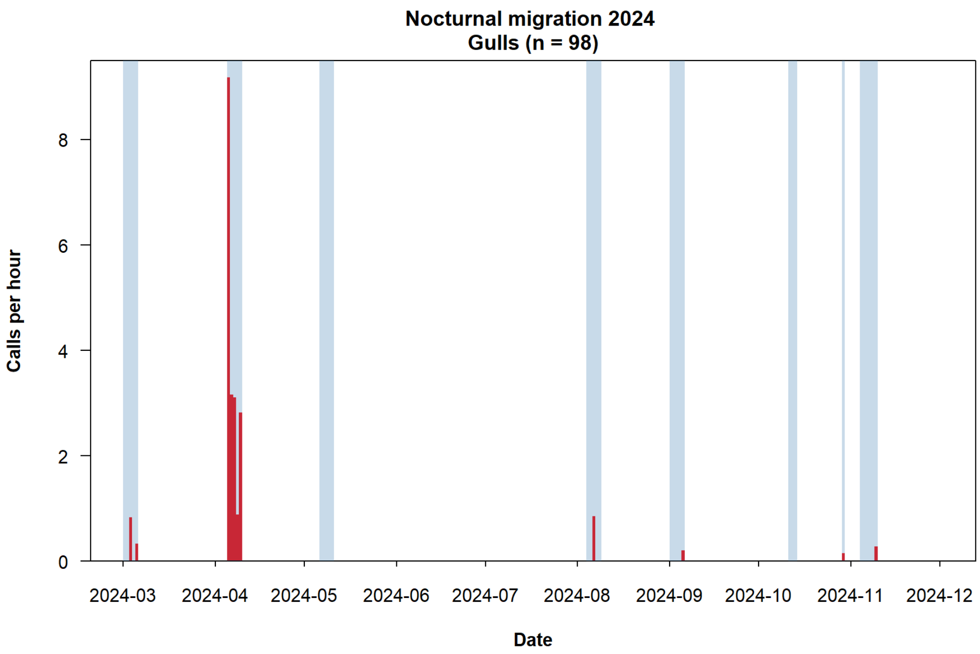
Diurnal migration 2023
Gulls (n = 462)
Birds per hour
0
2
4
6
8
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date



Diurnal migration 2024
Gulls (n = 505)
Birds per hour
0
2
4
6
8
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

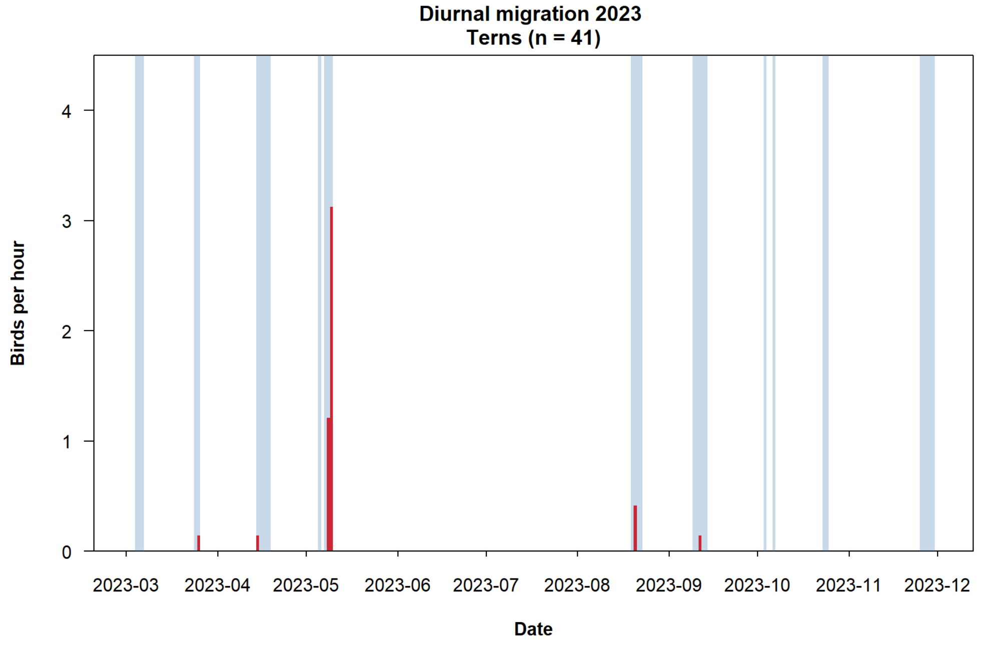


Nocturnal migration 2023
Gulls (n = 23)
Calls per hour
0
2
4
6
8
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date

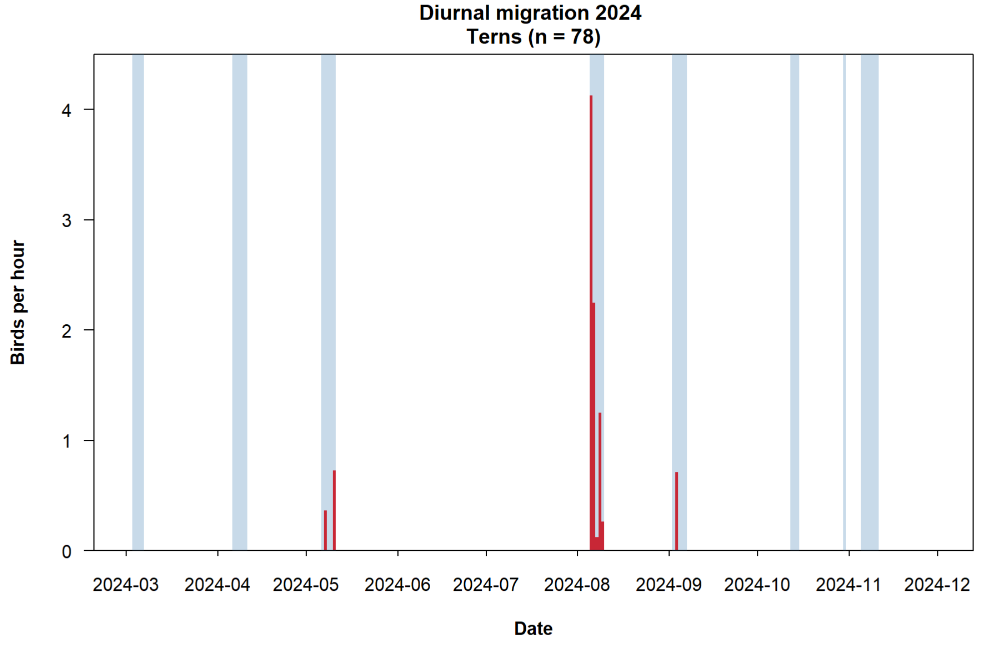


Nocturnal migration 2024
Gulls (n = 98)
Calls per hour
0
2
4
6
8
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

10.2.10 TERNS

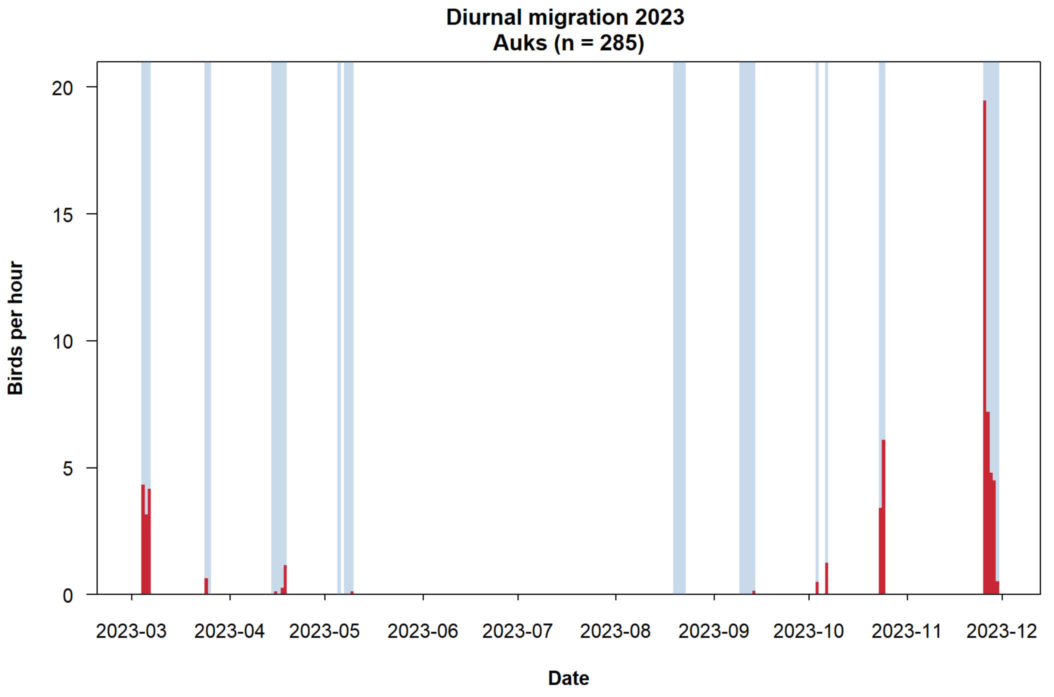


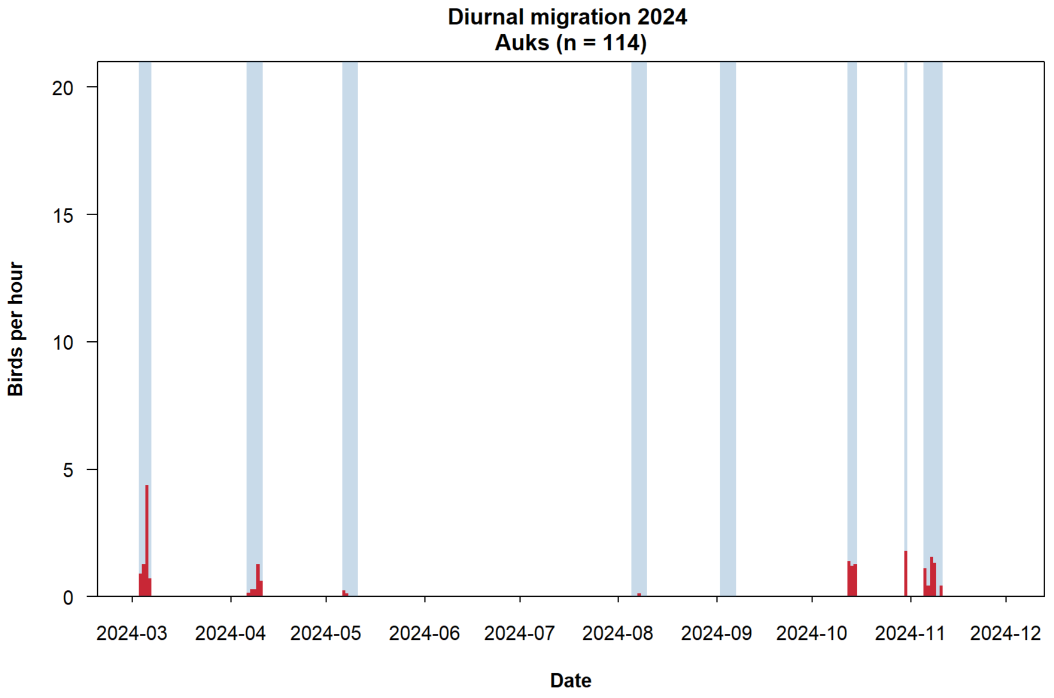
Diurnal migration 2023
Terns (n = 41)
Birds per hour
0
1
2
3
4
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date



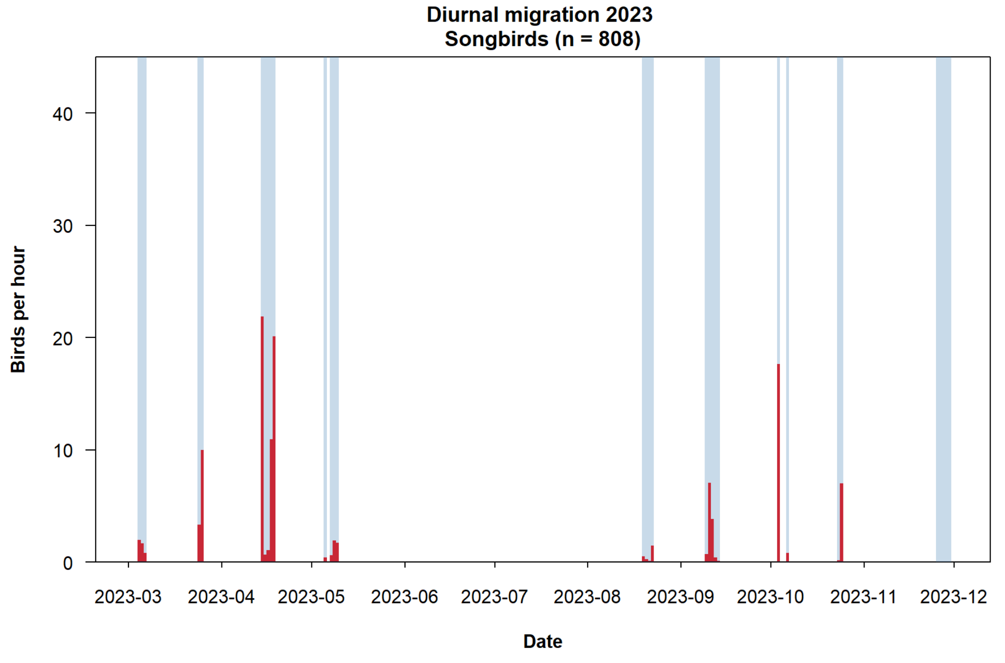
Diurnal migration 2024
Terns (n = 78)
Birds per hour
0
1
2
3
4
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

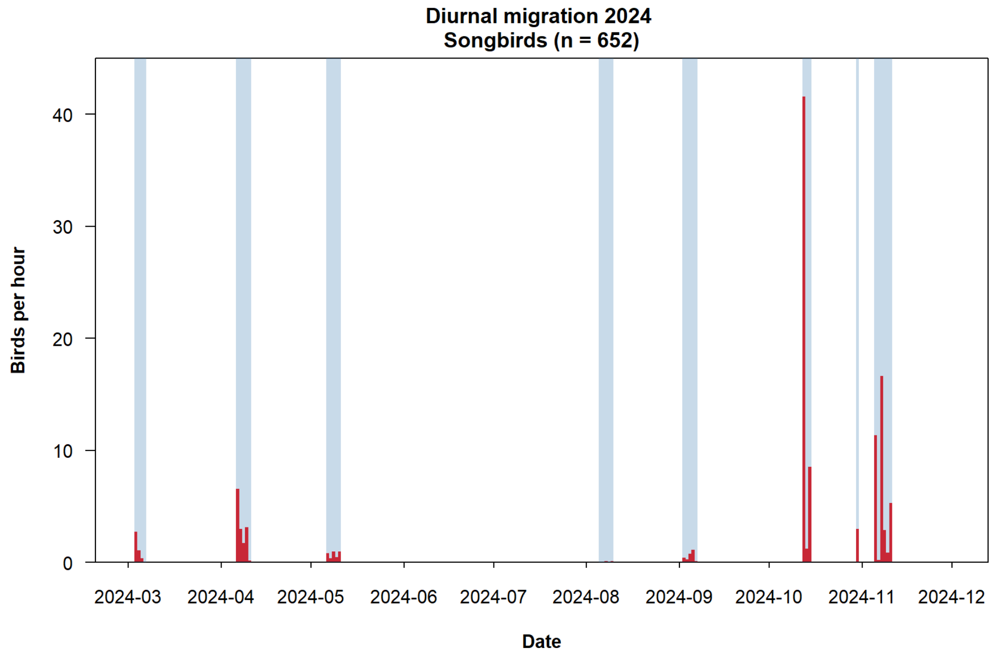
10.2.11 AUKS

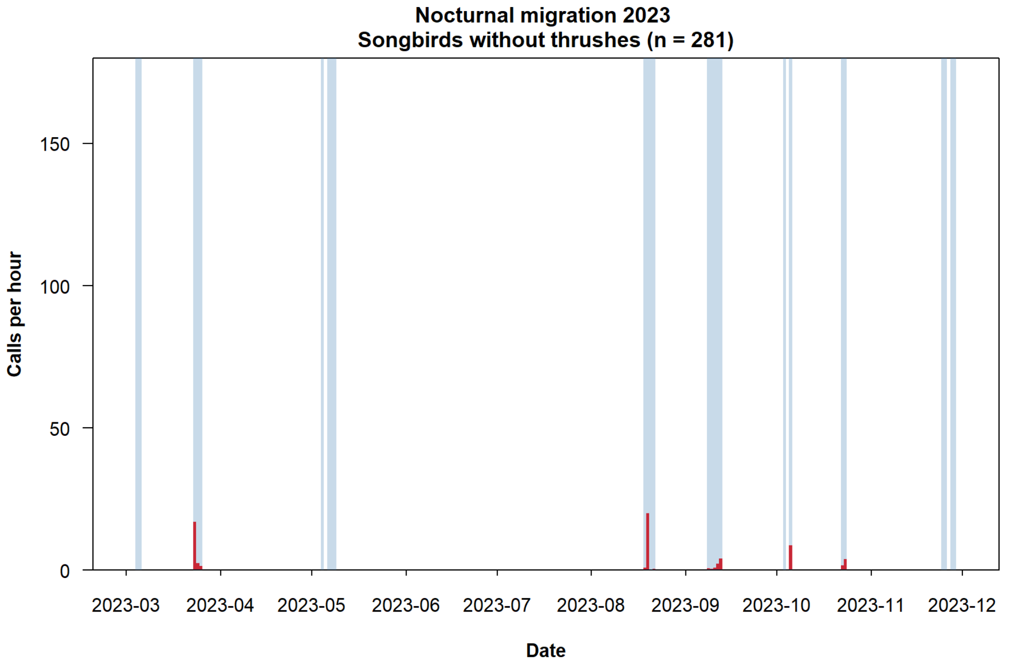

Diurnal migration 2023
Auks (n = 285)
Birds per hour
0
5
10
15
20
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date

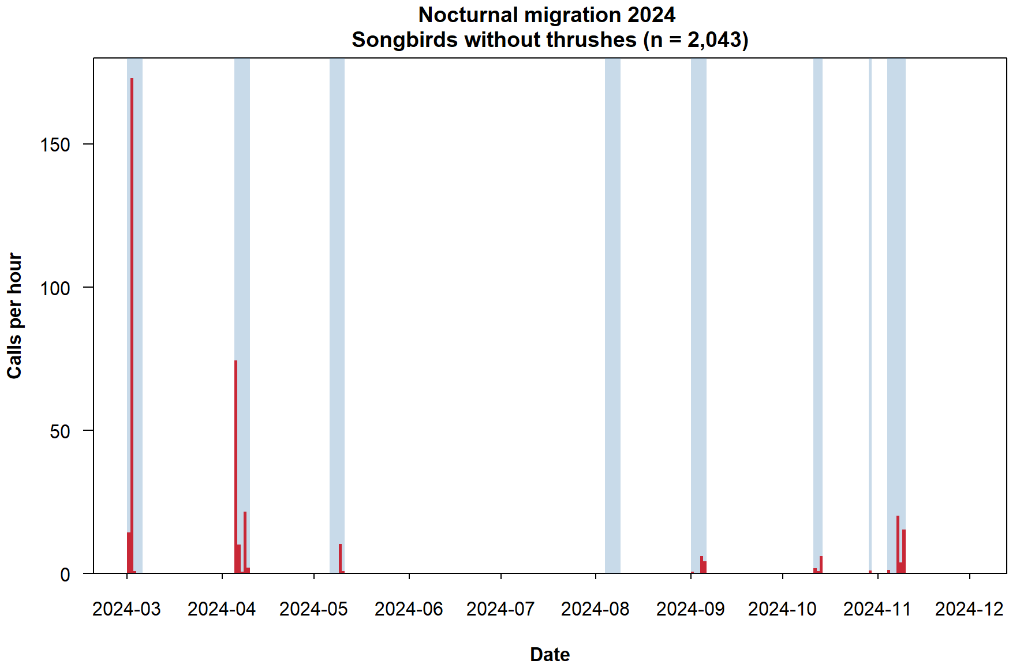

Diurnal migration 2024
Auks (n = 114)
Birds per hour
0
5
10
15
20
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date

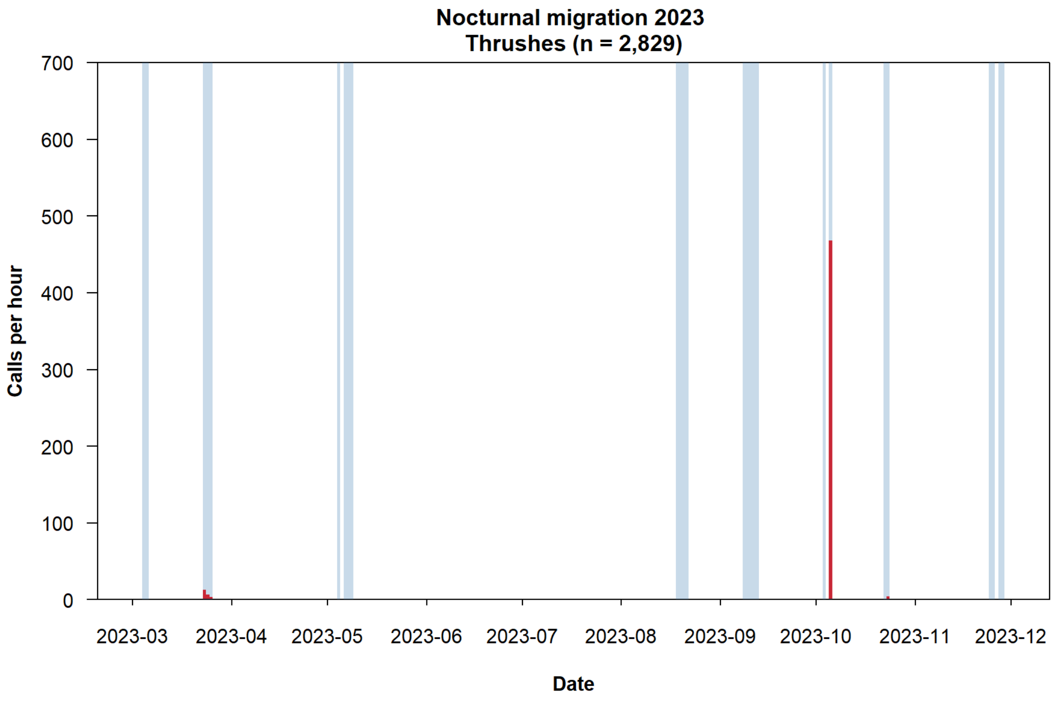
10.2.12 SONGBIRDS



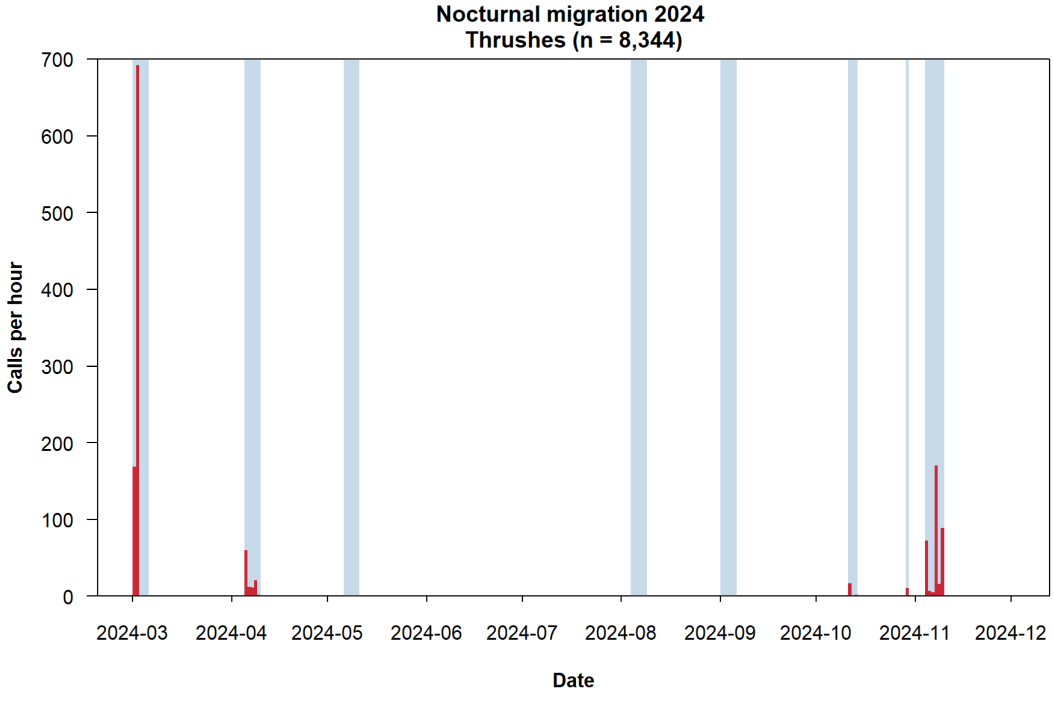



Nocturnal migration 2023
Songbirds without thrushes (n = 281)
Calls per hour
0
50
100
150
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date


Nocturnal migration 2024
Songbirds without thrushes (n = 2,043)
Calls per hour
0
50
100
150
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date



Nocturnal migration 2023
Thrushes (n = 2,829)
Calls per hour
700
600
500
400
300
200
100
0
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Date



Nocturnal migration 2024
Thrushes (n = 8,344)
Calls per hour
700
600
500
400
300
200
100
0
2024-03
2024-04
2024-05
2024-06
2024-07
2024-08
2024-09
2024-10
2024-11
2024-12
Date