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Horns Rev 3 Offshore Wind Farm

Technical report no. 8

MIGRATORY BIRDS

(WITH AN ANNNEX ON MIGRATING BATS)

APRIL 2014

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Client	Energinet.dk Att. Indkøb Tonne Kjærsvej 65 DK-7000 Fredericia
Consultant	Orbicon A/S Ringstedvej 20 DK-4000 Roskilde
Sub-consultant	IfAÖ GmbH Alte Dorfstrasse 11 D-18184 Neu Broderstorf
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Prepared by	Frederik Jensen, Martin Laczny, Werner Piper, Timothy Coppack
Reviewed by	Flemming Pagh Jensen
Approved by	Kristian Nehring Madsen
Cover photo	Thomas W. Johansen ©
Photos	Unless specified © Orbicon A/S – Energinet.dk
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SUMMARY

The aim of this report is to collate information on migratory birds from previous surveys in the Horns Rev region and to assess the severity of impacts (collisions, barrier effect) of the proposed offshore wind farm Horns Rev 3 (Horns Rev 3) on flying birds during construction, operation and decommissioning. Horns Rev 3 is planned to be built in an area situated north of the wind farms Horns Rev 1 (Horns Rev 1) and Horns Rev 2 (Horns Rev 2). Several alternative layouts exist, of which one worst-case scenario with respect to migrating birds was selected for the present impact assessment. This worst-case scenario considered distance of the wind farm from the coastline (higher migration rates expected along the coast) and number (density) of turbines, taking barrier effects and attraction of night-migrating birds through artificial lighting into account. Site-specific investigations, i.e., surveys that comprise the planning area of Horns Rev 3, were not carried out. Instead, results from the baseline and post-construction reports and EIA from Horns Rev 2, performed from September 2010 to May 2012, as well as from Horns Rev 1, performed from April 1999 to April 2000, were reconsidered and, where possible, projected to the area of Horns Rev 3.

Previous surveys in the Horns Rev area included various observational methods and radar studies. Species composition, abundance and phenology are assumed to show the same patterns or lie within the same order of magnitude found near Horns Rev 1 and Horns Rev 2. Baseline data from surveys on staging waterbirds carried out at Horns Rev 3 confirm the dominance of key waterbird species that pass the region in larger quantities on a seasonal basis.

The impact assessment weighs the magnitude of pressure and sensitivity regarding collision risk and barrier effects on movements for relevant migratory bird species as well as cumulative effects in combination with other large-scale offshore wind farms located in the same marine territory, notably Horns Rev 1 and 2. No significant impacts are expected during construction and decommissioning. For assessing the risk of collision during operation, the magnitude of the pressure was assumed to be proportional to the species' sensitivity. Sensitivity was assessed on the basis of current expert knowledge and by classifying predictive model outcomes relative to the rank list of a recent meta-analysis published by Furness et al. (2013). On-site information from Horns Rev 3 on the densities of staging water birds was introduced into a collision risk model, following the guidelines of Band (2012). Among all sea and water birds documented in the Horns Rev region large gulls seem to be exposed to the greatest risk of collision, followed by the gannet, small gulls and terns. The resulting degree of impact is classified very high for Great Black-backed Gull, European Herring Gull, Lesser Black-backed Gull, and high for the Northern Gannet. Including population size, local abundance (projected from frequencies measured between 2010 and 2012 at Horns Rev 1 and Horns Rev 2) and conservation status to the assessment of collision risk resulted in a medium severity of impact for Lesser Black-backed Gull, Little Gull and Sandwich Tern, taking the proposed worst-case array of wind turbines for Horns Rev 3 into account. For all other relevant bird species passing Horns Rev 3, the severity of impact is predecited to be low. In the case of potential barrier effects imposed on mi-

grating birds, the magnitude of pressure can be considered to be low for the majority of species, as the hypothetical adverse effect, i.e., higher energy expenditure due to detours, is temporary and unlikely to result in significant drawbacks for seasonal migrants that travel over larger spatial scales. The severity of potential barrier effects was assessed high for Common Scoter and Red-throated divers, which are abundant in the area of Horns Rev 3. The spacing of surrounding wind farm projects, however, is expected to cause no cumulative barrier effect on migratory movements. Cumulative effects arising from the combination of collisions at various planned and constructed wind farms in the surrounding of Horns Rev 3 are negligible for the predominant species in the Horns Rev region. It is unlikely that annual mortality caused by collisions with wind turbines will exceed 1 % of the individuals in flyway populations of bird species detected in the Horns Rev region.

The present report includes an annex on the potential impacts of Horns Rev 3 on migrating bats, which, from a functional perspective, fall into the same group as migrating birds. Despite the fact that bats may become attracted to wind turbines while following temperature-dependent insects , the number of collisions at Horns Rev 3 is expected to be low due to the generally low number of bats migrating over the open sea and the fact that foraging flights from the coast are most likely to take place under conditions of low wind, i.e., low turbine activity.

Gannet

1. INTRODUCTION

The purpose of the present study is to provide an assessment of the baseline conditions and impacts of the planned offshore wind farm Horns Rev 3 (Horns Rev 3) on migratory birds during construction and operation. The report analyses and assesses the collision risk for migratory birds, barrier effects on movements and cumulative effects in combination with other large-scale offshore wind farms located in the same marine territory. The baseline information is derived from the monitoring of bird migration carried out in relation to the existing wind farms Horns Rev 1 (Horns Rev 1) and Horns Rev 2 (Horns Rev 2) as well as on available literature. Site-specific empirical investigations, i.e. surveys that comprise the planning area of Horns Rev 3, were not carried out. Instead, results from the baseline and post-construction reports and EIA from Horns Rev 2, performed from September 2010 to May 2012, as well as from Horns Rev 1, performed from April 1999 to April 2000, were reconsidered and projected to the area of Horns Rev 3. Moreover, recent data on densities of relevant seabird species in the area of Horns Rev 3 were introduced into a collision risk model.

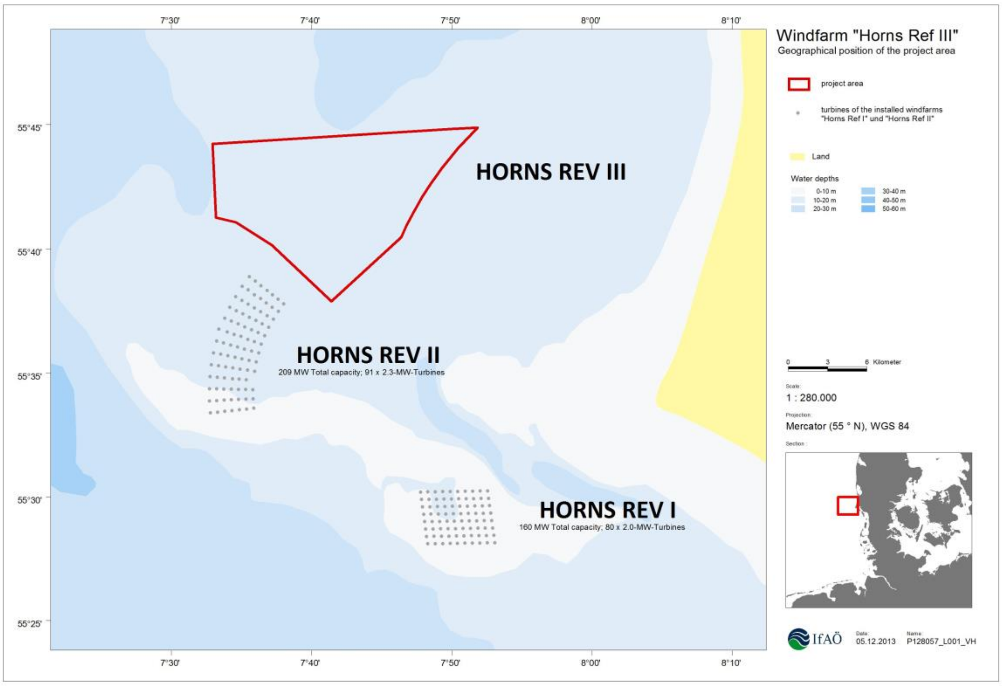


Figure 1.1. Overview on the location of the different wind farms in the Horns Rev area.

2. DESCRIPTION OF THE PROJECT

2.1. Description of the wind farm area

The planned Horns Rev 3 OWF (400 MW) is located north of Horns Rev in a shallow area in the eastern North Sea, about 20-35 km northwest of the westernmost point of Denmark, Blåvandshuk. The area is approximately 150 km^2. To the west it is delineated by gradually deeper waters, to the south/southwest by the existing OWF Horns Rev 2, to the southeast by the export cable from Horns Rev 2 OWF, and to the north by oil/gas pipelines (Figure 2.1).

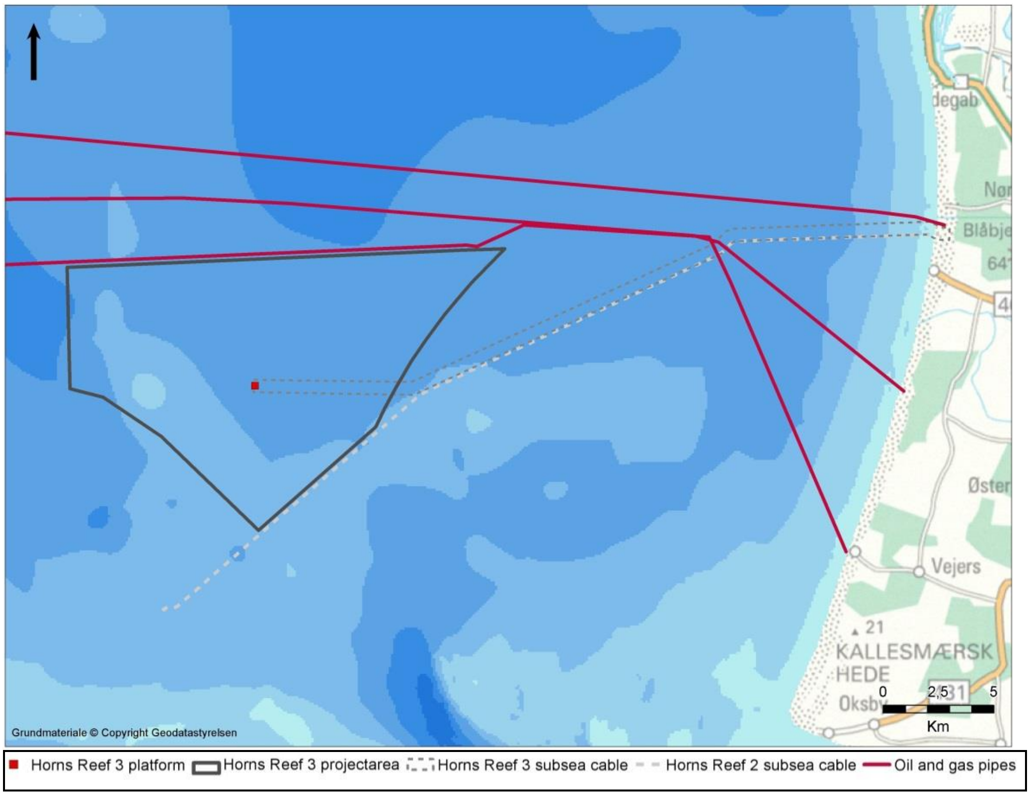


Figure 2.1 Location of the Horns Rev 3 OWF (400 MW) and the projected corridor for export cables towards shore. The area enclosed by the polygon is ca. 150 km2. The marked area includes the whole pre-investigation area, i.e. with an overlap of existing cables etc.

In the middle of the Horns Rev 3 project area there is a zone occupying 30–35 % of the area and is classified as a former WWII minefield and designated a ‘no fishing, no anchoring zone’. Also, just south/southeast of the Horns Rev 2 export cable an existing military training field is delineated. In 2012, the engineering consultant NIRAS completed a desk study on potential UXO (UneXploded Ordnance) contaminations in the Horns Rev 3 project area. For the central and eastern parts of the area the report concludes a medium to high UXO threat is present, while for the western part of the Horns Rev 3 project area the report concludes a low UXO threat is present.

The water depths in the Horns Rev 3 project area vary between app. 10-21 m (Figure 2.2). The minimum water depth is located on a ridge in the southwest of the site and the maximum water depth lies in the north of the area. Sand waves and mega-ripples are observed across the site.

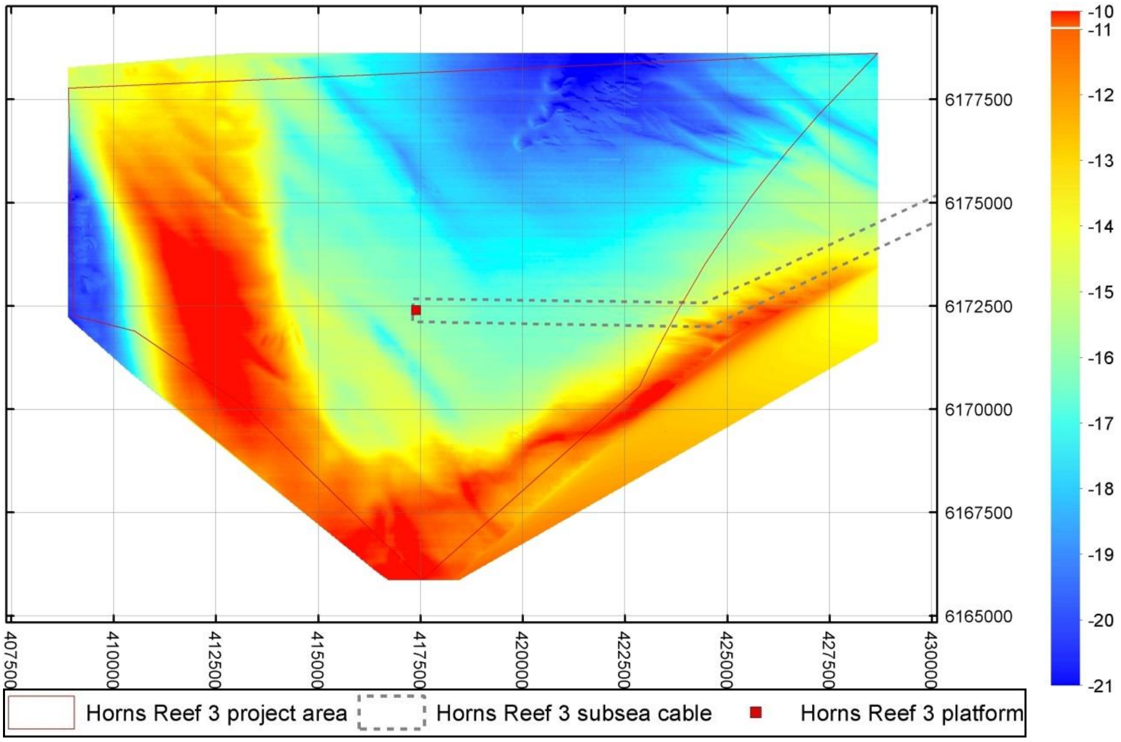


Figure 2.2 Bathymetric map of the Horns Rev 3 area showing depths below DVR90 as graded colour (see column on the right). The map is based upon the Geophysical survey in 2012.

2.2. The turbines

The maximum rated capacity of the wind farm is limited to 400 MW. The type of turbine and foundation had not been decided upon when this report was being prepared. However, the farm will include 40 to 136 turbines, depending on the rated energy of the selected turbines corresponding to the range of 3 to 10 MW. There is a possibility that more than one turbine model will be installed due to the rapid development of the wind turbine industry and a construction program that can be spread over more than one year.

Suggested layouts for different scenarios are presented in the figures below (Figures 2.3 to 2.11). The layouts are made for 3 MW, 8 MW and 10 MW, respectively – and for three different locations of the turbines; closest to the shore (easterly in project area), in the centre of the project area, and in the western part of the project area.

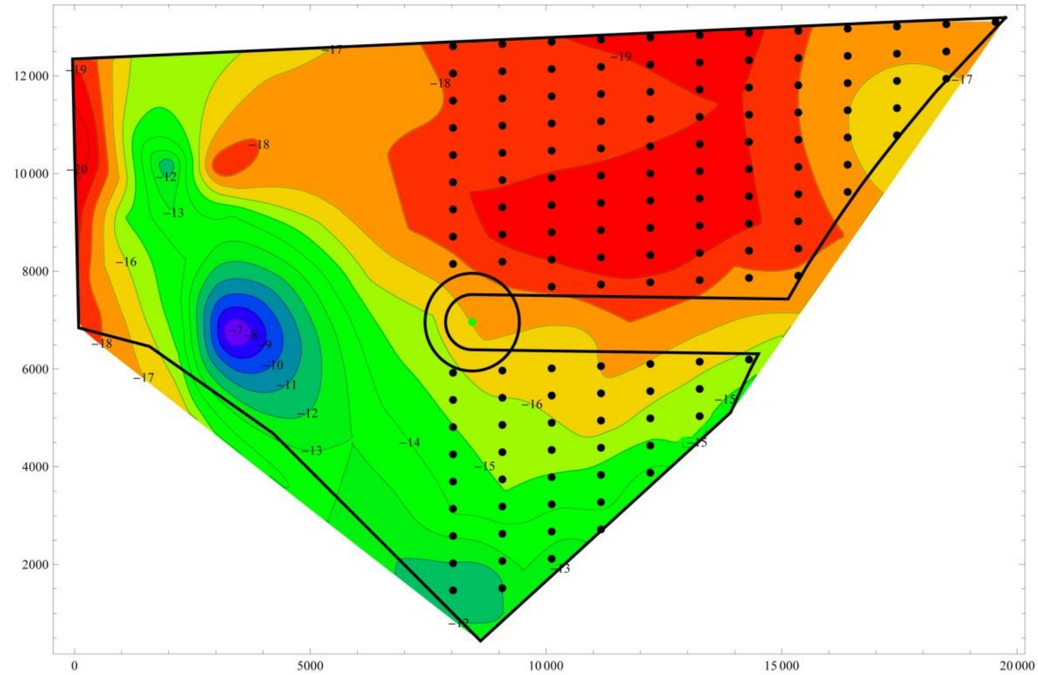


Figure 2.3 Suggested layout for the 3.0 MW wind turbine at Horns Rev 3, closest to shore. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

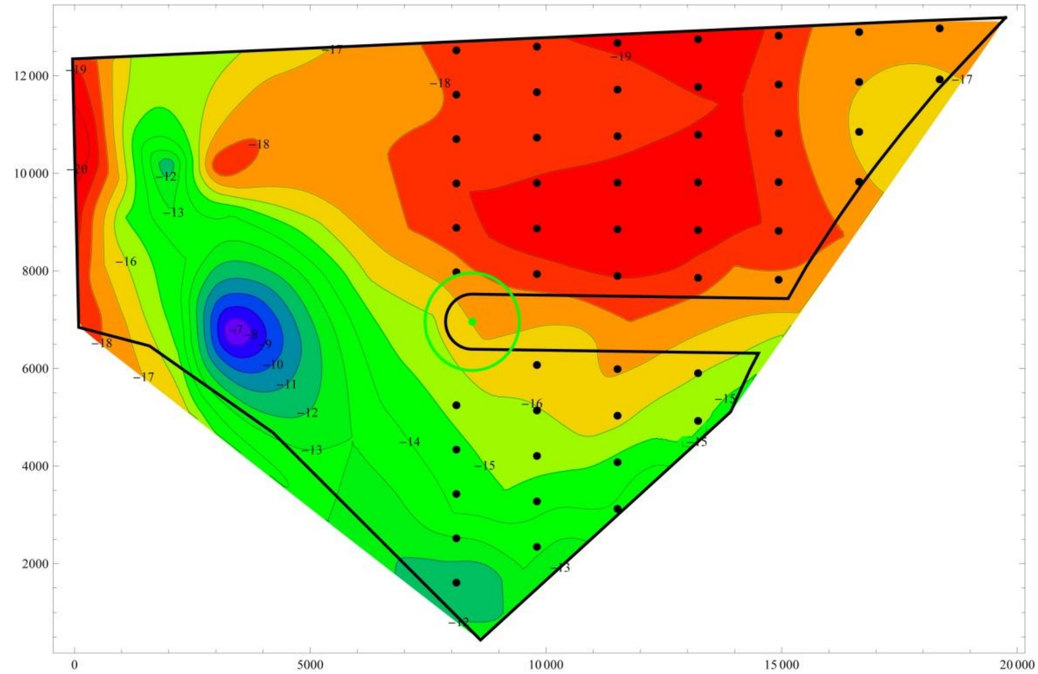


Figure 2.4 Suggested layout for the 8.0 MW wind turbine at Horns Rev 3, closest to shore. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

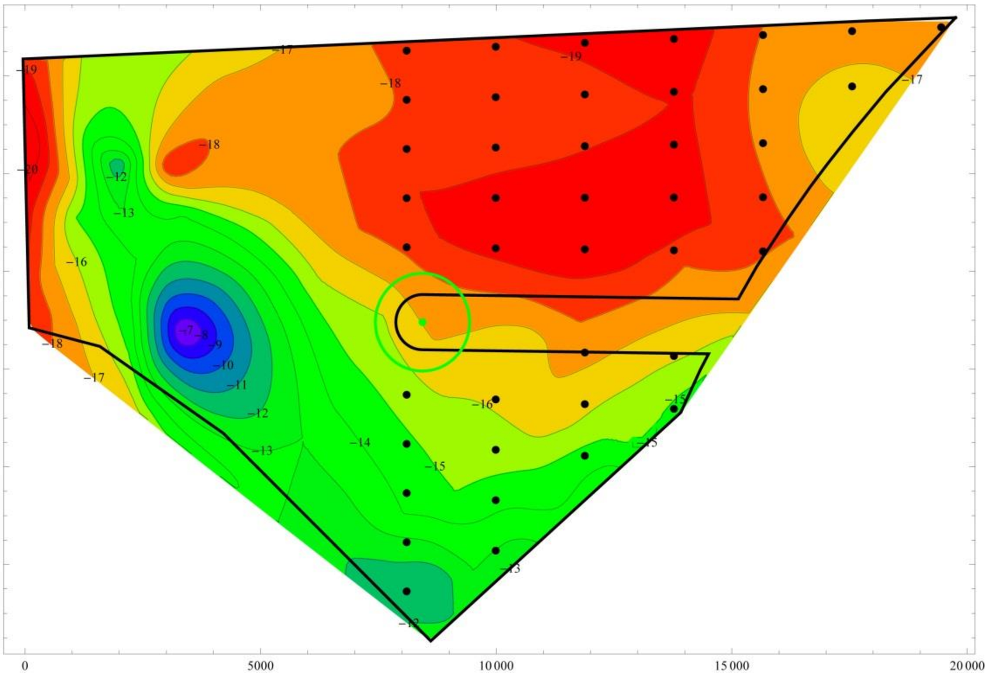


Figure 2.5 Suggested layout for the 10.0 MW wind turbine at Horns Rev 3, closest to shore. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

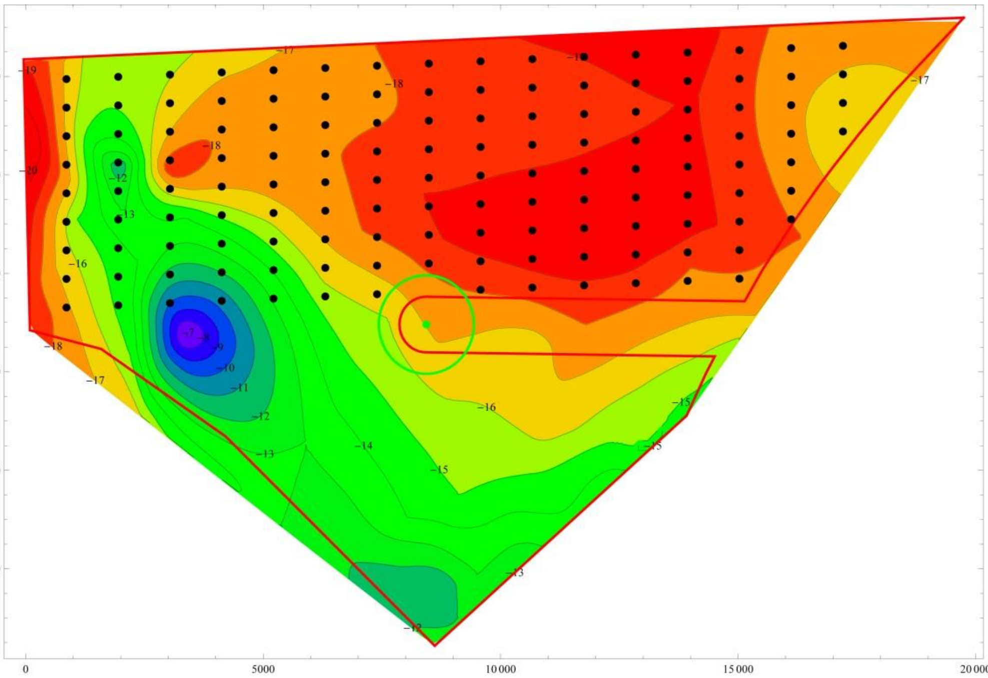


Figure 2.6 Suggested layout for the 3.0 MW wind turbine at Horns Rev 3, located in the centre of the area. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

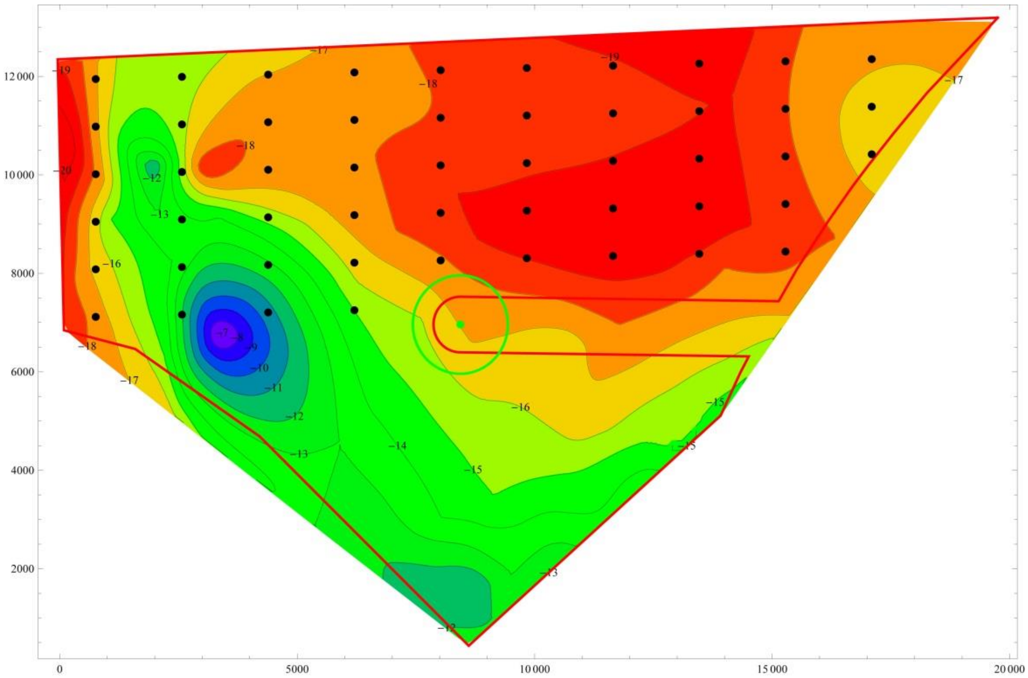


Figure 2.7 Suggested layout for the 8.0 MW wind turbine at Horns Rev 3, located in the centre of the area. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

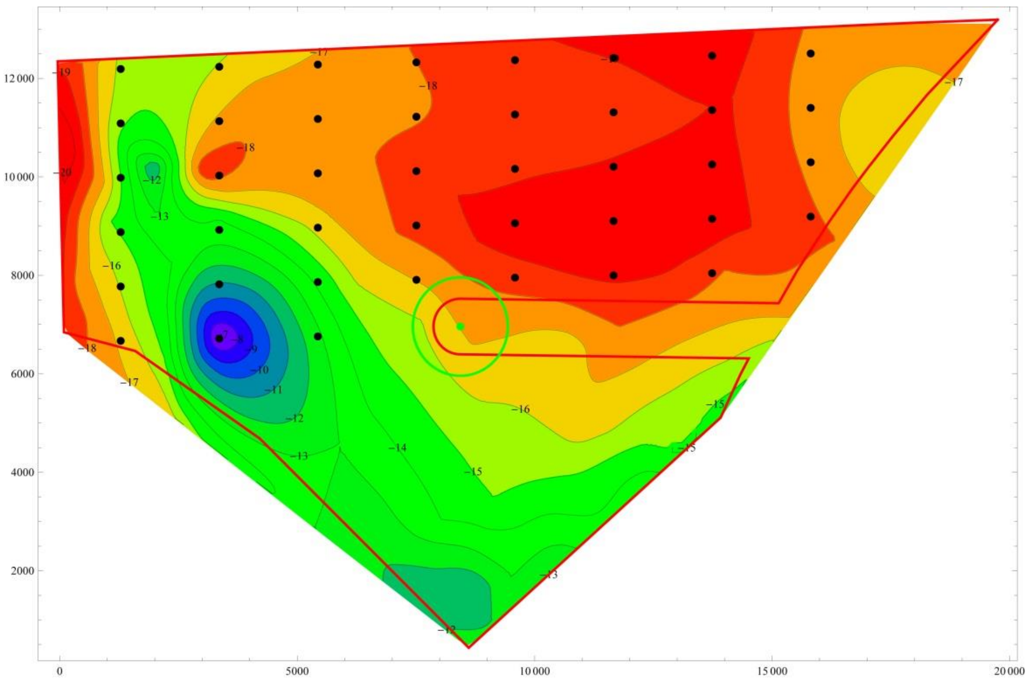


Figure 2.8 Suggested layout for the 10.0 MW wind turbine at Horns Rev 3, located in the centre of the area. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

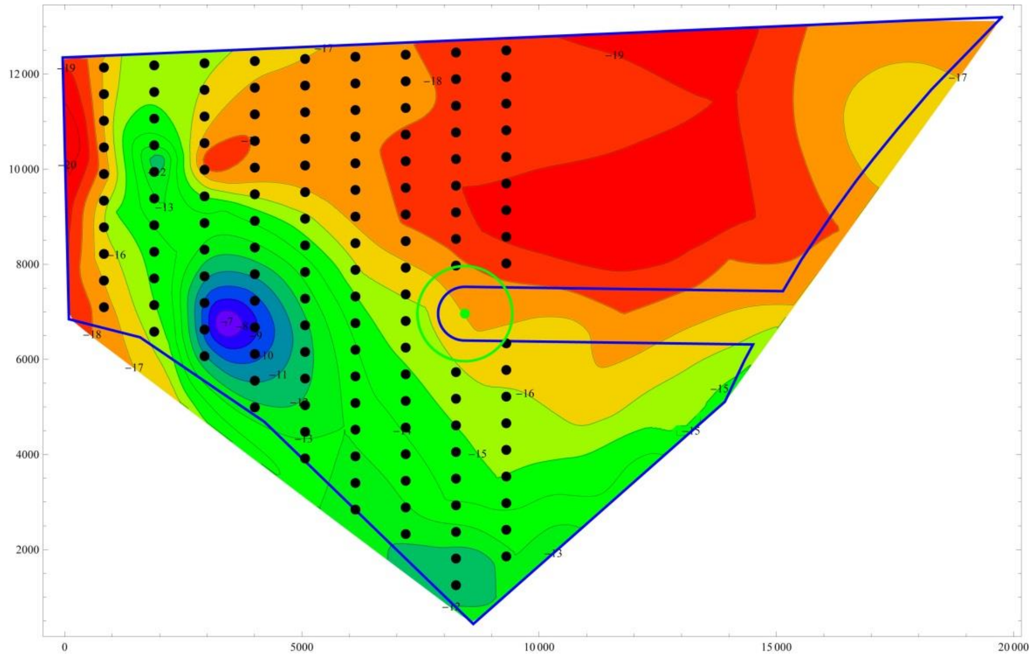


Figure 2.9 Suggested layout for the 3.0 MW wind turbine at Horns Rev 3, located most westerly in the area. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

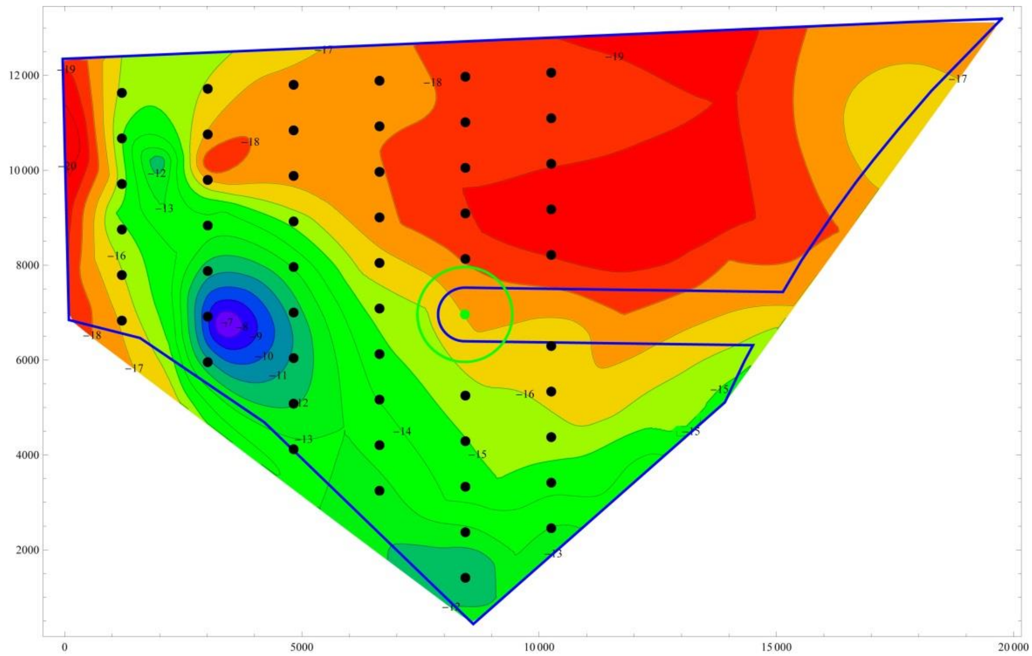


Figure 2.10 Suggested layout for the 8.0 MW wind turbine at Horns Rev 3, located most westerly in the area. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

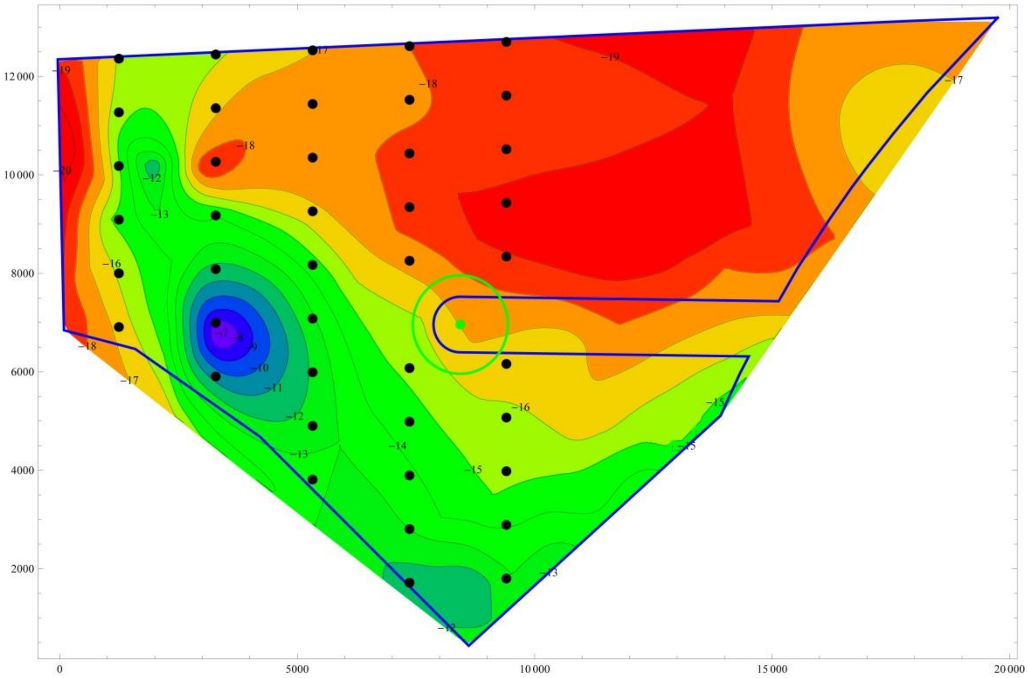


Figure 2.11 Suggested layout for the 10.0 MW wind turbine at Horns Rev 3, located most westerly in the area. Contourlines are colour coded to the nearest 1 m (Note that the coding order is reversed as compared to figure 2.2.).

It is expected that turbines will be installed at a rate of one every one to two days. The works would be planned for 24 hours per day, with lighting of barges at night, and accommodation for crew on board. The installation is weather dependent so installation time may be prolonged in unstable weather conditions. The worst-case layout with regard to the impacts on migratory birds is defined in section 4.4.

Horns Rev 1 Offshore Wind Farm

3. MIGRATING BIRDS IN THE HORNS REV AREA

3.1. Methods

3.1.1 Data sources

The assessment of the occurrence of bird migration (species composition and abundance) in the area of Horns Rev 3 (Horns Rev 3) is deduced from data available from pre- and post-construction surveys carried out for the wind farms Horn Rev 1 (Horns Rev 1) and Horns Rev 2 (Horns Rev 2), from surveys at the coastal peninsula Blåvandshuk (BL), as well as from the secondary literature. Previous surveys in the Horns Rev area included various observational and remote sensing methods (Table 3.1). The following reports were evaluated for gaining data as basis for the present baseline and impact assessment:

- Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 – Bird migration; Orbicon A/S & DHI A/S, 2012 (Skov et al. 2012)

- Investigations of the bird collision risk and the responses of harbour porpoises in the offshore wind farms Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark, Part I: Birds; Uiversität Hamburg & BioConsult SH, 2008 (Blew et al. 2008)

- Effects on birds of an offshore wind park at Horns Rev: Environmental impact assessment; NERI, 2000 (Noer et al. 2000)

These technical reports contain data and results which are considered as sufficient to describe the basic patterns of bird migration expected in the area of Horns Rev 3.

Table 3.1 The main investigations which were applied as database for the baseline and impact assessment for Horns Rev 3.

investigated area	investigation period	method used
Horns Rev 1: Environmental Impact Assessment	April 1999 – April 2000	ship-based visual surveys
Horns Rev 2: Offshore Wind Farm Bird Monitoring Progam	Autumn 2010 – Spring 2012	visual observation radar and rangefinder tracking

3.1.2 Survey techniques

This chapter summarizes the main methodologies used for the several investigations in HR 1 and HR 2 and applied as database for the following baseline study and the EIA.

3.1.2.1. Visual observations

In order to assess the relative importance of the Horns Rev 3 area for migratory birds, results from previous *parallel* visual observations at three observation points (see (Figure 3.1) were collated:

(1) the transformer station "Alpha" (Horns Rev 1; offshore windpark Horns Rev 1)

(2) the platform "Poseidon" (Horns Rev 2, offshore windpark Horn Rev 2)

(3) Blåvandshuk (BL)

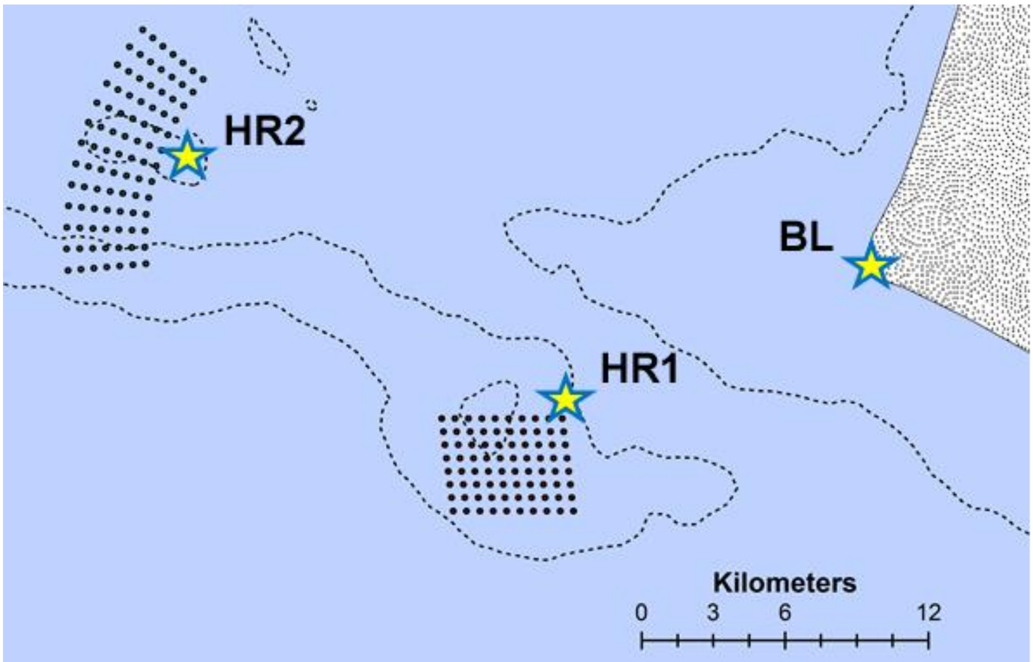


Figure 3.1 Location of the three observation stations Horns Rev 1, Horns Rev 2 and BL in the study area. The turbines of the operational wind farms are indicated by black dots.

The recording routines during the visual observations at all three stations (Figure 3.1) included observations of all movements of birds. The observations provided descriptions of migration rates, spatial distribution and orientation of birds in relation to the position of the offshore wind farm. Due to the generally low abundance of migrating birds at the two offshore locations, counts were undertaken continuously. The observers used binoculars and telescope and recorded species, flock size, flight altitude (25 m categories) and direction (8 categories). These observational data were supplemented by information on flight trajectories of individual birds or bird flocks acquired through horizontal radars (see Figure 3.2).

3.1.2.2. Tracking by rangefinder

During previous surveys in the Horns Rev area (Skov et al. 2012), laser rangefinders (Vectronix 21 Aero®) were used to collect species-specific data on flying birds. A laser rangefinder is comparable to a handheld binocular, but is equipped with a built-in, battery driven laser system, that allows recording distance, altitude and direction to a given object. Thus, operated at known geographical positions and elevations, laser rangefinders can be used to obtain three-dimensional information on the trajectory of a bird's flight. Under optimal conditions, laser rangefinders can cover distances between 2 and 3 km for larger bird species, depending on the angle of view and on bird flight behaviour (gliding, soaring or flapping). They can be operated with approximately 10-15 sec. intervals, and positions and altitudes are automatically logged via GPS. Laser rangefinders (LRF) were operated permanently at the observation points on Horns Rev 2 and Horns Rev 1 with a minimum of 15 minutes per hour allocated for tracking. The data from the laser rangefinder supplemented data collected by the horizontal radar. Metal structures of the two observer platforms (transformer station "Alpha" near Horns Rev 1 and the "Poseidon" platform near Horns Rev 2) limited accurate geo-positioning of the recorded data. To account for this, calibration data were collected at each wind farm once per hour by measuring the individual distances to three turbines in the wind farm using the rangefinder (for details, see Skov et al. 2012).

3.1.2.3. Tracking by radar

In previous studies at the stations near Horns Rev 2 and Horns Rev 1, individual bird species were tracked by horizontal radar (Figure 3.2). A dedicated software package enabled to follow tracks of individual birds or flocks in real-time video streams drawn from the horizontal surveillance radar (for details see Skov et al. 2012). The radar range was set to 6.0 km, potentially providing information on macro-avoidance but at the cost of visual ground-truthing of species that cannot be carried at this scale. During tracking the PC screen was divided into two sections, the radar video and a window to log specific parameters, including the frequency of bird signals, flock altitude, flock size, behaviour, start and end times. The number of nodes and coordinates per node were added automatically. Two observers were involved in the real-time radar-tracking (for details on work-flow and routine, see Skov et al. 2012).

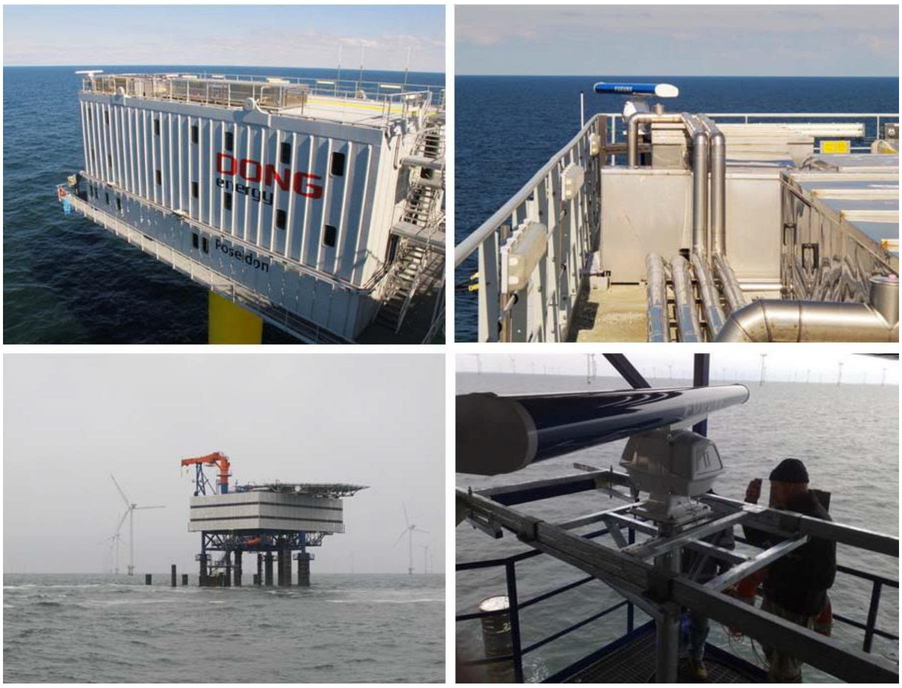


Figure 3.2 The mounted radars at the transformer station "Alpha" (Horns Rev 1, lower panel) and the "Poseidon" platform (Horns Rev 2, upper panel).

3.1.3 Data analysis

In order to describe the expected drop in migratory bird abundance with distance from the coast in relation to the project area HR 3, count data gathered by Skov et al. (2012) during a two-year monitoring programme in the closer surroundings of the two operational offshore wind farms Horns Rev 1 and Horns Rev 2 and a ornithological station located on the mainland (Blåvandshuk) were compared. Since the number of observation days within the four campaigns was different between the three observation stations (see Table 3.2), all count data were expressed as the number of individuals per hour of observation. Furthermore, because survey methods, periods and survey effort varied among sites, relative comparisons were based mainly on proportional data.

Table 3.2 Overview of time (h) spent for visual observation at the three observation stations within the four campaigns performed during the two-year baseline monitoring programme (Skov et al. 2012).

	Autumn 2010	Spring 2011	Autumn 2011	Spring 2012
Blåvandshuk	90.0	125.0	83.0	116.25
Horns Rev I	96.5	71.5	111.0	63.25
Horns Rev II	55.25	109.8	106.5	133.1

All other data presented in this report (e.g. migration rates, flight altitudes, etc.) have been adapted directly from the reports prepared by Noer et al. (2000), Blew et al. (2008) and Skov et al. (2012). The order of species or species groups and their nomenclature follows the order given in Skov et al. (2012), which is based on taxonomic order and on functional associations between bird families (e.g., passerines and pigeons). The selection of relevant migratory bird species for the importance and impact assessment was based on the consistency of occurance during visual observations carried out between 2010 and 2012 near Horns Rev 1 and Horns Rev 2 (Skov et al. 2012). Relevant species are defined as those species observed during at least 3 out of 4 migratory seasons near Horns Rev 1 and/or Horns Rev 2 and occurring in a total of >5 individuals. Total species-specific sums of visual observations during the entire study period (2010-2012) and from both sites (Horns Rev 1, Horns Rev 2) projected onto an annual migration period of 5 months were used as proxy for assessing the local abundance of a given species.

3.1.4 Literature based overview on the biogeography, phenology and abundance of migratory birds relevant to the Horns Rev area

In the following, a review is provided for relevant bird species regarding their biogeography, phenology and abundance, mainly based on the NERI Report (Noer et al. 2000). While the phenology of migratory species describes their seasonal occurrence, abundance refers to the number of individuals migrating per unit of time in a given space and is equivalent to migration rate or intensity.

3.1.4.1. Divers

Red-throated Diver *Gavia stellata* and Black-throated Diver *Gavia artica* have a circumpolar distribution and breed in fresh-water habitats in boreal and low arctic regions north of the 55th latitude (Cramp & Simmons 1977). The current estimates of the European and West Siberian flyway population are 75,000 red-throated divers and 120,000 black-throated divers (Rose & Scott 1997, see also Wetlands International 2013, see also Wetlands International 2013). The main wintering sites are found in areas below 30 m water depth in the southern part of the Baltic Sea, the North Sea and the Atlantic coasts around the British Isles. Wintering divers occur down to the Iberian Peninsula and the Mediterranean Sea (Cramp & Simmons 1977).

The Red-throated and Black-throated Diver occur in Danish waters during most of the year. However, the largest numbers are observed during October-June. The largest concentrations are found west of the Wadden Sea, along the west coast of Jutland and in the northern Kattegat. In the inner Danish waters, large concentrations were recorded in Smålandsfarvandet south of Sealand and in the Rødsand area south of Lolland-Falster (Laursen et al. 1997). Large numbers of divers were recorded south of Bornholm during a severe winter (Laursen et al. 1997). Compared to the maximum spring estimates of 39,000 during 1987-1989, the estimate of c. 28,000 divers west of the Wadden Sea (Laursen et al. 1997) emphasises the importance of this area. The populations of both the Red-throated and Black-throated Diver are not currently threatened, although the wintering population of the Red-throated Diver in north-western Europe shows a decreasing trend (Rose & Scott 1997, see also Wetlands International 2013). A large proportion (85%) of the divers staging at the west coast of

Jutland during spring was classified as Red-throated Diver, i.e. more than 20% of the entire population were present in Danish waters.
At Blåvandshuk, a maximum of 6.000 migrating divers per day were recorded during the main migration periods from March – May and October – November. Up to 5.500 red- and black-throated divers pass Blåvandshuk per day during spring migration from April - May. During autumn migration in October – November, up to 1.000 birds migrate per day through this area (Jakobsen 2008).

3.1.4.2. Northern Gannet

The Northern Gannet *Sula bassanus* is a colonial breeder on small uninhabited islands or inaccessible cliffs in the north Atlantic. Main colonies in Europe are generally old (> 50 years) and located in Britain, the Channel Islands and in Iceland. Smaller colonies exist on the Faroe Islands, northern Norway, and on the island of Heligoland. The current population estimate is 670,000-900,000 individuals (Rose & Scott 1994, see also Wetlands International 2013). Gannets are partially migratory. Adults may stay within the breeding range during winter, but most immature migrate southward as far as the tropical waters off West Africa (Cramp & Simmons 1977). Outside the breeding season, the Gannet is normally associated with continental shelf areas in the North Atlantic and North Sea. The autumn migration peak in northwest Europe is during August-September.

In Denmark, the Gannet is abundant along the west coast of Jutland and in east Skagerrak during late summer and autumn until October. Wintering gannets are rarely observed, but regular occurrences are recorded in spring at the North Sea coast. Based on surveys in 1987 - 89, Laursen et al. (1997) estimated the autumn population at 22,000 birds, mainly in the western part of the Danish North Sea.

The first gannets at Blåvandshuk get registered in July. Their main migration period is September – November in autumn, the peak migration occurs in September and October with a recorded maximum of 4.000 migrating gannets per day.

3.1.4.3. Sea Ducks

Among the sea ducks (*Merginae*), the Eider *Somateria mollissima* and Common Scoter *Melanitta nigra* reach high migration numbers around Blåvandshuk. In this area, a maximum of 30.000 eiders per day has been recorded (Jakobsen 2008). During spring and autumn migration, a total of 1.5-2 million eiders pass through Danish waters (Madsen et al. 1996). Up to 60.000 common scoters per day have been counted at Blåvandshuk during the autumn migration peaks in August-September (Jakobsen 2008). A medium migration intensity of 367 Indiv./h was counted during seawatching on the island Sylt, Germany (Hüppopo et al. 2009). Common scoters also undertake a moult migration and up to 20.000 pre-moulting birds have been observed at Blåvandshuk in June. The offshore area from Blåvandshuk to Rømø has been assigned as an internationally important area for autumn migration due to surveys in this area of Laursen et al. (1997).

The Common Scoter was the most counted bird while seawatching on the island Sylt, Germany, representing 68.2% of the 25 most frequently recorded birds (Hüppopo et al. 2009). The nominate race of this species breeds in the boreal and into low-arctic tundra regions from Iceland to river Olenek in Siberia (Dement'ev et al. 1967). The southern border of the breeding range extends to Ireland, northern Britain, southern Norway, central Sweden, central Finland and northern Russia (Hagemeijer & Blair 1997). The current population estimate is 1.6 million birds based on mid-winter counts (Rose & Scott 1997, see also Wetlands International 2013). Moult migrations are undertaken by adult males and non-breeding birds from the breeding areas to coastal and offshore waters in the Baltic in mid-June to early September. The autumn migration of breeding females with young takes place in October-November. The entire population winters in coastal waters of Western Europe and along the African coast (Cramp & Simmons 1977). They return during March-May in large concentrations, accumulating in the Baltic. Birds migrating over the sea typically fly at low altitudes whereas birds crossing larger landmasses fly high. In Denmark, the Common Scoter is numerous and widespread around all coasts for most of the year, since many immature birds remain through spring and summer. Highest concentrations occur in the Kattegat, in the North Sea off the Wadden Sea coast, and Sejerø Bugten (Laursen et al. 1997). The geographical distribution varies during the year and may also vary from year to year. Up to a million birds have been estimated wintering in Danish Baltic waters (Pihl 1994) and 80,000 may occur in the Wadden Sea (Laursen et al. 1997). During spring and autumn migration, several hundred thousand Common Scoters cross Danish waters on migration.

Common Scoter © Thomas W. Johansen

The Velvet Scoter *Melanitta fusca* has an almost circumpolar breeding distribution on the northern hemisphere; however, it is not breeding in northeast Canada and Greenland. Isolated breeding populations have been found in Caucasus. In Europe the breeding range extends from West Siberia over northern Finland and down on the Scandinavian peninsula. Coastal breeding areas are found in the Gulf of Bothnia and in the Gulf of Finland. The European population was estimated at 1 mill. birds (Rose & Scott 1997, see also Wetlands International 2013). Moult migration is undertaken by males in July and August. Females mainly arrive to the moult sites in August and September. Velvet Scoters are known to moult at remote coastal and offshore habitats within the breeding range. However, a substantial proportion of the scoters undertake long distance moult migration south of the breeding range, e.g. to Danish waters. Wintering Velvet Scoters occur along the Norwegian coast, in Danish waters, the Baltic, the Wadden Sea and even further south to Iberia and around the British Isles. Spring migration occurs from March to May (Cramp & Simmons 1977). For the Velvet Scoters, aerial surveys in the late 1980s indicated that Danish waters have lost their importance for moulting (Laursen et al. 1997). The most important moult sites are Kattegat, Sejerøbugten and Smålandsfarvandet. During autumn and winter, the same areas tend to be the most important staging areas whereas some dispersal to sites south of Funen and Lolland-Falster seems to occur during spring. In the late 1980s, estimated numbers of Velvet Scoters in Danish waters were 22,000-100,000 (autumn), 109,000-130,000 (winter) and 27,000-90,000 (spring) based on aerial and ship surveys (Laursen et al. 1997).

3.1.4.4. Geese

Referring to Noer et al. (2000), Dark-bellied Brent Goose *Branta bernicla bernicla* and Barnacle Goose *Branta leucopsis* are included in the annotated list of relevant species in the Horns Rev area. Conversely, Skov et al. (2012) documented two other species (Greylag Goose *Anser anser* and Pink-footed *Anser brachyrhynchus*) at the two offshore observation stations.

The Barnacle Goose breeds from arctic Greenland to Novaja Zemlya extending down to the boreal and temperate zone in Europe. The west Siberian/Scandinavian population of Barnacle Goose occurring in continental Europe in winter is estimated at 176,000 individuals. In addition, the Svalbard and Greenland population wintering in Britain hold 12,000 and 32,000, respectively. The Brent Goose has a circumpolar breeding distribution in the arctic region. The population estimate of the nominate race *B. b. bernicla* occurring in West Siberia and Europe is 300,000 (Rose & Scott 1997, see also Wetlands International 2013). In the most northerly populations autumn migration is initiated in August as snow cover makes feeding impossible. In northwest Europe the main migration period for Barnacle Goose and Brent Goose is in September-October. The winter range extends from southern Scandinavia and Britain down to France. Large numbers of both species gather in The Wadden Sea during April. Barnacle geese continue the spring migration from late April. Dark-bellied Brent geese depart the Wadden Sea in late May (Cramp & Simmons 1977).

No specific moult sites for Barnacle Goose are known for Denmark. During autumn and spring, significant migration occurs through Danish waters. Geese do not stage or winter in open sea (Olsen 1992).

The most northerly populations of Barnacle geese and Brent geese start migrating in August as snow cover inhibits feeding. In northwest Europe the main migration period is in September – October. Up to 1.000 Brent geese per day have been observed at Blåvandshuk during autumn migration. During spring, both geese take a route over the southern part of Denmark, including the southern part of Jutland, depending on weather conditions. They pass this part of Denmark again in September – October with daily maxima of 10.000 – 25.000 geese observed at some sites at the Baltic Sea (Olsen 1992).

3.1.4.5. Waders

Wader migration in Europe occurs in spring from early March to early June. The autumn migration starts by the end of July - November and is divided into an adult migration wave and a later occurring juvenile movement of two age groups, migrating with a time gap of around one month. The migration of waders at the Danish coast includes several hundred thousand individuals each spring and autumn. The most numerous species, migrating on one of the most conspicuous migrating routes along the west coast of Jutland, are Oystercatcher *Haematopus ostralegus*, Dunlin *Calidris alpina* and Knot *Calidris canutus*. The majority were oystercatchers and Dunlins (about 8.000 individuals per day). Their main occurrence is July – September. Knots were observed with up to 3.500 birds per day. Their main occurrence is in July – September and April – May. Waders migrating through Denmark breed from Canada to the Tajmyr-Peninsula. Waders are traditionally divided into boreal breeding species and arctic breeding species (Meltofte 1993). It was estimated that up to 10 million wintering waders occur along the African and European coasts (Smit & Piersma 1989, Piersma et al. 1987, Meltofte 1993). The spring migration of waders in northern Europe occurs from early March to early June. However, the species specific migration periods are much narrower. The period of autumn migration starts by the end of July and continues through November (Meltofte 1993). The autumn migration is divided into an adult migration wave (in long jumps) and a later occurring juvenile movement (in small jumps) with a gap of ca. one month between the two age groups. Waders which migrate along the east Atlantic flyway winter from northwest Europe to South Africa.

3.1.4.6. Auks

The Guillemot *Uria aalge* is more abundant and widely distributed in the North Sea than the Razorbill *Alca torda* (Laursen et al. 1997). 4.500 – 20.000 Guillemots were estimated in the German Bight in the late summer and increases to 15.000 – 30.000 individuals in autumn. Razorbills were estimated at 100 – 1.700 individuals during autumn and up to 4.200 birds in winter. Guillemot and Razorbill are most numerous at Blåvandshuk during October - November with up to 1.500 birds counted per day. In winter from Dezember to February the lowest numbers occur (Jakobsen 2008). The northwestern European population is estimated to be 1.5 million Guillemots and 200.000 Razorbills.

3.1.4.7. Gulls

Among the gulls occurring in Denmark, Herring Gull *Larus argentatus*, Great Black-backed Gull *Larus marinus*, Lesser Black-backed Gull *Larus fuscus*, Common Gull *Larus canus*, Little Gull *Larus minutes* and Kittiwake *Rissa tridactyla* are mentioned in this section due to their occurrence at the projected off-shore wind farm Horns Rev 3. According to the NERI Report (Noer et al. 2000), the Black-headed Gull *Larus ridibundusis* in primarily associated with inshore waters whereas the Little Gull occurs mostly in the west-north-west of Blåvandshuk.

55,000-58,000 pairs of the Herring Gull breed regularly in Denmark and are distributed over vast areas on the northern hemisphere from the arctic to sub-tropic and is divided into several sub-species. In northern Europe both the nominate race (*Larus argentatus argentatus*) (1.4 mill.) and the 'British Herring Gull' (*L. a. argenteus*) (1.3 mill.) occur. Herring Gulls are migratory in north-eastern Europe, whereas in the rest of Europe Herring Gulls are sedentary or dispersive. The main migratory periods last from September to October and from March to April. There is evidence for "leap-frog" migration, in which Herring Gulls from southern Scandinavia winter in the nearby Danish waters whereas Herring Gulls breeding further north winter in the Channel area. Herring Gulls occur in Danish waters throughout the annual cycle around almost all coasts. During autumn, the dispersive segment of the Danish breeding population is replaced by Herring Gulls from northern and north-eastern Europe. The total population in Danish waters from autumn onwards was estimated at 205,000-381,000 (Laursen et al. 1997).

The Great Black-backed Gull occurs at Blåvandshuk throughout the year. Highest numbers are recorded during summer and autumn with up to 750 birds counted per day (Jakobsen 2008). The species seems to be more pelagic during autumn and winter than during spring and summer (Skov et al. 1995). Rose & Scott (1997) estimated the north-eastern Atlantic population to be 480,000 Great Black-backed Gulls.

The Lesser Black-backed Gull breeds in colonies at coasts and lakes in Northern Europe. It breeds in colonies, often with other gulls, ranging from a few pairs to several tens of thousands (Snow and Perrins 1998, Richards 1990). Telemetry studies by Pütz et al. (2008) and Klaassen et al. (2012) show that the Lesser Black-backed Gull regularly follows the coastline of Europe on its journeys to North Africa. Autumn migration is started by the non-breeding birds in late-June, the breeding birds following from late-July to September (Olsen and Larsson 2004). The return migration takes place between February and late-June (del Hoyo et al. 1996), with the species arriving at breeding colonies from March onwards, and breeding from May or late-April to mid-June (del Hoyo et al. 1996). They migrate solitary or in small flocks and often feeding in flocks of hundreds of individuals on rubbish dumps or over shoals of fish at sea (Urban et al. 1986). This species winters all over the North Sea up to the African coast of the Atlantic (Svensson et al. 1999). The overall population trend is increasing, although some populations are decreasing (Wetlands International 2006, 2013).

Among the large gulls, the Herring Gull is very common in the area around Horns Rev, and during the spring migration (late February - May) numbers remain high with up to 5.000-7.000 birds per day. In autumn migration (late summer - November) a maximum number of 23.000 birds per day were measured. The highest numbers of Great-Black-backed Gulls Larus marinus, with up to 750 birds per day were recorded during summer and autumn. The autumn migration of the Lesser Black-backed Gull Larus fuscus starts in late-June until September, with a maximum number of 20 birds per hour in august (Hüppop et al. 2010) based on seawatching data on the German island Sylt. The spring migration takes place between February and late-June with up to 268 birds per hour, in that region (Hüppop et al. 2010). The estimated northwestern European population is 1.4 million Herring Gulls, the estimated northeastern Atlantic population is 480.000 Great-Black-backed Gulls.

The Common Gull breeds at the coast and inlands all over northern Europe as well as northern Asia and north-west North America. The global population is estimated to 2.5-3.7 million individuals (Wetlands International 2006, 2013). This species is fully migratory (del Hoyo et al. 1996). It breeds from May onwards in solitary pairs or in single- and mixed-species colonies of up to 300 pairs (Flint et al. 1984, del Hoyo et al. 1996) or more (e.g. 1,000 pairs in Baltic region (Snow and Perrins 1998). Outside of the breeding season the species remains gregarious, foraging in flocks of up to one hundred or more individuals during the winter, flock sizes depending upon the habitat and conditions (Snow and Perrins 1998). The spring migration of the Common Gull starts in March, reaching a maximum peak with 100 birds per hour in the early April and ends in late May. The autumn migration takes place in the early August – mid November. (Hüppop et al. 2010).

Denmark constitutes the western border of the breeding range for the Little Gull, where it breeds occasionally. The species has four discrete breeding populations: North America, East Siberia, West Siberia (between Ob and Ural), and the northwest Russian/Baltic breeding population (60,000-90,000) of which several 100 occur in northwest Europe outside the breeding season (Rose & Scott 1997, see also Wetlands International 2013). The eastern European population of Little Gulls migrates west and southwest in August-September to winter in the western part of the North Sea, the Irish Sea southward to the Mediterranean. Small numbers also winter in the Black Sea. Little Gulls return to the breeding areas between March and May. In mild winters up to 1,200 Little Gulls may winter in Danish waters (Olsen 1992). Little gulls are mostly observed during the migratory periods in the Baltic and west of Blåvandshuk. In January – April, up to 200 Little Gulls per day are passing at Blåvandshuk. A maximum of 600 birds per day has been recorded during the autumn migration in October – November (Jakobsen 2008, Laursen et al. 1997). The Central/Eastern European population is estimated to be 60.000-90.000 Little Gulls.

The Kittiwake occurs in the North Sea, Skagerrak and Kattegat (estimated at 315,000 individuals) during autumn and winter. Kittiwakes (ca. 625 pairs) regularly breed in Denmark. It has a circumpolar breeding distribution down to 40ºN on coastal cliffs. Kittiwakes may in the absence of natural habitats nest on buildings. The eastern Atlantic population of Kittiwakes was estimated to be 8.4 million. Wing moult in all gulls is sequential and is typically commenced in May and lasts several months before the last moulted primary is regrown. Kittiwakes disperse over the North Atlantic when not breeding and become more coastal again towards the breeding season. During autumn and winter, Kittiwakes occur in the North Sea, Skagerrak and Kattegat (estimated at 315,000 individuals). The influx of Kittiwakes to Danish waters during autumn is observed as migratory movements, most conspicuous at the northwest coast of Jutland; up to 33,000 Indiv./day. The return to the breeding areas is in particular recorded at Skagen; up to 30,000 Indiv./day (Rose & Scott 1997, see also Wetlands International 2013). Kittiwakes may be seen at Blåvandshuk with up to 5.000 birds per day from late August to late October (Jakobsen 2008). The estimated eastern Atlantic population of Kittiwakes counts 8.4 million (Rose & Scott 1997, see also Wetlands International 2013).

3.1.4.8. Terns

Common Tern *Sterna hirundo* (1,000-1,500 pairs), Arctic Tern Sterna paradisaea (8,000-9,000 pairs), Sandwich Tern *Sterna sandvicensis* (4,500 pairs), Little Tern *Sterna albifrons* (400-600 pairs), and Gull-billed Tern *Gelochelidon nilotica* (ca. 10 pairs) breed in colonies in the coastal zone in Denmark. The Caspian Tern *Sterna caspia* and Black Tern *Chlidonias niger* also breed in small numbers in Denmark – the latter species was recorded on one occasion during field work at Horns Rev 1.

Common Tern and Arctic Tern have a circumpolar breeding distribution in the temperate and arctic zone. Arctic Tern breeds at higher latitudes than Common Tern. Arctic Terns prefer to breed in the coastal zone whereas Common Tern also breeds on freshwaters. Sandwich Tern, Little Tern, and Gull-billed Tern are distributed around the world in the temperate zone often in isolated populations. Population estimates are: Common Tern (780,000 indiv., Europe), Arctic Tern (unknown but more than 100,000 pairs breed in northwest Europe). Sandwich Tern (150,000 indiv., western Europe), Little Tern (34,000 indiv., eastern Atlantic) and Gull-billed Tern (12,000, western Europe) (Rose & Scott 1997, see also Wetlands International 2013). None of the tern species occurring in Denmark winter within the borders of Europe. Common Tern, autumn migration in northern Europe (AM): July - September; wintering area (W): western Africa; spring migration (SM): April - May. Arctic Tern AM: July-September; W: Antarctica, South Africa; SM: April-May, Sandwich Tern AM: July-November; W: western Africa; SM: March-May. During the breeding season terns are dispersed along the coasts as they make foraging trips from the breeding colonies to areas with shallow water. Large numbers of Common Terns, Arctic Terns and Sandwich Terns pass Danish waters during the migration period. During spring, the migration of Common Terns is most notable with up to 15,000 migrating individuals at Skagen. The autumn migration tends to proceed at a slower pace. Hence, large concentrations of roosting terns are observed, in particular at the west coast of Jutland, e.g. up to 8,000 Common Terns at Langli, up to 17,000 Arctic and Common Terns (Kjær 2000) and up to 10,000 Sandwich Terns at Blåvandshuk (Olsen 1992). From the roosts daily foraging trips are undertaken by the terns to nearby waters. At Blåvandshuk, a maximum of 15.000 migrating terns per day were recorded. Their main migration period was from July – September. Up to 5.000 Terns (Arctic Tern and Common Tern) can be observed at Blåvandshuk whereas the spring migration peaks in late April - early May (Jakobsen 2008). Highest numbers of Sandwich terns with up to 1.800 birds per day were observed in April - May and up to 6.000 birds per day during migration in July – August May (Jakobsen 2008). The European population of Common Tern is estimated to be 780.000 birds, the western European and western African population of Sandwich Terns is estimated to be 150.000 birds (Rose & Scott 1997, see also Wetlands International 2013).

3.1.4.9. Raptors

Raptors can be divided in to three different categories based on their wintering area: 1) resident species that stay in the breeding area throughout the year (e.g. Danish Goshawks *Accipiter gentilis* and some of the Sparrowhawk populations); 2) short migrating species wintering in southern-Europe and around the Mediterranean (e.g. the populations of Buzzard and Kestrel in northern Europe); and 3) long migrating species that winters in Africa, and hence, migrate over the Sahara desert (e.g. Honey-buzzard and Osprey *Pandion haliaetus*). Soaring raptors need the land-depended thermals for their migration, and are consequently, funnelled into places that give them the shortest route over water. Consequently, the migration routes over-water of these broad-winged birds of prey are relatively limited in space. By contrast, the strong fliers that rely on active flight regularly cross long stretches of water, resulting in a broad fronted migration pattern.

The raptors that migrate over Danish waters breed mainly in Scandinavia (incl. Denmark) and north-western Russia. A crude estimate for the total Scandinavian raptor population (all species combined) amount to 160,000-200,000 breeding pairs (Gensbøl 1987, Risberg 1990, Grell 1998). The most numerous species are Sparrowhawk *Accipiter nisus* (38,000 pairs), Buzzard *Buteo buteo* (34,000 pairs), Honey-buzzard *Pernis apivorus* (14,000 pairs), Merlin *Falco columbarius* (12,000 pairs) and Kestrel *Falco tinnunculus* (10,000 pairs). The spring migration in northern Europe starts in early February and continues until early July. The specific peak throughout the spring migration for the Buzzard Buteo buteo is March, for the Sparrowhawk and *Merlin Falco columbarius* late April and for the Honey-buzzard Pernis apivorus late May. The autumn migration starts in late August till the end of October. Data on migrating raptors for Denmark in spring are 7.000 – 14.000 Buzzards, 9.000 – 12.000 Sparrowhawks and 500 – 700 Merlins (Olsen 1992). Each autumn 19.000 Buzzards, 30.000 Sparrowhawks and 5.500 Honey-buzzards are heading for Denmark from Sweden. During visual observations in the Horns Rev wind farm area, Marsh harrier *Circus aeruginosus*, Sparrowhawk, Red kite *Milvus milvus*, Merlin, Peregrine falcon *Falco peregrinus* and Kestrel *Falco tinnunculus* were recorded (Blew et al. 2008). Migrating raptors were rare at Horns Rev 1 and Horns Rev 2 (Skov et al. 2012). Kestrel and Peregrine falcon were the most frequently recorded species at Horns Rev 2, four and three individuals, respectively. One Marsh harrier was observed in Horns Rev 2, Sparrowhawk, Merlin and Hen harrier Circuscyaneuswere recorded also once in Horns Rev 1.

3.1.4.10. Passerines (and Pigeons)

Denmark is an area of great importance for passerines migrating from their breeding grounds in Scandinavia to continental Europe. Due to the high number of juveniles in the post-breeding season, the autumn migration is more voluminous and over 1.5 million passerines head towards Denmark. Most of the species passing Denmark on migration are breeders from Scandinavia, the Baltic States or western Russia. The migration periods in northern Europe are March-May and August-November. They prefer to fly over land, but also cross over open sea when necessary. They migrate either in flocks or solitary, some species are nocturnal others daylight migrants. The flight altitude varies among species and weather condition as well as the nature of landscape (Alerstam 1977).

The dominant day-time migrants of the survey of Skov et al. (2012) were Meadow Pipit, Chaffinch and Starling. The most common pipit is the Meadow Pipit *Anthus pratensis*. This species breeds i.a. in Island, Skandinavia and tundra, but passes the winter in Western Europe and the Mediterranean area. Strong migration of Meadow Pipit from the Northeast occurs in March/April and from September until November. The highest peak is in October (Svensson et al. 1999). Hüppop et al. (2009) estimated a mean migration rate of 170 Indiv./h for the island Sylt, Germany. According to census data by Blew et al. (2008) in the Horns Rev area, the Meadow Pipit was the most abundant songbird species, with e.g. 13% of all recorded passerines (n=9940) in autumn of 2005 and 2006.

The Chaffinch *Fringilla coelebs* is the most abundant breeding bird in Europe. North easterly populations winter in the temperate zones of Europe. They are daylight and nocturnal migrants and follow coast lines, river valley or mountain passes. Migration starts in the middle of September up to the end of October and is also noticeable in March (Svensson et al. 1999).

Starling *Sturnus vulgaris* breed almost everywhere in Europe. This species is found in enormous numbers after breeding. North-easterly populations migrate mainly between September and March towards temperate zones of Europe. Up to 500 individuals in one migrating flock can be observed (Hüppop et al. 2009). A maximum of 3.079 Ind/h was observed on the island of Sylt, Germany (Hüppop et al. 2009). Of all identified passerines (34%), counted in the Horns Rev area, the starling was the second abundant bird with 7% of all observed individuals in autumn in 2006 and 2006 (Blew et al. 2008).

The Woodpigeon *Columba palumbus* breeds all over Europe (Svensson et al. 1999). Migrating birds from the North and East winter mainly in the West of Europe. Compact flying flocks are mostly seen on migration with highest peaks in March to April and October to November. This species shows gregarious migration behaviour with flocks counting several thousand individuals. Migration often occurs at several hundred metres. The population in Denmark was estimated at 291.000 pairs (Jacobsen 1997) and approximately 50% are residents. The Scandinavian migrants winter in western and southwest Europe (Olsen 1992, Grell 1998). The woodpigeon is the most numerous migrating pigeon in Denmark. More northern Scandinavian breeders in contrast migrate in flocks which may count several thousand individuals to west and southwest Europe and thereby forced to cross Danish waters. They try to avoid flights over open waters and are most conspicuous in eastern Denmark (Olsen 1992).

3.1.5 Comparative approach to species composition and relative abundance of migratory birds in the Horns Rev region

During the previous post-construction bird monitoring program at "Horns Rev I" (Horns Rev 1) and "Horns Rev II" (Horns Rev 2) (period: autumn 2010 - spring 2012), approximately 159,000 birds were counted and 195 species were classified during daytime. Marked differences in the number of observed individuals and species composition occur between Blåvandshuk (BL) and the two offshore observation stations in the vicinity of the wind farms (Figure 3.3). In all four campaigns (autumn 2010 through spring 2012), the number of individuals and the number of species observed at the two offshore sites were significantly lower than at Blåvandshuk (Figure 3.3).

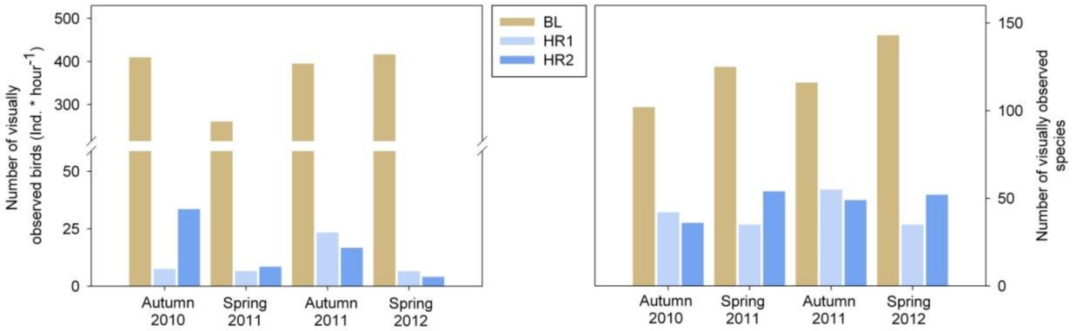


Figure 3.3 Number of birds and species observed visually at the three observation stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

Figure 3.4 and 3.5 provide a more detailed picture of species composition at the three sites and reveal marked seasonal differences between autumn and spring. In autumn 2010 and 2011, the species group "passerines and pigeons" dominated species composition at HR 2 and BL. In spring 2010 and 2011, seabirds (ducks and gulls) dominated the pattern, except for HR 2, where waders contributed most to the frequency proportion. Generally, among-site variation in species composition was higher in spring than in autumn. Spring migration is generally found to take place during a shorter period of time and is dominated less by juvenile individuals, which may explain differences in relative species composition found among seasons. However, among-site variation remains largely unexplained due to the multitude of potential influences, such as species specific flight route ecology (broad front vs. narrow front migration), among-year variation in demography, among-year and -site variation in weather conditions and seasonality. Separating the effects of these variables on species composition and phenology is not possible on the basis of descriptive single-year and single-site surveys. Moreover, sea watching from the coast may be more thoroughly performed as from offshore platforms where conditions are unfavourable, leading to a higher detection probably from land. Thus, an observer bias between coastal and offshore surveys cannot be excluded.

Altogether, day-time bird migration over the Horns Rev region is dominated by passerines, pigeons and sea duck species, most notably the Common Scoter.

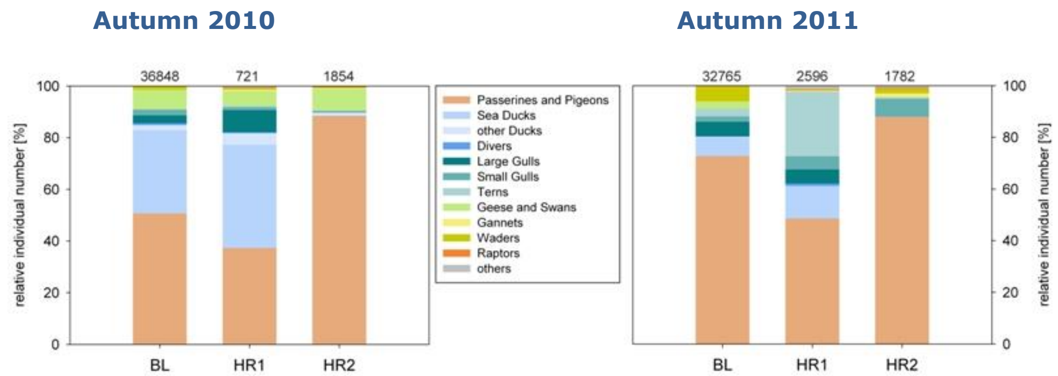


Figure 3.4 Relative proportions of individuals of the most abundant bird groups at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total number of individuals seen in flight at each of the study sites.

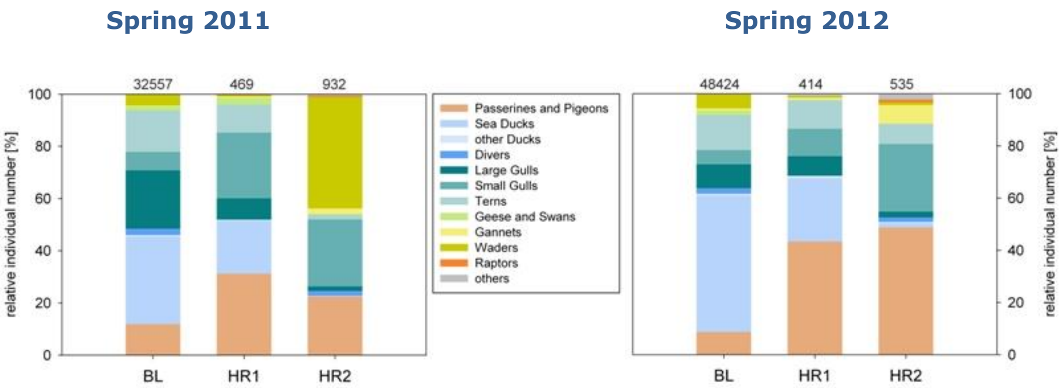


Figure 3.5 Relative proportions of individuals of the most abundant bird groups at the three observation stations in spring 2011 and 2012. Numbers above the bars give the total number of individuals seen at each of the study sites.

3.1.5.1. Divers

2,188 divers were counted and three species (Red-throated Diver, Black-throated Diver, Great Northern Diver) were classified during the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012). As shown in Figure 3.6, there were marked differences during all four campaigns in the number of observed individuals between Blåvandshuk (BL) and the two offshore observation stations at Horns Rev (Horns Rev 1, Horns Rev 2), with substantially lower numbers at the offshore sites as compared to Blåvandshuk. From the three diver species recorded during the monitoring program, only the two common species (Red-throated Diver, Black-throated Diver) were recorded at the offshore sites (Figure 3.7 and Figure 3.8).

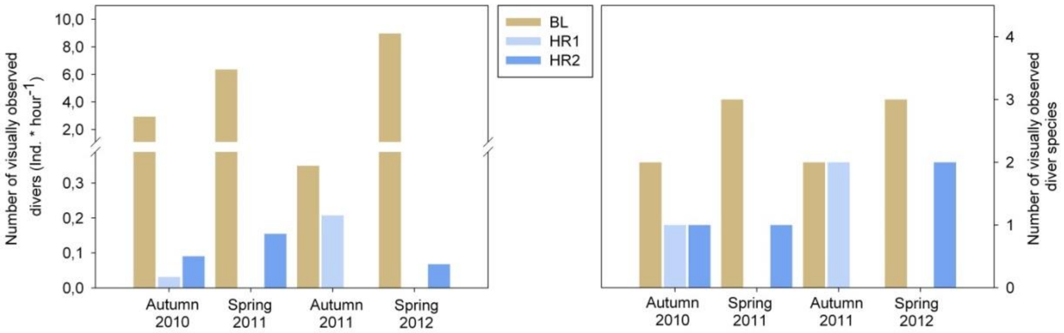


Figure 3.6 Numbers of individual divers and species observed during day-time at the three stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

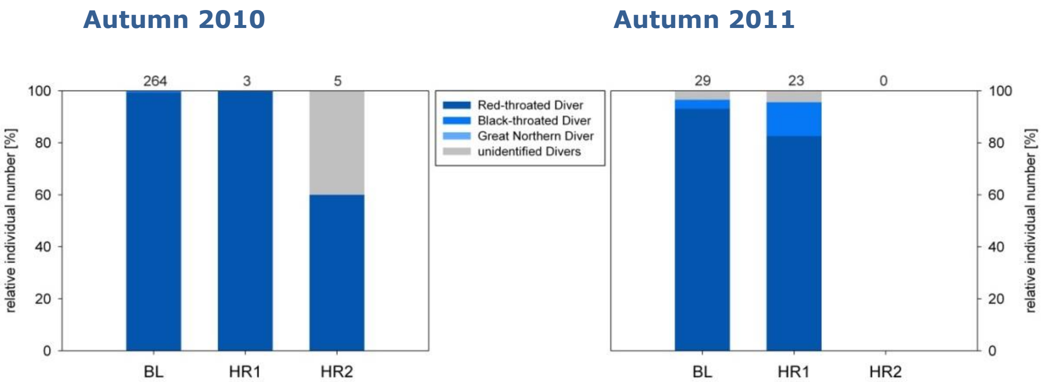


Figure 3.7 Relative proportions of individuals of the most abundant diver species at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total sample size at each site.

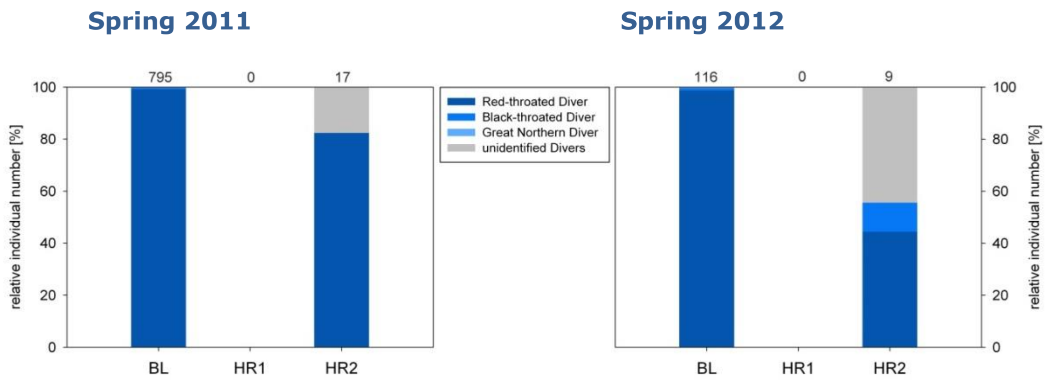


Figure 3.8 Relative proportions of individuals of the most abundant diver species at the three observation stations in spring 2010 and 2011. Numbers above the bars give the total sample size at each site.

3.1.5.2. Northern Gannet

664 Northern Gannets were observed during the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012), with generally higher numbers found at Blåvandshuk (BL) as compared to the two offshore sites at Horns Rev (Figure 3.9).

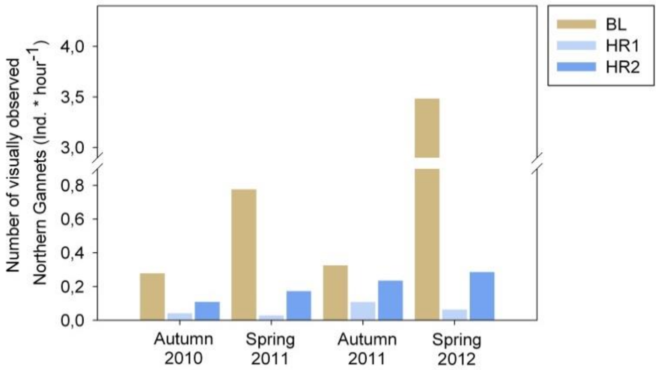


Figure 3.9 Number of individuals "Northern Gannet" observed during day-time at the three observation stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

3.1.5.3. Sea ducks

During day-time, 50,890 sea ducks *(Merginae)* were counted on migration belonging to six species - i.e. Common Scoter, Common Eider, Velvet Scoter, Long-tailed Duck, Goldeneye, and, as an exception, the Nearctic Surf Scoter - were classified within the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012). In all four campaigns, individual and species numbers were substantially lower at the two offshore sites than at Blåvandshuk (Figure 3.10), supporting the general finding that migratory movements and foraging in these benthivorous species take place mainly in the shallow-waters near the coastline. From the six species recorded during the monitoring program, five species (Common Scoter, Eider, Velvet Scoter, Long-tailed Duck and the exceptional Surf Scoter) were recorded at the two offshore sites (Figure 3.11

and Figure 3.12). Of all species, only the Common Scoter was represented with relatively high numbers, yet only at Blåvandshuk and Horns Rev 1. The individual numbers of all other sea ducks species recorded at both offshore sites at Horns Rev during all four campaigns were generally negligible (Figure 3.11 and Figure 3.12). Again, observations were confined to the day-time; hence, additional migratory and foraging flights of Common Scoters at night cannot be excluded.

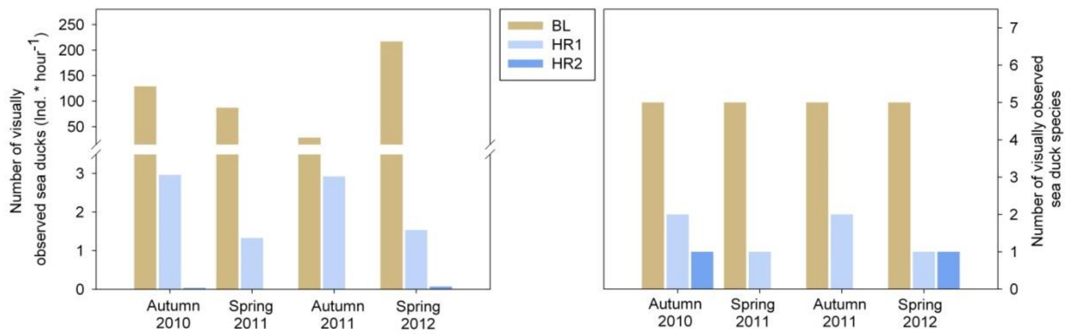


Figure 3.10 Individual and species numbers among the group "sea ducks" observed during day-time at the three sites during four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

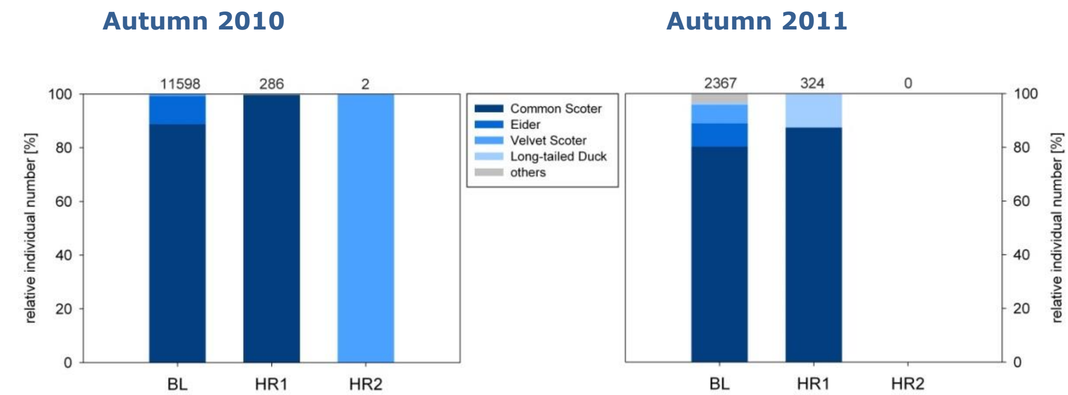


Figure 3.11 Relative proportions of individuals of the most abundant sea duck species at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total sample size at each site.

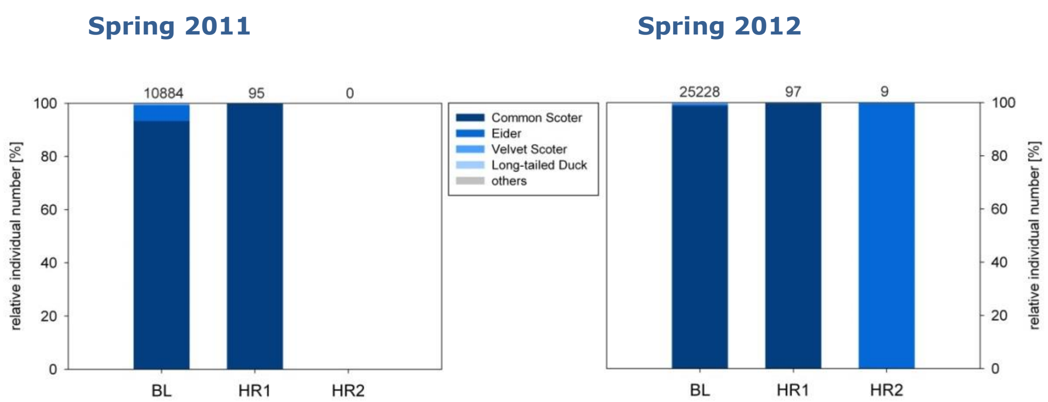


Figure 3.12 Relative proportions of individuals of the most abundant sea duck species at the three observation stations in spring 2011 and 2012. Numbers above the bars give the total sample size at each site.

3.1.5.4. Geese (and Swans)

Overall, 5,136 individuals and six species (i.e. Greylag Goose, Pink-footed Goose, White-fronted Goose, Barnacle Goose, Brent Goose and Mute Swan) were recorded during the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012). As shown in Figure 3.13, differences were seen in the number of observed individuals and species between Blåvandshuk (BL) and the two offshore stations at Horns Rev (Horns Rev 1, Horns Rev 2) in all four campaigns, with substantially lower numbers recorded offshore than at Blåvandshuk. Altogether, of the six species recorded during the monitoring program, only two species (Greylag Goose and Pink-footed) were recorded at the two offshore observation stations (Figure 3.14 and Figure 3.15). The numbers of individuals of these two species were notably low at the two offshore stations. In conclusion, migratory geese (and swans) seem to play a minor role in the offshore Horns Rev area, which may be explained by the specific flyway characteristics of these social migrants that follow the coastline to their Scandinavian breeding grounds and habitually stopover in salt-marsh habitats.

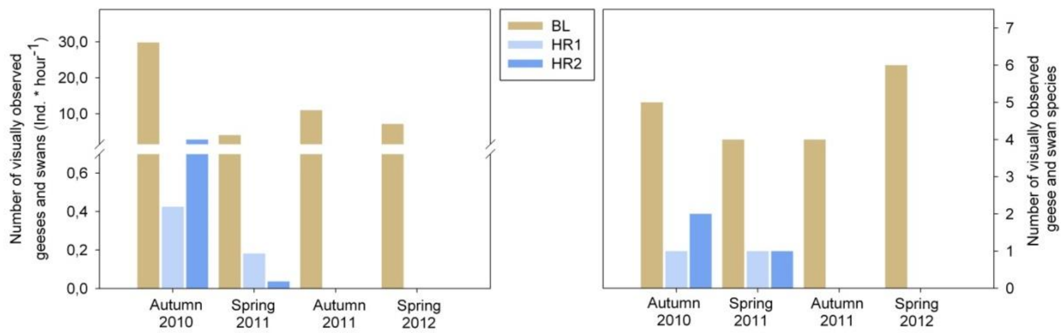


Figure 3.13 Number of individuals and species in the group "Geese and Swans" observed during day-time at the three observation stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

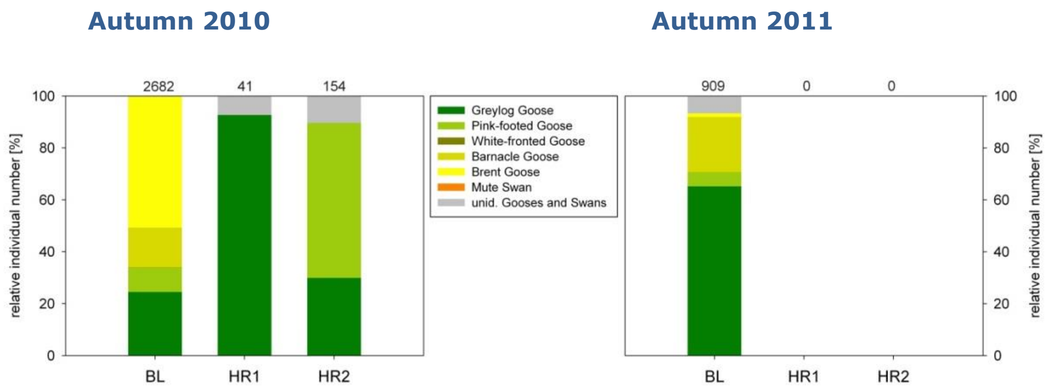


Figure 3.14 Relative proportions of individuals of the most abundant geese and swan species at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total sample size at each site.

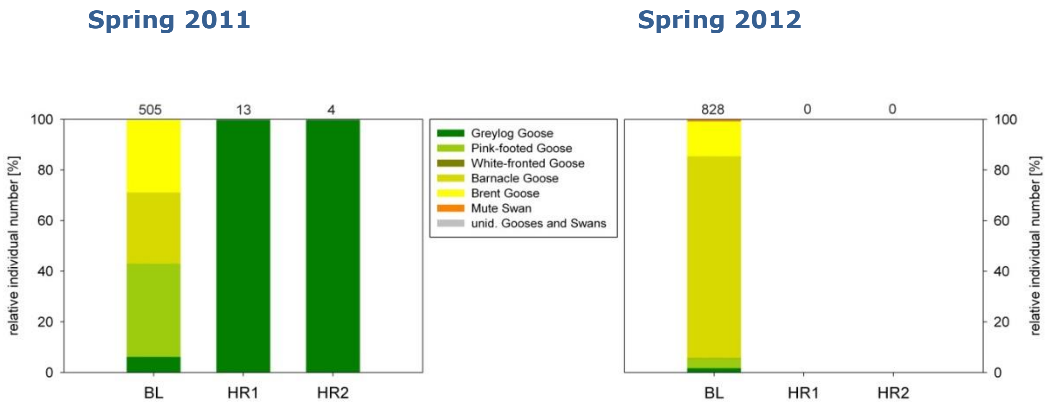


Figure 3.15 Relative proportions of individuals of the most abundant geese and swan species at the three observation stations in spring 2010 and 2011. Numbers above the bars give the total sample size at each site.

3.1.5.5. Waders

6,675 waders were counted during the day within the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012), which fell into 27 classifiable species. As shown in Figure 3.16, generally more individuals and species were recorded at Blåvandshuk (BL) than at the two offshore sites at Horns Rev (Horns Rev 1, Horns Rev 2). This was found in all four campaigns. From the 26 species recorded during the monitoring program, only 14 species were recorded from the two offshore observation stations (Figure 3.17 and Figure 3.18). Only during one campaign carried out in spring 2011, a relative high number of Knots was observed at Horns Rev 2 (Figure 17). In general, migration rates of waders may be significantly higher than suggested by the available data from day-time observation in the Horns Rev region.

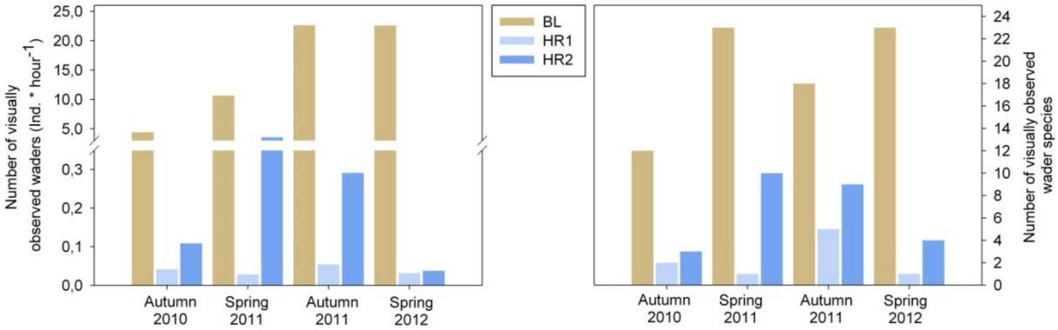


Figure 3.16 Number of individuals and species in the group "Waders" observed during day-time at the three observation stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

Autumn 2010 **Autumn 2011**

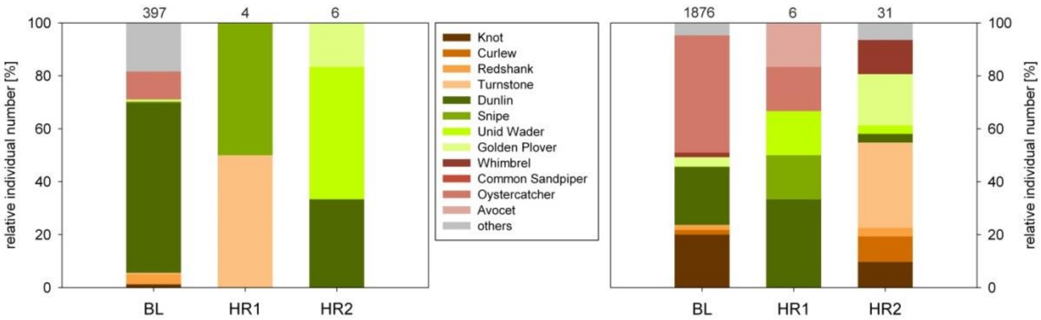


Figure 3.17 Relative proportions of individuals of the most abundant wader species at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total sample size at each site.

Spring 2011 **Spring 2012**

Figure 3.18 Relative proportions of individuals of the most abundant wader species at the three observation stations in spring 2010 and 2011. Numbers above the bars give the total sample size at each site.

3.1.5.6. Small Gulls (and Kittiwake)

During the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012), 7,219 small gulls were counted and five species were recorded, i.e. Common Gull, Black-headed Gull, Kittiwake, Little Gull, and Sabine´s Gull. There were pronounced differences in the number of observed individuals between Blåvandshuk (BL) and the two offshore observation stations at the Horns Rev sites (Figure 3.19). In all four campaigns, the number of individuals observed at the two offshore sites (Horns Rev 1, Horns Rev 2) was substantially lower than at Blåvandshuk. From the five species recorded during the monitoring period, only four species (Common Gull, Black-headed Gull, Kittiwake and Little Gull) were recorded at the two offshore sites (Figure 3.20 and Figure 3.21). Again, variation in the relative proportion of observed species among sites and seasons is hard to interpret on the basis of short-term, sporadic survey data. As pelagic foragers Little Gulls were more frequently observed in the two offshore regions, as expected.

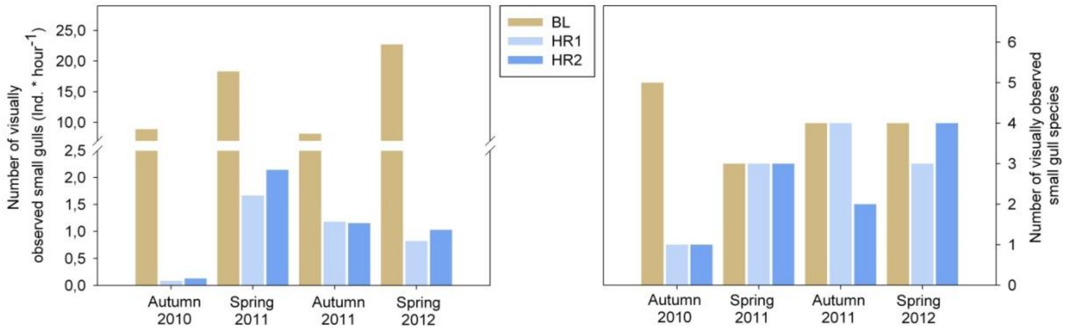


Figure 3.19 Number of individuals and species of the group of "Small Gulls" observed during day-time at the three observation stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

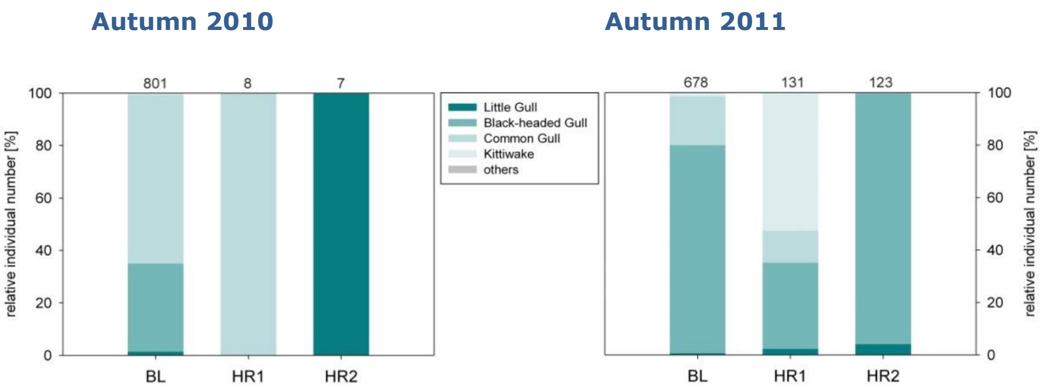


Figure 3.20 Relative proportions of individuals of the most abundant small gull species at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total sample size at each site.

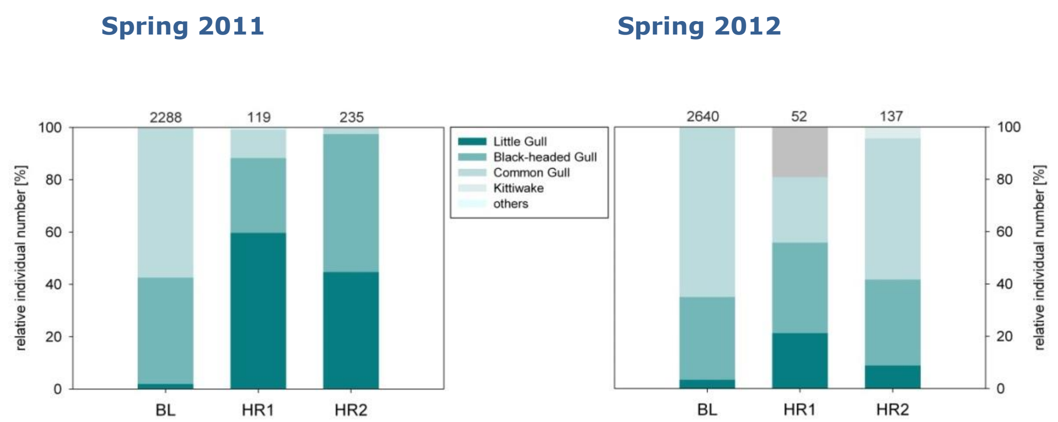


Figure 3.21 Relative proportions of individuals of the most abundant small gull species at the three observation stations in spring 2010 and 2011. Numbers above the bars give the total sample size at each site.

3.1.5.7. Large Gulls

During the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012), 14,902 large gulls were counted and four species were classified, i.e. Herring Gull, Great Black-backed Gull, Lesser Black-backed Gull, and Glaucus Gull. Marked differences were seen in the number of observed individuals (and species) between Blåvandshuk (BL) and the two offshore sites (Horns Rev 1, Horns Rev 2) in the Horns Rev region (Figure 3.22). In all four campaigns, the number of individuals was substantially lower at the offshore sites than at Blåvandshuk. From the four large gull species recorded during the monitoring program, only three species (Herring Gull, Great Black-backed Gull and Lesser Black-backed Gull) were recorded at the two offshore observation stations (Figure 3.23 and Figure 3.24). The number of individuals of these two species was generally lower at the offshore sites. Surprisingly, no large gull species was recorded in autumn at Horns Rev 2.

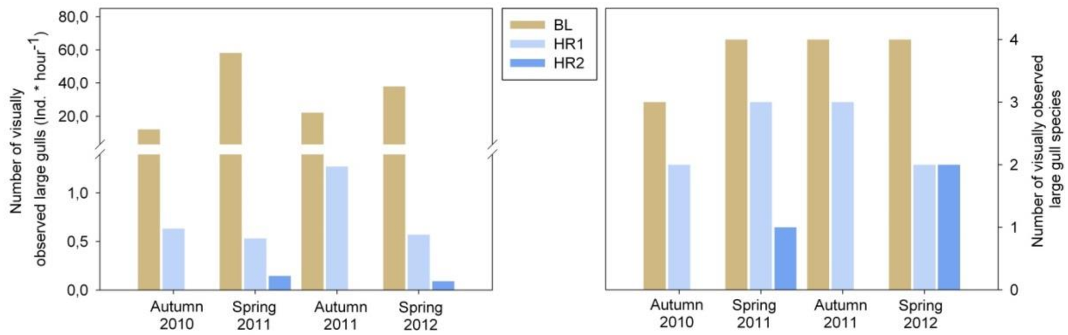


Figure 3.22 Number of individuals and species of “Large Gulls” observed during daytime at the three observation stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

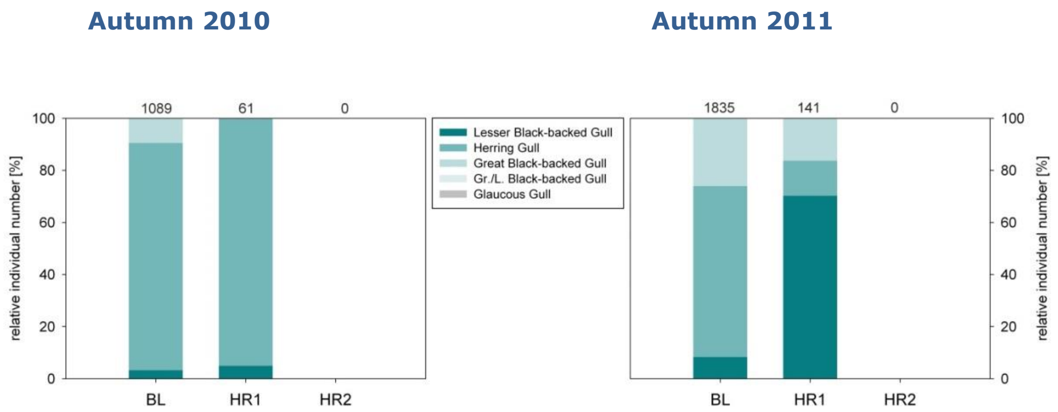


Figure 3.23 Relative proportions of individuals of the most abundant large gull species at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total sample size at each site.

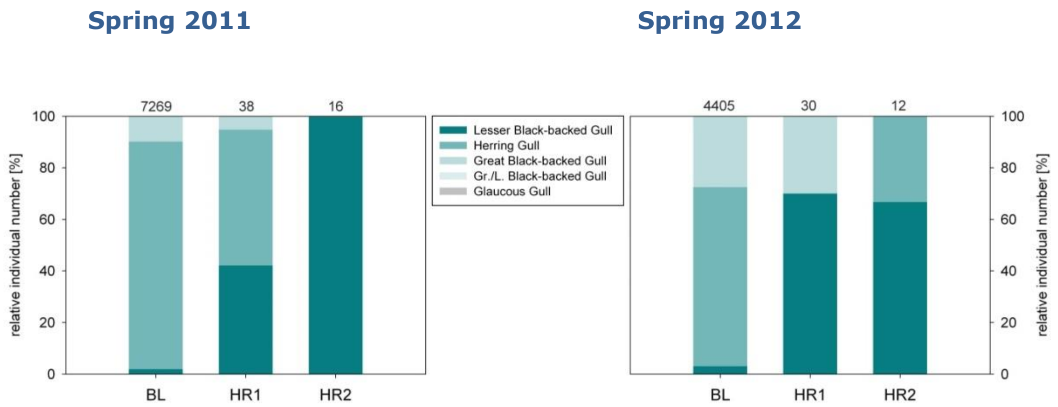


Figure 3.24 Relative proportions of individuals of the most abundant large gull species at the three observation stations in spring 2010 and 2011. Numbers above the bars give the total sample size at each site.

3.1.5.8. Terns

13,499 terns were counted during the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012), and six species were observed, i.e. Artic Tern, Black Tern, Caspian Tern, Common Tern, Little Tern, and Sandwich Tern. As shown in Figure 3.25, the number of observed individuals and species varied significantly between Blåvandshuk (BL) and the two offshore observation stations at Horns Rev 1 and Horns Rev 2. During all four campaigns, the number of individuals counted at the two offshore sites was substantially lower than at Blåvandshuk. Only during the autumn of 2011 did the number of terns counted at station Horns Rev 1 reach the order of magnitude of terns recorded closer to the coast at Blåvandshuk. In spring, generally more species of terns were observed at Blåvandshuk. Four species (Artic Tern, Black Tern, Common Tern and Sandwich Tern) were recorded with even lower numbers from the two offshore stations (Figure 3.26 and Figure 3.27). This variation in the relative proportion of observed species among sites and seasons is hard to interpret on the basis of habitat availability.

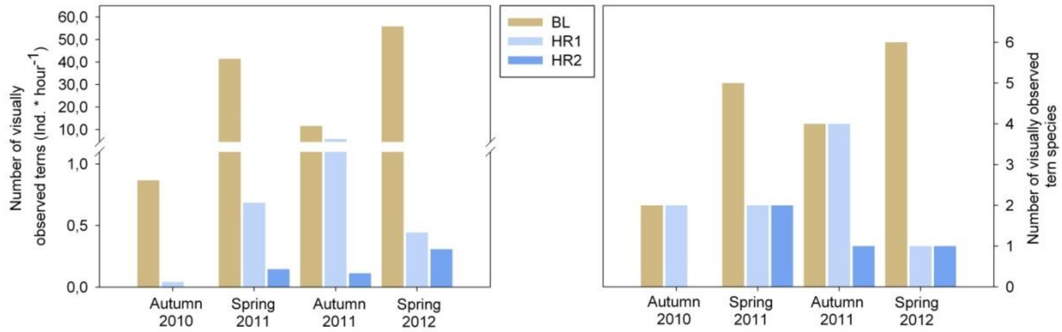


Figure 3.25 Number of individuals and species among the group "Terns" observed during day-time at the three observation stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

Autumn 2010 **Autumn 2011**

Figure 3.26 Relative proportions of individuals of the most abundant tern species at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total sample size at each site.

Spring 2011 **Spring 2012**

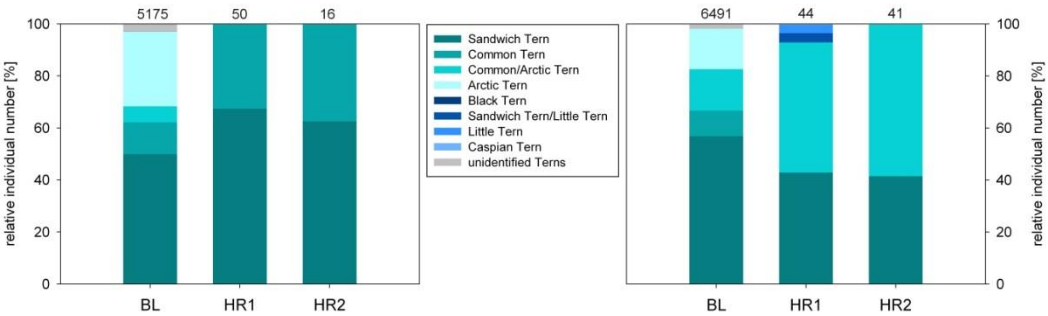


Figure 3.27 Relative proportions of individuals of the most abundant tern species at the three observation stations in spring 2010 and 2011. Numbers above the bars give the total sample size at each site.

3.1.5.9. Raptors

322 raptors were counted and 14 species were recorded during the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012). The number of observed individuals and species differed significantly between Blåvandshuk (BL) and the two offshore observation sites near Horn Rev (Figure 3.28). In all four campaigns, the number of observed individuals and species were substantially lower offshore than closer to land near at Blåvandshuk. Raptors on migration are generally known to maximize the time spent over land and seem to avoid larger bodies of water, resulting in narrow front patterns of migration as found in most species (Newton 2008). Active flapping species (e.g. Sparrowhawk, Peregrine, Merlin) are found more often at sea than broad-winged raptor species that depend on thermals for gaining flight altitude. From the 14 raptor species recorded during the monitoring scheme, only eight species (Buzzard, Hen Harrier, Marsh Harrier, Sparrow hawk, Hobby, Kestrel, Merlin and Peregrine) were recorded from the two offshore observation stations (Figure 3.29 and Figure 3.30). However, the low frequency of offshore observations in the present series of surveys is far too low to allow for any generalization concerning the migratory strategies of raptors crossing the Horns Rev area.

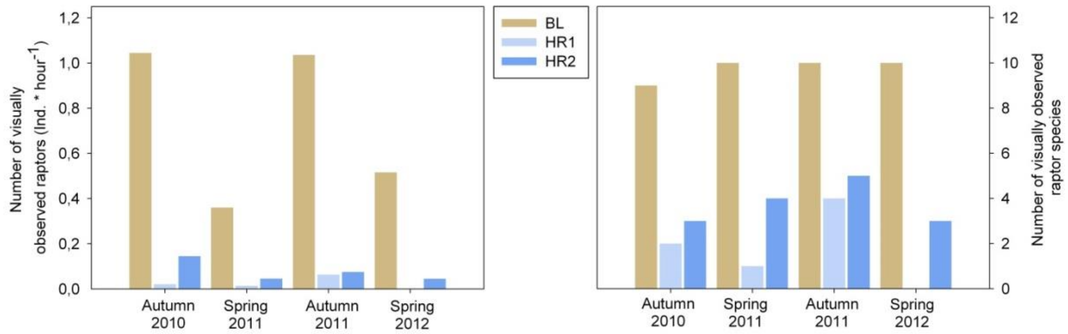


Figure 3.28 Number of individuals and species in the group "Raptors" observed during the day at the three observation stations during the four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

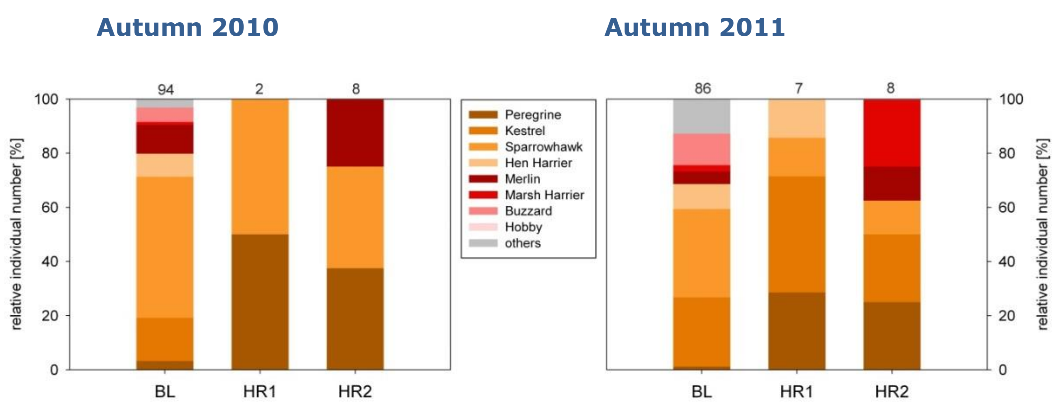


Figure 3.29 Relative proportions of individuals of the most abundant raptor species at the three observation stations in autumn 2010 and 2011. Numbers above the bars give the total sample size at each site.

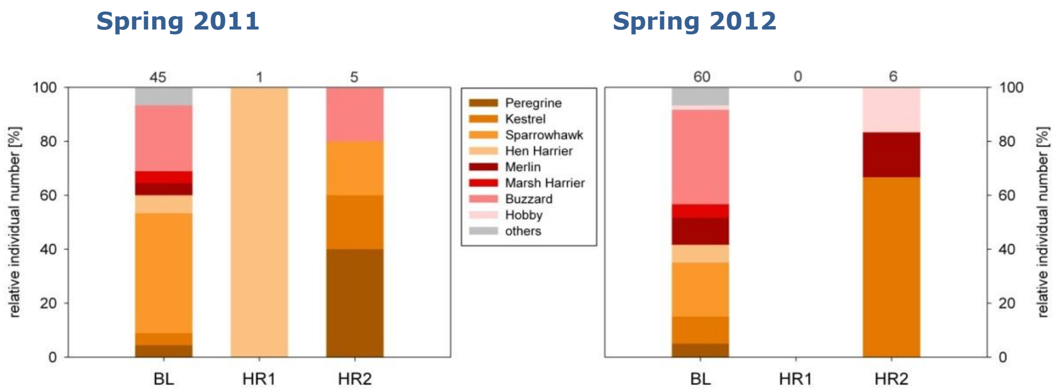


Figure 3.30 Relative proportions of individuals of the most abundant raptor species at the three observation stations in spring 2010 and 2011. Numbers above the bars give the total sample size at each site.

3.1.5.10. Passerines (and Pigeons)

During the Offshore Wind Farm Bird Monitoring Program (period: autumn 2010 - spring 2012), 55,476 individuals were counted and 80 day-time migratory species were recorded. As shown in Figure 3.31, the number of individuals and species observed at the two offshore observation stations Horns Rev 1 und Horns Rev 2 were substantially lower than at the observation station Blåvandshuk. The dominant day-time migrants were meadow pipit, chaffinch and starling (Figure 3.32 and Figure 3.33). Again, differences in the relative proportion of the dominant species remain largely unexplained due to the multitude of potential influences. Songbirds are generally known to migrate in broad front, although coastal peninsulars and islands can lead to a canalization of migrants, leading to what is perceived as “mass migration” (Berthold 2000, Newton 2008), which becomes particularly evident in diurnal migrants that follow land marks (e.g. blue tits amassing at Falsterbo, SE). The overall higher numbers of individuals counted at Blåvandshuk clearly indicate such a coast-line effect. It is likely that the majority of day-time migrants attempt to maximize the time spent over land, and their numbers are seen to drop significantly at offshore sites (see Figure 3.31). For nocturnal migrants, the coast-line effect seems to be less pronounced, as is suggested by long-term data from offshore islands and research platforms, where nocturnal migratory species generally dominate (Dierschke et al. 2011, Hüppop et al. 2009). Among-site variation remains largely unexplained due to the multitude of potential influences, such as species specific flight route ecology (broad front vs. narrow front migration), among-year variation in demography, among-year and -site variation in weather conditions and seasonality. Separating the effects of these variables on species composition and phenology is not possible on the basis of descriptive single-year and single-site surveys.

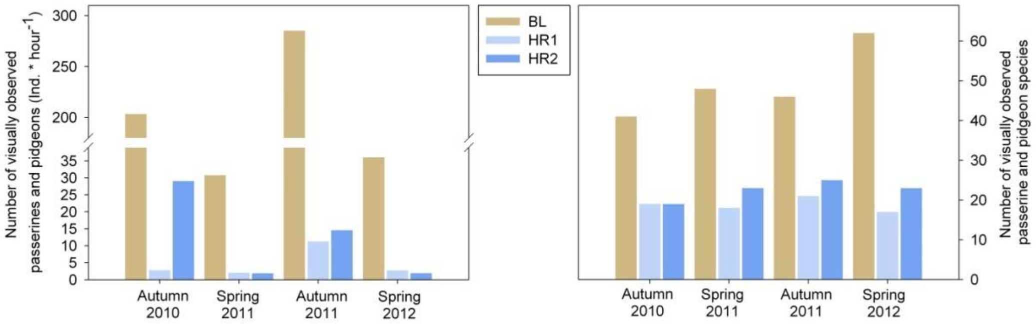


Figure 3.31 Individual and species numbers among the group "passerines and pigeons" observed during day-time at the three sites during four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

Autumn 2010 **Autumn 2011**

Figure 3.32 Relative proportions of individuals among the group "passerines and pigeons" observed during day-time at the three sites during four campaigns carried out within the Horns Rev 2 Offshore Wind Farm Bird Monitoring Program 2010-2012 (Skov et al. 2012).

Spring 2011 **Spring 2012**

Figure 3.33 Relative proportions of individuals of the most abundant passerine and pigeon species at the three observation stations in spring 2011 and 2012. Numbers above the bars give the total sample size at each site.

3.1.6 Flight altitudes of relevant species in relation to wind farms in the Horns Rev region

The following information on flight altitudes refers to data gathered at the operational wind farms Horns Rev 1 and Horns Rev 2, and, strictly speaking, does not represent baseline information for Horns Rev 3. Nevertheless, for assessment of the sensitivity of species towards barrier effects and collisions this post-construction information provides valuable insight. The flight altitudes used in the collision risk models (see below), however, were taken from Cook et al. (2012).

Species-specific flight-altitude information is given in Blew et al. (2008) and Skov et al. (2012) for the regions around Horns Rev 1 and Horns Rev 2. Information at species level mainly includes observational estimates in day-time migratory birds, and is occasionally supplemented by range-finder measurements. Post-construction information is available in both cases, but is strongly focused on day-time migrating species. Due to the nature of these inhomogeneous data and their high variability with respect to behavioural responses and environmental context, a calculation of species-specific mean values would be meaningless, and an introduction of such parameters into collision risk model is not recommended. It need to be stressed that flight altitude is highly wind and weather dependent. In nocturnal migrants, artificial light in combination with low visibility may cause birds to adjust their flight altitude (e.g., Aumüller et al. 2011). Thus, there is no general rule, which can be derived from the currently available survey data.

3.1.6.1. Divers

Four out of all 36 divers flew inside the wind farm Horns Rev 1 (two in 5-30 m altitude and two above), while 28 flew outside. The remaining four individuals flew within the 300 m transect and hence were not allocated inside or outside. Six birds were observed, including three of those flying inside the wind farm. Only one of the tracked individuals showed an obvious reaction but still entered the wind farm. Flight altitudes ranged from water surface to turbine height (plus one individual flying above turbine height). Most birds flew below the rotor swept zone (Figure 3.34). Numbers recorded close to the sea surface and within the rotor range were similar (ten and eight respectively).

At Horns Rev 2, there is no interpretable information with respect to flight altitudes in divers.

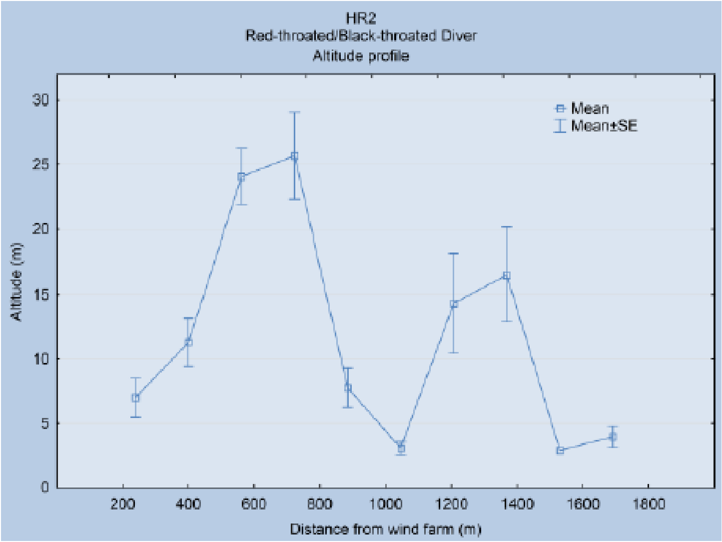


Figure 3.34 Spatial distribution of divers recorded during observations in Horns Rev wind farm area. (Data source: Skov et al. 2012).

3.1.6.2. Northern Gannet

66 Gannets were recorded during standard transect counts at Horns Rev 1 area. Only two of them flew inside the wind farm, at an altitude of 0 – 5 m and 30 – 110 m, respectively. There were no seasonal differences. The altitude distribution is shown in Figure 3.35 Gannets were also observed foraging in the area of Horns Rev 1.

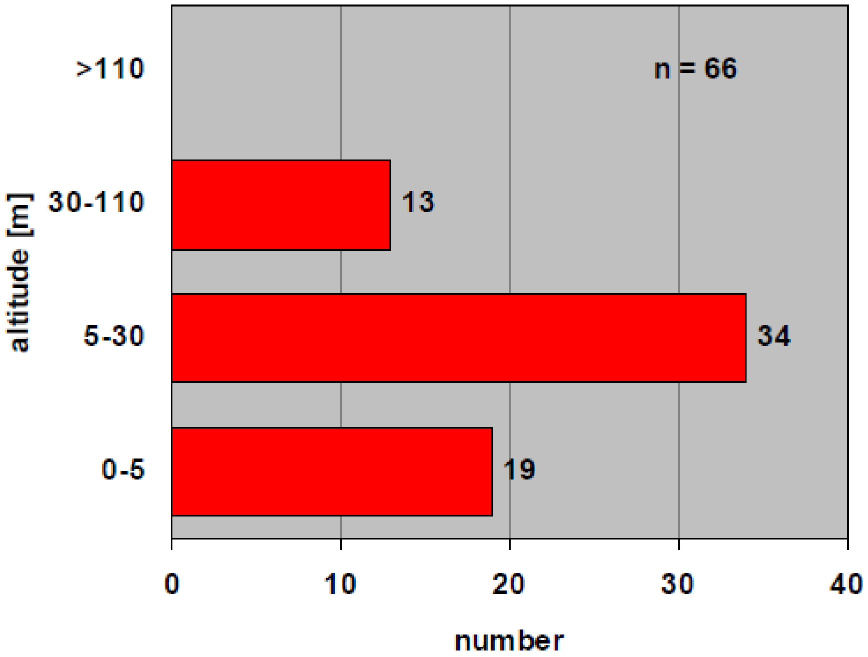


Figure 3.35 Altitude distribution of Gannets recorded during standard transect counts in Horns Rev wind farm area in 2005 and 2006 (n = 66; 2 birds inside wind farm, 64 birds outside). Data source: Blew et al. (2008).

3.1.6.3. Sea Ducks

The most numerous species in the HR area is the Common Scoter. During standard transect counts 2300 Common Scoters were recorded 349 of which flew inside and 1951 outside the wind farm. The diagram shows the altitude distribution inside and outside the wind farm (Figure 3.36). Common Scoters were mainly observed flying at altitudes lower than 30 m.

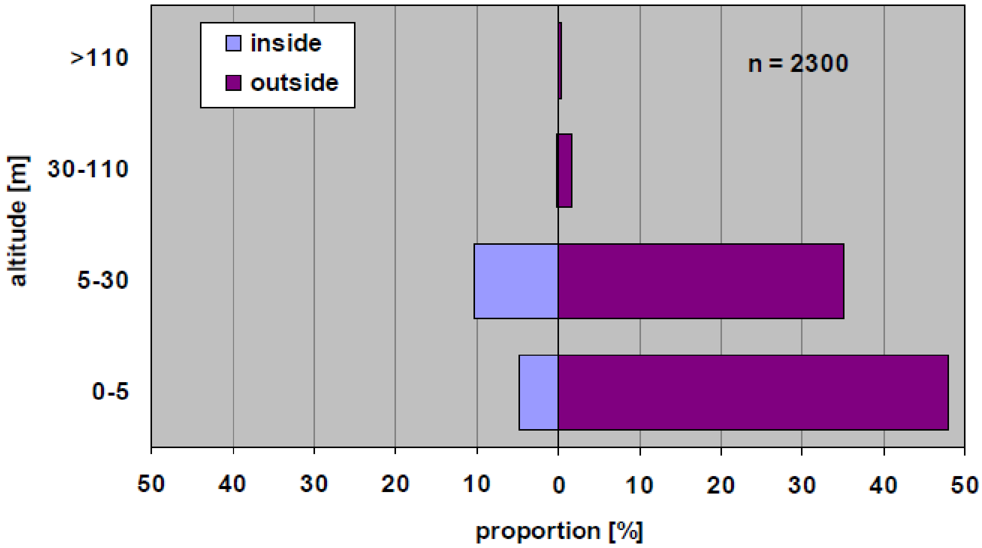
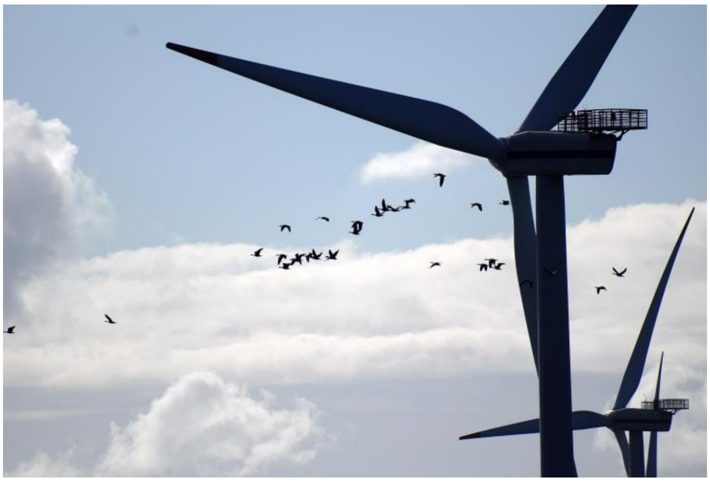


Figure3.36 Spatial distribution of Common Scoters recorded during standard transect counts in Horns Rev wind farm area in 2005 and 2006 (n = 2300). inside: inside the wind; outside: outside the wind farm. Data source: Blew et al. (2008).

3.1.6.4. Geese

The majority of geese were recorded outside the wind farm area of Horns Rev 1. Individuals touching the wind farm area flew almost always above 110m (Figure 3.37). However, the dataset is too small to justify statistical treatment.



Grey lag geese over Horns Rev 1

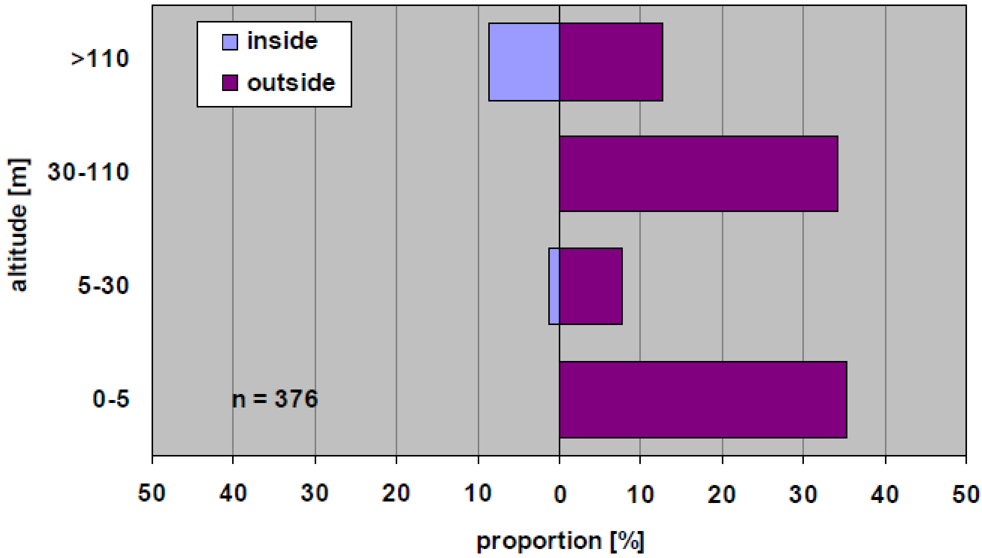


Figure 3.37 Spatial distribution of geese recorded during standard transect counts in Horns Rev wind farm area in 2005 and 2006 (n = 376). inside: inside the wind; outside: outside the wind farm.Data source: Blew et al. (2008).

3.1.6.5. Waders

61 waders were recorded in Horns Rev 1 during standard transect counts, 14 in spring and 47 in autumn. Nine species were observed. All altitude bands were covered, the lowest a bit more pronounced than the others. Waders occurred inside the wind farm. Among 15 tracked individuals, no obvious reactions towards the wind turbines could be observed.

3.1.6.6. Small Gulls

1187 small Gulls were observed during the standard transect counts at the Horns Rev 1 area, 327 were inside and 860 outside the wind farm. Figure 3.38 shows the percentage for each height class and transect side. Generally the abundance decreases continuously with increasing altitude class. Small Gulls obviously avoided the wind farm Horns Rev 1.

Kittiwake

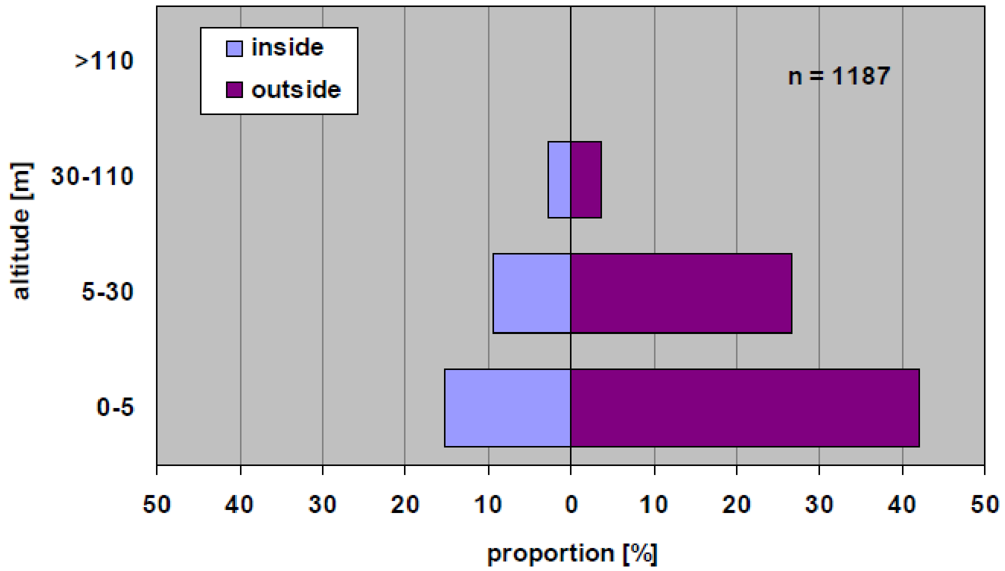


Figure 3.38 Spatial distribution of Little Gulls recorded during standard transect counts in Horns Rev wind farm area in 2005 and 2006 (n = 1187). inside: inside the wind; outside: outside the wind farm. Data source: Blew et al. (2008).

3.1.6.7. Large Gulls

At Horns Rev 1, the spatial distribution shows a clear preference of large gulls towards altitudes below 30m. The second most preferred height class inside the wind farm was the rotor range while outside the wind farm it was just above sea surface. Only a small percentage flew above turbine height.

Gull numbers differed significantly between inside and outside the wind farm in 781 gullpositive observation intervals, and altitude distribution varied significantly between both sides (Figure 3.39).

Lesser black backed gull

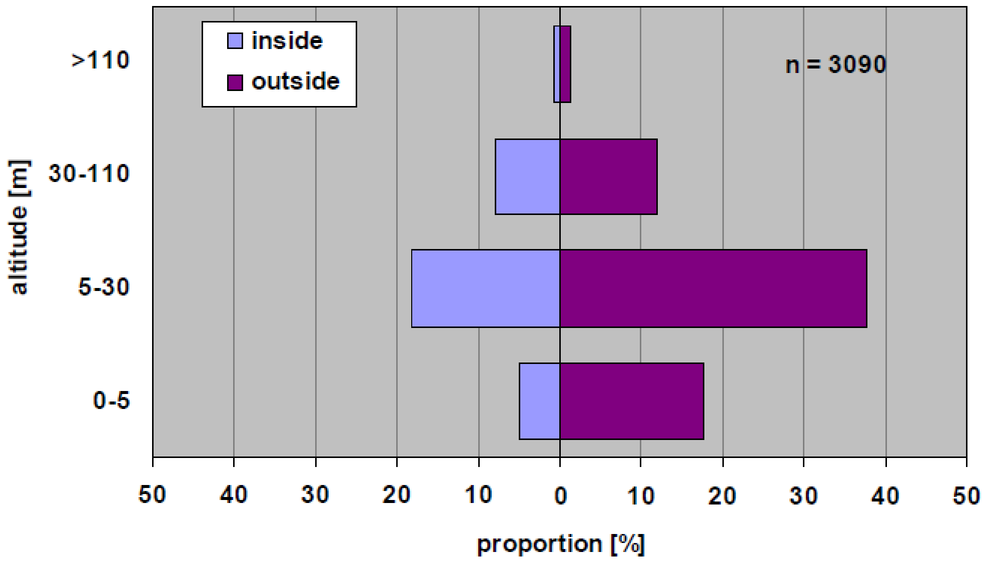


Figure 3.39 Spatial distribution of gulls (except Little Gulls) recorded during standard transect counts in Horns Rev wind farm area in 2005 and 2006 (n = 3090). inside: inside the wind; outside: outside the wind farm.Data source: Blew et al. (2008).

3.1.6.8. Terns

All terns observed in the investigated area of Horns Rev 1, i.e., Sandwich Tern *Sterna sandvicensis*, Common Tern *S. hirundo* and Arctic Tern *S. paradisaea*, were pooled as one group. Standard transect counts yielded a total of 855 terns 207 of which flew inside the wind farm and 648 outside. Figure 3.40 shows a general preference towards lower altitudes. However, inside the wind farm only a minor percentage flew just above the water. Terns clearly avoided the wind farm Horns Rev 1with significant differences between inside and outside the wind farm.

Sandwich Tern © Thomas W. Johansen

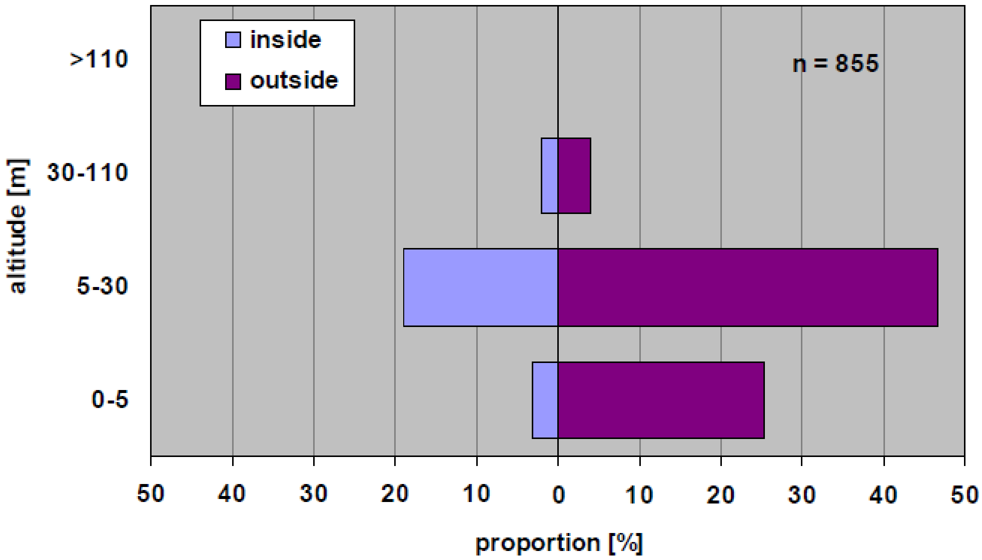


Figure 3.40 Spatial distribution of terns recorded during standard transect counts in Horns Rev wind farm area in 2005 and 2006 (n = 3090). inside: inside the wind; outside: outside the wind farm.Data source: Blew et al. (2008).

3.1.6.9. Raptors

The flight altitudes of raptors recorded at the area of Horns Rev 2 show a widely spread altitude spectrum (from about 20m up to 90m) (Figure 3.41). According to Skov et al. (2012) raptors try to avoid flying through windfarms by altering their migration height.

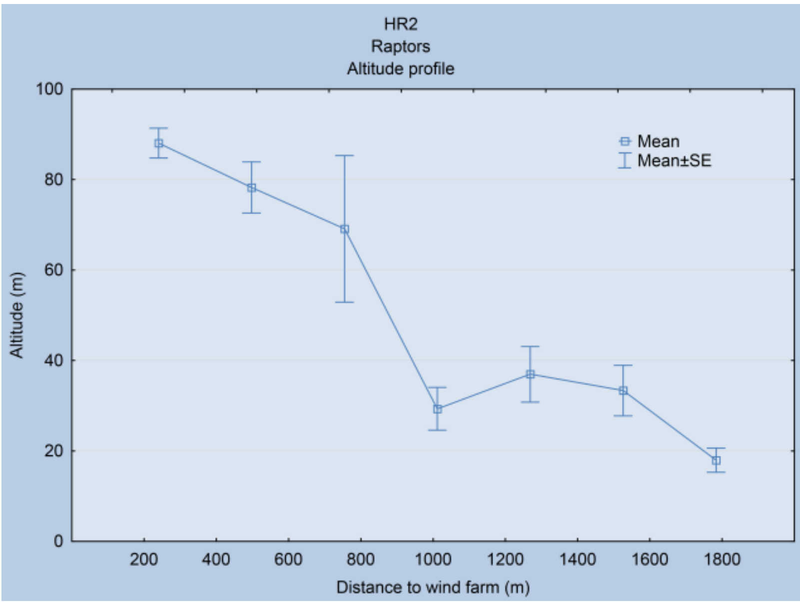


Figure 3.41 Continued altitude profile of raptors recorded by rangefinder at Horns Rev 2 showing the mean and SE altitude as a function of distance from the turbines in the wind farm. Data source: Skov et al. (2012).

3.1.6.10. Passerines

Figure 3.42 shows the flight altitudes of songbirds (excluding corvids) within 30 to 300 m on each side of the wind farm Horns Rev 1. The side distribution was very similar. With regard to altitude distribution day-time migrating songbirds showed a preference towards lower flight altitudes (below rotor range; lowest rotor tip=30m).

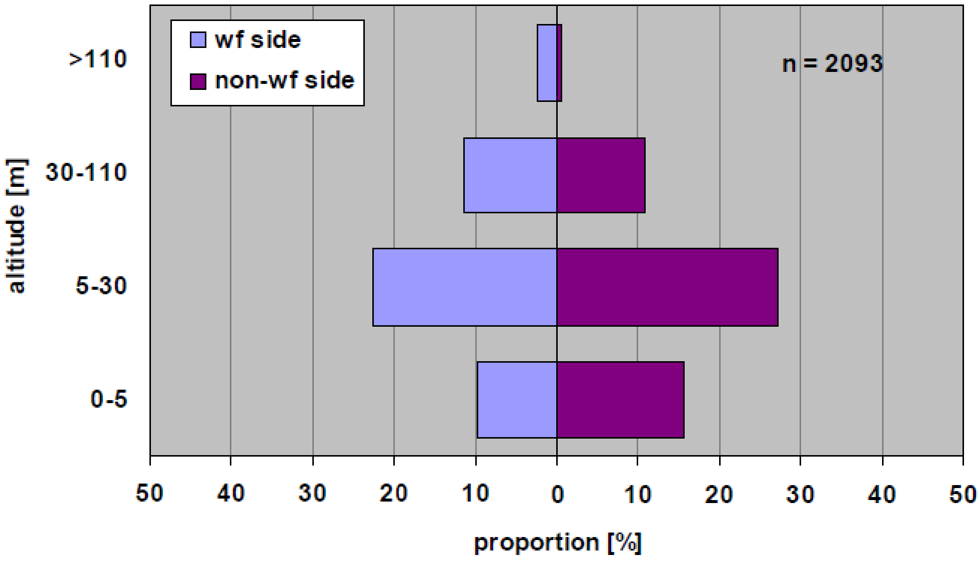


Figure 3.42 Flight altitudes of songbirds except corvids recorded during visual surveys inside and outside Horns Rev wind farm in 2005 and 2006 (n = 2093). wf: wind farm side; non-wf: outside the wind farm. Data source: Blew et al. (2008).

Great Grey Shrike © Graeme Pegram

4. IMPACT ASSESSMENT

4.1. Assessment methodology

4.1.1 General impact assessment methods

To ensure a uniform and transparent basis for the EIA, a general impact assessment methodology for the assessment of predictable impacts has been prepared together with a list of terminology.

The overall goal of the assessment is to describe the Severity of Impact caused by the project. The assessment comprises two steps; where the first step is an analysis of the magnitude of the pressure and an analysis of the sensitivity of the environmental factor. Combining the two analyses leads to the Degree of Impact. In the second step; the results from the Degree of Impact is combined with the importance leading to the Severity of Impact.

In some cases it is necessary to consider the risk of a certain impact occurring. In these cases, the Severity of Impact is considered against the Likelihood of the occurrence, giving the Degree of Risk.

As far as possible the impacts are assessed quantitatively, accompanied by a qualitative argument. The assessment steps are shown in figure 4.1.

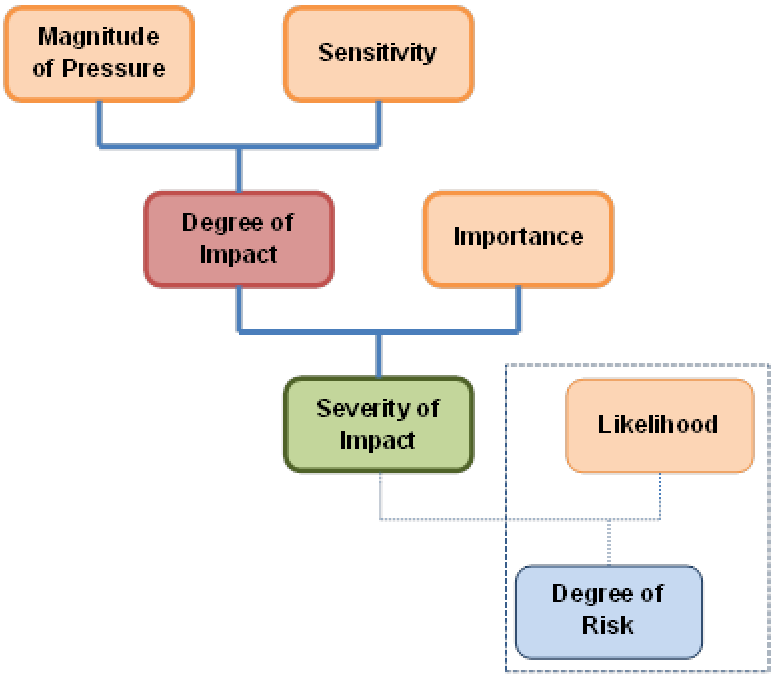


Figure 4.1 Drawing of the overall assessment approach.

The assessment of migratory birds bases on literature studies.

4.1.1.1. Magnitude of Pressure

There are several crucial steps in the outlined assessment procedure shown in figure 2.1. The foremost are the determination of the Magnitude of Pressure and the Sensitivity. The content of the Magnitude of Pressure is made up of;

- intensity (i.e., level of collision risk and barrier effect)
- duration (i.e., construction activities vs. permanent structures)
- range (i.e., spatial extent of a wind farm; number of turbines)

The *intensity* evaluates the force of the pressure and should as far as possible estimated quantitatively.

The *duration* determines the time span of the pressure. Some pressures (like footprints) are permanent and do not have a finite duration. Some pressures occur in events of different duration.

The *range* of the pressure defines the spatial extent. Outside of the range, the pressure is regarded as non-existing or negligible.

Distinctions are made between direct and indirect pressures where direct pressures are those imposed directly by the Project activities on the environmental factors while the indirect pressures are the consequences of those impacts on other environmental factors and thus express the interactions between the environmental factors.

The Magnitude of Pressure is described by pressure indicators. The indicators are based on the modes of action on the environmental factor in order to achieve most optimal descriptions of pressure for the individual factors; e.g. mm deposited sediment within a certain period.

As far as possible the Magnitude of Pressure is worked out quantitatively. The method of quantification depends on the specific pressure (spill from dredging, noise, vibration, etc.) and on the environmental factor to be assessed (calling for different aggregations of intensity, duration and range).

Table 4.1 Aggregates included in the Magnitude of Pressure.

Magnitude of Pressure		
Intensity	**Duration**	**Range**
Very High	Recovery takes longer than 10 years or is permanent	International
High	Recovered within 10 years after end of construction	National
Medium	Recovered within 5 years after end of construction	Regional
Low	Recovered within 2 years after end of construction	Local

4.1.1.2. Sensitivity

The optimal way to describe the sensitivity to a certain pressure varies between the environmental factors. To assess the sensitivity more issues may be taken into consideration such as the intolerance to the pressure and the capability to recover after impairment or a temporary loss. In most cases the sensibility of a certain environmental factor will be collected from the literature and is very often given as a threshold value. To assess the sensitivity of migratory birds for the two impacts "collision risk" and "barrier effect", many issues have be taken into consideration; such as flight altitude, flight agility, migration density etc.. The sensitivity to the certain pressures was taken from the current literature. The sensitivity to both pressures are discussed species-specifically (where possible) or for each species group.

4.1.1.3. Degree of Impact

In order to determine the Degree of Impact; the Magnitude of Pressure and Sensitivity are combined in a matrix, see Table 4.2. The Degree of Impact is the pure description of an impact to a given environmental factor without putting it into a broader perspective (the latter is done by including the Importance in the evaluation, see below).

Table 4.2 The matrix used for the assessment of the Degree of Impact.

		Sensitivity			
		Very high	**High**	**Medium**	**Low**
Magnitude of pressure	**Very high**	Very High	Very High	High	High
	High	Very High	High	High	Medium
	Medium	High	High	Medium	Low
	Low	Medium	Medium	Low	Low

4.1.1.4. Importance

The importance of the environmental factor is assessed for each environmental sub-factor. Some sub-factors are assessed as a whole, but in most cases, the importance assessment is broken down into components and/or sub-components in order to conduct a fulfilling environmental impact assessment.

Considerations about standing stock sizes and spatial distribution are important for some sub-factors, such as bird populations, and are in these cases incorporated into the assessment. The assessment is based on importance criteria defined by the functional value of the environmental sub-factor and the legal status given by EU directives, national laws, etc.

The importance criteria are graded into four tiers, see Table 4.3. In a few cases, such as climate, grading does not make sense. As far as possible the spatial distribution of the importance classes are shown on maps.

Table 4.3 The definition of Importance to an environmental factor.

Importance level	Description
Very high	Components protected by international legislation/conventions (Annex I, II and IV of the Habitats Directive, Annex I of the Birds Directive), or of international ecological importance. Components of critical importance for wider ecosystem functions.
High	Components protected by national or local legislation, or adapted on national "Red Lists". Components of importance for far-reaching ecosystem functions.
Medium	Components with specific value for the region, and of importance for local ecosystem functions
Low	Other components of no special value, or of negative value

4.1.1.5. Severity of Impact

Severity of impact is assessed from the grading of Degree of Impact and Importance of the environmental factor using the matrix in Table 4.4. If it is not possible to grade Degree of Impact and/or Importance, an assessment is given based on expert judgment.

Table 4.4 The matrix used for the assessment of the Severity of Impact.

		Importance of the environmental component			
		Very high	**High**	**Medium**	**Low**
Degree of Impact	**Very high**	Very High	High	Medium	Low
	High	High	High	Medium	Low
	Medium	Medium	Medium	Medium	Low
	Low	Low	Low	Low	Low

Table 4.5 shows the explanation for each grade of the Severity of Impact. Based on the Severity of Impact, such an expert judgement can state the significance of the impact through the provided phrases. The contents of the table have been defined by Energinet.dk.

Table 4.5 The definition of Impact to an environmental factor. The column to the left is an attempt to include the overall assessment methodology to the scheme defined by Energinet.dk.

Severity of Impact	**Relative Impact** *(påvirkningens relative størrelse)*	**Following effects are dominating** *(følgende effekter er dominerende)*
Very high	**Significant negative impact** *(Væsentlige negative påvirkninger)*	**Impacts are large in extent and/or duration. Re-occurrence or likelihood is high, and irreversible impacts are possible.** *(Der forekommer påvirkninger, som har et stort omfang og/eller langvarig karakter, er hyppigt forekommende eller sandsynlige, og der vil være mulighed for irreversible skader i betydelig omfang).*
High	**Moderate negative impact** *(Moderat negativ påvirkning)*	**Impacts occur, which are either relative large in extent or are long term in nature (lifetime of the project). The occurrence is recurring, or the likelihood for recurrence is relatively high. Irreversible impact may occur, but will be strictly local, on e.g. cultural or natural conservation heritage.** *(Der forekommer påvirkninger, som enten har et relativt stort omfang eller langvarig karakter (f.eks. i hele anlæggets levetid), sker med tilbagevendende hyppighed eller er relativt sandsynlige og måske kan give visse irreversible men helt lokale skader på eksempelvis bevaringsværdige kultur- eller naturelementer).*
Medium	**Minor negative Impact**	**Impacts occur, which may have a certain extent or complexity. Duration is longer than**

Severity of Impact	Relative Impact *(påvirkningens relative størrelse)*	Following effects are dominating *(følgende effekter er dominerende)*
	(Mindre negativ påvirkning)	**short term. There is some likelihood of an occurrence but a high likelihood that the impacts are reversible.** *(Der forekommer påvirkninger, som kan have et vist omfang eller kompleksitet, en vis varighed udover helt kortvarige effekter, og som har en vis sandsynlighed for at indtræde, men med stor sandsynlighed ikke medfører irreversible skader).*
Low	**Negligible negative impact** *(Ubetydelig negativ påvirkning)*	**Small impacts occur, which are only local, uncomplicated, short term or without long term effects and without irreversible effects** *(Der forekommer små påvirkninger, som er lokalt afgrænsede, ukomplicerede, kortvarige eller uden langtidseffekt og helt uden irreversible effekter).*
Low	**Neutral / no impact** *(Neutral/uden påvirkning)*	**No impact compared to status quo** *(Ingen påvirkning i forhold til status quo).*
	Positive impacts *(Positive påvirkninger)*	**Positive impact occurring in one or more of the above statements** *(Der forekommer positive påvirkninger på en eller flere ovennævnte punkter).*

4.1.1.6. Significance

The impact assessment is finalised with an overall assessment stating the significance of the predicted impacts. This assessment of significance is based on expert judgement. The reasoning for the conclusion on the significance is explained. Aspects such as Degree and Severity of Impact, recovery time and the Importance of the environmental factor are taken into consideration.

4.1.1.7. Assessment of cumulative impacts

The aim of the assessment of cumulative impacts is to evaluate the extent of the environmental impact of the project in terms of intensity and geographic extent compared with other projects in the area and the vulnerability of the area. The assessment of the cumulative conditions includes activities associated with existing utilised and unutilised permits or approved plans for projects.

When more projects within the same region affect the same environmental conditions at the same time, they are defined to have cumulative impacts. A project is relevant to include, if the project meets one or more of the following requirements:

- The project and its impacts are within the same geographical area as the Project
- The project affects some of the same or related environmental conditions as the Project
- The project has permanent impacts in its operation phase interfering with impacts from the Project

For each environmental component it is considered if cumulative impact with the projects above is relevant.

4.1.1.8. Assessment of transboundary pressures

According to the Espoo Convention on Environmental Impact Assessment in a Transboundary Context and EU Directive 85/337/EEC the offshore wind farm Horns Rev 3 can potentially implement transboundary environmental impacts.

The Espoo Convention's primary aim is to prevent, mitigate and monitor environmental damage by ensuring that explicit consideration is given to transboundary environmental factors before a final national decision is made as to whether to approve a project. In addition, the objective of the Espoo Convention is the identification and communication of potential transboundary impacts to stakeholders via the application of an impact assessment.

The assessment of the transboundary pressure in connection with migratory birds will be followed according to a verbal argumentative assessment based upon expert judgment.

4.1.1.9. Impacts related to climate change

On the basis that the currently expected lifetime of the offshore wind farm Horns Rev 3 is estimated to about 25 years, we do not expect any impacts associated with climate change. Thus, this aspect is not discussed further in this report.

4.1.1.10. Mitigation and compensation issues

A significant part of the purpose of an EIA is to optimize the environmental aspects of the project applied for, within the legal, technical and economic framework. Remediation measures are described in the technical background reports. The most important ones are included in the EIA.

4.1.2 Application of the Assessment methodology for migratory birds

4.1.2.1. Magnitude of pressure

According to the assessment methodology (see Horns Rev 3-TM-017 Assessment methodology), the magnitude of a pressure is classed "very high" in case recovery takes longer than 10 years or is permanent and its range is "international". At the individual level, collisions with wind turbines (permanent structures) are assumed to be lethal (irreversible) in almost all cases, but the risk of such events varies strongly depending on species-specific responsiveness and ecological context. The decommissioning of the Horns Rev 3 wind farm is planned to start after about 25 years (see technical description). Until then, the magnitude of pressure for individual migratory birds is theoretically "very high". With regard to avian collision risk, however, the magnitude of pressure and sensitivity cannot be assessed independently. At the population level, the magnitude of pressure (collision rate) depends on species-specific behaviour (e.g. flight height, avoidance rate), which determines a species' sensitivity (see below). We therefore assume that for the risk of collision, the magnitude of the pressure is proportional to the degree of species' sensitivity. In the case of potential barrier effects imposed on migrating birds, the magnitude of pressure can be considered to be generally "low", as the hypothetical adverse effect, i.e. higher energy expenditure due to detours, is temporary and unlikely to result in significant drawbacks for species that travel at intercontinental spatial scales.

4.1.2.2. Sensitivity

To assess the sensitivity of migratory birds concerning the risk of collision and barrier effects, several species-specific aspects, such as density (in staging/foraging water birds), migration/flight rate, flight altitude, sensory capacities determining avoidance behaviour, have to be taken into account. The sensitivity of a certain species or species group towards a given pressure can be ranked according to evidence-based knowledge and/or on the basis of output values resulting from collision risk models (e.g. Band 2012). The latter modelling approach can only by performed if adequate input data (density values) are available. For some migratory birds over Horns Rev (individuals and species that fly by night and remain unnoticed), adequate site-specific information is generally scarce, because acoustical ground-truthing of radar information is limited to those birds that call by night. The sensitivity analysis provided for the Horns Rev 3 project was therefore based predominantly on evidence from post-construction surveys carried out elsewhere, on literature-based meta-analyses (Furness et al. 2013) and on basic ornithological knowledge. In cases where species-specific information on migration intensity was scarce (small-bodied passerines, pigeons, waders), qualitative sensitivity statements were performed for each relevant species group (or ecotype), and conclusions were generalized across taxa. For the relevant water and seabird species documented in the area around Horns Rev 3, model predictions of the risk of collision were assessed quantitatively, introducing site-specific survey data into the revised version of the Band model (Band 2012). As mentioned above, the magnitude of pressures arising from collisions and from barrier effects cannot be unequivocally separated from the degree of species-specific sensitivity estimates. Furthermore, there is a strong negative dependence between the risk of collision and the strength of the barrier effect, such that when the barrier effect is complete (i.e., macro-avoidance rate is 100%), the risk of collision can be formally set to zero.

4.1.2.3. Degree of impact

In order to determine the degree of impact, the magnitude of pressure and the indices of sensitivity are formally combined in a matrix (see table 4.6), resulting in species-specific scores of the degree of impact. As mentioned above, the magnitude of pressure and the sensitivity of a species or species group are considered in conjunction when assessing the risk of collision and barriers to movement. Consequently, the degree of impact equals both input ratings, or in other words, for a bird species that is prone to collide due to its flight behaviour and sensory ecology (sensitivity classed "very high") the magnitude of pressure and the degree of impact is predicted to be "very high", too.

Table 4.6 Criteria for assessing the Degree of Impact for migrating birds in the Horns Rev 3 area based on the sensitivity of a species to a pressure.

Construction-, structure- or operation related pressures of the project	Degree of Impact	Description of the Degree of Impact
Barrier effect	**Very high**	Barrier is complete for a large proportion of a migratory population. There are no alternative flight routes. No connectivity between areas at different sides of the barrier.
	High	Barrier results in strong behavioural reactions of flying birds. Reduced connectivity between areas at different sides of the barrier.
	Medium	Barrier results in reactions, but will be crossed eventually by flying birds.
	Minor	Minor barrier effect; birds show minor reactions and fly above or between the structures.
Collision risk	**Very high**	A high proportion of a migratory population in the area is expected to collide with the structure on a regular basis under a wide range of condition conditions.
	High	A small proportion of birds flying in the area are expected to collide with the structure on a regular basis. Adverse weather conditions are expected to increase collision rates.
	Medium	Collisions are unlikely, but adverse weather conditions may result in

Construction-, structure- or operation related pressures of the project	Degree of Impact	Description of the Degree of Impact
		collision incidents.
	Minor	Collisions are unlikely. Only single birds are expected to collide with the structure.

Band Model

For calculating the collision risks for migrating sea birds, we used the modified version of the collision model issued by Band (2012). We included those bird species relevant to the Horns Rev area, following Skov et al. 2012 (i.e., Red-/Black-throated Diver; Northern Gannet; Common Scoter; small gull species, including Common Gull, Black-headed Gull, Little Gull; large gull species, including Herring Gull, Great- and Lesser Black-backed Gull; Kittiwake; terns, including Sandwich Tern, Common Tern and Artic Tern) and which were documented during aerial bird surveys on-site, which has been the general practice in previous EIA in the Horns Rev area. A detailed description of the model has been published by Band (2012). In the following, we specify the input data introduced into the model.

Bird length (m) and wingspan (m) were represented by mean values derived from Svensson et al. (1999). Values of species-specific flight speeds (m/s) were taken from the meta-analysis by Alerstam et al. (2007), except for the average flight speed of the Northern Gannet, which was derived from data published by Pennycuick (1987). Nocturnal activity factors - 1 (hardly any flight activity at night) to 5 (much flight activity at night) - have been applied by data of Garthe and Hüppop (2004), as well as King et al. (2009) for most of the modelled species. The nocturnal activity factor for the Common Scoter was down-scaled from 3 to 1, following Skov et al. (2012), assuming that night-activity levels are comparatively low in this species (cf., Guillemette et al. 2007; Lewis et al. 2005).

Site-specific bird densities were based on nine flight surveys carried out in the Horns Rev 3 study area from January 2013 to September 2013 (see report on resting birds for Horns Rev 3 (Dorsch et al. 2013) In the majority of cases, the relative proportion of birds in flight was based on published monitoring information as described in Skov et al. (2012). For example, about 2% of all staging divers counted in this area spend the time aloft, 64% of all counted Northern Gannets and 43% of all large gulls are on the wing (Skov et al. 2012). The proportion of time a bird spent at rotor height was based on Cook et al. (2012) as well as the spreadsheet on flight heights provided therein. The proportion of flights upwind or downwind was uniformly distributed with 50%.

For the worst case scenario of avian collision, it was assumed that the wind farm comprises 133 3MW turbines. This layout and constellation was used throughout all collision risk modelling procedures. Wind farm parameters and turbine measures were assumed as follows: width of the wind farm: 17km, latitude of the centre point of the wind farm (to account for seasonal changes in day-length): 55.7°, diameter of a 3MW turbine: 112m (according to technical specifications of existing turbines in the North Sea), rotation speed: 19rpm, rotor radius: 56m, hub height: 79m, max blade width: 4m, pitch: average value given in Band (2012): 15°. Inter alia due to the calculated availability of offshore turbines in the offshore wind farm "Egmond aan Zee", the Netherlands over a period of 5 years of operation (Fraunhofer IWES 2012), we considered the monthly proportion of operational time with 85%.

The output values of the collision risk model of Band (2012) can be evaluated in three ways. We used option number 3 (for details see Band 2012), for analysing and comparing our results with Skov et al. (2012) and Furness et al. (2013).

4.1.2.4. Importance

The task of the EIA for Horns Rev 3 is the assessment of potential impacts on the marine environment which needs to include which part of a population or total numbers may be exposed to a certain impact. There are no accepted criteria for the assessment of bird migration, though migration hotspots have been mentioned as sites of conservation interest (BirdLife International 2004). The assessment criteria for non-breeding waterbirds have been transferred to criteria for migrating birds. This is considered appropriate, as the RAMSAR convention from 1971 and the further development of its principles follow the idea that the protection of all sites hosting more than 1% of a biogeographical population will protect the species. This is also valid for migrating birds, as they are dependent on the integrity of their migratory pathways just in the same way.

The importance of the Horns Rev 3 area for migrating bird species is limited to those species that have been shown to be of relevance in the Horns Rev area (evidence-based approach). The selection of relevant migratory bird species was based on the consistency of occurance of species recorded during visual observations between 2010 and 2012 near Horns Rev 1 and Horns Rev 2 (see, Skov et al. 2012, Appendix 2 therein). Relevant species are defined as those species observed during at least 3 out of 4 consecutive migratory seasons at Horns Rev 1 and/or Horns Rev 2 and occurring in a total frequeny of >5 individuals. The list of selected species was supplemented by those species observed in significant numbers at Horns Rev 3 by Dorsch et al. (2013), e.g., Kittiwake, Common Eider.

We introduced the internationally approved importance definition in accordance to the Ramsar-Convention, which states that those areas are of international importance that contain at least 1% of the biogeographical population of a species as described in BirdLife International (2004). Cumulative species-specific frequencies over the entire study period (2010-2012) at both sites (Horns Rev 1, Horns Rev 2) were used as proxy for assessing the abundance of a relevant species in the area around Horns Rev 3. Total species-specific sums of visual observations projected onto an annual migration period of 5 months were used as proxy for assessing the local abundance of a given species per year. The abundance estimates were subsequently weighted in relation to the international conservation status of a given species. Note that species included in the collision risk model were confined to those seabird species for which site-specific, spatial density estimates were available (cf., Dorsch et al. 2013).

The general criteria for assessing the importance of an area in four grades (Table 4.3) were transferred into an assessment matrix relating to migratory birds and relevant impacts, i.e., collisions and barrier effects (Table 4.7). The most important step was to link the conservation status of a given species with its projected abundance in the area of Horns Rev 3 (Table 4.8).

Table 4.7 Criteria for assessing the importance of the Horns Rev area to migratory birds.

Criteria	Importance	Description
International conservation status Proportion of the biogeographical population	Very high	- Areas (e.g. parallel to the coast), which are used by more than 1.0% of the biogeographical population of a species - Areas (e.g. parallel to the coast) that are used by 0.5 to 1.0% of the biogeographical population of a species with very high international conservation status according to Annex I of the Birds Directive or according to SPEC 1 or SPEC 2
	High	- Areas (e.g. parallel to the coast) that are used by 0.5 to 1.0% of the biogeographical population of a species with high international conservation status (SPEC 3) - Areas (e.g. parallel to the coast), used by 0.1 to 0.5% of the biogeographical population of a species with very high or high international conservation status (Annex I of the Birds Directive or SPEC 1 or SPEC 2 or SPEC 3)
	Medium	- Areas (e.g. parallel to the coast) that are used by 0.5 to 1.0% of the biogeographical population of a species with medium or without international conservation status (NON-SPEC^{E} or NON-SPEC) - Areas (e.g. parallel to the coast), used by 0.1 to 0.5% of the biogeographical population of a species of medium international conservation status (NON-SPEC^{E})
	Low	- All other areas

For assessing the importance, three criteria were used: the consistency of occurance for species recorded in the Horns Rev area (Skov et al. 2012), an estimate of abundance based on total frequency determined over 4 successive migration periods (Skov et al. 2012), 1% values of the biogeographical populations as well as conservation status according BirdLifeInternational (2004). These criteria were entered into a crosstab to determine a combined importance level (Table 4.8). This table is not completely "symmetric" because the internationally accepted so-called 1% criterion cannot be undercut by low-conservation status. The co-determining criterion of abundance is measured by the occurring proportion of a species in the considered area in respect to its biogeographical population (Table 4.9). Two criteria were chosen for the classification of the importance of the area for the representative species based on their conservation status: 1st is the listing in Annex I of the EU Birds Directive, 2nd is the SPEC status as categorized in BirdLife International (2004) (Table 4.10). In case a species is listed in Annex I of the EU Birds Directive, but classified in a lower SPEC category, the highest importance level is chosen ("very high").

Table 4.8 Scheme for determining the importance of Horns Rev 3 area for a given species. The importance is based on the link between the conservation status (Table 4.10) with projected abundance in the Horns Rev 3 area relative to the biogeographical breeding population (Table 4.9).

		Conservation status			
		Very high[5]	High[6]	Medium[7]	Low[8]
Abundance (in %) of the biogeographical population	Very high[1]	Very high	Very high	Very high	Very high
	High[2]	Very high	High	Medium	Medium
	Medium[3]	High	High	Medium	Low
	Low[4]	Low	Low	Low	Low

Table 4.9 Ranking of importance based on the relationship between the abundance to its biogeographical population. For migratory birds with population size of >2,000,000, the number of 20,000 birds is the limit for setting the importance to very high (adjusted to the Ramsar Convention criterion).

Criteria	Description
[1]Very high	≥1% of a relevant population or ≥20,000 of a relevant migratory bird species*
[2]High	≥0.5% and <1% of a relevant population
[3]Medium	≥0.1% and <0.5% of a relevant population
[4]Low	<0.1% of a relevant population

Table 4.10 Grading of importance based on a species' conservation status according to the EU Birds Directive and SPEC-status (BirdLife International, 2004). Definitions: SPEC 1: European species of global conservation concern, i.e. classified as Critically Endangered, Endangered, Vulnerable, Near Threatened or Data Deficient und the IUCN Red List Criteria at a global level; SPEC 2: Species whose global populations are concentrated in Europe, and which have an Unfavourable conservation status in Europe; SPEC 3: Species whose global populations are not concentrated in Europe, but which have an Unfavourable conservation status in Europe; Non-SPECE: Species whose global populations are concentrated in Europe, but which have a Favourable conservation status in Europe; Non-SPEC: Species whose global populations are not concentrated in Europe, but which have a Favourable conservation status in Europe.

Criateria	Birds Directive	SPEC-Status
[5]Very high	Listed in Annex I	SPEC 1 or 2
[6]High		SPEC 3
[7]Medium		Non-SPEC^{E}
[8]Low		Non-SPEC

4.1.2.5. Severity of impact

The severity of impact for migrating birds was assessed following the scheme presented in Table 4.4. The severity of impact is assessed by combining the Degree of Impact with the importance level assessed for a species.

For pressures related to displacement and collision of birds a quantitative approach for determining the severity of impairment is followed wherever possible. Here, the Severity of Impact is assessed accounting for the number of birds predicted to be removed from the impact zone due to mortality or displacement in relation to the species biogeographic reference population and the species' conservation status (see importance criteria above).

4.2. Relevant Project pressures

Migratory bird populations are confronted with a variety of anthropogenic pressures in their habitats. These include a deterioration of breeding, staging and wintering areas through various human activities, as well as long-term climatic changes. In addition, a large number of birds are lost annually through direct human influences. In Scandinavia, more than 100 million birds die each year through collisions with anthropogenic structures (windows), traffic, hunting, fishing or pollution (see e.g. Klem 1990, Svensson 1998, Erritzøe 2002, Kube 2002). Recoveries of birds ringed on Heligoland Island in the North Sea provide evidence that anthropogenic bird mortality has increased significantly over the last century, particularly through traffic on roads and collisions with buildings ("passive causes of death": 14% of all dead individuals over the past two decades, 49% for birds of prey and owls; Hüppop & Hüppop 2002).

In the context of the Horns Rev 3 project, the following pressures on migratory birds needs to be assessed:

Environmental pressures related to the construction of HR 3 wind farm:

- Barrier effect related to construction vessels

The presence of a large number of construction vessels might result in a barrier, reducing the movements of birds on migration.

- Collision risk related to construction vessels

Birds may collide with construction vessels especially at night if they are attracted by lights.

Environmental pressures related to the system and operation of HR 3 wind farm:

- Barrier effects at various spatial scales, leading to avoidance (or attraction)

The offshore wind farm Horns Rev 3 through its physical structure from the several turbines/plants might constitute a barrier to migrating birds which prefer to fly over open waters and are reluctant to pass such obstacles.

- Collision risk related to turbine blades

Migratory birds might collide with the structure of the wind farm if they do not perceive the obstacle during inclement weather conditions and during the night or if they would be attracted by the lights.

Aumüller et al. (2013) postulate avoidance behaviour in response to wind farms, meaning that wind farms can act as barriers for migrants. Substantial evidence for this reaction comes from Denmark and The Netherlands (see section 4.3.2). However, monitoring potential threats in the German Bight failed in providing evidence of an avoidance response of migrating birds to offshore wind farms. Further investigations and analysis accordingly have led to substantiated results for avoidance reactions of migratory birds.

4.3. Sensitivity analysis

For assessing the sensitivity of migrating birds to project-related impacts, we considered species-specific or group-specific flight and migration characteristics as well as the proneness of "migration types" (cf. Table 4.11) to collide with vertical structures or to be obstructed during flight (barrier effects). The selection of relevant bird species and groups was based on Skov et al. (2012). Collision risk models following Band (2012) included those species reported by Dorsch et al. (2013) from on-site surveys at Horns Rev 3.

Table 4.11 Summary of "migration types" and generalised flight behaviour of relevant species groups for the migration through the Horns Rev 3 area (adapted from Dierschke & Daniels 2003, Garthe and Hüppop 2004, Blew et al. 2008, King et al. 2009, cf. FEBI 2013).

Migration type	Definition	Generalised flight behaviour
1	Water birds preferentially migrating over water – divers, grebes, seaducks, mergansers, auks etc.	flight altitude – low flight direction – parallel to the coastline
2	Water birds less dependent to migrate over water – geese, waders – with migration preferences steered by destination and stopover sites	flight altitude – high flight direction – parallel to the coastline
3	Land birds migrating during daytime, dependent on updrafts / thermals	flight altitude – mostly low, some high flight direction – parallel to the coastline
4	Land birds migrating in broad-front during night-time	flight altitude – mostly high, 20-30% low flight direction – parallel to the coastline

4.3.1 Collision risk

4.3.1.1. Construction phase

Construction-related structures (construction vessels, cranes) need to be considered as potential collision hazards for migrating birds. While excess light emission through the presence of construction vessels at night may exert an effect of displacement under conditions of high visibility, attraction effects with increased risks of collision need to be considered under adverse weather conditions (fog, rain; according to the well-known phenomena of bird strike at lighthouses). Especially night-migrating land birds are negatively affected by such phototactic attraction (Hansen 1954, IfAÖ own observations). However, the fact that offshore wind farm construction depends on favourable weather conditions reduces the likelihood that critical adverse weather conditions with high collision risk for migrating birds coincide with the presence of construction related structures. Thus, the impact of the construction vessels and cranes are limited to a relatively small area at a particular time period, and the number of collisions is expected to be low. The sensitivity to collisions with construction vessels was therefore assessed as **low** for all migrating bird species.

4.3.1.2. Post-construction phase: Collisions with turbines

Divers

Observations in this Horns Rev 3 region show that divers fly at altitudes up to 100 m, i.e. within the rotor-swept zone. Due to the pronounced avoidance behaviour towards offshore wind farms (Christensen et al. 2004), however, collisions are very unlikely. So far, no risky situations have been observed in divers flying near wind farms. Again, the data of Hansen (1954) support the predicted low probability of collisions in divers: only 12 red-throated divers (0.2 birds per year) and 2 black-throated divers collided with lighthouses over a period of 54 years. Sensitivity towards collisions is generally assessed to be **low**.

Sea ducks

Sea ducks usually fly very low over the water surface (own data: almost 100% below 50 m). Thus, they fly mainly below the rotor swept zone, but collisions with static vertical structures are conceivable. Due to the very pronounced avoidance behaviour towards offshore wind farms (for the Common Scoter see Christensen et al 2004; for the Common Eider see Pettersson & Stalin 2003, Pettersson 2005, Kahlert et al. 2004, Fox et al. 2006) collisions are predicted to be very rare events. Since flight obstacles are recognized during the day (and even at night, but not so robustly as during the day, cf. Christensen et al. 2004), critical situations are expected to arise only in bad weather conditions. The low probability of sea ducks colliding with vertical structures is also confirmed by Hansen (1954) who analysed collision rates of sea ducks at lighthouses / lightships: Long-tailed Duck 1.2 indiv./year; Eider 1.6 indiv./year; Scoter 2.4 indiv./year ; Velvet Scoter 0.2 indiv./year.

For waterbirds migrating at night (e.g. Common Eider about 10% nocturnal, Alerstam et al. 1974) it can be assumed that they recognize flight obstacle under conditions of good visibility (Christensen et al. 2004, Dirksen et al. 1998) and so may largely avoid collisions. The observed adjustments of flight directions at night along arrays of offshore wind turbines confirm this assumption (Christensen et al. 2004, Kahlert et al. 2004). In contrast, increased risk can be assumed during adverse weather conditions. However, sensitivity towards collisions is generally assessed to be low.

Geese

Geese show strong mass-specific wind dependencies, which significantly limit their flight heights under headwinds. Evidence from visual observations suggests that most flocks of geese fly under 50 m. In autumn, brent geese fly on average at about 210 m (about 32% below 200 m); in the spring they fly slightly higher (Green et al. 2002), potentially entering the height range of wind turbines. Geese primarily migrate during daytime and are expected to avoid wind farms at the macro-scale (Plonczkier & Simms 2012). Although a small proportion of geese may also enter offshore wind farms, collisions are not likely during the day if meso- and micro-avoidance is sufficient. A breaking-up of flight formations (as observed at Horns Rev) is associated with increased energy expenditure, which seems negligible with respect to the overall challenge of migration. Among Danish Lighthouse victims registered over 54 years, there were a total of only 37 brent geese and one pink-footed goose (Hansen 1954). This illustrates that geese collide very rarely with vertical structures, though it is not clear to what extent information from lighthouses can be transferred to wind farms. Collision studies at coastal windfarms indicate that there is a low collision risk for geese (e.g. Plonczkier & Simms 2012). Thus, sensitivity towards collisions is generally assessed to be low.

Gulls and Terns

Gulls and terns are frequently detected as collision victims of wind farms on land, though the most severe case can be explained through the unfavourable location of the wind farm close to a tern breeding colony (Winkelman 1989). Migrating common and arctic terns showed avoidance towards offshore wind farms (Christensen et al. 2004). Of all birds detected in offshore wind farm areas, gulls are the most frequently observed group and regularly fly within a potentially hazardous height range. The spatial distribution of gulls (especially large gull species) also depends strongly on human fishing activities. While fishing activities are predicted to be limited in the wind farm itself, it can be expected that local fish stocks will increase through beneficial reef effects, which in turn could lead to a higher fishing activity in the vicinity of wind farms. Gulls following fishing boats and moving from one boat to another may be at high collision risk, even though wind farms are otherwise generally avoided by gulls (Christensen et al. 2004 , Fox et al. 2006). Regular collisions are to be expected in gulls, which are classified to be the seabird group with the highest sensitivity towards offshore wind farms at the individual and population level (Furness et al. 2013). Sensitivity of tern and gulls towards collisions is generally assessed to be low to very high (Furness et al. 2013) respectively (?).

Raptors

Day-time migrants that depend on thermals (most raptors) generally ascend into great heights (aided by thermal columns over land) before crossing the open sea. When crossing the Strait of Gibraltar, for example, raptors fly at around 400 meters and would thus be outside the rotor-swept zone (Meyer et al. 2000). Accordingly, the majority of individuals attempt to maximize the time spent over land and usually follow the coast line. Thus, the numbers of raptors (storks and cranes can be neglected in the case of Horns Rev 3) crossing the open sea at turbine height is expected, and has been shown, to be low (Skov et al. 2012).

Critical situations for raptors are expected to occur mostly on land on the breeding grounds during foraging, particularly if wind turbines are built in areas of ascending thermals (e.g. on mountain ridges) and/or close to the breeding sites. These situations do not occur on the open sea. At Horns Rev, raptors were observed in very low numbers. Mean flight heights and passage rates were insufficient to calculate the risk of collision. As day-time migrants with outstanding eyesight and manoeuvrability, the sensitivity of raptors towards collisions in the Horns Rev area is generally low. Analyses of collision victims at lighthouses over a period of 54 years resulted in only two honey buzzards and one rough-legged buzzard (Hansen 1954).

In conclusion, for migrants that depend on thermals it must be emphasized that they usually fly so high that they are far beyond the rotor swept zone. Due to their good eyesight and flight abilities they are also likely to be able to avoid turbines at the macro- and meso-scale. Nevertheless, it cannot be excluded that under certain adverse weather conditions raptors are forced to lower their flight height and are exposed to the risk of collision. Low flying gliding raptors could be particularly susceptible towards turbulence caused by wind turbines and wake flows. However, sensitivity towards collisions is generally assessed to be low.

Passerines (and Pigeons)

Nocturnal bird migration usually takes place at higher elevations than day-time movements. Due to the expected high number of songbirds and waders migrating across the North Sea at night (and over the area of Horns Rev 3) and the proven effect of phototactic attraction towards artificial light sources, including offshore wind turbines, the collision risk for this group of birds is assessed to be relatively high compared to other groups of birds. To what degree songbird populations are affected by the risk of collision is not known, but it can be assumed that the impacts are low in view of generally larger populations with higher reproduction rates as compared with long-lived non-passerines. Although measurements using tracking radar showed that songbirds fly relatively higher than gulls and terns (van Gasteren et al. 2002), the flight altitudes of birds of all species is highly dependent on weather conditions and the presence of artificial light in combination with low visibility (fog, rain), which may lead to spontaneous, unpredictable reactions hampering the explanatory power of mean flight heights used in collision risk models.

Analyses of lighthouse victims show very strong species-specific differences in collision rates (Hansen 1954). 75 % of all collisions victims comprise only five species: Eurasian Skylark (24.3%), Song Thrush (15.2%), Redwing (15.0 %), Starling (12.9%), Robins (6.2%); further species : Fieldfare (3.7%) , Blackbird (2.6%) , Redstart (1.9%), Willow Warbler (1.7%), Brambling (1.7%), Wheatear (1.4%), Goldcrest (1.4%), Pied Flycatcher (1.3%), Garden Warbler (1.0%). The five dominant species are all nocturnal migrants (Skylark and Starling also migrate partially during the day). It needs to be considered that songbird population sizes in Scandinavia were generally higher in former periods covered by Hansen (1954). Of the 14 species that constitute more than 1% of all collisions, one species falls into category 2 of SPEC (Redstart; unfavourable conservation status, concentrated in Europe), and two species fall into category 3 (Skylark, Weatear). Nine of the 14 species are medium-distance migrants, five species are long-distance migrants. Four species are decreasing in Europe (Skylark, Wheatear, Starling, Redstart). These data indicate that endangered species may also be susceptible to collisions with vertical structures, e.g., Skylark, Redstart, Starling. At the same time, the species with the highest collision rate (Skylark, thrush species) are also listed in Annex II / 2 of the EU Birds Directive and subject to a very high hunting pressure in the Mediterranean. At the research platform FINO 1 in the North Sea, a similar species composition was determined from carcass retrievals (Hüppop et al. 2005). During day-time, terrestrial migrants are expected to occur to a much smaller extent at low altitudes over the open sea than at night. In addition, the visibility of flight obstacles is generally higher during the day, enabling birds to detect and avoid wind turbines. The generally very good manoeuvrability of small birds is also expected to significantly lower their risk of colliding. Observations at existing offshore wind farms at Horns Rev show that daytime migrating land birds recognize the wind farms as obstacle and mostly circumvent these areas (wood pigeons, thrushes). However, visual surveys conducted by BioConsult SH in the offshore wind farm Nysted also showed that some daytime migrants flew through the wind farm (Blew et al. 2008). However, collisions are still unlikely to occur as most birds have strong visual capabilities and can perceive flight obstacles under conditions of good visibility (Stübing 2001).

In conclusion, although the collision probability is estimated to be low during the day, because birds can see flight obstacles, critical situations may arise for terrestrial migrants crossing the open sea under conditions of poor visibility or through wind drift.

4.3.2 Barrier effects

4.3.2.1. Construction phase

Noise emissions of vessels and construction activities and visual disturbance through construction-related structures (vessels, cranes, working platforms) and activities may entail various direct species-specific impacts like barrier effects on migrating birds. Construction-related ship traffic would result in the reduction of barrier free flight paths to those species of migratory water birds in the area which are sensitive to these activities. However, the overall temporal and spatial extent of these impacts is expected to be very low. We therefore assume a low magnitude of pressure for the relevant species of migratory birds in accordance with construction vessels.

Migratory birds normally react to an obstruction by vertical or horizontal changes in their intended flight route. Species that migrate at low altitudes could be affected by construction vessels. Ships can lead to an attraction of gulls and terns (e.g. Walter & Becker 1997, Garthe & Scherp 2003, Garthe et al. 2004, Mendel et al. 2008), while divers and scooters generally show avoidance responses to human strcutures (Bellebaum et al. 2006, Schwemmer et al. 2011). For the latter groups of species it is expected that they will respond by avoiding the site by flying around the construction vessels at a far distance. This behaviour could lead to extra energy expenditure, but since construction activities are a limited in space and time, significant effects are not expected. The sensitivity of all migrating bird species is assessed to be low with regard to barrier effects through construction-related structures.

4.3.2.2. Operation phase

As permanent structures, wind farms may represent significant barriers to avian flight (Desholm & Kahlert 2005). A barrier effect and a consequent distraction of migratory routes can be expected mainly for species that migrate during the day, because birds can see and avoid the structures. According to previous studies, offshore wind farms represent a very distinct barrier for scoters and divers (Christensen et al. 2004), while eiders fly partly through rows of wind turbines (Kahlert et al. 2004, Fox et al. 2006). For gulls and some terns, offshore wind farms seem to be a less marked barrier to movement - only terns may avoid wind farms to a limited extent (Christensen et al. 2004). However, observations by BioConsult SH in the offshore wind farm Nysted indicate a certain barrier effect for gulls (Blew et al. 2008). Skov et al. (2012) postulate a barrier effect of Horns Rev 1 and Horns Rev 2 for most of the species investigated. Accordingly, for most species the barrier effect can be judged as partial as no species abandoned the wind farms completely.

Several investigations on land showed barrier effects as well as a decrease in the number of breeding and staging birds in wind farm areas. The intensity of this displacement effect is species-specific and can act up to a range of 800 m (e.g. Winkelman 1992 a-d, Schreiber 1994, Clausager & Noer 1995, Kruckenberg & Jaene 1999). In contrast, the sensitivity of migrating water birds towards offshore wind farms in relation to barrier effects is expected to be significantly higher because habituation to structural changes is unlikely to occur in migrating birds crossing the open sea. Avoidance movements were detected particularly when birds were flying against the wind while during tailwinds less change in fleight direction was registred (probably due to the faster flight and the limited range of possibilities to maneuver at short notice). Deviations in connection with headwinds were especially evident in large bird species (ducks, geese, gulls). During poor visibility, the flight distance from wind turbines were lowest for ducks (Dirksen et al. 1998), whereas van der Winden et al. (1999) showed that ducks recognize wind turbines and avoid them at an early stage, even during dark nights.

For nocturnally migrating land birds it is assumed that they may recognize illuminated wind farms as obstacle under conditions of good visibility. Avoidance rates have so far not been determined for birds migrating offshore and therefore cannot be assessed. Furthermore, an attraction of nocturnal migrants through artificial lighting is to be discussed, especially during bad weather conditions such as fog, rain or adverse winds. The high variation in species-specific collision rates seen among nocturnal migrants at light houses (Hansen, 1954) suggests that there are also great species-specific differences in barrier effects.

Divers

Divers are known to fly at rather low elevations over the water surface (Dierschke & Daniels 2003, FEBI 2013). According to the FEBI report (2013), divers gain considerable height when crossing e.g. the Öresund Bridge and thus represent the species group with by far the strongest altitudinal response when crossing human installations. Several reports suggest that divers show the strongest avoidance reactions to offshore wind farms among all water birds (Garthe and Hüppop 2004, Petersen et al. 2006, Mendel et al. 2008, Krijgsveld et al. 2010, 2011, Leopold et al. 2010) and are significantly sensitive to disturbance by ships (Bellebaum et al. 2006, Schwemmer et al. 2011). In general, we expect a high sensitivity of divers with respect to barriere effects through the wind farm Horns Rev 3.

Northern Gannet

Gannets were seen flying within the wind farm Horns Rev 2 despite the fact that the species was not recorded during baseline surveys. Accordingly, the barrier effect could be judged as partial as no gannets completely abandoned the wind farm area (Skov et al. 2012). We expect a medium sensitivity of gannets towards Horns Rev 3 as a barrier to movement.

Sea Ducks

Eiders show alternative flight responses and partly fly between wind turbines (Kahlert et al. 2004, Fox et al. 2006). Significant changes in the direction of approach to the offshore wind farm Horns Rev 1 were observed within a range of 400 to 1000 m (Christensen et al. 2004). At Nysted, eiders showed reactions towards the wind farm at a distance of 3 km during day time, and >1km at night (Kahlert et al. 2004). In small-scale wind farms (e.g. Tunø Knob, Guillemette et al. 1998, 1999, Utgrunden / Yttre Stengrund, Pettersson 2001, Pettersson & Stalin in 2003, Pettersson 2005) migrating eiders flew widely around the offshore wind turbines. In the offshore wind farms within the Kalmarsund, 99.5% of the eiders observed during passage flew at distances of > 200 m (horizontal) and > 50 m (vertical) relative to the wind turbines. However, the degree of avoidance was within the natural, wind-related deviation of ± 5 km from the migration route of eider ducks in the Kalmarsund (Pettersson 2001, Pettersson 2005). Scoters are known being especially sensitive to disturbance through ships (e.g. Bellebaum et al. 2006, Schwemmer et al. 2011). Earlier studies reported that e.g. disturbance distances with regard to moving ships are larger during daytime (~2,000 m) than during night-time (~500 m). The same studies suggest that scoters fly at higher altitudes during the night (Dirksen et al. 2004). They also seem to avoid offshore wind farms to a higher degree than other water bird species (Leopold et al. 2010, Krijgsveld et al. 2010, 2011). However, there is also an indication for some habituation to existing wind farms in this species (Petersen and Fox 2007, Blew et al. 2008). We expect a medium to high sensitivity of seaducks towards Horns Rev 3 as a barrier to movement.

Geese

Migratory geese are likely to respond to offshore wind farms by adopting strong horizontal and vertical avoidance behaviour. Plonczkier & Simms (2012) showed that pink-footed geese robustly avoid nearshore wind farms and calculated an avoidance rate of 94.46%. According to Krijgsveld et al. (2010), geese show distinct avoidance towards wind farms, at least when flying at rotor height, and only a few collisions have been registred at onshore wind farms where, for example, pink-footed geese may habituate to onshore wind farms on their wintering grounds (Madsen & Boertmann 2008). We expect a medium sensitivity of geese towards Horns Rev 3 as a barrier to movement.

Waders

Several studies have shown that birds fly at altitudes well above 300 m (according to FEBI (2013) even 500 m possible) and follow coastal topography with potential stop-over sites (e.g. Red Knots: Gudmundsson 1994, Piersma et al. 1990, Leyrer et al.

2009, Dunlin: Meltofte 2008, waders in general: Alerstam & Gudmundsson 1999). No significant barrier effects through offshore wind farms are to be expected. We expect a low sensitivity of wader with regard to barrier effects through Horns Rev 3.

Gulls and Terns

Offshore wind farms are not a significant barrier to movement for most gull species (Christensen et al. 2004). However, observations by Bio Consult SH in the offshore wind farm Nysted indicate a certain barrier effect for gulls (Blew et al. 2008). A distinct avoidance towards wind farms was observed in the Little Gull (Petersen et al. 2006, Leopold et al. 2010). Gulls generally show only little sensitivity towards disturbance through ships. On the other hand, ships may attract gulls (e.g. Walter & Becker 1997, Garthe & Scherp 2003, Garthe et al. 2004, Mendel et al. 2008). We expect a low sensitivity of gull species with regard to barrier effects through Horns Rev 3.

Terns fly mostly at low altitudes (Dierschke and Daniels 2003, FEBI 2013).However, for some terns, offshore wind farms seem to be no barrier and avoidance rates are generally low (Christensen et al. 2004). Blew et al. (2008), Krijgsveld et al. (2010) and Leopold et al. (2010) postulate a medium to weak avoidance of terns towards offshore wind farms. For the Sandwich Terns, no barrier effect has become evident (Leopold et al. 2010). We expect a low sensitivity of terns with regard to barrier effects through Horns Rev 3.

Raptors

The flight altitudes of raptors recorded at the area of Horns Rev 2 show a widely spread altitude spectrum (from about 20m up to 90m). According to Skov et al. (2012) raptors avoid flying through windfarms by altering their migration height. The sensitivity towards wind farms as barriers is considered to be **low**, because raptors generally fly at high elevations when crossing the sea.

4.4. The worst-case scenario for the wind farm project regarding migratory birds

The worst-case scenario refers to the initial design of the wind farm layout with the highest predicted impact on migratory birds.
Migrating birds are affected by displacement through barrier effects and collision. Moreover, attraction of night-migrating birds through artificial lighting can occur under adverse weather conditions (light-house effect). Regarding barrier effects, parameters like turbine size, wind farm layout / design, distance and location in relation to migration routes are relevant. Regarding collisions, factors like turbine characteristics (rotor swept zone, distance between water surface and lowest position of blade tips etc.), wind farm layout / design, distance and relation to migration routes plus obstruction lighting are important.

Besides these structural parameters, species-specific size, sensory capability, physical condition, flight behaviour (altitude), avoidance rate, population density etc. determine collision probability. Not all of these parameters are considered in the Band model!
At this time the final design of the offshore wind farm Horns Rev 3 is not yet decided. For the worst case scenario we assume that a lot of small turbines which are placed nearshore will lead to a highest impact on migratory birds, since denser and closer to water migration corridors. Figure 4.2 shows the design of Horns Rev 3 which will be the baseline for the worst case scenario. Which turbines are to be installed is not yet decided. However, 8 MW turbines would lead to a different layout (less dense placement of turbines), and the total rotor-swept area would change accordingly. Nevertheless, for the calculation of the collision risk based upon the Band model, we introduced the following specifications of the turbines:

- Number of turbines – 133,
- Capapicity of turbines – 3 MW,
- Distance between rotor tip and water surface is set to 23 meters.

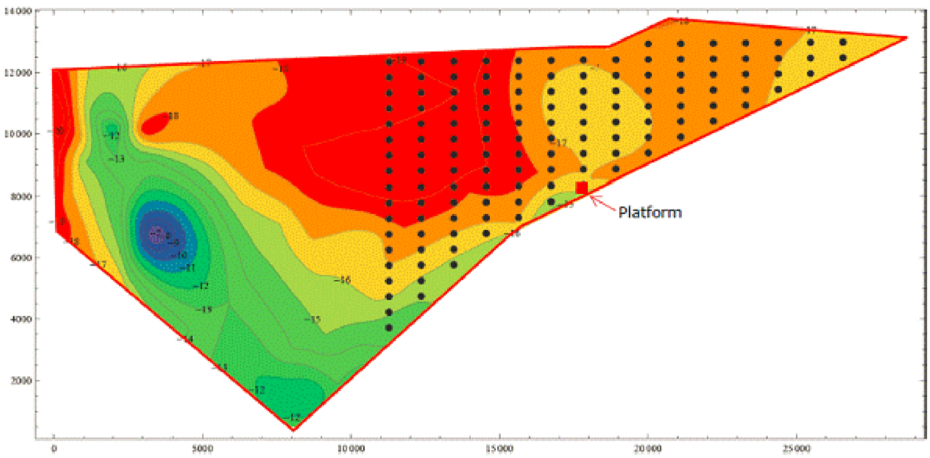


Figure 4.2 Design of the offshore wind farm Horns Rev 3 which is expected for the worst case scenario (contour lines are colour-coded).

4.4.1 Construction phase

During the construction phase of the wind farm the pressures and effects of barrier and collision are assumed to increase with the progress of the construction works. Working areas may function as barriers both during day- and night-time and may pose collision risks during night-time mainly.

It is not expected that construction activities *per se* influence birds moving through the open airspace. However, any structure that protrudes into the open airspace can be seen as a potential collision hazard. Thus, from a worst-case perspective, even construction vessels (that are illuminated at night) may pose a threat to night-migrating birds, although this impact is temporary.

4.4.2 Operation phase - Collision risk

In theory, collision risk depends on turbine characteristics and the design (lay-out) of wind farm. The emphasis here is set on long-term impacts of permanent structures, in particular rotor blades and obstruction lights and their relative spacing.

Collision risk theoretically increases with the total area / volume affected by rotating blades (swept zone) and by attraction through obstruction lighting and potential attraction of diurnal staging birds through habitat changes.

According to models for Horns Rev 1 and 2, collision risk for low flying scoters and seabirds was higher at Horns Rev 2 where the rotor swept zone reaches nearly 10 m closer to the sea surface than at Horns Rev 1. For scoters, the larger rotors could therefore (formally) constitute the worst-case scenario. However, differences between suggested turbine types at Horns Rev 3 are marginal, so that locality and density of turbines are the critical parameters to consider. Since different wind turbine types suggested in the technical description show similar values of about 21-23m for this measure, there is no worst case to be defined regarding turbine dimension.
Arieal lights of the entire wind-farm design may contribute to collision risk. The less intense arial lights, the lower the attraction and thus the collision risk will be.

4.4.3 Operation phase - Barrier effects

The operation phase will affect species like water birds (especially divers, ducks, and geese) to varying degrees.

The larger the affected area the greater is the barrier effect. The different scenarios differ only slightly in their size, thus there is no worst case scenario regarding the size of the proposed wind farm layouts.

The closer the wind turbines are to the coast, the higher are the expected effects on bird species that migrate parallel to the coast line.

Wind turbines standing closer together may pose a more effective barrier than turbines spaced further apart.

4.5. Assessment of collision risks

4.5.1 Construction phase

4.5.1.1. Degree of Impact

The degree of impact regarding the collision risk with construction vessels is deducted from the sensitivity assessment (see above). Based on the minor sensitivity to this temporary pressure, the degree of impact is assessed to be low for all relevant migrating bird species passing the Horns Rev 3 area.

4.5.1.2. Importance

In accordance with chapter 4.1.12, table 4.12 shows the overall importance of the Horns Rev 3 area for the relevant bird species. The area is of very high importance for the Common Scoter, Peregrine Falcon, Knot, and Little Gull, and of high importance for the Red-throated Diver and Kestrel. The estimated very high abundance of the Knot relative to its 1%-value was driven by one exceptional observation at Horns Rev 1 (see, Skov et al. 2012). For all other documented species the importance of the Horns Rev area is assessed to be of medium or low importance. The area of Horns Rev 3 is generally of low importance for songbirds.

Table 4.12 Importance of relevant species of migratory birds at Horns Rev 3, combining their conservation status and abundance (estimated annual passage rate based on data from Horns Rev 1 and Horns Rev 2). SPEC-status and 1%values are from BirdLife International (2004). For water birds, the European breeding-population was the basis to calculate the 1%-value (breeding pair x2). For raptors, the calculation size was limited to northern Europe (Sweden, Finland, Denmark and Norway).

species	Bird directive I	SPEC	1%-value	Estimated number of individuals passing Horns Rev 3 per year	Conservation status	Abundance	Importance
Red-throated Diver	X	3	1.840	215	Very High	Medium	**High**
Northern Gannet		Non-SPEC[E]	6.200	550	Medium	Low	Low
Cormorant		Non-SPEC	7.400	535	Low	Low	Low
Mallard		Non-SPEC	102.000	130	Low	Low	Low
Common Scoter		Non-SPEC	2.600	**3.800**	Low	Very High	**Very High**
Sparrow Hawk		Non-SPEC	890	35	Low	Low	Low
Kestrel		3	260	50	High	Medium	**High**
Peregrine Falcon	X	Non-SPEC	15	**50**	Very High	Very high	**Very High**
Golden Plover	X	Non-SPEC[E]	14.800	50	Very High	Low	Low
Dunlin		3	11.400	30	High	Low	Low
Knot		3W	600	**1.900**	High	Very High	**Very High**
Arctic Skua		Non-SPEC	2.800	95	Low	Low	Low

species	Bird directive I	SPEC	1%-value	Estimated number of individuals passing Horns Rev 3 per year	Conservation status	Abundance	Importance
Great Black-backed Gull		Non-SPEC[E]	3.600	170	Medium	Low	Low
European Herring Gull		Non-SPEC[E]	20.000	505	Medium	Low	Low
Lesser Black-backed Gull		Non-SPEC[E]	7.000	815	Medium	Medium	**Medium**
Black-headed Gull		Non-SPEC[E]	44.000	1.910	Medium	Low	Low
Common Gull		2	30.000	650	High	Low	Low
Kittiwake		Non-SPEC	20.000	375	Low	Low	Low
Little Gull	x	3	1.160	1.070	Very High	High	**Very High**
Common Tern	X	Non-SPEC	11.400	205	Very High	Low	Low
Arctic Tern	X	Non-SPEC	18.000	2.190	Very High	Medium	**High**
Sandwich Tern	X	2	2.600	1.285	Very High	Medium	**High**
Guillemot		Non-SPEC	54.000	170	Low	Low	Low
Woodpigeon		Non-SPEC[E]	340.000	1.235	Medium	Low	Low
Skylark		3	1.600.000	170	High	Low	Low
Barn Swallow		3	720.000	620	High	Low	Low
Meadow Pipit		Non-SPEC[E]	320.000	13.105	Medium	Low	Low
Pied Wagtail		Non-SPEC	520.000	305	Low	Low	Low
Yellow Wagtail		Non-SPEC	280.000	60	Low	Low	Low
European Robin		Non-SPEC[E]	1.660.000	45	Medium	Low	Low
Song Thrush		Non-SPEC[E]	720.000	210	Medium	Low	Low
Reed Bunting		Non-SPEC	176.000	50	Low	Low	Low
Brambling		Non-SPEC	440.000	125	Low	Low	Low
Chaffinch		Non-SPEC[E]	4.800.000	1.065	Medium	Low	Low
Greenfinch		Non-SPEC[E]	6.400.000	40	Medium	Low	Low
Linnet		2	560.000	205	Very	Low	Low

species	Bird directive I	SPEC	1%-value	Estimated number of individuals passing Horns Rev 3 per year	Conservation status	Abundance	Importance
					High		
Starling		3	1.120.000	1.620	High	Low	Low
Jackdaw		Non-SPEC[E]	300.000	2.915	Medium	Low	Low

4.5.1.3. Severity of Impact

Construction-related pressures resulting from the installation of offshore wind farms are considered to be limited in time and space. The use of space through the construction activities (habitat loss through vessel traffic) has no relevance for migratory birds passing through the wind farm area. Due to the time-space limitations of potential stressors, and on the basis of current knowledge, the construction-related impact of the Horns Rev 3 project on migratory birds is predicted to be low for all relevant species.

4.5.2 Operation

4.5.2.1. Degree of Impact

For assessing the degree of impact, in a first step the results of the different collision rate calculations based upon the Band (2012) model were taken into account. Based on bird migration data of further literature the collision rates of day- and night-time migrating birds were calculated. In a second step, the species sensitivity levels were considered in the assessment of the degree of impact.

With regard to the Horns Rev 3 area, collision probabilities can only be indirectly derived from radar-based and visual observation of bird reactions to the existing wind farms (Horns Rev 1, Horns Rev 2) or quantitatively through collision risk models, introducing density estimates for Horns Rev 3. Predictions on the collision risk for well documented bird species can therefore be generalized on the basis of the knowledge from existing post-construction surveys and through quantitative collision risk models, using known densities of birds staging in the Horns Rev 3 region.

For comparing collision risk estimates for Horns Rev 3 with previous assessments, we followed the same approach as outlined in Skov et al. (2012), introducing the same species into the collision risk model of Band (2012). Overall, similar mean densities of key bird species were detected in the Horns Rev 3 area (cf. Dorsch et al. 2013) as compared to previous surveys carried out for Horns Rev 1 and Horns Rev 2, except for the Common Scoter. This species was less abundant in the area around Horns Rev 3 than in previous surveys at Horns Rev 1 and Horns Rev 2.

The frequencies of predicted collision victims arising from the Band model (version 2012) are given as ”individuals per study period (January to September) and wind farm area” throughout the following section. Concerning the collision risk model, we included those bird species relevant to the Horns Rev area, following Skov et al. 2012, i.e., Red- and Black-throated Diver; Northern Gannet; Common Scoter; Small gull species, including Common Gull, Black-headed Gull, Little Gull; Large gull species, including Herring Gull, Great- and Lesser Black-backed Gull; Kittiwake; Terns, including Sandwich Tern, Common Tern and Artic Tern) and which were documented during aerial bird surveys on-site (Dorsch et al. 2013).

Divers

Concerning Red- and Black-throated Divers, we obtained similar results as Skov et al. (2012) (Table 4.13). The mean density of all birds was similar for the area of Horns Rev 2 and Horns Rev 3. The proportion of birds at rotor height varied between 1.1% (estimation by Cook et al. 2012 as used in the Horns Rev 3 model) and 33.3% (as estimated by Skov et al. 2012 for Horns Rev 2). The number of birds colliding with offshore wind turbines was low at Horns Rev 2 and zero for Horns Rev 1 and for Horns Rev 3. The highest frequency of collisions was 5 individuals in the 98 % avoidance rate scenario and 1 individual assuming 99.5 % avoidance rate for Horns Rev 2. Without avoidance, 8 individuals of Red- or Black-throated Divers would be at risk at Horns Rev 3, considering the worst case layout for migratory birds.

Table 4.13 Collision risk estimates for divers at Horns Rev 1, Horns Rev 2 and Horns Rev 3 offshore wind farms, along with species-specific values of key input parameters. Collision risk calculated for 98% avoidance rate and 99.5% avoidance rate scenarios. Assumption of no avoidance (0% avoidance rate) is provided for Horns Rev 3. Results of option 3 of the Band model (Band 2012) are given. * Horns Rev 1 and Horns Rev 2 data (Nov-Apr), ** Horns Rev 3 data (Jan-Sep), ² % of birds flying at rotor height at Horns Rev 1 and 2 as given in Skov et al. (2012), at Horns Rev 3 as given in Cook et al. (2012).

Red- and Black-throated Divers	*Horns Rev 1	*Horns Rev 2	**Horns Rev 3
Mean density of all staging birds (indiv./km²)	0.05	0.65	0.56
% of birds flying (assumption)	2%	2%	2%
Mean density of flying birds (indiv./km²)	0.001	0.013	0.01
² % of bird flying at rotor height	20%	33.3 %	1.1%
Collision risk (0% avoidance), number of birds colliding			8
Collision risk (98% avoidance), number of birds	0	5	0

colliding			
Collision risk (99.5% avoidance), number of birds colliding	0	1	0

The collision risk assessment depends on the proportion of birds flying at rotor height, the density of flying birds as well as the technical data of the wind farm (width of wind farm, length of blade, etc.). As an example, the proportion of birds flying at rotor height estimated by Skov et al. (2012) for Horns Rev 2 (33.3%) was applied for modelling the collision risk for the worst case scenario in Horns Rev 3 for divers (Table 4.14). At first sight, the results were identical for two of the analytical options (option 2 and 3) outlined by Band (2012). These options are based on the flight heights provided by Cook et al. (2012). In contrast, option 1 of the three analytical options of the Band model is based on the given proportion of birds flying at rotor height. The results show very strong differences in collision risk outcome. The number of birds colliding in the Horns Rev 3 area, assuming no avoidance and that 33.3% of individuals fly at rotor height, is 32 times higher than in the same area when assuming that 1.1% of birds are flying at rotor height. The number of birds colliding is zero when assuming that 1.1% of birds fly at rotor height and 4 (99.5% avoidance) to 15 (98% avoidance) if 33.3% of birds flew at rotor height.

Table 4.14 Collision risk estimates for divers at Horns Rev 3 offshore wind farms, along with taxon-specific values of key input parameters. Collision risk calculated for pessimistic (98% avoidance rate) and optimistic (99.5% avoidance rate) scenarios. Results of option 1 of the Band model (2012) are given. [2]% of birds flying at rotor height at Horns Rev 1 and 2 as given in Skov et al. (2012), at Horns Rev 3 as given in Cook et al. (2012).

Red- and Black-throated Divers	**[1]Horns Rev 3**	**[2]Horns Rev 3**
Mean density of all staging birds (indiv./km²)	0.56	0.56
% of birds flying (assumption)	2%	2%
Mean density of flying birds (indiv./km²)	0.01	0.01
[2]% of bird flying at rotor height	1.1%	33,3%
Collision risk (0% avoidance), number of birds colliding	23	741
Collision risk (98% avoidance), number of birds colliding	0	15
Collision risk (99.5% avoidance), number of birds colliding	0	4

Northern Gannet

So far, mean densities of Northern Gannets were highest in the area around Horns Rev 3 (Table 4.15). The proportion of birds flying at rotor height estimated from ship surveys at Horns Rev 1, is similar to the values published by Cook et al. (2012) and were introduced into the collision risk model for Horns Rev 3. In the case of Horns Rev 1, no collision risk has been estimated so far. The collision risk at Horns Rev 2 and Horns Rev 3 was generally low, but higher at Horns Rev 2, with 7 birds predicted to collide.

Table 4.15 Collision risk estimates for northern gannets at Horns Rev 1, Horns Rev 2 and Horns Rev 3 offshore wind farms, along with species-specific values of key input parameters. Collision risk is calculated for 98% avoidance rate and 99.5% avoidance rate scenarios. Assumption of no avoidance (0% avoidance rate) is provided for Horns Rev 3. Results of option 3 of the Band model (2012) are given. * Horns Rev 1 and Horns Rev 2 data (Nov-Apr), ** Horns Rev 3 data (Jan-Sep), ² % of bird flying at rotor height at Horns Rev 1 and Horns Rev 2 as given in Skov et al. (2012), at Horns Rev 3 as given in Cook et al. (2012).

Northern Gannet	*Horns Rev 1	*Horns Rev 2	**Horns Rev 3
Mean density of all staging birds (indiv./km²)	0.006	0.018	0.04
% of birds flying (estimated from ship surveys)	64%	64%	64%
Mean density of flying birds (indiv./km²)	0.004	0.012	0.03
² % of bird flying at rotor height	8.7%	39.1%	9.6%
Collision risk (0% avoidance), number of birds colliding			130
Collision risk (98% avoidance), number of birds colliding	0	7	3
Collision risk (99.5% avoidance), number of birds colliding	0	2	1

Skov et al. (2012) estimated that 39.1% of birds would fly at rotor height in the area of Horns Rev 2. We obtained the following results for gannets from option 1 within the Band model (2012) (Table 4.16): model outputs were identical among analytical options 2 and 3, due to the spreadsheet provided by Cook et al. (2012). The results of option 1 show great differences in collision risk, depending on the given proportion of birds flying at rotor height. The number of colliding birds (assuming no avoidance, 98% or 99.5% avoidance) is four times higher with a four times higher proportion of birds flying at rotor height. Collision risk without avoidance increases proportionally with increasing frequency of birds flying at rotor height, as seen for divers and gannets, using two different values of the proportion of birds flying at rotor height (Table 4.15, 4.16).

Table 4.16 Collision risk estimates for northern gannets at Horns Rev 3 offshore wind farm, along with species-specific values of key input parameters. Collision risk is calculated for 98% avoidance rate and 99.5% avoidance rate scenarios. Results of option 1 of the Band model (2012) are given. ¹% of bird flying at rotor height at Horns Rev 3 as estimated by Cook et al. (2012), ²% of bird flying at rotor height at Horns Rev 3 as given in Skov et al. (2012).

Northern Gannet	¹Horns Rev 3	²Horns Rev 3

Mean density of all staging birds (indiv./km²)	0.04	0.04
% of birds flying (estimated from ship surveys)	64%	64%
Mean density of flying birds (indiv./km²)	0.03	0.03
% of bird flying at rotor height	9.6	39.1%
Collision risk (0% avoidance), number of birds colliding	603	2456
Collision risk (98% avoidance), number of birds colliding	12	49
Collision risk (99.5% avoidance), number of birds colliding	3	12

Sea ducks (Common Scoter, Velvet Scoter, Common Eider)

Due to the lower density of Common Scoter detected in the Horns Rev 3 area (12.21 indiv./km²) as compared to Horns Rev 1 and Horns Rev 2 (156.05 and 274.05 indiv./km²), the collision risks estimated for three scenarios (0%, 98% and 99.5% avoidance) were lowest for Horns Rev 3 (Table 4.17). This discrepancy between wind farm sites is most likely driven by interannual variation in bird presence and detection stochasticity. The aerial surveys at Horns Rev 1 and Horns Rev 2 were conducted in winter and spring (November 2006-April 2007) whereas from January to September 2013 in the case of Horns Rev 3. Moreover, the geographical distribution of the Common Scoter varies strongly throughout the year and among years, depending on a multitude of external factors, including resource availability, weather conditions and the degree of anthropogenic disturbance. The proportion of birds flying at rotor height was estimated highest for Horns Rev 2 (6.1%) and lowest for Horns Rev 3 (1%). Altogether the pessimistic scenario (98% avoidance) for the Common Scoter resulted in values ranging between 5 and 178 individuals potentially colliding in the Horns Rev area. In the optimistic scenario (99.5% avoidance), 1-45 individuals are under risk of collision. The proportion of birds flying at rotor height as well as the number predicted collisions is highest at Horns Rev 2 where the highest density of Common Scoters has been documented so far.

Table 4.17 Collision risk estimates for common scoters at Horns Rev 1, Horns Rev 2 and Horns Rev 3 offshore wind farms, along with species-specific values of key input parameters. Collision risk is calculated for 98% avoidance rate and 99.5% avoidance rate scenarios. Assumption of no avoidance (0% avoidance rate) is provided for Horns Rev 3. Results of option 3 of the Band model (2012) are given. * Horns Rev 1 and Horns Rev 2 data (Nov-Apr), ** Horns Rev 3 data (Jan-Sep), ² % of bird flying at rotor height at Horns Rev 1 and 2 as given in Skov et al. (2012), at Horns Rev 3 as estimated by Cook et al. (2012).

Common Scoter	***Horns Rev 1**	***Horns Rev 2**	****Horns Rev 3**
Mean density of all staging birds	156.05	274.0	12.21

(indiv./km^2)		5	
% of birds flying (estimated from ship surveys)	1%	1%	1%
Mean density of flying birds (indiv./km^2)	1.56	3	0.12
[2] % of bird flying at rotor height	2.3%	6.1%	1%
Collision risk (0% avoidance), number of birds colliding			232
Collision risk (98% avoidance), number of birds colliding	31	178	5
Collision risk (99.5% avoidance), number of birds colliding	8	45	1

For comparing the collision risk of sea ducks using option 1 of the Band model (2012), there was no information on flight heights for Velvet Scoter and Common Eider in Cook et al. (2012) (Table 4.18). We therefore used the estimated proportions of birds flying in rotor height given in Furness et al. (2013) for all three sea duck species. For a better comparison between the three species, the nocturnality score of Garthe and Hüppop (2004) was applied. The mean density of the Common Scoter was highest, with 12.21 indiv./km^2. The mean density of the Velvet Scoter was lowest, with 0.22 indiv./km^2. The proportion of birds flying at rotor height was 3%, the nocturnal activity score was 3 for all three species. Due to the higher density of the Common Scoter, the risk of collision (assuming no avoidance) is highest for this species, with 887 predicted collision victims. 35 Velvet Scoters and 80 Common Eiders would be at risk of collision when excluding avoidance. The pessimistic scenario (98% avoidance) for sea ducks ranges from 1-18 collision victims; the optimistic scenario (99.5% avoidance) ranges from 0-4 birds.

Table 4.18 Collision risk estimates for sea ducks at Horns Rev 3 offshore wind farm, along with species-specific values of key input parameters. Collision risk calculated for no avoidance, 98% avoidance rate and 99.5% avoidance rate scenarios. Results of option 1 of the Band model (2012) are given. Density of birds based on Horns Rev 3 data (Jan-Sep), *% of bird flying estimated from ship surveys (Skov et al. 2012), **% of bird flying assumed for sea ducks (Skov et al. 2012).

Sea ducks	**Common Scoter**	**Velvet Scoter**	**Common Eider**
Mean density of all staging birds (indiv./km^2)	12.21	0.22	0.57
% of birds flying	*1%	**2%	**2%
Mean density of flying birds (indiv./km^2)	0.12	0.004	0.01
% of bird flying at rotor height	3%	3%	3%
nocturnal activity	3	3	3
Collision risk (0% avoidance), number of birds colliding	887	35	80
Collision risk (98% avoidance), number	18	1	2

of birds colliding			
Collision risk (99.5% avoidance), number of birds colliding	4	0	0

Small Gulls

Model outputs concerning the collision risk for small gull species, including Common Gull, Black-headed Gull and Little Gull, are well in line with the results of Skov et al. (2012) (Table 4.19). The mean density of birds as well as the proportion of birds flying at rotor height is similar at Horns Rev 1 and Horns Rev 3. However, the predicted number of colliding individuals is two times higher at Horns Rev 3. This difference is probably due to the slightly higher density of small gulls found at Horns Rev 3 and/or due to different technical specifications of wind farms. Although Skov et al. (2012) estimated higher proportions of birds flying at rotor height for Horns Rev 2, the collision risk was lower due to the lower density of birds in this area and/or the technical specifications of the wind farm.

In general, small gulls are the third most susceptible of all modelled species in the Horns Rev area. The Common and Black-headed Gull had the strongest impact on the model outputs due to their higher mean density and the highest proportion of birds flying at rotor height (22.9% for the Common Gull).

Table 4.19 Collision risk estimates for small gull species at Horns Rev 1, Horns Rev 2 and Horns Rev 3 offshore wind farms, along with species-specific values of key input parameters. Collision risk is calculated for 98% avoidance rate and 99.5% avoidance rate scenarios. Assumption of no avoidance (0% avoidance rate) is provided for Horns Rev 3. Results of option 3 of the Band model (2012) are given. * Horns Rev 1 and Horns Rev 2 data (Nov-Apr), ** Horns Rev 3 data (Jan-Sep), ² % of bird flying at rotor height at Horns Rev 1 and 2 as given in Skov et al. (2012), at Horns Rev 3 as estimated by Cook et al. (2012).

Small gull species	*Horns Rev 1	*Horns Rev 2	**Horns Rev 3
Mean density of all staging birds (indiv./km²)	0.409	0.095	0.48
% of birds flying (estimated from ship surveys)	41%	41%	41%
Mean density of flying birds (indiv./km²)	0.168	0.039	0.2
² % of bird flying at rotor height	12.5%	22.9%	12.1%
Collision risk (0% avoidance), number of birds colliding			1696
Collision risk (98% avoidance), number of birds colliding	18	10	34
Collision risk (99,5% avoidance), number of birds colliding	4	2	8

Large Gulls

The group of large gulls, including Herring Gull, Great- and Lesser Black-backed Gull, contain some of the most susceptible species towards wind farms (Cook et al. 2012, Furness et al. 2013). This group of birds shows the second highest mean density (0.56-1.754 Indiv./km²) of all representative species in the whole Horns Rev area (Table 4.20). The proportion of birds at rotor height varies from 28.9% to 55.8%. The range of modelled collision victims ranges from 149-378 individuals in pessimistic and 37-95 individuals in optimistic scenarios.The lower numbers of predicted collision victims at Horns Rev 3 are most likely due to the lower density of birds found in this area as well as the lower proportion of birds flying at rotor height. The highest number of collision victims was estimated for Horns Rev 1.

Our results are in line with the conclusions of Skov et al. (2012): while the densities of wintering small and large gulls are not very high, a relatively high proportion of birds in flight and flying at rotor height result in a high flux of birds through the wind farms and the rotor-swept area.

Table 4.20 Collision risk estimates for large gull species at Horns Rev 1, Horns Rev 2 and Horns Rev 3 offshore wind farms, along with species-specific values of key input parameters. Collision risk calculated for 98% avoidance rate and 99.5% avoidance rate scenarios. Assumption of no avoidance (0% avoidance rate) is provided for Horns Rev 3. Results of option 3 of the Band model (2012) are given. * Horns Rev 1 and Horns Rev 2 data (Nov-Apr), ** Horns Rev 3 data (Jan-Sep), ² % of bird flying at rotor height at Horns Rev 1 and 2 as given in Skov et al. (2012), at Horns Rev 3 as estimated by Cook et al. (2012).

Large gull species	***Horns Rev 1**	***Horns Rev 2**	****Horns Rev 3**
Mean density of all staging birds (indiv./km²)	1.754	0.920	0.59
% of birds flying (estimated from ship surveys)	43%	43%	43%
Mean density of flying birds (indiv./km²)	0.754	0.396	0.25
² % of bird flying at rotor height	39.5%	55.8%	28.9%
Collision risk (0% avoidance), number of birds colliding			7434
Collision risk (98% avoidance), number of birds colliding	378	360	149
Collision risk (99.5% avoidance), number of birds colliding	95	90	37

Kittiwake

Kittiwakes are generally uncommon in the Horns Rev area (Skov et al. 2012). The can be confirmed for the Horns Rev 3 area. The mean densities of Kittiwakes are equally low in all three areas (Horns Rev 1-Horns Rev 3) (Table 4.21). The highest relative density was found at Horns Rev 1 (0.05 Indiv./km²), the lowest at Horns Rev 3 (0.03

Indiv./km²). The estimated proportion of birds at rotor height is similar between Horns Rev 1 and Horns Rev 3 (15.7%-18.2%), yet two times higher (36.4 %) at Horns Rev 2. With 8 potential collisions (assuming 98% avoidance), the predicted collision risk is higher at Horns Rev 2 than at the other two sites. In general, the pessimistic collision scenario ranges from 2-8 potential collision victims, the optimistic scenario from 0-2 potential collision victims for the whole Horns Rev area.

Table 4.21 Collision risk estimates for kittiwakes at Horns Rev 1, Horns Rev 2 and Horns Rev 3 offshore wind farms, along with species-specific values of key input parameters. Collision risk calculated for 98% avoidance rate and 99.5% avoidance rate scenarios. Assumption of no avoidance (0% avoidance rate) is provided for Horns Rev 3. Results of option 3 of the Band model (2012) are given. * Horns Rev 1 and Horns Rev 2 data (Nov-Apr), ** Horns Rev 3 data (Jan-Sep), ² % of bird flying at rotor height at Horns Rev 1 and 2 as given in Skov et al. (2012), at Horns Rev 3 as estimated by Cook et al. (2012).

Kittiwake	*Horns Rev 1	*Horns Rev 2	**Horns Rev 3
Mean density of all staging birds (indiv./km²)	0.05	0.029	0.03
% of birds flying (estimated from ship surveys)	56%	56%	56%
Mean density of flying birds (indiv./km²)	0.028	0.016	0.02
² % of bird flying at rotor height	18.2%	36.4%	15.7%
Collision risk (0% avoidance), number of birds colliding			97
Collision risk (98% avoidance), number of birds colliding	6	8	2
Collision risk (99.5% avoidance), number of birds colliding	1	2	0

Terns (Sandwich, Common and Artic Tern)

The densities of terns, including Sandwich, Common and Artic Tern were comparatively low in the seasons surveyed by Skov et al. (2012). At Horns Rev 3, data were also collected during the summer season. The mean densities vary between 0.006-0.08 Indiv./km² (Table 4.22). The proportion of birds at rotor height is similar between Horns Rev 1 and Horns Rev 3 (6.8% for Horns Rev 1 and 5.7% for Horns Rev 3). Horns Rev 2 showed a three times higher proportion of birds at rotor height (16.4%). Collision risk estimates are very low and suggest that 0-1 birds (99.5% avoidance) or 0-3 birds (98% avoidance) would collide with turbines in the Horns Rev area, with the highest risk in the Horns Rev 3 area based on the worst case scenario.

Table 4.22 Collision risk estimates for terns at Horns Rev 1, Horns Rev 2 and Horns Rev 3 offshore wind farms, along with species-specific values of key input parameters. Collision risk calculated for 98% avoidance rate and 99.5% avoidance rate scenarios. Assumption of no avoidance (0% avoidance rate) is provided for Horns Rev 3. Results of option 3 of the Band model (2012) are given. * Horns Rev 1 and Horns Rev 2 data (Nov-Apr), ** Horns Rev 3 data (Jan-Sep), ² % of bird flying at rotor height at Horns Rev 1 and 2 as given in Skov et al. (2012), at Horns Rev 3 as estimated by Cook et al. (2012).

Terns	*Horns Rev 1	*Horns Rev 2	**Horns Rev 3
Mean density of all staging birds (indiv./km²)	0.006	0.021	0.08
% of birds flying (estimated from ship surveys)	70%	70%	70%
Mean density of flying birds (indiv./km²)	0.004	0.014	0.06
² % of bird flying at rotor height	6.8%	16.4%	5.7%
Collision risk (0% avoidance), number of birds colliding			126
Collision risk (98% avoidance), number of birds colliding	0	2	3
Collision risk (99.5% avoidance), number of birds colliding	0	0	1

Auks (Guillemot/Razorbill)

With 0.1 indiv./km², the mean density of auks was very low at Horns Rev 3 (Table 4.23). Assuming that 0.2% of birds would fly at rotor height, the collision risk model excluding avoidance predicts 1 colliding individual. The numbers of collision victims, assuming 1% of birds flying at rotor height, amounts to 3 individuals. The collision risk in the pessimistic and optimistic scenarios is zero. Using the analytical option 3 of the Band model (2012), the risk of collision would be 1 collision victim excluding avoidance and no victim introducing avoidance, independent of the proportion of birds flying at rotor height. This value was used to compare the ranked species list of Furness et al. (2013) with ranks resulting from the Band model (Table 4.24).

Table 4.23 Collision risk estimates for Guillemot/Razorbill at Horns Rev 3 offshore wind farm, along with species-specific values of key input parameters. Collision risk calculated for no avoidance, 98% avoidance rate and 99.5% avoidance rate scenarios. Results of option 1 of the Band model (2012) are given. ¹% of bird flying at rotor height at Horns Rev 3 as estimated by Cook et al. (2012), ²% of bird flying at rotor height at Horns Rev 3 as estimated by Furness et al. (2013).

Guillemot/Razorbill	¹Horns Rev 3	²Horns Rev 3
Mean density of all staging birds (indiv./km²)	0.1	0.1
% of birds flying (estimated from ship surveys)	2%	2%
Mean density of flying birds (indiv./km²)	0.002	0.002
% of bird flying at rotor height	0.2%	1%

Collision risk (0% avoidance), number of birds colliding	1	3
Collision risk (98% avoidance), number of birds colliding	0	0
Collision risk (99.5% avoidance), number of birds colliding	0	0

4.5.2.2. Species ranking with respect to the risk of collision

The comparison of the species ranking between Furness et al. (2013) and the available collision risk data from the worst case scenario of the offshore wind farm Horns Rev 3 is shown in Table 4.24. Both ranks confirm the highest risk for gulls. Whereas the Herring Gull leads both ranking lists, the Black-headed Gull appears to be exposed to a relatively higher collision risk according to the Band model (2012) than estimated by Furness et al. (2013). According to the Band model, collision risk for the Common Scoter is also ranked higher than by Furness et al. (2013). Velvet Scoter and Common Eider were introduced only approximately into the ranked species list following the Band model, because flight height information as for the other species was not available for these species (Cook et al. 2012). Nevertheless, the total risk score for these species was ranked low according to Furness et al. (2013), and we assume that model outcomes would lead to the same classification. The collision rate excluding avoidance and using option 1 of the Band (2012) model would amount to 35 potential collision victims for the Velvet Scoter and 80 for the Common Eider (Table 4.18). Assuming 98% avoidance, the number of colliding individuals would be zero for both species. Altogether, large gulls are the most sensitive species, followed by small gulls. Divers and terns are clearly less susceptible. In conclusion, the ranked species list according to Furness et al. (2013) is almost identical to the ranked species list developed independently on the basis of the Band model (2012).

Table 4.24 Ranked species sensitivity towards the risk of collision according to Furness et al. (2013) and the degree of impact after site-specific application the collision risk model by Band (2012) for the Horns Rev 3 project (species as documented by Dorsch et al. 2013). Results of collision risk are based on option 3 for all selected species, except for Common eider and Velvet scoter (option 1).

Ranked species after Furness et al. (2013)		**Ranked species after collision risk model of Band (2012) for Horns Rev 3**		
Species	**Total risk score**	**Species** (Dorsch et al. 2013)	**Collisions** (Jan-Sep, 0% avoidance)	**Collisions** (Jan-Sep, 98% avoidance)
European Herring Gull	Very High	European Herring Gull	7286	148 (Very High)
Great Black-backed Gull	Very High	Lesser black-backed Gull	5772	115 (Very High)
Lesser Black-backed Gull	Very High	Black-headed Gull	951	19 (High)

Northern Gannet	High	Common Gull	859	18 (High)
Common Gull	Medium	Common Scoo-ter	228	5 (Medium)
Kittiwake	Medium	Great black-backed Gull	177	4 (Medium)
Black-headed Gull	Low	Northern Gan-net	130	3 (Medium)
Sandwich Tern	Low	Kittiwake	97	2 (Medium)
Black-throated diver	Low	Sandwich Tern	96	2 (Medium)
Common Tern	Low	Arctic Tern	56	1 (Low)
Red-throated Diver	Low	Common Tern	35	1 (Low)
Arctic Tern	Low	Red-throated Diver	13	0 (Low)
Common Eider	Low	Black-throated Diver	3	0 (Low)
Common Scoter	Low	Common Eider		0 (Low)
Velvet Scoter	Low	Velvet Scoter		0 (Low)
Guil-lemot/Razorbill	Low	Guil-lemot/Razorbill	1	0 (Low)

The following table 4.25 gives the conclusion of the estimated degree of impact. For birds of prey on migration (which by definition are not foraging) we expect a low risk of collision risk, because they migrate primarily during daytime under favourable weather conditions and are bound to perceive flight onstacles.

Table 4.25 Degree of Impact concerning the risk of collision for relevant bird species at Horns Rev 3.

Species	**Degree of Impact**
Red/Black-throated Diver	Low
Northern Gannet	High
Cormorant	Low
Mallard	Low
Common/Velvet Scoter	Low
Common Eider	Low
Sparrow Hawk	Low
Kestrel	Low
Peregrine Falcon	Low
Golden Plover	Low
Dunlin	Low
Knot	Low
Arctic Skua	**Medium**
Great Black-backed Gull	**High**

European Herring Gull	**Very High**
Lesser Black-backed Gull	**Very High**
Black-headed Gull	**Medium**
Common Gull	**High**
Kittiwake	**Medium**
Little Gull	**Medium**
Common Tern	Low
Arctic Tern	Low
Sandwich Tern	**Medium**
Guillemot	Low
Woodpigeon	Low
Skylark	Low
Barn Swallow	Low
Meadow Pipit	Low
Pied Wagtail	Low
Yellow Wagtail	Low
European Robin	Low
Song Thrush	Low
Reed Bunting	Low
Brambling	Low
Chaffinch	Low
Greenfinch	Low
Linnet	Low
Starling	Low
Jackdaw	Low

4.5.2.3. Importance

In accordance with chapter 4.1.12, the table 4.12 shows the overall importance of the Horns Rev area for the relevant bird species (see section 4.5.1.2.).

4.5.2.4. Severity of Impact

The impacts assessment of the risk of collision results in a medium severity of impact for the Lesser Black-backed Gull, the Little Gull and the Sandwich Tern. For all other relevant species as classified on the basis of Skov et al. (2012), a low severity of impact will arise from the Horns Rev 3 project (Table 4.26).

It needs to be stated that with regard to the Horns Rev 3 area, collision probabilities were only indirectly derived from radar-based and visual observation of bird reactions to existing wind farms (Horns Rev 1, Horns Rev 2) or quantitatively through collision risk models introducing destiny estimates for Horns Rev 3.

It is currently not known which type of wind turbine will be installed at Horns Rev 3 (see chapter 2.2). If turbines are installed that roughly resemble the systems of other wind farms in the North Sea, turbine heights will range from 120 and 150 m. This variation may have little impact on the outcome of stochastic models but may be of significance as soon as migrants lower their flight elevation in response to adverse weather or artificial light. Due to regulations to ensure the safety of ship and air traffic, the turbines will be marked by flashing lights and possibly also partially by continuous lighting. For night migrating bird species, the risk of collision at the turbines may therefore correspond to that known from light vessels / platforms (100-200 collisions per year). The annual number of nocturnally migrating birds entering the wind farm will vary greatly depending on the coincidence of adverse weather condition and the magnitude of migration waves. Species-specific information on this potential impact is currently unavailable.

To conclude, it is unlikely that annual mortality caused by collisions with wind turbines will exceed 1 % of the individuals in flyway populations of those bird species detected in the Horns Rev region.

Table 4.26 Severity of collisions for relevant bird species at Horns Rev 3 during operation.

Species	Severity of Impact
Red/Black-throated Diver	Low
Northern Gannet	Low
Cormorant	Low
Mallard	Low
Common/Velvet Scoter	Low
Sparrow Hawk	Low
Common Eider	Low
Kestrel	Low
Peregrine Falcon	Low
Golden Plover	Low
Dunlin	Low
Knot	Low
Arctic Skua	Low
Great Black-backed Gull	Low
European Herring Gull	Low
Lesser Black-backed Gull	**Medium**
Black-headed Gull	Low
Common Gull	Low
Kittiwake	Low
Little Gull	**Medium**
Common Tern	Low
Arctic Tern	Low
Sandwich Tern	**Medium**
Guillemot	Low
Woodpigeon	Low
Skylark	Low

Barn Swallow	Low
Meadow Pipit	Low
Pied Wagtail	Low
Yellow Wagtail	Low
European Robin	Low
Song Thrush	Low
Reed Bunting	Low
Brambling	Low
Chaffinch	Low
Greenfinch	Low
Linnet	Low
Starling	Low
Jackdaw	Low

4.6. Assessment of barrier effects

4.6.1 Construction

4.6.1.1. Degree of Impact

Based on the low sensitivity to the barrier effect assessed for nearly all migrating bird species and the relatively low magnitude of pressure through construction vessels, the degree of impact is assessed to be minor to all affected birds in the Horns Rev 3 area.

4.6.1.2. Importance

In accordance to the chapter 4.1.12, the table 4.12 shows the overall importance of the Horns Rev area for the relevant bird species (see section 4.5.1.2.).

4.6.1.3. Severity of Impact

Construction-related pressures resulting from the installation of the offshore wind farm Horns Rev 3 are considered to be limited in time and space. The use of space through the construction activities has no relevance for migratory birds passing through the wind farm area. Due to the time-space limitations of potential stressors, and on the basis of current knowledge, the construction-related impact of the Horns Rev 3 project on migratory birds is predicted to be low.

The duration of the impact of the pressure "barrier from construction vessels" is restricted to the construction period. No impact from this pressure is predicted to occur after finalisation of the construction works.

4.6.2 Operation

4.6.2.1. Degree of Impact

Installations like wind turbines and their operation in the Horns Rev 3 area are expected to result in barrier effects for birds being sensitive to this pressure (see chapter 4.3).

A barrier effect may potentially lead to higher energy expenditures. But the question arises how relevant this is in view of the spatial scales over which migrating birds move.

In order to assess the extra energy expenditures as a result from avoidance reactions to a barrier the summary of FEBI (2013) was included (Table 4.27). Here, the extra energy expenditures were calculated for different detour flight scenarios for a selected number of species avoiding a bridge (vertical structure comparable with wind turbines, yet static). Information is only available for a limited number of species.

For species with short migration distances the highest relative additional costs in connection with a barrier effect were calculated. For long-distance migrants additional energetic costs would rarely exceed values of 1% of total migration costs, even when assuming the most conservative scenario 3. Further calculation with the daily energy expenditure (DEE) showed that for all non-breeding water birds the additional energy costs contributed to less than 5% of the daily expenditure.

Most of the observed migratory bird species in the Horns Rev area are medium- to long-distance migrants. Therefore, the degree of impact on relevant bird species of the barrier effect is assessed to correspond to the sensitivity level presented in chapter 4.3.

Table 4.27 Energy expenditure (costs) for 3 water bird species for which avoidance of wind farms during migration has been shown: results of different scenarios in kJ and in % of total migration costs (taken from FEBI 2013).

Species	Scenario 1 – flying over obstacle (climb of 120 m)		Scenario 2 – flying around the obstacle (detour of 18 km)		Scenario 3 – circling for 10 min and flying over obstacle (climb of 120 m)		Scenario 4 – flying over obstacle (climb of 250 m)	
	Costs (kJ)	% of migration costs	Costs (kJ)	% of migration costs	Costs (kJ)	% of migration costs	Costs (kJ)	% of migration costs

Red-throated Diver	13.6	0.1	99.7	0.8	148.6	1.2	28.4	0.2
Red-necked Grebe	5.0	0.1	29.8	0.6	52.1	1.0	10.5	0.2
Common Scoter	6.1	0.0	44.8	0.3	74.5	0.5	12.8	0.1

The following table gives the conclusion of the estimated degree of impact (Table 4.28).

Table 4.28 Degree of Impact on relevant bird species at Horns Rev 3 in relation barrier effects during operation.

Species	**Degree of Impact**
Red-/Black-throated Diver	**High**
Northern Gannet	**Medium**
Cormorant	**Medium**
Mallard	**Medium**
Common/Velvet Scoter	**Medium**
Common Eider	**Medium**
Sparrow Hawk	Low
Kestrel	Low
Peregrine Falcon	Low
Golden Plover	Low
Dunlin	Low
Knot	Low
Arctic Skua	Low
Great Black-backed Gull	Low
European Herring Gull	Low
Lesser Black-backed Gull	Low
Black-headed Gull	Low
Common Gull	Low
Kittiwake	Low
Little Gull	Low
Common Tern	Low
Arctic Tern	Low
Sandwich Tern	Low
Guillemot	Low
Woodpigeon	Low
Skylark	Low
Barn Swallow	Low
Meadow Pipit	Low
Pied Wagtail	Low
Yellow Wagtail	Low
European Robin	Low
Song Thrush	Low
Reed Bunting	Low
Brambling	Low

Chaffinch	Low
Greenfinch	Low
Linnet	Low
Starling	Low
Jackdaw	Low

4.6.2.2. Importance

In accordance to the chapter 4.1.12, the table 4.12 shows the overall importance of the Horns Rev area for the relevant bird species (see section 4.5.1.2.).

4.6.2.3. Severity of Impact

The severity of impact is assessed based on the degree of impact (in this case equaling the species' sensitivity, compare with chapter 4.3) and the species' importance level according to the scheme displayed in Table 4.10 (Methods chapter 4.1.5). The duration of the pressure "barrier effect" would be permanent, thus the impact on migratory birds is predicted to be permanent as well. No habituation is predicted for migrating birds. The pressure would persist for all sensitive species permanently. Concerning the potential barrier effect on migratory birds imposed by the operational wind farm Horns Rev 3, a generally **low** severity of impact is expected, except for divers and common scoters (Table 4.29) that fly at low elevations and have been shown to avoid wind farms when aloft. For these two species, a high severity of impact through Horns Rev 3 cannot be excluded.

Table 4.29 Severity of impact for relevant bird species at Horns Rev 3 regarding potential barrier effects.

Species	Severity of Impact
Red-/Black-throated Diver	**High**
Northern Gannet	Low
Cormorant	Low
Mallard	Low
Common/Velvet Scoter	**High**
Common Eider	Low
Sparrow Hawk	Low
Kestrel	Low
Peregrine Falcon	Low
Golden Plover	Low
Dunlin	Low
Knot	Low
Arctic Skua	Low
Great Black-backed Gull	Low
European Herring Gull	Low
Lesser Black-backed Gull	Low

Black-headed Gull	Low
Common Gull	Low
Kittiwake	Low
Little Gull	Low
Common Tern	Low
Arctic Tern	Low
Sandwich Tern	Low
Guillemot	Low
Woodpigeon	Low
Skylark	Low
Barn Swallow	Low
Meadow Pipit	Low
Pied Wagtail	Low
Yellow Wagtail	Low
European Robin	Low
Song Thrush	Low
Reed Bunting	Low
Brambling	Low
Chaffinch	Low
Greenfinch	Low
Linnet	Low
Starling	Low
Jackdaw	Low

4.7. Decommissioning

During the decommissioning phase similar effects are expected as predicted for the construction phase.

4.8. Mitigation

Mitigation is defined as actions taken to minimise or eliminate impacts on envorinmental components during design, construction and/or operation of the offshore wind farm Horns Rev 3.

Mitigation of the risk of collision can be achieved at four levels:

(1) Location - wind turbines should be situated the furthermost from the coastline where lowest concentrations of migrating landbirds are expected. A precise distance value cannot be given due to the complexity of the interactions between topography and bird migration patterns and the multitude of species and ecotypes involved.

(2) Wind farm layout – the wind farm should include as few wind turbines as possible, and turbine spacing should be maximized. Recently, Johnston et al. (2013) demonstrated statistically that raising hub height and using fewer, larger turbines are effective measures for reducing collision risk, which is in agreement with empirical evidence (e.g., Barclay et al. 2007, Hötker 2006).

(3) Illumination – a reduction of night lighting in combination with a wide spacing of turbines could limit the extent of phototactic attraction of night-migrating birds as long as this is not in conflict with safety requirements.

(4) Turbine activity – shutting down turbines activity during peak of migration under weather situations has been conceived in Germany.

Measures 1 to 3 are straightforward and are technically feasible. The efficiency of the latter mitigation measure (4) is currently subject to basic research and requires further evaluation. Before focusing further on this mitigation measure, it important to stress that for none of the bird species detected in the Horns Rev region it is likely that annual mortality caused by collisions with wind turbines will exceed 1 % of the individuals in the flyway populations of those species. Thus, mitigation through shutting down wind turbines to reduce the effects of the projected impacts would not be required.

4.9. Assessment of cumulative impacts

The EU Directive 97/11/EC requires assessment of the cumulative effects and impacts arising from each proposed wind farm development including both other wind farms and relevant anthropogenic impacts that affects the same flyway populations. Such assessments are extremely difficult because there is no common yard stick for quantifying different magnitudes of pressures that vary strongly over space and time and among species. Anthropogenic pressures may, for example, enhance energy expenditure (barrier effects) or kill birds (collisions), but neither of these impacts are comparable in their quality, magnitude and net effect on populations.

Summation-effects are particularly relevant with respect to adjacent wind farm projects in the Horns Rev area and beyond. It is important to address both wind farms that are already installed and those which have been consented or are being planned along the flyway of the relevant migratory bird species. The projects which are relevant in relation to the wind farm Horns Rev 3 are listed in Table 4.30 and depicted in Figure 4.3. In the case of migratory birds that move along north-to-south migratory flyways (but also in a trans-meridian manner), however, it is hardly possible to draw a sharp line between projects that potentially influence each other in their effects on bird species at population level. Including Horns Rev 3 (133 turbines, worst-case layout), a total of at least 960 turbines of various types exist or are under way in the larger area around Horns Rev 3. Following construction of the Horns Rev 3 offshore wind farm, three large wind farms containing 304 turbines would be present in the Horns Rev area alone, with a maximum distance between wind farms of 14 km. When jointly assessing wind farm projects, migratory birds are affected by the same potential impacts as when assessing individual wind farms in isolation (risk of collision and barrier effects, increasing migration distance). However, whether the joint (cumulative) impacts of wind farms on migratory birds can be dealt with as the sum of the effects of each wind farm is unknown. Model predictions can be hardly achieved, given the diversity of species and potential responses involved. Introducing the technical specifications of each wind farm generates an even greater complexity of potential impacts that cannot be quantitatively addressed for individual bird species and populations. Only broad estimates based on conclusions by analogy are possible.

Table 4.30 Potential overlapping/summation-effects of various offshore projects potentially impacting migratory birds passing the wider region (wind farm information from http://www.4coffshore.com/offshorewind/)

Project	Placement	Number of turbines	Rotor diameter (m)	Max. height (m)	Phase	Possible interactions
Horns Rev 1	south of Horns Rev 3	80	80	110	in operation	collision risk, barrier effect
Horns Rev 2	south of Horns Rev 3	91	93	114.5	in operation	collision risk, barrier effect
Dan Tysk DK	south of Horns Rev 3	240	-	-	in planning	collision risk, barrier effect
Dan Tysk	south of Horns Rev 3	80	120	148	in construction	collision risk, barrier effect
Nordpassage	south of Horns Rev 3	80	-	-	in planning	collision risk, barrier effect
Butendieck	south of Horns Rev 3	80	120	150	approved	collision risk, barrier effect
Sandbank	south of Horns Rev 3	72	130	145	approved	collision risk, barrier effect
Nördlicher Grund	south of Horns Rev 3	64	125	162.5	approved	collision risk, barrier effect
Vesterhavet Syd	north of Horns Rev 3	not decided	-	-	in planning	collision risk, barrier effect

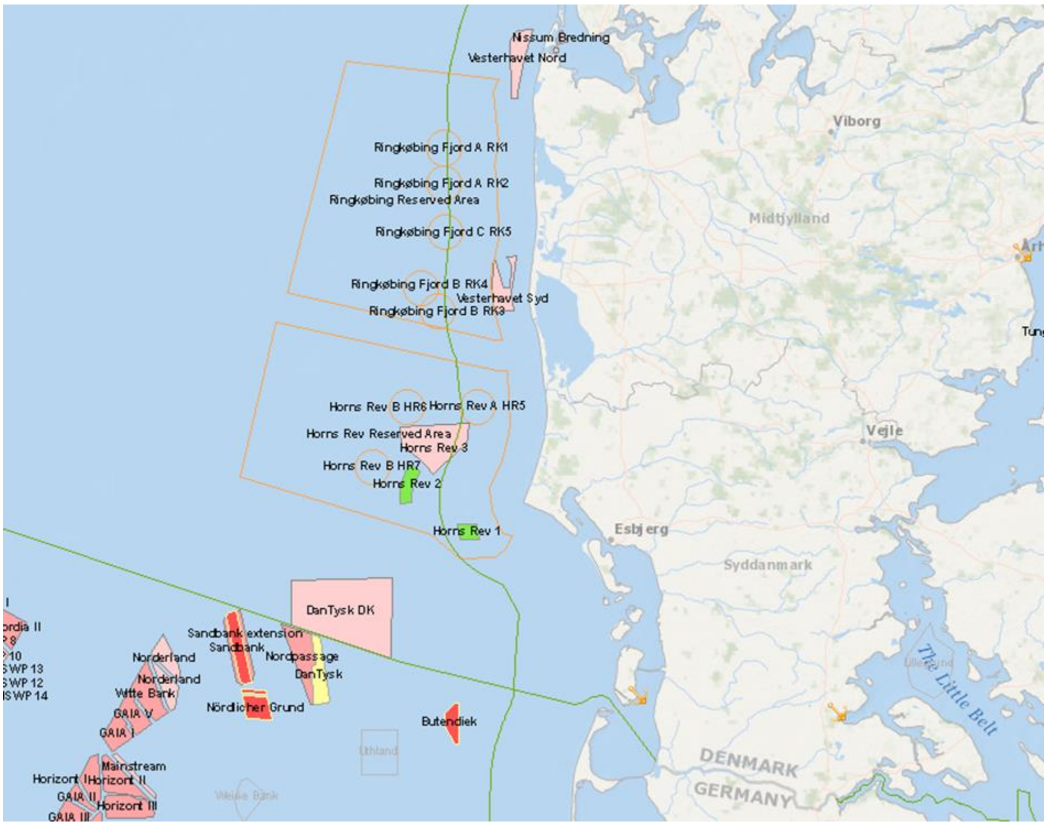


Figure 4.3 Location of several offshore wind farms in the geographical vicinity to Horns Rev 3 which will have a potential cumulative impact (http://www.4coffshore.com/offshorewind/).

4.9.1 Collision risk

It is assumed that also in the wind farm Horns Rev 3, about 90% of all avian collision victims will be nocturnally migrating passerines (compare species composition of collision victims at FINO 1, Hüppop et al. 2005, and at FINO 2, IfAÖ own data). Waterbirds – in particular gulls - will collide occasionally (cf. Fox et al. 2006), soaring birds (raptors) only exceptionally. In the following, the collision risk at the wind farm Horns Rev 3 is described in the context of cumulative effects for specific bird species/species groups.

Assuming broad front migration, Horns Rev 3 is likely to contribute with around 13.85 percent (explained below) to the relative cumulative impact of large-scale wind farm projects in the wider surrounding. For a quantitative impact assessment of cumulative collision risk based on Band-model predictions, the impact of Horns Rev 3 predicted for the predominant water bird species in this region would amount to a 7- to 8-fold higher value, when projected onto the relevant wind farms areas in the surrounding Horns Rev 3.

For those species, for which collision frequencies have been modelled, the projected impact of the surrounding wind farms (Table 4.31) can be calculated on the basis of the model outcomes on the number collision risk victims for Horns Rev 3 and the expected number of turbines involved.

Table 4.31 Extrapolated potential cumulative collision frequencies imposed on key bird species by offshore wind farm projects surrounding Horns Rev 3

Ranked species after collision risk model of Band (2012) for Horns Rev 3			
Species	**Predicted number of collision victims** (98% avoidance)	**Cumulative number of collision victims at nearby wind farm projects** (cf. Table 4.30)	**Cumulative number of collision victims including Horns Rev 3**
Herring gull	149	920.27	1068.27
Lesser black-backed gull	115	715.08	830.08
Black-headed gull	19	118.14	138.14
Common gull	18	111.92	119.92
Common scooter	5	31.09	36.09
Great black-backed gull	4	24.87	28.87
Northern gannet	3	18.65	21.65
Kittiwake	2	12.44	14.44
Sandwich tern	2	12.44	14.44
Arctic tern	1	6.21	7.21
Common tern	1	6.21	7.21
Red-throated diver	0	0	0
Black-throated diver	0	0	0
Common eider	0	0	0
Velvet scoter	0	0	0
Guillemot/Razorbill	0	0	0

For small-bodied terrestrial migrants for which the model assumptions are not applicable and predictions are hence unavailable, the only possibility for assessing cumulative effects is by transferring known collision rates of birds at other anthropogenic structures in the marine environment, such as lighthouses and offshore platforms, to offshore wind turbines and by drawing on measurements of bird fluxes at turbine height detected elsewhere with motion-controlled videography. Results from the North Sea wind farm alpha ventus provide a first proxy (IfAÖ, own data). Again, assuming broad front migration to be the norm over larger areas of the North Sea, bird fluxes measured within the rotor-swept zone of one turbine may reflect the number of individuals that are potentially at risk. Taking interannual variation of migration intensities (and turbine design) into account, we may therefore expect 300 to 1000 birds to enter the rotor-swept zone of a single turbine per year. Projected to 827 planned or constructed turbines defined as relevant to the Horns Rev 3 project, we can predict an order of magnitude of 250.000 to 830.000 individuals to be at risk of collision (excluding Horns Rev 3). Horns Rev 3 would potentially lead to an approximate increase of about 13 percent to this estimation.

However, the number of actual collisions will be significantly lower, possibly below 20.000 individuals per year, since there is evidence that bird passage rates at rotor height are negatively correlated with turbine activity, indicating that micro-avoidance will offset the rate of collisions expected from passage rates alone. However, if particularly unfavourable conditions occur (coincidence of mass migration events with precipitation and strong wind; cf. Aumüller et al. 2011), the number of collision victims could exceed the order of magnitude given above in some years. Nevertheless, compared to other anthropogenic losses of migrants of the same populations (loss of breeding and staging habitats, collisions with onshore man-made structures, hunting, predation through feral cats, etc.), the number of collision victims expected at the wind turbines of concern seems low. Furthermore, only a limited number of species may be affected, since the collision probability of migrants with illuminated structures at sea is species-specific. Studying collision victims at Danish lighthouses, Hansen (1954) recorded in total 190 bird species of which only five species accounted for about 75% of collision victims. These were Skylark *(Alauda arvensis)*, Song Thrush *(Turdus philomelos)*, Redwing *(Turdus iliacus)*, Starling *(Sturnus vulgaris)* and Robin *(Erithacus rubecula)*. Correspondingly, a proportion of about 90% of collision victims was made up by 14 bird species which were nearly exclusively nocturnal migrants. Similarly, at the research platform Fino 1 in the North Sea, thrushes were recorded as the most abundant collision victims (Hüppop et al. 2005, Aumüller et al. 2011). According to the study of Hansen (1954), diurnal migrants collided only exceptionally with lighthouses (and concerned nearly exclusively low-flying species with large breeding populations in Scandinavia) and hardly any thermal migrants (three individuals) were recorded. Also at the research platform FINO 2 in the southern Baltic Sea, the vast majority of collision victims recorded was made up by nocturnal migrants. Of these, the Willow Warbler *(Phylloscopus trochilus)*, a long-distance-migrant, was by far the most abundant species (more than 50 % of found carcasses), and also other long-distance migrants (which are in most cases nocturnal migrants) were found regularly (Schulz et al. 2011; IfAÖ, own data). Differences in species composition at different sites most likely has biogeographic reasons – the point made here, however, is the dominance of nocturnal migrants found as collision victims of vertical structures situated in marline environments, which seems to affect species in a specific manner.

4.9.2 Barrier effect

These results are in accordance with the findings of Petersen et al. (2006) and Skov et al. (2012) who showed that more than 50% of the birds avoided the wind farm when being within 1-2 km from it. Along these lines, it can be safely concluded that due to the limited spatial scale of the barrier effect of local seabirds at Horns Rev 1, Horns Rev 2 and Horns Rev 3 no cumulative barrier effect exists between wind farms that lie sufficiently far apart (though minimum spacing distances are currently unknown). Likewise, cumulative barrier effects on seabirds caused by the future expansion of wind farms planned for the Horns Rev region are likely to be rather limited.

4.10. Assessment of trans-boundary impacts (ESPOO)

Due to the low severity of impact for both the collision risk and the barrier effect, no trans-boundary impacts are expected for migratory bird species during the construction as well as the operation phase.

Short-eared Owl © Graeme Pegram

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ANNEX 1 – MIGRATING BATS

DESCRIPTION OF THE STATUS QUO ANTE

Denmark has registered a total of 17 species of bats (Møller et al. 2013). All the Danish species of bats are listed in the Habitats Directive Article 12 - Annex IV, and are therefore subject to strict protection, regardless of whether they are registered outside or within a Natura 2000 area. It is therefore necessary to consider the wind park's possible effects on bats.

Species of bats are also covered by the Bern-Convention (convention on the conservation of European wildlife and natural habitats) and the Bonn-Convention (convention on the conservation of migratory species of wild animals).

Under the Bonn-Convention, Denmark has also joined a sub-agreement under the convention on bats, EUROBATS, to ensure better protection of the 45 species of bats occurring in Europe, the Middle East and North Africa (Møller et al. 2013).

Bats are characterized by a long life and a very low reproductive rate. So even by a loss of a limited number of individuals, the mortality can take dimensions, which can affect populations of bats negatively.

While influences of onshore wind turbines on foraging and migratory bats are illustrated by a number of studies in Europe, the issue of offshore wind turbines and bats are only poorly studied in Europe (Ahlén et al. 2007). With regard to offshore wind farms not yet constructed, it is also difficult to carry out studies on bat occurrences in the project area before the wind turbines are built, seeing that turbines due to their concentration of insects can attract bats from the shore (Møller et al. 2013, Ahlén et al. 2007, Ahlén et al. 2009).

This is especially true in areas where concentrations of migrating bats are assumed to occur on a small level, and where it primarily will be foraging bats, which might occur in the planned offshore wind farm.

It is therefore meaningless to conduct baseline surveys of bats in a given offshore area if the area is not estimated to be some potential migration route for bats, because, on the basis of negative findings, it is not possible to conclude whether a given sea area will be used for foraging by bats, after construction of the offshore wind farm.
The impact on bats by the construction of the offshore wind farm at Horns Rev 3, is therefore based on a literature study of how bats move in and around existing wind farms in Scandinavia and knowledge about how bats migrate over the sea - including literature about bats observations in the North Sea (Walter et al. 2007, Boshamer & Bekker 2008, Poerink et al. 2013, Russ et al. 2000, Baagøe & Bloch 1994, Skiba 2007, Walter 2005).

Bats occurrences offshore in the Baltic Sea and North Sea

In Scandinavia, there are a number of detailed studies of offshore occurrences of bats, especially related to environmental studies in connection to the Fehmarn Belt project. The Scandinavian bat experts Ingmar Ahlen and Hans Jørgen Baagøe have also made intensive studies of bats offshore in Kalmar Sound and Oresund (Ahlén et al. 2007, Ahlén et al. 2009). These studies have both referred to bats foraging offshore and bats migrating over the Baltic Sea.

In connection with the Fehmarn Belt project, the initial environmental studies conducted extensive field studies of both foraging and migrating bats. These field studies are performed partly with ultrasound detection equipment at coastal stations on the Danish and the German side of the belt, but also with ultrasound detection equipment installed on ferries between Rødby and Puttgarden and with equipment installed on environmental research vessels anchored at certain positions. The studies were supplemented with bats equipment suspended from a kite from the ship, so that the altitude of bats flying over the sea could be investigated (FEBI 2013).

Also in the North Sea, surveys of offshore occurrences of bats are made. One of the most extensive studies carried out in the Dutch part of the North Sea, which during a period of 19 years registered 34 bats at the 65 platforms in the Dutch part of the North Sea (Boshamer & Bekker 2008). The results from this study should be interpreted with some caution, since individual bats were retrieved coincidentally by platform staff, and are not the result of systematic effort. There were also observed bats in the English part of North Sea (Russ et al. 2000) and in the German part of the North Sea (Walter et al. 2007, Baagøe & Bloch 1994).

The common feature of these records is that they all are carried out from the drilling platforms and that the number of registered bat is very low, considering the size of the area and the long period of studying. Thus, both the number of individuals and the number of different species is many times smaller compared to the number of individuals and species that have been recorded in the Fehmarn Belt and the more coastal waters in Kalmar Sound and Oresund.

The picture changes, however, when approaching the Frisian Islands and the inner part of the German North Sea (German Bight), where for instance on Heligoland, the Frisian islands, and other coastal observation sites bats are frequently observed during spring and autumn migration (Skiba 2007, Frey et al. 2011).

The large field studies in Scandinavia in recent years (Ahlén et al. 2007, Ahlén et al. 2009, Boshamer & Bekker 2008) have expanded the number of bat species recorded over sea. Thus, Ahlén et al. (2009) have recorded 11 species of bats across the open sea. Bats recorded over sea either consist of individuals that feed on insect rich sites of the sea in the late summer (Ahlén et al. 2007), while during autumn and spring, primarily migrating individuals are recorded. The migrating individuals are also foraging when they migrate over the sea.

Annex table I.1 Species composition of bats observed over sea – from Ahlén et al. 2009.

Species observed	No. observations	Mitgratory or resi-dent
Myotis daubentonii	93	Resident
Myotis dasycneme	118	Migratory
Pipistrellus nathusii	112	Migratory
Pipistrellus pipistrellus	5	Migratory
Pipistrellus pygmaeus	179	Partially migratory
Nyctalus leisleri	12	Migratory
Nyctalus noctula	3266	Migratory
Eptesicus nilssonii	112	Resident
Eptesicus serotinus	113	Partially migratory
Vespertilio murinus	40	Resident
Plecotus auritus	1	Resident
Total	4051	

While foraging individuals in late summer are always found near the coast (average distance values are currently unavailable), migratory individuals can be observed far out at sea. It has been shown that more species are migrating than first thought (Ahlén et al. 2007, Ahlén et al. 2009), and a part of the populations migrate to hibernate in the south-western part of Europe.

In calm weather or under light breeze there can be significant concentration of insects at sea, a situation which is exploited by bats especially during migration when they can stay at these offshore positions to forage for short or longer periods. This can also be observed in late summer, though to a lesser extent: when particular offshore locations are rich in insects bats can be registered foraging over sea or around offshore wind turbines, major bridges, lighthouses etc. where insects accumulate in significant numbers, probably due to heat radiated from these constructions (Møller et al. 2013, Ahlén et al. 2007, Ahlén et al. 2009).

The bats feed in these offshore locations primarily on insects, but also on spiders drifting with the wind as well as small crustaceans which they can capture from the water surface; the has been observed in *Myotis daubentonii* and *Myotis dasycneme* (Ahlén et al. 2007).

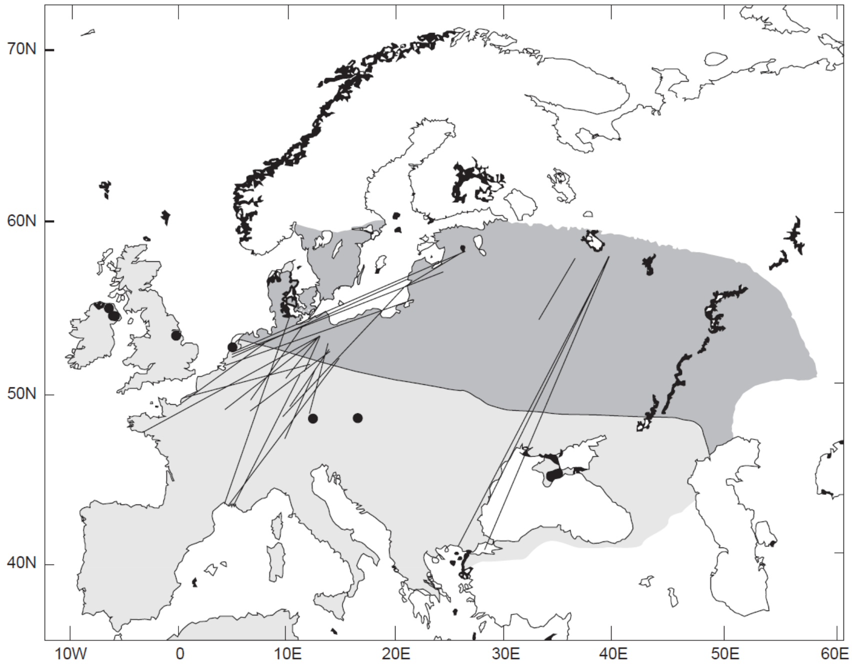
Offshore foraging always takes place under dry and almost completely wind still weather conditions where the insects are easily available over the still water surface (Ahlén et al. 2007, Ahlén et al. 2009, Poerink et al. 2013).

Foraging usually takes place close to the water surface (in an altitude less than 10 m), but around wind turbines and other offshore installations, even typically low flying bats change their flight pattern and hunt up and down the towers (Møller et al. 2013). Bats are apparently not afraid of the rotor blades as they can be seen foraging between them.

More species of bats than expected have been shown to migrate (Ahlén et al. 2007, Ahlén et al. 2009), although some species only migrate regionally. The bats migrate from the more continental parts of Scandinavia in the autumn, to hibernate under less harsh climatic conditions in Western Europe.

The species with the longest migration routes, which are also the species most frequently crossing the open sea, are mostly *Pipistrellus nathusii*, *Nyctalus noctula*, *Nyctalus leisleri*, *Vespertillius marinus* and to some extent *Pipistrellus pygmaeus* (Ahlén et al. 2007, Ahlén et al. 2009, Baagøe & Bloch 1994).

Pipistrellus nathusii is the species most often detected on offshore platforms in the Dutch part of the North Sea (Poerink et al. 2013, Boshamer & Bekker 2008) and the most frequently detected species crossing the Fehmarn Belt (Baagøe & Bloch 1994). It is known that population of *Pipistrellus nathusii* in the Baltic countries hibernate in the Netherlands, Belgium, Germany, and possibly also in England (Russ et al. 2000) and the Scandinavian and Baltic populations perform a south-western migration in autumn and a north-eastern migration in spring. It is not known where the Danish, Norwegian and Swedish populations of *Pipistrellus nathusii* prefer to hibernate, because there are no rings tagging data from these populations /Skiba 2000).



Annex figure I.1 Known migration routes of *Pipistrellus nathusii* in Europe. Dark gray is breeding area, when light gray indicates areas where *Pipistrellus nathusii* hibernate – from (Rus et al. 2000).

It is known that bats follow linear landscape structures such as shorelines etc. (Ahlén et al. 2009, Boshamer & Bekker 2008). In Scandinavia, it has been observed that migratory bats accumulate in large numbers during bad weather conditions at certain departure sites before they migrate over the Baltic Sea or Femeren Belt (Ahlén et al. 2009, FEBI 2013). Known departure sites for bats in Denmark is Gedser, the southern tip of Lolland and Dueodde on the island of Bornholm (Ahlén et al. 2009, FEBI 2013). Visual observations have shown that migratory bats predominantly fly at altitudes less than 10 meters (Ahlén et al. 2007, Ahlén et al. 2009) while migrating over sea. This also seems to apply to the typical high flying species such as *Nyctalus noctula*. However, with the use of radar this species is observed at altitudes of more than 40 m. The smaller species, such as *Pipistrellus nathussi* and *Pipistrellus pygmaeus*, are rarely flying at a height of more than 3 m (Ahlén et al. 2007). Flight altitude seems to be lowered by increasing wind speeds (Boshamer & Bekker 2008) due to calmer winds close to the water surface (Ahlén et al. 2009).

The timing of autumn migration varies among species but appears to take place from the mid-August to mid-October (Ahlén et al. 2007, Ahlén et al. 2009, FEBI 2013). The time of spring migration also varies among species but primarily occurs from mid-April to the end of May. While autumn migration is typically concentrated around certain departure sites, bats seem to arrive in spring over a larger spatial scale.

In poor weather conditions, large swarms of bats can be concentrated at known departure sites, while bats await favourable weather to carry on migration over the open sea. Take-off is always under calm or almost calm weather. Take-off to cross the Baltic Sea appears to take place mostly at wind speeds less than 5 m/s. A wind tolerant species such as *Nyctalus noctalu* is registered to take off under wind speeds up to 10 m/s. Almost all observations of bats crossing the open sea have been made in nights without rain or predicted precipitation (Ahlén et al. 2007, Ahlén et al. 2009, FEBI 2013). The activity of bats recorded over sea seems to be constantly increasing with increasing temperature (FEBI 2013).

IMPACT ASSESSMENT OF MIGRATORY BATS

Relevant project pressures

In the following the relevant project pressures are described which will affect the various migratory bat species on several ways during construction and operation of the offshore wind farm Horns Rev 3.

Barrier effects and the risk of collision were determined as the main project pressures following the baseline description. In the context of the Horns Rev 3 project, the magnitude of the following relevant pressures on migratory bats needs to be assessed:

Environmental pressures related to the construction of Horns Rev 3 wind farm:

- Collision risk related to construction vessels
  Bats may collide with construction vessels especially at night if insects (as prey organism) are attracted by lights (indirect impact by predator-prey relationship).

Environmental pressures related to the system and operation of HR 3 wind farm:

- Collision risk related to turbine blades
  Migratory bats might collide with the structure of the wind energy plants if they do not perceive the obstacle during inclement weather conditions and during the night if insects (as prey organism) are attracted by lights (indirect impact by predator-prey relationship).

Assessment of potential impact of the project

The project's impact on offshore occurrences of bats is assessed on the basis of available literature. The onshore part of the project and the impacts of onshore bat populations are treated in the relevant subject report Orbicon 2014.

It is known from several studies that insects at certain times of the year may be attracted to turbine blades and towers. Under certain weather conditions, there can be greater accumulations of insects around wind turbines. Accumulation of insects is probably a result of the fact that turbine components heat up during the day and that they radiate heat at night and that this heat attracts insects. The phenomenon is most common during low wind speeds below 5-6 m/sec, but is known for both wind turbines onshore and offshore (Ahlén et al. 2007).

Hunting bats, but also migratory bats (Ahlén et al. 2007, Ahlén et al. 2009), can collide directly with the turbine rotors, or can be affected by barotrauma (Baerwald et al. 2008), even to a level where it is likely that populations are negatively affected (Sterner et al. 2007). The problem has been the subject of extensive research, in particular in the United States and in Germany.

Hötker et al. (2004) and Brinkmann & Shauer-Weisshahn (2006) have compiled data from previous studies in which the calculated numbers of bats exposed to collisions were up to 50 bats killed per turbine per year. The number of collisions depends strongly on the placement of the wind turbines. The existing knowledge indicates that the placement of wind turbines in forests, forest clearings and on ridges pose a particular risk for bats, while the risk of collision is much smaller in open landscapes where the highest known collision rate is 3.2 dead bats per wind turbine per year (Hötker et al. 2004).

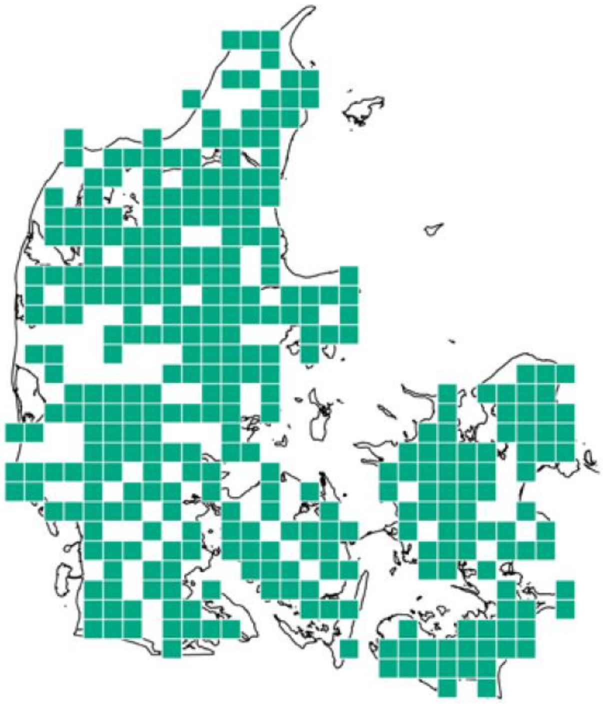
This problem has not yet been studied in Denmark but DCE (former DMU) is currently undertaking a study of the collision rate of bats at the Danish test centre for wind turbines at Østerild to illustrate the level of the problem under Danish conditions (DCE 2011, 2012).

Whether bats get killed to the same extent by wind turbines located offshore has not been properly investigated so far. Individuals killed by offshore wind turbines cannot be found, as they fall into the sea, and only larger bat species, such as *Nyctalus noctula* and *Vespertilio murinus*, can be studied by radar near wind farms (Ahlén et al. 2007). The smaller species can only be detected by their characteristic ultrasonic sounds, but this recording method does not illustrate how bats move relative to the turbines.

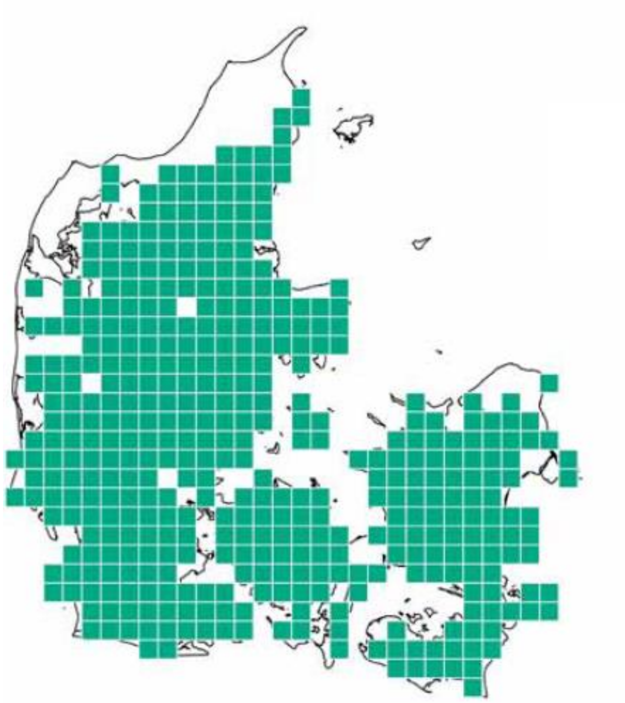
It is known, however, from a number of studies that several bat species on their spring and autumn migrations can fly over long distances of up to 1,000 km and also over sea (Walter et al. 2007). In addition, a number of studies in southern Scandinavia show that even species not previously considered to migrate, such as *Pipistrellus pygmaeus*, can be found far from land at certain departure sites and that some species are foraging around offshore installations under certain weather conditions (Ahlén et al. 2007, Ahlén et al. 2009).

It is therefore possible that offshore wind turbines at certain locations and under certain weather conditions can remove as many bats as onshore wind turbines. This problem will be discussed in the following chapters.

The Western part of Jutland is generally characterized by a low density of bats recorded in connection with the national monitoring program with the use of ultrasound equipment in 10x10 km squares (Møller et al. 2013). The small population in this part of Jutland is probably a result of the lack of large old trees for the establishment of breeding colonies, which for many bat species is a preferred breeding site (Møller et al. 2013). A generally windier climate and an open landscape structure is also one explanation, since bats hunt only at relatively low wind speeds - below 10 m/s. Only *Myotis daubentonii* and *Eptesicus serotinus* are known from the 10x10 km squares at Blåvand, while *Nyctalus noctula* is registered in neighbouring squares (Møller et al. 2013).



Annex figure I.2 Distribution of *Myotis daubentonii* in Denmark (from Møller et al. 2013).



Annex figure I.3 Distribution of *Eptecicus serotinus* in Denmark (from Møller et al. 2013).

During the migration period in April/May/June and in August/September/October bats are registered in the English, German and Dutch part of North Sea, although there are very few individuals recorded (Boshamer & Bekker 2008, Russ et al. 2000, Skiba 2007).

Of the 34 bats that were found in the Dutch part of the North Sea on oil rigs over a period of 19 years, 26 individuals of *Pipistrellus nathusii*, 3 individuals of *Vespertilio murinus*, 2 individulas of *Eptesicus nilssonii*, 2 individuals of *Nyctalus noctula* and 1 individual of *Eptesicus serotinus* were registered (Boshamer & Bekker 2008).

The individuals of *Pipistrellus nathusii* found roosting on the Dutch North Sea platforms are characterized by having a significantly lower weight than individuals on land, and by the fact that they let themselves get caught by human hands, something one usually cannot do with bats (Boshamer & Bekker 2008). It is therefore likely that these are individuals which have off course during their south-western migration along the Baltic coast to their hibernacula in Holland and the Frisian Islands (Boshamer & Bekker 2008, Russ et al. 2000). They are not suspected to be individuals drifted by the wind, as there are no significant correlations between wind direction and the dates of the findings on the Dutch platforms (Boshamer & Bekker 2008).

For the German Bight, it is estimated that annually approximately 3700 *Pipistrellus nathushii* and approximately 990 *Nyctalus noctula* migrate within a distance of 200 km measured from the inner part of the bay (Skiba 2007). The expected departure sites for these bats during their south-western migration will then be at Blåvandshuk, direction S (SW), the contours of Jutland's coastline in mindiv. Bats departure from Blåvandshuk will then pass south-west around the wind farm area. It seems unlikely that there are departure sites north of Blåvandshuk, as the distance that the bats should fly over open water would be very long.

Construction phase

It is well known that insects are attracted to particular blue-white lights. During the construction phase, both construction vessels, service vessels and workplaces around the turbine foundations, will be illuminated if it is designed to work offshore in the dark hours. On quiet and dry days without rain in late summer, bats may therefore seek food around these vessels and on the construction sites at near coastal locations.
Bat species that forage offshore in late summer are 3 species known from the area around Blåvandshuk (*Nyctalus noctula*, *Myotis daubentoni*, *Epteticus serotinus*). Since construction vessels are moving slowly, offshore foraging bats are not at risk of collisions with vessels, as the bats will be able to escape. There are no negative impacts on bats to be expected during the construction phase.

Construction-related pressures resulting from the installation of the offshore wind farm Horns Rev 3 are considered to be limited in time and space. The use of space through the construction activities has no relevance for migratory bats passing through the wind farm area. Due to the time-space limitations of potential stressors, and on the basis of current knowledge, the construction-related severity of impact of the Horns Rev 3 project on migratory bats is predicted to be low.

Operational phase

During the operational phase, the turbines will be equipped with aviation lights at night. Both light and heat radiation from the blades and the towers can potentially attract insects that bats can forage on in nights without precipitation - especially in late summer. Bats will only forage offshore in very calm weather. At wind speeds greater than 5-6 m/s, insects get drifted away from the tower (Ahlén et al. 2009) and this food resource. Since the turbines cut-in speed is around 4 m/s, it is only a very small range between 4 and 6 m/s in which the turbines are running and insects are not blown away from the turbine by the wind. In late summer, there will consequently be a few nights where both the turbines are running and there are insects that bats can forage on near towers.

The turbines are so far from the nearest coast (approx. 18 km), and the abundance of bats at Blåvandshuk in the summer time is so low (Møller et al. 2013), that collision risk for bats foraging around the turbines in late summer is negligible.I t is also likely that the amount of insects at sea, along the west coast at Jutland, is much smaller than the amount of insects over the Baltic Sea, due to the harsher climate and the more salty sea, but this is not confirmed by studies.

It is estimated that approximately 3700 *Pipistrellus nathusii* and approximately 1000 *Nyctalus noctula* migrate through the inner part of the German Bight each year. Similarly, *Pipistrellus nathusii* is the species that most frequently is recorded on oil rigs in the North Sea. The bats that migrate across the inner part of the German Bight will then have their departure sites around Sylt. Bats that migrate cross the outer part of the German Bight may depart from Blåvandshuk.

Bats which migrate along the North Sea coast might however, in rare cases, navigate in the wrong direction and then pass through the Horns Rev 3 area. Migration over open sea predominantly takes place at wind speeds less than 5 m/s, however, *Nyctalus noctula* has been seen taking off at wind speeds of up to 10 m/sec. Bats can also collide with wind turbines at wind speeds lower than the cut-in speed. Collisions with the rotors can be avoided by stopping the blades completely at wind speeds lower than the cut-in speed.

Pipistrellus nathusii, *Pipistrellus pygmaeus* and the other smaller bat species typically migrate over the open sea at an altitude between 1 and 3 meters, while *Nyctalus noctula* typically migrate over the open sea at elevations below 10 meters.

*Nyctalus noctularare*ly migrate over the sea at an altitude of more than 40 meters and thus at the lower part of the rotor area. The phenomenon of high flying individuals will frequently occur in tailwind situations, i.e., southerly winds during the spring migration and northerly winds during autumn migration period.

Therefore it cannot be completely excluded that a few *Nyctalus noctula* will move towards the open sea during spring and autumn migration and could collide with the wind turbines of Horns Rev 3 at wind speeds between 4 and 10 m/sec. There will only be very few incidents, as several unfortunate circumstances need to coincide, such as dry hot weather during the migration season with tail winds causing elevated flight heights in *Nyctalus noctula*. It is also likely that individuals of *Nyctalus noctula* crossing the Horns Rev 3 region on migration would otherwise drown under these circumstances.

The smaller migratory bat species, such as *Pipistrellus nathusii*, fly too low to get near the rotor-swept area. Foraging at the turbines during migration will only take place at wind speeds up to 5 m/s, since insects drift away at higher wind speeds. Thus, foraging during migration will take place within a very narrow range of low wind conditions with limited turbine activity, such that the risk of collision is negligible for bats. This will only be the case if the rotor is stopped completely at wind speeds less than the cut-in speed.

In conclusion, the severity of impact for migrating bats is predicted to be low in accordance to the operational phase of the offshore wind farm Horns Rev 3.

<u>Decommissioning</u>
During the decommissioning phase similar effects are expected as predicted for the construction phase, i.e., no severe impacts on bats.

<u>Mitigation</u>
Due to the low severity of impact for migratory bats in connection with the construction as well as the operational phase, no significant mitigation actions are needed. Since the topic of bats in the North Sea has not yet been subject to thorough field studies, it is recommended that one or more acoustical detection boxes are placed on turbines. If - against expectation - it becomes necessary to care for migrating bats in the wind farm area a mitigation method could be a to shut-down turbines completely at wind speeds lower than the cut-in speed and on the basis of threshold values of bat presence detected with automatic devices (bat detectors, cameras).

<u>Cumulative impacts</u>
Collision situations with migrating *Nyctalus noctula* and the wind turbines at Horns Rev 3 are assessed to be very rare. This is assessed on the basis of knowledge of migrating bats at sea, their behaviour during migratory flights and the known abundance of bats in the western part of Jutland. It is therefore expected that the establishment of the wind farm Horns Rev 3 will not have any cumulative effects that may affect local or national populations of *Nyctalus noctula*, which is one of the most common bat species in Denmark.

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