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VESTERHAV SYD OFFSHORE WIND FARM

EIA – background report **FINAL**

Migrating birds and bats

Project

Vesterhav Syd Offshore Wind Farm
EIA - background report
Energinet.dk

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1 SUMMARY

Vesterhav Syd offshore wind farm is proposed be located in the North Sea approximately 4 km off the coast Northwest of Hvide Sande, Denmark. The site is approximately 60 km², with an estimated generation capacity of up to 200 MW. The number and power of turbines is not yet defined and options considered range between 3 MW and 10 MW.

The aim of this report is to present the results of the baseline investigations and to assess the impacts on migrating birds and bat during the periods of construction, operation and decommissioning.

A literature review was conducted studying flyways of migratory species over offshore areas off the western coast of Denmark. The following species show potential association with the Vesterhav Syd project: Pink-footed Goose; Greylag Goose; Barnacle Goose; Light-bellied Brent Goose; Eurasian Wigeon; Eurasian Teal; Northern Pintail; Common Eider; Common Scoter; Red-breasted Merganser; Red-throated Diver; Arctic Skua; Kittiwake; Black-headed Gull; Little Gull; Common Gull; Lesser Black-backed Gull; Herring Gull; Great Black-backed Gull; Sandwich Tern; Common Tern; and Arctic Tern. Following analysis of bird numbers, in relation to reference populations and connectivity with Vesterhav Syd, the expected number of birds crossing the Project area was calculated. Further, the proportion of birds at collision height (PCH) was determined according to literature knowledge. These data were implemented in a collision risk modeling procedure (CRM) and collision rates were compiled including species specific avoidance rates and different turbine constellations. Results ranged from less than one collision per annum for Light-bellied Brent Goose; Northern Pintail; Red-throated Diver; Arctic Skua; Kittiwake; Little Gull; Common Gull; Herring Gull; Sandwich Tern; Common Tern; and Arctic Tern to 21 colliding Greylag Goose (using the 3 MW turbine scenario). Collision risk modelling results, in relation to the relevant reference population, were used as the basis for impact assessment. For all wildfowl species, Eider and Lesser Black-backed Gull the impact was rated as “Minor” and for all remaining species “Negligible/no impact”.
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Collision risk modeling of migrating birds with connectivity to Vesterhav Syd revealed a cumulative impact of “Minor” magnitude. A maximum of 59 Greylag Goose are expected to collide as a result of cumulative effects of Vesterhav Syd, Vesterhav Nord and Nissum Bredning, representing the highest result of cumulative collision risk modelling for wildfowl. For migratory seabirds, the highest result of cumulative collision risk modelling was a predicted 150 migratory period collisions for Herring Gull, which includes a contribution from Horns Rev 3.

Bat occurrence was investigated by means of a literature review. Vesterhav Syd wind farm is located in an area with few bats present inland close to the wind farm and not in any known or likely unknown migratory pathway. Therefore, few

bats are thought to be present in the planned wind farm area. The most common species to be expected are *Myotis daubentonii* and *Eptesicus serotinus* according to the occurrence inland. Impacts on bats during installations and decommissioning are not expected. During operation bats may come close to the wind farm by following insects attracted by the light of turbines. Mainly migratory species are expected to occur offshore – the potential species *Pipistrellus nathusii* and *Nyctalus noctula* are rare in north west Jutland and no migration routes crossing Vesterhav Syd are known. Therefore, the number of affected bats that may collide with turbines is assessed to be low. In combination with a high conservation status and a permanent persistence (death of colliding bats) the magnitude of impacts on bats is rated as “Minor”.

The cumulative effects on bats including Vesterhav Nord and Nissum Bredning wind farms is rated as “Minor” as bats are expected to be present in low numbers in all projects areas.

A screening of European sites, ornithological features and potential project specific impacts has been undertaken with the aim to identify potential Likely Significant Effects (LSE). It is concluded that no LSE is predicted on any Natura 2000 sites as a result of Vesterhav Syd offshore wind farm project and also in combination with other projects.

2 INTRODUCTION

On March 22nd 2012 a broad political majority of the Danish Parliament agreed on the energy policy for the period 2012-2020. Establishment of nearshore wind farms, generating up to 450 MW of energy, will ensure part fulfillment of the agreement and the conversion to a green energy supply in Denmark by 2020. On November 28th 2012 the Danish government identified six sites around Denmark which are to be subject to pre-investigations prior to their development, including turbines, submarine cables and cable landfall. The selected sites are: Bornholm; Smålandsfarvandet; Sejerø Bugt; Sæby; Vesterhav Syd; and Vesterhav Nord. The Danish Energy Agency (DEA) is responsible for the procurement of the 450 MW wind power for the six nearshore wind farm areas.

The six projects are divided into two packages. Package 1 with sites Bornholm, Vesterhav Syd and Vesterhav Nord is covered together and studies on resting and migrating birds/bats are performed parallel by the same consultants (NIRAS, IBL Umweltplanung GmbH, Bureau Waardenburg bv). NIRAS Consortium is responsible for the Environmental Statements of the three wind farm sites. This ornithological report will be annexed to the main Environmental Statement report for Vesterhav Syd Offshore Wind Farm. Energinet.dk is responsible for the EIA process related to the projects.

This report presents the details of the Environmental Impact Assessment for the potential impacts on migrating bird and bat interests within the area of influence of the offshore elements of the proposed "Vesterhav Syd" wind farm (hereafter the "Project". In this report the potential impacts of the Project on migrating birds and bats are identified according to the relevant development phase of the Project (construction, operation and decommissioning).

The final layout of the wind farm is not yet defined, but the turbines will be distributed within a pre-investigation area that is referred to as "development area" in this report.

2.1 Objectives

The specific objectives of this assessment were to:

- Describe and evaluate the importance of the area of the proposed wind farm Vesterhav Syd for migratory birds and bats;
- Determine the potential impacts of the construction, operation and decommissioning of the offshore elements of the proposed wind farm Vesterhav Syd on sensitive species and to predict the significance of those impacts;
- Identify the potential for cumulative and transboundary effects with other developments.

- Present a Habitats Regulations Assessment (HRA) for the Proposed Development, including the HRA screening process and an assessment of the potential effects of the Proposed Development on the integrity of those SPAs for which connectivity with the latters cited features are shared

3 PROJECT DESCRIPTION

Vesterhav Syd offshore wind farm comprises the establishment of a nearshore wind farm, inter-array and export cables as well as cable landfall facilities including cable termination station (and additional substations) on land. The entire survey area is shown in Figure 1.

Figure 1: Overview of location of wind farm area Vesterhav Syd sea cable corridors and onshore cable corridors

3.1 Wind farm location

The area for offshore wind farm Vesterhav Syd is located in the North Sea about 4 and 10 km off the coast northwest of Hvide Sande. Water depths in the area are between 15 m and 25 m. The wind farm will have a maximum capacity of 200 MW. The corner points of the pre-investigation area are shown in (Figure 2) and the respective coordinates in Table 1.

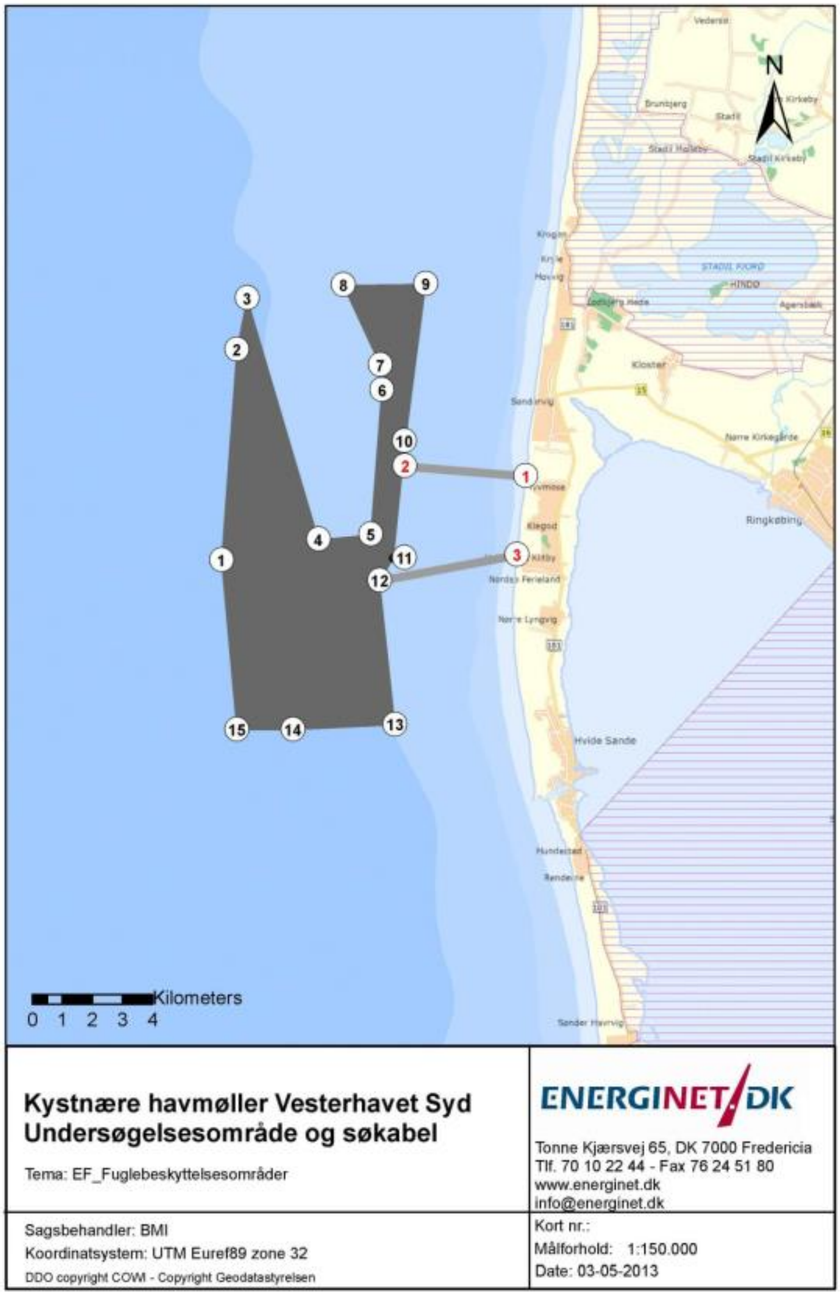

Figure 2: Location of Vesterhav Syd wind farm development area with indication of corner points

Remark: *red figures indicate the location of points related to the cable corridor*

Table 1: Coordinates of corner points of the development area. The ID numbers refer to the numbers in Figure 2

Development area for offshore wind farm		
ETRS 1989 UTM Zone 32N		
ID	East	North
1	434101.9582	6214229.361
2	434610.4553	6221178.822
3	434949.4534	6222873.812
4	437322.4399	6214907.357
5	439063.7754	6215080.538
6	439436.3504	6219910.265
7	439377.0946	6220667.046
8	438155.5095	6223312.346
9	440889.4040	6223351.430
10	440175.0276	6217890.419
11	439809.9019	6214302.662
12	439356.4284	6213551.365
13	439864.9255	6208805.392
14	436474.9447	6208635.893
15	434610.4553	6208635.893
Export cable corridors		
ETRS 1989 UTM Zone 32N		
ID	East	North
1	444217.6258	6217000.646
2	440199.4950	6217337.941
3	443918.6222	6214408.611
4 (11)	439809.9019	6214302.662

3.2 Turbines and park layout

The type and size of turbines have yet to be determined. The capacity of the single turbines to be installed will be between 3 and 10 MW. The number of turbines range between 66 turbines of 3 MW (198 MW) and 20 turbines of 10 MW (200 MW). The measurements of the turbines (and further possible turbine capacities to consider) vary between 3 and 10 MW models as outlined in Table 2.

Table 2: Measurements of wind turbines

Turbine Capacity (MW)	Rotor Diameter (m)	Total Height (m)	Hub Height above MSL (m)	Swept area (m^2)
3.0 MW	112 m	137 m	81 m	9,852 m^2
3.6 MW	120 m	140 m*	80 m*	11,500 m^2
4.0 MW	130 m	150 m*	85 m*	13,300 m^2
6.0 MW	154 m	174 m*	97 m*	18,600 m^2
8.0 MW	164 m	184 m*	102 m*	21,124 m^2
10 MW	190 m	220 m	125 m	28,400 m^2

*Based on 20m air gab between MSL and wing tip.

The air gap between Mean Sea Level (MSL) and wing tip will be determined based on the actual project and will need approval from the Danish Maritime Authority. The air gap is expected to be at least 20m.

Possible layouts of the offshore wind farm for Vesterhav Syd have been developed by DTU Wind Energy (DTU Wind Energy 2014) and are shown for the 3 MW and 10 MW arrangement in Figure 3.

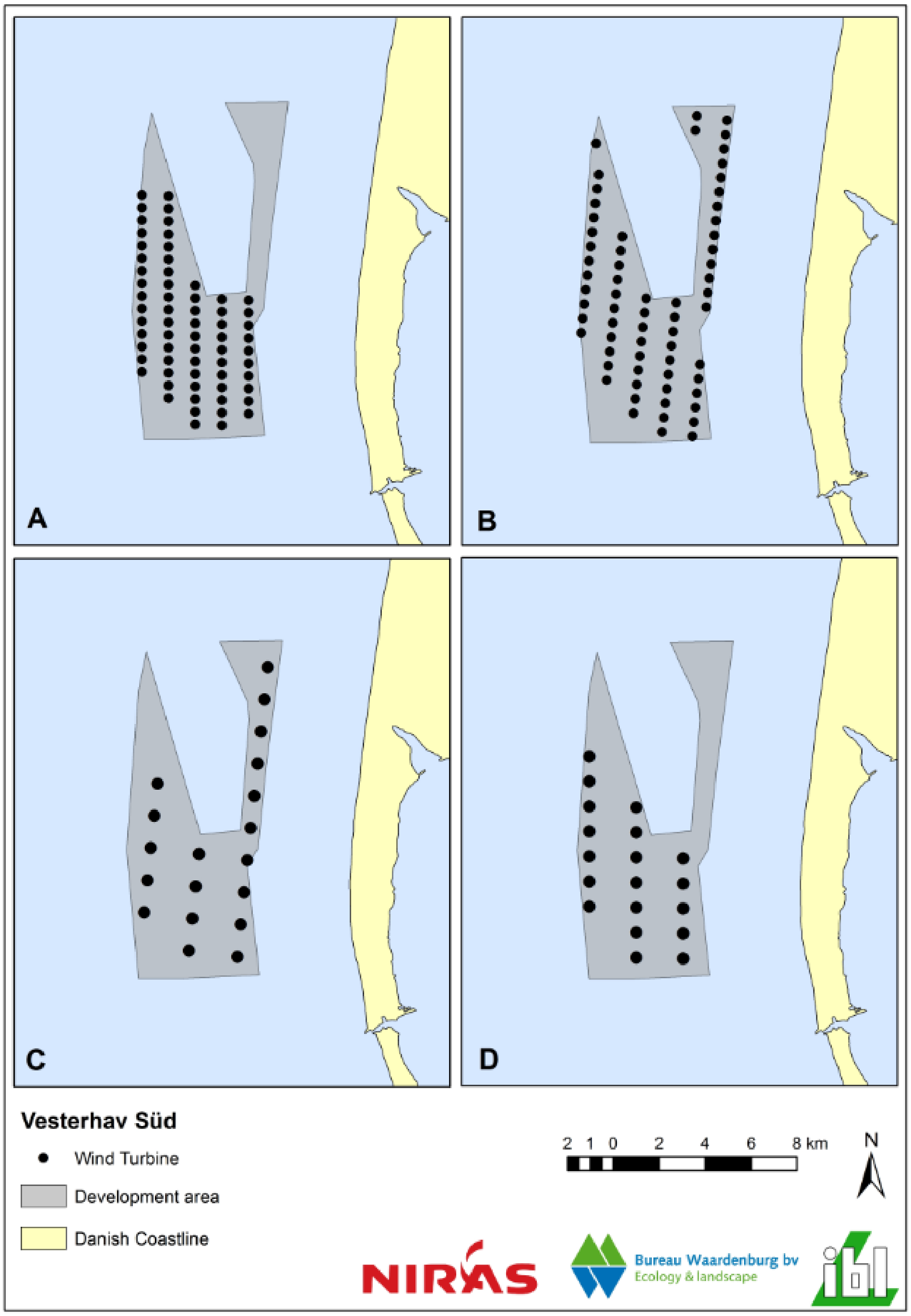

Figure 3: Suggested layouts for the 3 MW turbines (A and B, top) and 10 MW turbines (C and D, bottom).

The export cables from the wind farm to the mainland may be installed in two 500 m broad corridors, one running from the northern part of the wind farm to the coast near Klegod and Tyvmose and the second from the southern part of the development area to the coastlind near Nørre Lyngvig. Both sites located north of Hvide Sande (see Figure 1). A project description including construction methods is presented in a separate report (Energinet.dk 2015).

3.3 Decommissioning

The lifetime of the wind farm is expected to be between 25 and 30 years. It is expected that two years in advance of the expiry of the production time the developer shall submit a decommissioning plan. The method for decommissioning will follow best practice and the legislation at that time.

Similar to the period of installation the vessel traffic is supposed to be the major pressure on migrating birds and bats.

4 BACKGROUND

In the following sections background information is given referring methods, data sources, data analyses and worst case assumption on migratory birds.

Data on bats are presented in the separate Section 0.

4.1 Methods and data sources

A literature review was carried out investigating records and data of migratory species using potential flyways over offshore areas off the western coast of Denmark. A bird monitoring program undertaken at the Horns Rev offshore wind farms including two offshore stations was considered as well as direct bird observation data were obtained from Blåvand Bird Observatory to the north-west of Esbjerg on the western coast of Denmark. These data were investigated to determine those species with likely migratory flyway connectivity with Vesterhav Syd. This information was considered alongside information relating to the migratory movements of birds through the region containing Vesterhav Syd to produce a long-list of species for consideration in this assessment.

The species groups considered within the scope of this report are those that were considered not likely to be recorded by the snapshot baseline surveys of Vesterhav Syd. Migratory seabirds (including seaducks) are therefore not included. The assessment therefore focuses on migratory landbird species (e.g. wildfowl,, waders and raptors where applicable). However, data on a selection of migratory seabirds (including seaducks) has also been sourced and assessed as to the potential for significant collision effects.

4.2 Data analyses

4.2.1 Collision risk modelling

Collision risk modelling (CRM) has been carried out for those populations of key migratory species identified as having with connectivity during migration to Vesterhav Syd wind farm where applicable using the methodology defined in Band et al. (2007). The updated Band (2012) model designed for use for off-shore wind farms was not used in this case as this model is dependent on site-specific baseline species density information. The Band *et al*. (2007) direct flight model, whilst originally designed for use in onshore wind farms provides an appropriate index of flight activity to achieve the aims of this work. Collision risk modelling for 'resting birds' recorded within the baseline surveys of Vesterhav Syd is undertaken using Band (2012) and the methodology underpinning this (and in some respects for this migratory species CRM) is detailed in NIRAS (2015) in Section 4.3.

The basic model within Band (2012) is fundamentally the same model as that used in Band (2007). The Band (2007) model consists of six steps which culminate in the calculation of collision risk estimates:

- Step 1: Calculation of the number of birds passing through the wind farm incorporating the population interacting with the wind farm, the number of transits through the wind farm (2 unless otherwise specified) and the proportion of birds at collision height;
- Step 2: Flight risk window, incorporating width of risk window and height of rotors;
- Step 3: Area swept by wind farm rotors, incorporating number of turbines and rotor radius;
- Step 4: Number of transits, incorporating the results of Steps 1, 2 and 3;
- Step 5: Collision risk, incorporating the result of Step 4 and the single transit collision risk; and
- Step 6: Avoidance rates, incorporating the result of Step 5 and avoidance rates to provide the overall collision risk estimates.
-

A worked example for the Barnacle Goose is added in Appendix 18.2

4.2.2 CRM parameters

The biometric parameters used within the CRM for each species are shown in Table 3.

Table 3: Species-specific modelling parameters used for collision risk modelling of migratory species

Species	Bird length (m)	Wingspan (m)	Bird speed (m/sec)	Flapping or Gliding	Size of risk window (km)	Avoidance rate (%)
Pink-footed Goose	0.68	1.52	15	Flapping	7.2	99
Greylag Goose	0.82	1.64	17.1	Flapping	7.2	99
Barnacle goose	0.64	1.38	17.0	Flapping	7.2	99
Light-bellied Brent Goose	0.58	1.15	17.7	Flapping	7.2	99
Eurasian Wigeon	0.48	0.80	20.6	Flapping	7.2	98
Eurasian Teal	0.36	0.61	19.7	Flapping	7.2	98
Northern Pintail	0.58	0.88	20.6	Flapping	7.2	98

The bird length and wingspan for each species were sourced from Robinson et al. (2005) while flight speeds were taken from Alerstam et al. (2007).

The avoidance rate for goose species has been determined based on: (1) advice for offshore wind farms provided by UK statutory agencies including Scottish Natural Heritage (SNH) as part of ongoing guidance to inform the assessment of collision risk and (2) Natural England's recent (2014) advice on pink-footed goose collision risk as part of Issue Specific Hearings in 2014 for the proposed Walney Extension Offshore Wind Farm (Natural England 2014).

In 2006, SNH commissioned the British Trust for Ornithology to review a study authored by Fernley et al. (2006) which investigated the avoidance behaviour of goose species. Using data from wind farms in the USA, Fernley et al. (2006) calculated that goose avoidance rates were likely to be 99.9%. The BTO review suggested that due to methodological issues within both the Fernley et al. (2006) report and the various other studies underpinning the conclusions a lower default value of 99% should be used for geese (Pendlebury 2006).

In 2013, SNH provided an update to this report incorporating further studies and data from Europe and additional wind farm sites in the USA (SNH 2013). This included post-construction monitoring studies at sites in Germany, Sweden, Norway, Belgium and the Netherlands. All of the evidence presented in this report consistently concluded that geese have not, to date, collided with onshore wind farms in numbers that are of conservation concern. The review suggests that the probability of avoidance rates being as low as 99% is extremely unlikely. Therefore SNH updated their advice to recommend that an avoidance rate of 99.8% be used within CRMs for wintering geese at onshore wind farms.

As the SNH guidance pertains to those geese observed onshore it is considered that an avoidance rate of 99.8% is suitably precautionary. Advice from Natural England pertaining to a migratory collision risk assessment for Pink-footed Goose at the Walney Extension Offshore Wind Farm stated that a 99% avoidance rate is appropriate for both onshore and offshore wind farms (Natural England 2014).

As such a 99% avoidance rate is used for migratory geese species in this assessment with a default rate of 98% used for all other species (SNH 2010).

4.3 Legal basis / legislation

The ornithological assessment in this report is based on the legislative background around bird management and protection. The legal framework is implemented in the Danish and the international EU legislation.

The main international EU legislation is based on the Habitat Directive (92/43/EEC), Birds Directive (1009/147/EC) and the Ramsar Convention. The Habitat Directive and the Birds Directive forms the joint Natura 2000 network of protected sites and species.

The Birds Directive protect natural populations of birds as well as sensitive species. The Annex 1 of the Birds Directive lists species which are:

- In danger of extinction;
- Vulnerable to specific changes in their habitat;
- Considered rare because of small populations or restricted local distribution; and
- Requiring particular attention for reasons of the specific nature of habitat.

For these species member states must conserve their most suitable territories in number and size as Special Protection Areas. Today (July 2014), the list includes 193 species and sub-species.

The Habitat Directive conserve natural habitats through designated sites and conserve flora and fauna. Annexed to the directive there are lists of designated sites as well as lists on species included in the designations.

The Ramsar Convention is a treaty for the conservation and sustainable utilization of international important wetlands, including birds. Some species migrate over long distances why e.g. collision with wind turbines may be an important issue in the assessment of impact.

- In addition to compliance with the international bird protection, the main Danish legislation includes:
- Nature Protection act: Naturbeskyttelsesloven. Bekendtgørelse af lov om naturbeskyttelse (LBK nr. 933 af 24/09/2009);
- Wildlife Management act: Bekendtgørelse af lov om jagt og vildtforvaltning (LBK nr. 930 af 24/09/2009);
- Marine Strategy act: Lov om havstrategi (LOV nr. 522 af 26/05/2010);
- Environmental act: Miljømålsloven. Bekendtgørelse af lov om miljømål m.v. for vandforekomster og internationale naturbeskyttelsesområder (Miljømålsloven) (LBK nr. 932 af 24/09/2009)

Finally, Denmark maintain a red-list of bird species. The list identifies vulnerable and/or threatened species. The red-list is regularly updated and complies with the regulations in the Biodiversity Convention.

4.4 Worst case – assumptions

4.4.1 Collision risk modelling

Two turbine models, with capacities of 3 MW and 10 MW respectively, are being considered for installation at Vesterhav Syd.

In order to determine the collision risk worst case scenario for migrating birds at Vesterhav Syd scenarios were modelled for each turbine model using generic data[1]. The turbine parameters used are shown in Table 4. In terms of worst case scenario, the larger the rotor swept area the more risk of collision for birds passing through a wind farm. The outputs from the collision risk model indicated that, in terms of rotor swept area, the 3 MW turbine scenario represents the worst case for migratory birds.

[1] Generic data which remained consistent between each model included interacting population (10,000 birds), proportion at rotor height (50%), risk window (5 km) and single transit collision risk (10%). These data were used in order to calculate collision risk estimates and provide an indication as to the worst case scenario.

Table 4: Determination of the worst case scenario for flight risk window and rotor swept area for Vesterhav Syd

Parameter	**Turbine model (MW)**	
	3	**10**
No. of turbines	66	20
Rotor diameter (m)	112	190
Rotor swept area (m^2)	**650,234**	567,058

The collision risk model also relies on the calculation of the risk of collision for a single rotor transit by a species of bird. The incremental value of this factor depends on the turbine specifics in addition to biometric aspects of the species in question. As such, an explorative modelling process for the species carried forward from Section 6.2 was undertaken to determine the worst case turbine scenario for a single rotor transit (Table 5). For each species the 3 MW turbine scenario was identified as the worst case.

Table 5: Determination of the worst case scenario collision risk for a single rotor transit (% chance of collision)

Species	**Turbine model (MW)**	
	3	**10**
Pink-footed Goose	**7.7**	5.9
Greylag Goose	**7.9**	6.0
Barnacle Goose	**7.1**	5.5
Light-bellied Brent Goose	**6.6**	5.2
Eurasian Wigeon	**5.8**	4.7
Eurasian Teal	**5.3**	4.4
Northern Pintail	**6.2**	4.9

4.4.2 *Migratory front*

In order to ensure an accurate representation of collision risk across the risk window the migratory movements of each species is taken into account in order to determine the migratory front (taken as being the width of the migration zone as detailed in Wright et al. 2012))[2] relevant to each species. The migratory front across Vesterhav Syd has been determined on a species by species basis through a literature review. The width of the migratory front across the wind farm is measured in order to determine the collision risk window.

[2] Migration front is the width of the likely migration route/corridor

4.5 0-alternative

If the project is not executed, the existing environmental impacts on migrating birds in the offshore area will develop in future according to expected changes in existing pressures.

4.6 Migratory seabirds

In order to determine the population interacting with Vesterhav Syd, bird observation data has been sourced from www.dofbasen.dk.. Data presented on this website was previously used to aid in the determination of those migratory wildfowl species to be included in the previous assessments for Vesterhav Syd. Of those observation points located on the north-western and western coasts of Jutland, the largest dataset is associated with Blåvand bird observatory.

5 METHODOLOGY OF IMPACT ASSESSMENT

5.1 Introduction

The Project description throughout the full lifecycle (installation, operation and decommissioning) has been cross referenced with information on the ornithological baseline to identify the potential interactions between the Project and ornithological receptors. Potential impacts are then assessed for the level of magnitude of the respective effects on each ornithological receptor.

Potential impacts on migrating bird populations within the Project site and surrounding study area have been assessed using a methodology outlined by Energinet.dk and NIRAS. Four criteria have been developed in order to assign values to the sensitivity of receptors and the significance of potential impacts. These include:

- Degree of disturbance/impact;
- Importance;
- Likelihood of occurrence; and
- Persistence.

The magnitude of an impact is then determined by cross-referencing the output of the four criteria. These criteria are defined and discussed in the following sections.

5.2 Degree of disturbance

The assessment of the degree of disturbance will differ when assessing the potential for collision and the potential for barrier effect.

5.2.1 Collision

Collisions are generally considered to cause fatality and therefore the degree of impact on an individual bird is regarded as high. However, the impact on the population as a whole is considered as a parameter to judge the magnitude of impact. For example, if one collision per year is predicted for a species with a population of one million, the degree of impact is regarded as low.

The assessment of collisions is not based on the NIRAS guidance as the applicabitlity of impact criteria is limited in case of collisions. e.g., the degree of disturbance would always be high, as a collision means the death of a bird. If other criteria would also be rated as high (e.g. international importance), major impacts could result from this assessment method even when few individuals would collide per year and acutally no severe impact can be expected. Therefore, the assessment of collisions is based directly on the results of collision modeling. The assessment is done by expert judgement taking into account the number of colliding bird in relation to reference populations. The magnitude of impact of collisions can only be judged if the number of collisions is compared to a reference population. For this purpose the following approach is used.

The rating of collisions is based on effects of additional mortality on the population level.

Thresholds for the assessment of possible impacts on the population level can be developed using Potential Biological Removal (PBR). PBR provides a means of estimating the number of additional mortalities that a given population can sustain. Wade (1998) and others have defined a simple formula for PBR:

$$PBR = \frac{1}{2} r_{max} N_{min} f$$

Where:

r_{max} is the maximum annual recruitment rate
N_{min} is a conservative estimate of the population size
f is a “recovery factor” applied to depleted populations where the management goal may be to facilitate growth back to a target population size

Wade (1998) showed that PBR can be used to identify sustainable harvest rates that would maintain populations at, or above, maximum net productivity level (MNPL or maximum sustained yield). Based on a generalised logistic model of population growth and assuming that the density dependency in the population growth is linear (θ = 1.0) then MNPL is equivalent to 0.5K (where K is the notional carrying capacity) and the net recruitment rate at MNPL (RMNPL) is 0.5 r_{max}.

Wade (1998) also showed that PBR is conservative for populations with θ > 1.0 (i.e. a convex density-dependent growth curve) where RMNPL will be > 0.5 r_{max} (see Figure 1 in Wade 1998).

5.2.1.1 *Estimating rmax*

The maximum annual recruitment rate (r_{max}) is equivalent to λ_{max} – 1, therefore:

$$r_{max} = \lambda_{max} - 1$$

Where:

λ_{max} is the maximum discrete rate of population growth.

Niel & Lebreton (2005) show two methods for calculating λ_{max}:

A quadratic solution (equation 15 of Niel & Lebreton 2005) also used by Watts (2010):

$$\lambda_{max} \approx \frac{(s\alpha - s + \alpha + 1) + \sqrt{(s - s\alpha - \alpha - 1)^2 - 4s\alpha^2}}{2a}$$

And a relationship based on mean optimal generation length (equation 17 of Niel & Lebreton 2005):

$$\lambda_{max} = exp\left[\left(\alpha + \frac{s}{\lambda_{max} - s}\right)^{-1}\right]$$

Where:

s is annual adult survival
α is age of first breeding

Niel & Lebreton (2005) suggest that the second method is most suitable for short-lived species. A comparison of the results of both methods indicated that the first generated slightly more precautionary PBRs for the relatively long-lived species considered in this note. Consequently λ_{max} has been estimated using the first method for all species below.

5.2.1.2 Estimating Nmin

N_{min} is a conservative estimate of the population size. Population (flyway) sizes for the migratory wildfowl species considered have been identified in Section 6.2

5.2.1.3 Selecting f

The recovery factor *f* is an arbitrary value set between 0.1 and 1.0 and its purpose is to increase conservatism in the calculation of PBR or to identify a value for PBR that is intended to achieve a specific outcome for nature conservation (e.g. population recovery). The recovery factor is relecting the population trend: in a decreasing population additional mortality has much higher effects than in increasing populations and a removal of a lower number of birds would cause adverse impacts. The recovery factor is defined as 0.1=decreasing population, 0.5=stable population, 1=increasing population.

The removal can also be expressed in terms of percentage of the population. In order to get information about the relationship between removal in terms of number of birds and % of population data analysed by Poot et al. (2011) are presented for relevant species in the Vesterhav Syd report on resting birds (NIRAS 2015) in Section 6.2.5.

It should be noted that due to the nature of the assessment of migratory seabirds (i.e. focusing on landbased counts to provide an indication of potential interacting populations with Vesterhav Syd), PBR is not considered an appropriate tool to assess the degree of disturbance. As the defined population is not referenced to any breeding or biogeographic platform, an assessment through assessment of sustainability would not be biologically meaningful. In the case of migratory seabirds, degree of disturbance is defined through expert judgment based on conservation trends and most critically the scale of the CRM outputs.

5.2.1.4 *Summary*

The removal can also be expressed in terms of percentage of population. In order to get an information about the relationship between removal in terms of number of birds and % of population, data analysed by Poot et al. (2011) used with respect to the report on resting birds at Vesterhav Syd. As Poot et al. (2011) does not present information on many migratory wildfowl species considered in this report, PBR has been undertaken specifically for the flyway populations considered to have potential association with Vesterhav Syd. The Rf value used for assessment (based on the population trend) highlighted in bold (see section 5.2.1.3)

Table 6: PBR in number of individuals

Species	**Population size (Nmin)**[3]	**Age of First Breeding (α)**[4]	**Annual Adult Survival (s)**[4]	**Growth Rate (λ_{max})**	**Population Trend**[5]	**Rf=0.1**	**Rf=0.5**	**Rf=1.0**
Pink-footed Goose	63,000	3	0.829	1.188	Moderate increase	593	2,968	**5,934**
Greylag Goose	610,000	3	0.830	1.188	Moderate increase	5,735	28,675	**57,350**
Barnacle Goose	770,000	3	0.910	1.146	Moderate increase	5,613	28,063	**56,127**
Light-bellied Brent Goose	7,600	2	0.900	1.200	Moderate decline	**76**	380	760
Eurasian Wigeon	1,500,000	1	0.530	1.686	Stable	51,417	**257,087**	514,174
Eurasian Teal	500,000	1	0.530	1.686	Stable	17,139	**85,696**	171,391
Northern Pintail	60,000	1	0.663	1.580	Moderate decline	**1,742**	8,708	17,415
Common Eider	976,000	3	0.820	1.192	Decline	**9,379**	46,895	93,789
Common Scoter	550,000	2	0.783	1.280	Decline	**7,689**	38,422	76,885
Kittiwake	6,600,000	4	0.882	1.133	Decline	**43,928**	219,638	439,277
Black-headed Gull	3,700,000 - 4,800,000	2	0.900	1.200	Stable	37,000	**185,000**	370,000
Common Gull	1,200,000 - 2,500,000	3	0.860	1,174	Possible decline	**10,461**	52,302	104,605
Lesser Black-backed Gull	530,000 - 570,000	4	0.913	1.118	Increase	3,138	15,691	**31,381**
Herring Gull	1,300,000 - 3,100,000	4	0.880	1.134	Stable	8,707	**43,536**	87,071
Great Black-backed Gull	330,000 - 540,000	4	0.930	1.109	Increase	1,792	8,961	**17,922**
Sandwich Tern	166,000 - 171,000	3	0.898	1.153	Stable	1,274	**6,370**	12,740
Common Tern	160,000 - 200,000	3	0.900	1.152	Stable	1,218	**6,090**	12,181
Arctic Tern	1,000,000	4	0.900	1.125	Stable	6,250	**31,250**	62,500

[3] See Section 6.2

[4] Robinson (2005)

[5] Various sources including Burfield and Van Bommel (2004)

Taking 0.5 as rf-value, the removal rate would be > 2% of population in all species. Using the precautionary principle and defining rf=0.1 as given factor, a value 0.5% of the population can be applied as lower limit. If additional mortality exceed 0.5% of the reference population a negative impact can be expected.

For the impact assessment of collision the following levels are defined:

- **Major**: mortality due to collisions ≥0.5% of the biogeographical reference population;
- **Moderate**: ≥0.1% and < 0.5% of biogeographic population; and
- **Minor**: ≥0.01% and < 0.1% of biogeographic population
- **Negligible/No impact**: < 0.01% of biogeographic population

A modification is possible according to expert judgment based on the conservation status of the species.

5.2.2 Barrier effect

Barrier effects cause an increase in flight path in migrating birds (macro-avoidance) and thus, an increase in energy expenditure. The characteristics and boundary of the Vesterhav Nord wind farm and the anticipated flight direction of the relevant species are used to calculate the increase in flight path. This is predicted to be 3.47 km assuming a north-southward migration direction (see Section 8.2). This additional flight path is then presented as a percentage of the species specific migratory route length. In Eider, an increase in migration route from 1,400 to 1,450 km is expected to cause significant effects (approximately 3.5 % addition to migration route; Masden et al. 2009b). This value is taken as reference for the ranking:

- **High**: >3.5% increase of species specific migration route;
- **Medium**: ≥1% and ≤3.5% increase of species specific migration route; and
- **Low**: <1% increase of species specific migration route.

5.3 Importance

The importance of an area for a species has been assessed using the conservation status and its abundance in the area in relation to the relevant flyway population.

In migrating birds the basic information on flyway populations are derived from Wetlands International (2014). The relevant project specific flyway populations are identified and estimated from analyses of connectivity of species between resting and breeding sites. As a measure of the abundance of the species the bird numbers in the Vesterhav Syd project area are referred to the total flyway population.

For the assessment of impact the 1% criterion is used. The abundance is classified in ”*very high, high, medium, low”* according to the following criteria:

- **Very high**: ≥ 1% of the flyway reference population
- **High**: ≥0.5% and < 1% of flyway reference population
- **Medium**: ≥0.1% and < 0.5% of flyway reference population
- **Low**: <0.1% of flyway reference population

The conservation status of a migrating species includes an appraisal of international and national conservation policy including the EU Birds Directive, IUCN criteria, Species of European Concern (SPEC) and Danish conservation policy. Of importance to this assessment are those species listed in Annex 1 of the EU Birds Directive and SPEC 1, 2 and 3[6]. The rating is as follows:

- **Very high** when the species is listed in the Annex I or holds the SPEC-status 1 or 2 (1: European species with global conservation concern, 2: European species whose global population is concentrated in Europe, unfavourable conservation status);
- **High** when SPEC-status is 3 (global population not conentrated in Europe, but unfavourable conservation status in Europe);
- **Medium** when global population is concentrated in Europe with favourable conservation status (Non-SPEC-E); and

Low when global population is not concentrated in Europe, and have a favourable conservation status in Europe (Non-SPEC).

A combination of the criteria according to results in an assessment of the importance of the area for migrating birds. The resultant categories are ”*International*”, ”*National/regional*”, ”*Local*” and ”*Not important*”.

[6] SPEC 1 species are those of global conservation concern, SPEC 2 are those species with an unfavourable conservation concern in Europe and are concentrated in Europe (over 50% of global population found in Europe) and SPEC 3 are those species with an unfavourable conservation status in Europe but not concentrated in Europe. Non-SPEC-E indicates species with a favourable conservation status and concentrated in Europe.

Table 7: Scheme for determination of importance of Vesterhav Syd area to bird species

Abundance	Conservation status			
	Very high	**High**	**Medium**	**Low**
Very high	International	International	International	International
High	International	National/ regional	Local	Local
Medium	National/ regional	National/ regional	Local	Not important
Low	Local	Local	Not important	Not important

5.4 Likelihood of occurrence

5.4.1.1 Collisions

The likelihood of occurrence of collision is classified using expert judgment. If a wind farm is in operation it presents a permanent obstacle with the potential for birds to collide. The likelihood of occurrence is derived from the following parameters:

- Abundance of birds in the wind farm area (not in relation to population, but total counts); if there are many birds present, also many can collide; and
- Species specific collision risk.

5.4.1.2 Barrier effect

The likelihood of occurrence of barrier effects is also classified using expert judgment. If a wind farm is in operation it presents a permanent obstacle with the potential for birds to potentially avoid during migration. The likelihood of occurrence of an effect considers appropriate references e.g. Langston & RSPB (2010) and Masden et al. (2009a). Migratory species will be affected on two flights per annum only.

5.5 Persistence

The persistence of the impact gives a temporal scale of how long the pressure is present (e.g. for collision, the time period for which collisions can occur and for barrier effects, the time the barrier is present.. Three categories are defined:

- **Permanent**: impact lasts for more than 5 years;
- **Temporary**: impact lasts for a period of 1 to 5 years; and
- **Short-term**: impact lasts for a period of less than one year.

In terms of collisions the duration of the effect is by definition ”Permanent” as the result of colliding birds is usually death and this is a permanent status. For barrier effects the duration of the presence of the barrier is regarded.

5.6 Summary

A combination of these criteria according to Table 77, Table 78 and Table 79 in the Appendix Section 18.1 leads to a given magnitude of impact relating to the categories *“Major”*, *“Moderate”*, *“Minor”* or *“Negligible/neutral/no impact”*. A description of these categories with examples of dominating effects is given in Table 8. In addition to these negative/neutral impacts, it is possible for positive impacts to occur. These are mentioned separately in the text and do not follow the impact criteria described below.

Table 8: Explanation of magnitude of impact.

Magnitude of impact	Explanation
Major	Impacts with a large extent and/or long-term effects, frequently occurring and with a high probability, and with the possibility of causing significant irreversible impacts.
Moderate	Impacts with either a relatively large extend or long-term effects (e.g. throughout the lifespan of the wind farm), occurs occasionally or with a relatively high probability and which may cause some irreversible but local effects on elements worthy of preservation (culture, nature etc.).
Minor	Impacts of some degree or complexity, a certain degree of persistence beside the short-term effects, and with some probability to occur, but which will very likely not cause irreversible effects.
Negligible / neutral/no impact	Small impacts of local interest, which are uncomplicated, persist for a short-term or are without long-term effects and without any reversible effects. Or No impacts compared to status quo.

Table 9 gives an overview of the evaluation basis for different pressures and impact criteria for migrating birds.

Table 9: Description of the basis of evaluation for impact assessment for different pressures in migrating birds.

Pressure Impact Criteria	Collision	Barrier Effect
Degree of disturbance	Number of collisions in relation to flyway population	Estimation of extra energy expenditure due to increase in flight path
Importance	Conservation status and abundance relation to bio-geographical population	Conservation status and abundance in relation to bio-geographical population
Likelihood	Likelihood of occurrence of an effect	Likelihood of occurrence of an effect
Persistence	Duration of effect	Duration of effect

6 EXISTING CONDITIONS

6.1 Introduction

It is difficult to quantify the movements of migratory species offshore given the snapshot nature of survey methods used to collect data in this environment. Existing collision risk models (e.g. Band 2012 and derivatives) are able to take this into account for birds that are resident in areas for certain periods of the year (e.g. the breeding or wintering seasons), however, a different approach is required for ephemeral species. The quantification of movements is not as important in the assessment of barrier effects, instead this assessment concentrates on the increase in energy expenditure that may result due to the additional distance a bird may have to travel in order to avoid the wind farm.

As such, a theoretical assessment has been devised, which incorporates information relating to flyway populations and the potential interactions between these populations and Vesterhav Syd, using literary sources and expert judgment in order to quantify the collision risk and barrier effect posed to migratory species at Vesterhav Syd. Whilst the process described below is inherently theoretical, it is considered that by building in appropriate precaution in the analysis it provides an effective tool to identify where collision effects of a significant magnitude are likely to occur on migratory species populations.

This section provides a summary of the collision risk modelling process (CRMs) applied to assess the potential interactions of migratory species with the proposed near-shore wind farm, Vesterhav Syd, on the western Danish coast. Presented within this section is full narrative of parameter selection for use in the modelling.

The aims of the migratory CRM are therefore to:

- Provide an overview of migratory species population dynamics and migratory flyways relevant to Vesterhav Syd;
- Detail the methodology involved in determining the process by which parameters used in the collision risk models are derived;
- Provide an overview of the collision risk modelling methodology and critical assumptions made; and
- Present and interpret CRM outputs to inform EIA

6.2 Literature review of species Populations Migrating over the West Coast of Jutland, Denmark

6.2.1 Species for consideration

6.2.1.1 Overview

The migratory populations of the following species groups are considered in this assessment:

- Wildfowl (swans, geese and ducks);
- Raptors;
- Cranes;
- Waders;
- Passerines; and
- Migratory seabirds.

A literature review was carried out investigating records and data of migratory species using potential flyways over offshore areas off the western coast of Denmark.

Direct bird observation data were obtained from Blåvand Bird Observatory to the north-west of Esbjerg on the western coast of Denmark; approximately 50 km south of Vesterhav Syd. These data were analysed to determine those species with likely migratory flyway connectivity with Vesterhav Syd. This information was considered alongside information relating to the migratory movements of birds through the region containing Vesterhav Syd and the conservation status of individual species. The analysis of data from Blåvand Bird Observatory and examination of relevant literature produced a long list of species that would be considered further in the assessment.

6.2.1.2 Wildfowl

A bird monitoring program undertaken at Horns Rev 3 Offshore Wind Farm including two offshore stations recorded a total of 5,136 birds of six goose and swan species (Greylag Goose, Pink-footed Goose, White-fronted Goose, Barnacle Goose, Brent Goose and Mute Swan). However, the majority of these observations occurred from the onshore station at Blåvandshuk with only two species recorded offshore (Greylag Goose and Pink-footed Goose) (Jensen et al. 2014).

Observations of migratory movements recorded at Blåvand Bird Observatory indicate significant passage of geese along the western coast of Denmark during autumn. The peak monthly counts of four goose species recorded at Blåvand Bird Observatory between 2009-2013 are shown in Figure 4.

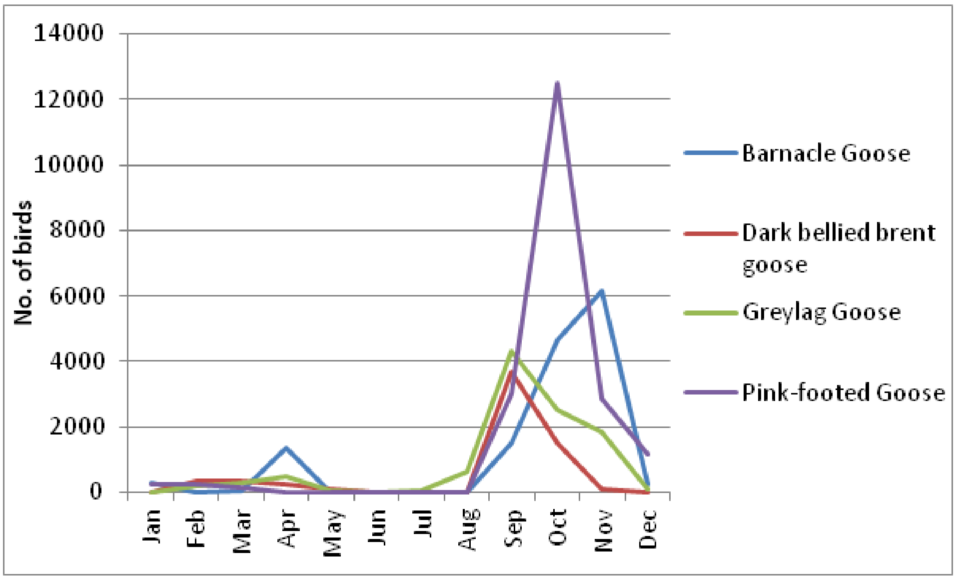

Figure 4: Peak monthly counts of four goose species recorded at Blåvand Bird Observatory between 2009-2013.

For all four goose species included in Figure 4**Error! Reference source not found.** except Barnacle Goose, the peak counts recorded at Blåvand exceeded the 1% threshold of the relevant flyway population. Barnacle Goose is, however included for further assessment based on the species inclusion on Annex 1 of the EU Birds Directive. One further species, Light-bellied Brent Goose, is also included for further assessment based on peak counts of the species at Blåvand Bird Observatory also breaching the 1% threshold of the relevant flyway population. All other goose species recorded at Blåvand Bird Observatory, including Bean Goose and White-fronted Goose were not recorded in numbers considered sufficient to warrant further assessment.

Observations of migratory movements recorded at Blåvand Bird Observatory also indicate significant passage of ducks along the western coast of Denmark during autumn. The peak monthly counts of three duck species recorded at Blåvand Bird Observatory between 2009-2013 are shown in Figure 5.

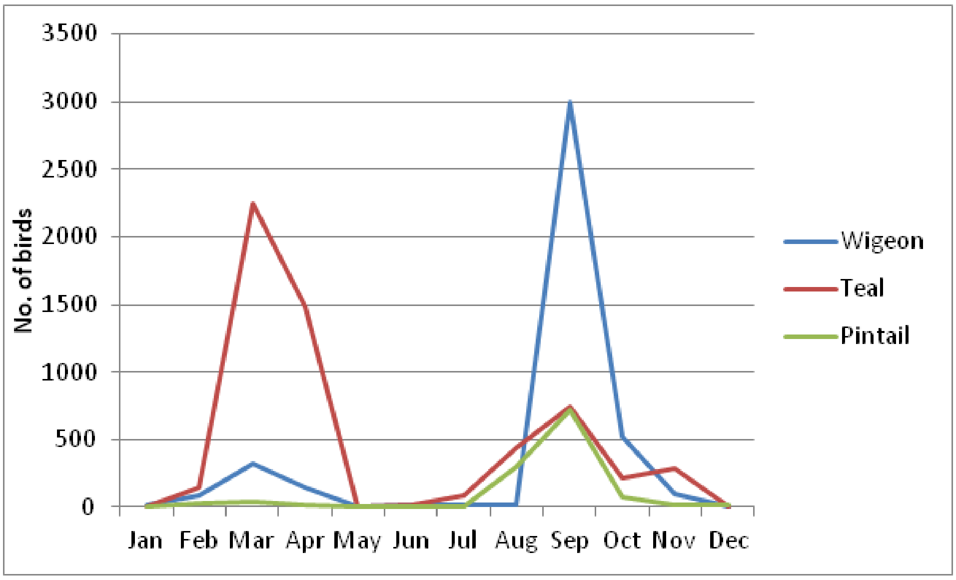

Figure 5: Peak monthly counts of three duck species recorded at Blåvand Bird Observatory between 2009-2013.

For all three duck species included in Figure 5**Error! Reference source not found.** the peak numbers recorded at Blåvand Bird Observatory were considered high enough to warrant further assessment. All other duck species recorded at Blåvand Bird Observatory, including were not recorded in numbers considered sufficient to warrant further assessment.

6.2.1.3 *Raptors*

The bird monitoring program undertaken for Horns Rev 3 offshore wind farm recorded a total of 322 raptors of 14 species. When comparing the offshore and onshore observation sites, the number of raptors recorded offshore was substantially lower (Jensen et al. 2014).

No species of raptor were recorded at Blåvand Bird Observatory in numbers sufficient to warrant further investigation within this assessment (i.e. numbers above the 1% threshold of relevant flyway populations). This conclusion is supported by current general knowledge of the predominant migratory movements of these species within Europe (BWPI 2009).

Raptors can be divided into three categories based on migratory behaviour:

1. Resident species that remain at breeding areas throughout the year (e.g. sparrowhawk, Golden Eagle);
2. Species that exhibit short distance migratory movements (e.g. Common Buzzard and Common Kestrel); and
3. Species that exhibit long distance migratory movements (e.g. Osprey and Hobby).

The migratory behaviour of raptors is dominated by soaring flight, with the migratory pathways of many species governed by thermals (Newton 2010). Due to this dependence on thermals soaring raptors mainly migrate over land and during the day, when thermals are created. The reliance on land means raptors tend to concentrate at land bridges or narrow sea crossings such as Gibraltar or Falsterbo in Sweden. Large numbers of raptors are recorded on the Swedish coast during autumn, especially at Falsterbo (Aarhus University & DHI 2014), with movements occurring in a south-westerly direction across the Baltic and through mainland Europe (BWPI 2009).

There is considered to be a lack of connectivity between migrating raptor species and the region within which Vesterhav Syd is located and, as such raptor species are not considered further in this assessment.

6.2.1.4 Cranes

Only 13 records of Common Crane (*Grus grus*) have been reported from Blåvand Bird Observatory in the last five years. Cranes use two main migration routes (BWPI 2009), both of which occur through the Baltic and across mainland Europe, exhibiting no connectivity with the western coast of Denmark and as such, Vesterhav Syd. Therefore Common Crane is not considered further in this assessment.

6.2.1.5 Waders

Wader migration is typified by long distance flights taken as a series of hops between discrete wetlands or 'staging areas' where birds pause to refuel and rehydrate (e.g. van de Kam et al. 2004). Radar studies have shown the majority of wader migration takes place at 500–4,000 m and across broad fronts with routes little influenced by landscape features (e.g. van de Kam et al. 2004). Only when migrating waders meet unfavourable weather, do they descend to lower altitude where they may follow leading lines like coasts until they reach acceptable staging areas. It is primarily during days with such weather that large numbers may be recorded from locations monitoring visible migration such as at Blåvand (Meltofte & Rabøl 1977, Meltofte 1993).

The bird monitoring program undertaken for Horns Rev 3 offshore wind farm recorded a total of 6,675 waders of 27 species. Generally more birds were recorded at the onshore observation site at Blåvandshuk (Blavand) than at the Horns Rev 1 & 2 offshore observation sites (Jensen et al. 2014).

The migration of waders along the Danish coast as recorded at Blåvand Bird Observatory, includes several hundred thousand individuals each spring and autumn, and is one of the most conspicuous migrating routes along the west coast of Jutland. As previously mentioned, waders typically fly high during migration between staging areas i.e. above potential collision height (but not necessarily out of human vision), descending to lower altitude (or not flying at all) during poor weather to follow topographical features e.g. the coasts.

It is considered that interaction between numbers of migrating waders and Vesterhav Syd, which lies 4km from the coastline, is unlikely. Therefore there is concluded to be a lack of connectivity between migrating wader species and Vesterhav Syd and, as such wader species are not considered further in this assessment.

6.2.1.6 Passerines

Passerines migrate across broad fronts (Newton 2010) limiting the potential for any population level effects resulting from any interaction with Vesterhav Syd. No passerine species are considered for this assessment as any direct impact from Vesterhav Syd can be expected to be low given the species have large populations and higher reproductive rates (i.e. r-selected species) compared to those of non-passerines.

6.2.1.7 Migratory seabirds

Data from Blåvand were collected for all months in the last five years (2009 – 2013) and were restricted to only those birds flying north or south. These data were therefore considered to represent only migrating birds. These data were analysed in order to identify those species occurring in numbers considered too low for population level impacts to occur. All taxonomic groups of seabirds were considered in this analysis. A species was considered for assessment if the average annual population recorded at Blåvand bird observatory surpassed 100 birds.

The following species were considered for collision risk modelling based on the scoping exercise conducted for Vesterhav Syd:

- Common Eider;
- Common Scoter;
- Red-breasted Merganser;
- Red-throated Diver;
- Arctic Skua;
- Kittiwake;
- Black-headed Gull;
- Little Gull;
- Common Gull;
- Lesser Black-backed Gull;
- Herring Gull;
- Great Black-backed Gull;
- Sandwich Tern;
- Common Tern; and
- Arctic Tern.

6.2.1.8 Summary

Potential migratory connectivity between Vesterhav Syd and the following species is investigated further within this assessment:

- Pink-footed Goose (*Anser brachyrhynchus*);
- Greylag Goose (*Anser anser*);
- Barnacle Goose (*Branta leucopsis*);
- Dark-bellied Brent Goose (*Branta bernicla bernicla*);
- Light-bellied Brent Goose (*Branta bernicla hrota*);
- Eurasian Wigeon (Anas penelope);
- Eurasian Teal (*Anas crecca*);
- Northern Pintail (*Anas acuta*); and
- Thirteen migratory seabird species.

The following sections 6.2.2 to 6.2.9 outline the following information in regards to those species listed above:

- The flyway population relevant to Vesterhav Syd and the movements size of this population;

- The conservation status of a species; and

- The connectivity between the migratory movements of a flyway population and Vesterhav Syd.

The conservation status of a species includes an appraisal of international and national conservation policy including the EU Birds Directive, IUCN criteria, Species of European Concern (SPEC) and Danish conservation policy. Of primary importance to this assessment are those species listed on Annex 1 of the EU Birds Directive and those listed on SPEC 1, 2 and 3 (Burfield et al. 2004) [7].

6.2.2 Pink-footed Goose

6.2.2.1 Migratory population

The Pink-footed Goose is a monotypic species with a global population estimated at 413,000 individuals (Wetlands International 2014). The species has a breeding distribution restricted to two separate biogeographical regions: eastern Greenland and Iceland, and Svalbard. The entire winter population is distributed within a few European countries which border the North Sea. Individuals that breed in Greenland and Iceland migrate to Britain and Ireland, whereas the Svalbard population migrates southwards via Norway to autumn staging areas in Denmark and the Netherlands. These populations are to be geographically distinct (Joint Nature Conservation Committee 2009).

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[7] SPEC 1 species are those of global conservation concern, SPEC 2 are those species with an unfavourable conservation concern in Europe and are concentrated in Europe (over 50% of global population found in Europe) and SPEC 3 are those species with an unfavourable conservation status in Europe but not concentrated in Europe. SPEC 4 indicates species with a favourable conservation status.

The Svalbard population is estimated at 63,000 individuals (Wetlands International 2014). The wintering grounds of the Svalbard population are divided between Belgium, the Netherlands and Denmark (Madsen et al. 1999). In the 1990s up to 31,000 Pink-footed Geese were recorded in western Jutland (Madsen et al. 1999) which, at that time, represented the entire Svalbard breeding population (Wetlands International 2014). This suggests that the main migratory route of Pink-footed Geese is down the western coast of Denmark.

The largest numbers of Pink-footed Geese in Denmark occur during the autumn and spring migratory periods (Figure 7). The first flocks arrive in mid-September, with numbers peaking in October, however, due to foraging pressure movements to wintering areas are now occurring earlier in October (Madsen et al. 1999). From late February to mid-April, or earlier in mild winters, the wintering population is concentrated in Denmark with northward movements occurring in May (Madsen et al. 1999). In spring, migrating geese use a larger number of staging sites than in autumn when disturbance restricts the migrating population to only two sites (Madsen et al. 1999). The spring distribution extends from the Danish-German border north to Vejlerne in northern Jutland.

6.2.2.2 *Conservation status*

Pink-footed Goose is identified as a species of Least Concern on the IUCN Red List (IUCN 2014). Pink-footed Goose is a SPEC 4 species and is categorised as a species of National Responsibility outside of the breeding season in Denmark. The overall conservation status of the species in Denmark has been preliminarily assessed as favourable (Pihl et al. 2006).

Pink-footed Goose is a qualifying feature at 19 SPAs in Denmark due to at least 1% of the biogeographic population occurring at each of these sites. Of these SPAs, 12 are located on the western coast of Denmark with two, Stadil Fjord og Vest Stadil Fjord (4.76 km north-east) and Ringkøbing Fjord (7.13 south-east) on the coast adjacent to Vesterhav Syd.

There are eight Danish sites that meet both criteria A4[8] and B1[9] of the Important Bird Area (IBA) designation for Pink-footed Goose (Heath & Evans 2000). Seven

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[8] Criteria A4 refers to congregatory bird populations with the following characteristics:

i. The site is known or thought to hold, on a regular basis, ≥1% of a biogeographic population of a congregatory waterbird
ii. The site is known or thought to hold, on a regular basis, ≥1% of the global population of a congregatory seabird or terrestrial species
iii. The site is known or thought to hold, on a regular basis, ≥20,000 waterbirds or ≥10,000 pairs of seabird of one or more species
iv. The site is known or thought to be a ‘bottleneck’ site where at least 20,000 storks, raptors or cranes regularly pass during spring or autumn migration

[9] Criteria B1 refers to congregatory bird populations with the following characteristics:

i. The site is known or thought to hold ≥1% of a flyway or other distinct population of a waterbird species
ii. The site is known or thought to hold ≥1% of a distinct population of seabirds
iii. The site is known or thought to hold ≥1% of a flyway or other distinct population of other congregatory species

of these are located on the western coast of Denmark, with two identified for passage populations of Pink-footed Goose, these are Filisø and Ballum og Husum Enge, Kamper strandenge.

6.2.2.3 *Connectivity*

Figure 6 shows the distribution of Pink-footed Goose along the western coast of Denmark throughout the non-breeding season. These movements indicate that there is potential for connectivity between migrating birds and Vesterhav Syd during both autumn and spring migratory movements.

Observations recorded at Blåvand Bird Observatory on the western Danish coast provide supporting evidence for these movements in autumn. On average over 5,000 birds are recorded from the observatory in October with over 10,000 birds recorded in some years (Figure 7). Additional information relating to flight direction associated with these observations indicate that the majority of these autumn movements occur in a southerly direction.

Based on the evidence presented here Pink-footed Goose is included in the migratory bird collision risk assessment.

iv. The site is a ‘bottleneck’ site where over 5,000 storks, or over 3,000 raptors or cranes regularly pass on spring or autumn migration.

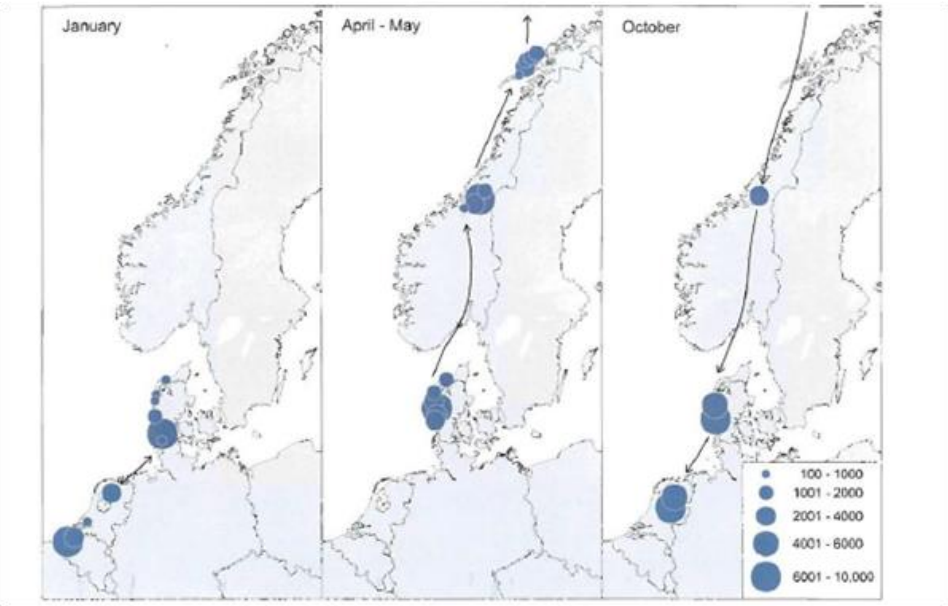

Figure 6: Flyway distribution of the Svalbard-breeding population of the Pink-footed Goose during autumn, winter and spring. Arrows show migration routes. Dots show average numbers during 1994/95 and 1995/96 (Madsen et al. 1999).

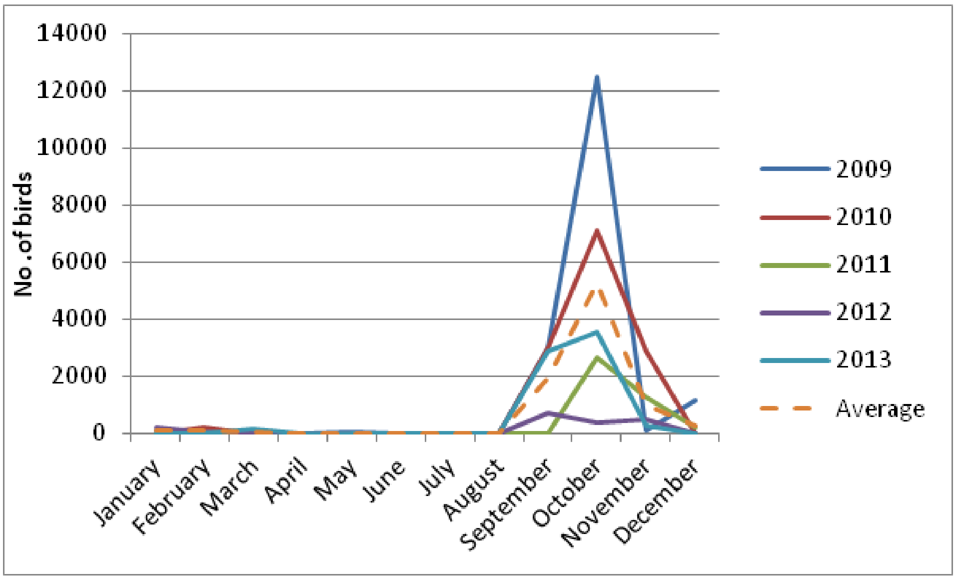

Figure 7: Monthly total passage counts of Pink-footed Goose at Blåvand Bird Observatory for each year between 2009-2013

6.2.3 *Greylag Goose*

6.2.3.1 *Migratory population*

Five discrete breeding populations of Greylag Goose exist in Europe of which the north-western European population is by far the largest with an estimated 610,000 individuals (Wetlands International 2014). This latter population can be further sub-divided into two groups that follow different migratory flyways, one from Norway to staging areas in Denmark and then onto the Netherlands and the second from concentrations in the southern Baltic to staging areas in the Netherlands.

Between July and October Greylag Geese are found throughout Denmark with 24 areas regularly supporting more than 1000 geese (Figure 8). The majority of those individuals found in eastern Denmark are of Danish breeding origin, with those on the western coast mainly of Norwegian breeding origin (Madsen et al. 1999). The peak abundance of birds also reflects this trend with peak autumnal abundance on the western coast of Denmark of much shorter duration than on the eastern coast. Small staging populations in western Jutland during April reflect the passage of Norwegian breeding birds (Madsen et al. 1999).

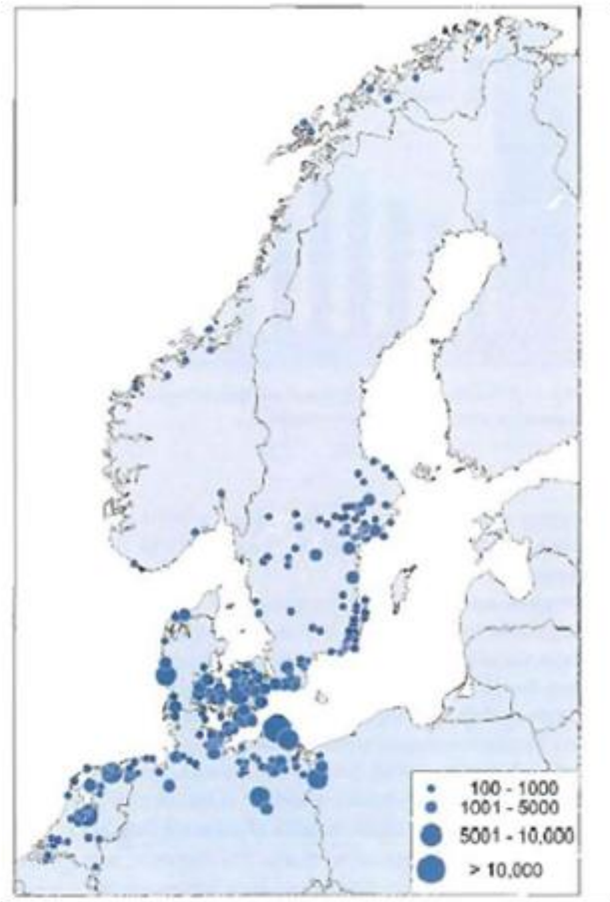

Figure 8: The distribution during September of Greylag Geese in north-western Europe collated from data between 1984-1996 (Madsen et al. 1999)

6.2.3.2 *Conservation status*

Greylag Goose is identified as a species of Least Concern on the IUCN Red List (IUCN 2014). The breeding population of the species is also designated as Least Concern as part of Danish conservation policy[10]. The species was categorized as a species of National Responsibility outside of the breeding season. The overall conservation status of the species in Denmark has been preliminarily assessed as favourable (Pihl et al. 2006).

Greylag Goose is a qualifying feature at 28 SPAs in Denmark due to the presence of at least 1% of the biogeographic population occurring at these sites. Of these SPAs, 10 are located on the western coast of Denmark with two, Stadil

[10] http://www2.dmu.dk/1_Om_DMU/2_Tvaer-funk/3_fdc_bio/projekter/redlist/gpdata_en.asp?Sortorder=NationalKategori&ID=4&mode=default#up

Fjord og Vest Stadil Fjord (4.76 km north-east) and Ringkøbing Fjord (7.13 km south-east) adjacent to Vesterhav Syd.

There are three Danish sites that meet both criteria A4 and B1 of the Important Bird Area (IBA) designation for Greylag Goose. A further five IBAs, which meet only criteria B1 are also found in Denmark (Heath & Evans 2000). One of these, Filisø, is located on the western coast of Denmark and is identified for passage populations of Greylag Goose.

6.2.3.3 Connectivity

Figure 9 shows the September distribution of Greylag Geese. The majority of records are in eastern Denmark and this may reflect the movements of Swedish or Danish breeding birds.

Bird observations from Blåvand Bird Observatory on the western coast of Denmark indicate movements of Greylag Geese between September and November. On average over 2,000 birds are recorded from the observatory during September with up to 5,000 birds recorded in some years (Figure 9). In 2013, Greylag Geese were also observed in April with these observations potentially indicating spring passage along the western coast of Denmark. Additional information relating to flight direction associated with these observations indicate that the majority of these autumn movements occur in a southerly direction.

Based on the evidence presented here Greylag Goose is included in the migratory birds collision risk assessment. The interacting population is restricted to the Norwegian breeding population only.

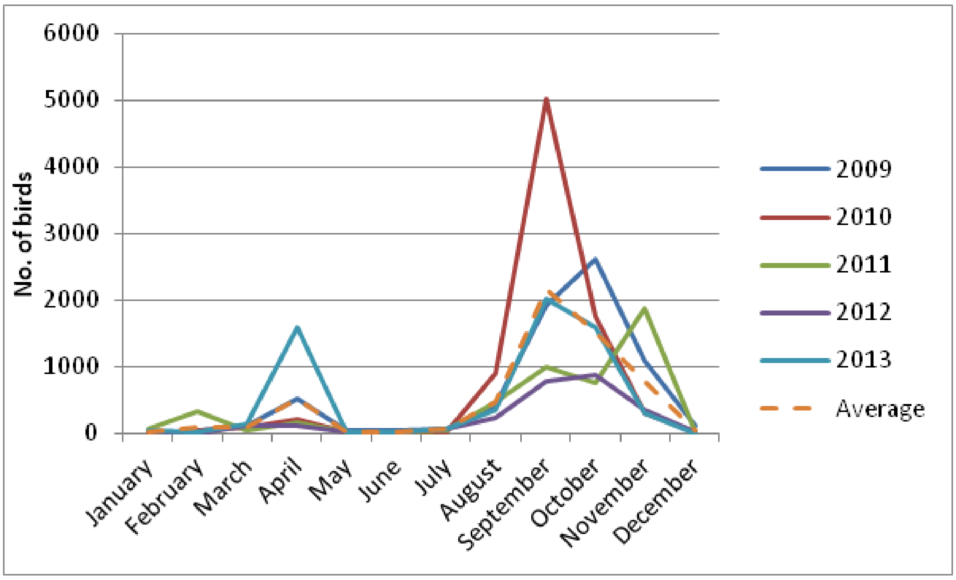

Figure 9: Monthly total passage counts of Greylag Goose at Blåvand Bird Observatory for each year between 2009-2013

6.2.4 *Barnacle Goose*

6.2.4.1 *Migratory population*

There are three breeding populations of Barnacle Goose in Europe with only one of these, the Russian/Baltic breeding population, wintering within and migrating across mainland Europe. The size of this population has been estimated at 770,000 individuals (Wetlands International 2014) with breeding grounds being found in the tundra zone of the Russian Arctic, along the coast of the Barents Sea and western Kara Sea with the Baltic population breeding on Swedish, Estonian, Finnish and Danish islands within the Baltic. Both the Russian and Baltic populations winter on the Dutch coast with staging areas found along the Wadden Sea coasts of Denmark, Germany and the Netherlands (Madsen et al. 1999).

A large part of the Russian population migrate through Denmark to wintering grounds in the Netherlands, although in mild winters increasing numbers have started to winter in Denmark (Pihl et al. 2006). Movements of this species from breeding to wintering grounds follow the route shown in Figure 10 moving southwest across the White Sea, overland to the Gulf of Finland and on through the Baltic. Censuses of Barnacle Geese undertaken during March have recorded 15,000-31,000 birds present in Denmark (Pihl et al. 2006).

Figure 10: Breeding areas, migration route and wintering areas of Russian and Baltic Barnacle Geese (Madsen et al. 1999)

6.2.4.2 *Conservation status*

Barnacle Goose is listed on Annex 1 of the EU Birds Directive and is identified as a species of Least Concern on the IUCN Red List (IUCN 2014). Barnacle Goose is listed as a SPEC 2 species with the Danish breeding population designated as Near Threatened as part of Danish conservation policy[11]. The conservation status of staging Barnacle Geese in Denmark has been preliminarily assessed as favourable (Pihl et al. 2006).

Barnacle Goose is a qualifying feature at 19 SPAs in Denmark due to the presence of at least 1% of the biogeographic population occurring at these sites. Of these SPAs, 10 are located on the western coast of Denmark with two, Stadil Fjord og Vest Stadil Fjord (4.76 km north-east) and Ringkøbing Fjord (7.13 km south-east) on the coast adjacent to Vesterhav Syd.

There are four Danish sites that meet both criteria A4 and B1 of the Important Bird Area (IBA) designation for Barnacle Goose (Heath & Evans 2000). Three of those are located on the western coast of Denmark, with one, Filsø, identified for passage populations of Barnacle Goose.

[11] http://www2.dmu.dk/1_Om_DMU/2_Tvaer-funk/3_fdc_bio/projekter/redlist/gpdata_en.asp?Sortorder=NationalKategori&ID=4&mode=default#up

6.2.4.3 *Connectivity*

Figure 11 presents yearly observations of Barnacle Geese from Blåvand Bird Observatory located to the south of Vesterhav Syd. On average, approximately 2,500 birds are recorded from the observatory during October representing autumn movements of the species. Additional information relating to flight direction associated with these observations indicates that the majority of these autumn movements occur in a southerly direction.

Masden et al. (1999) identify only three sites in Denmark that regularly support more than 1,000 staging Barnacle geese. Two of these are located far to the south of Vesterhav Syd in the Danish Wadden Sea with the other site located in eastern Denmark on the island of Møn (Figure 12)**Error! Reference source not found.** (Madsen et al. 1999). These sites are visited during both autumn and spring and indicate a degree of connectivity between migrating Barnacle geese and Vesterhav Syd. More contemporary information[12] indicate that there has been a recent population increase in this species and that further sites in the region support over 5000 staging Barnacle Geese.

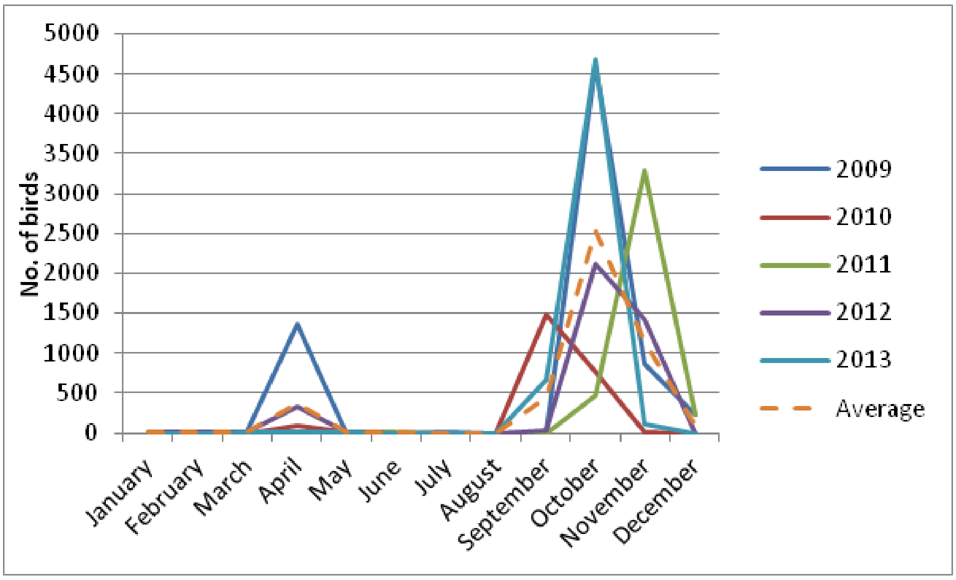

Figure 11: Monthly total passage counts of Barnacle Goose at Blåvand Bird Observatory for each year between 2009-2013

[12] www.dofbasen.dk

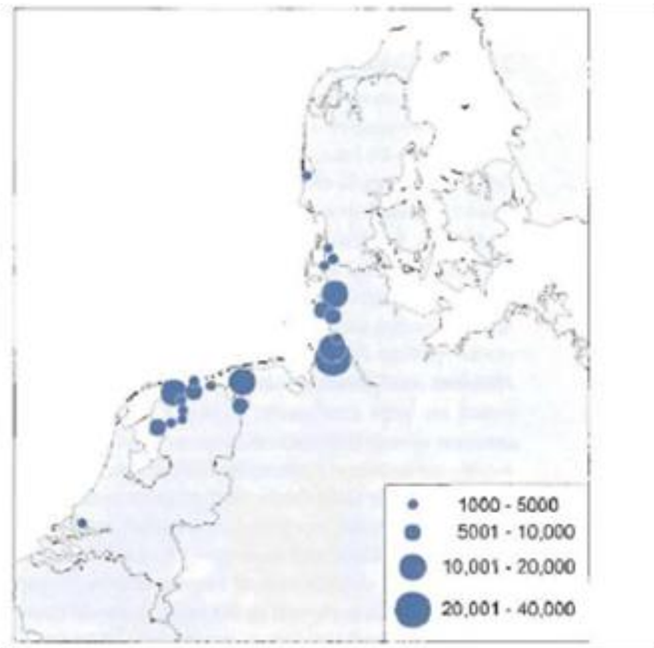

Figure 12: The distribution during March of Barnacle Geese collated from data collected between 1985-1996 (Madsen et al. 1999)

Data from GPS tracking studies of Barnacle Geese indicate that migratory movements of these species occur predominantly across northern Germany and the Danish-German border with (Shariatinajafabadi et al. o.J., Eichhorn et al. 2006), see Figure 13 and Figure 14. Figure 13 shows the GPS tracks of 12 Barnacle Geese tracked during spring migration with these geese exhibiting little connectivity with northern Denmark. A similar conclusion can be drawn from the GPS tracks of 19 Barnacle Geese shown in Figure 14, however, in this case there are numerous records of Barnacle Geese in the area containing Vesterhav Syd.

Numbers of Barnacle Geese recorded at Blåvand Bird Observatory suggest large movements of Barnacle Geese down the western coast of Denmark The observatory is located approximately 50 km further south of Vesterhav Syd When these data are considered alongside tracking data it is unlikely a significant proportion of the biogeographical population of Barnacle Geese exhibit connectivity with Vesterhav Syd. However, Figure 14 suggests a degree of connectivity with the Vesterhav Syd region and therefore considering this tracking data and the conservation status of Barnacle Goose, the species is included in the migratory birds collision risk assessment

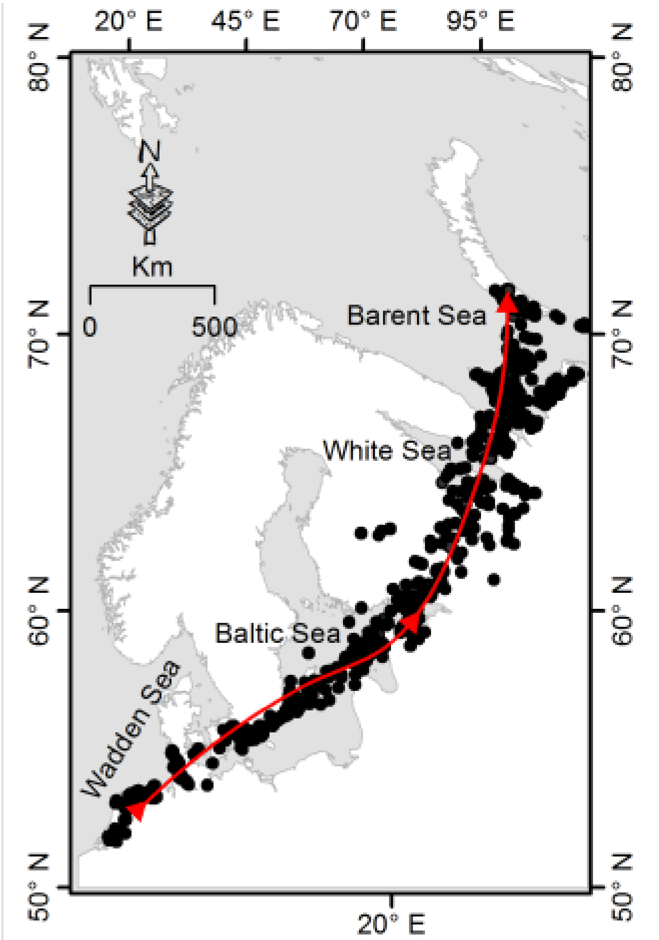

Figure 13: Spring migration route and GPS locations of 12 Barnacle Geese (Shariatinajafabadi *et al*., no date)

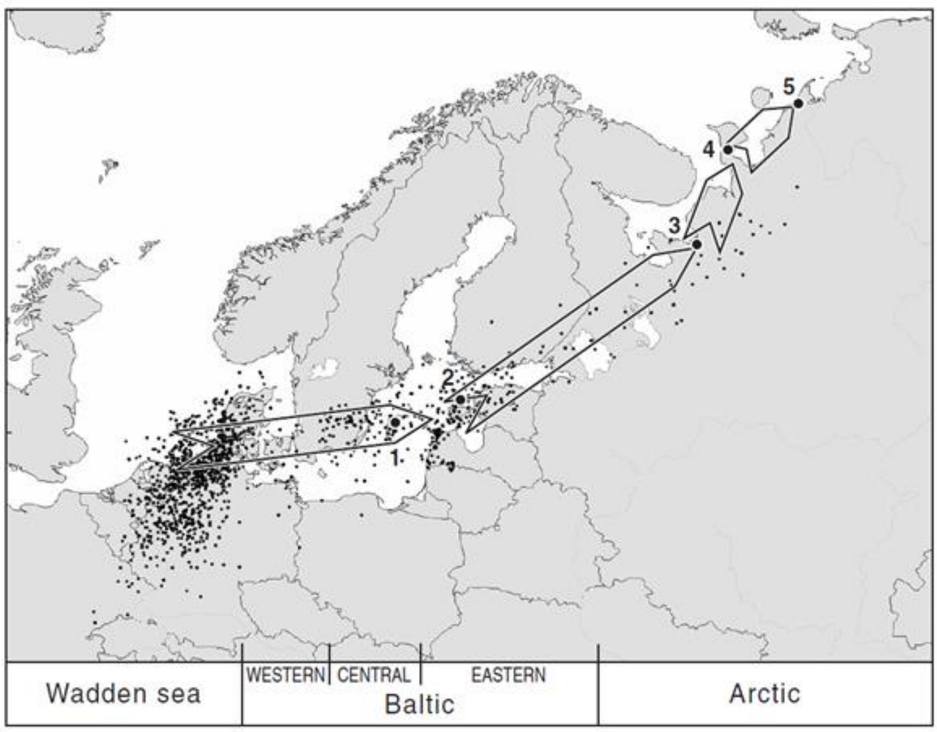

Figure 14: Positions of 19 Barnacle Geese derived from GLS loggers from the 15 April 2004. Also shown are staging sites: 1 = Gotland, 2 = Estonia, 3 = mouth of the river Dvina, 4 = Kanin Peninsula, 5 = breeding colony (Eichhorn et al. 2006).

6.2.5 *Dark-bellied Brent Goose*

6.2.5.1 *Migratory population*

There are currently three recognised subspecies of Brent Goose, the Dark-bellied Brent Goose (*Branta bernicla bernicla*), the Light-bellied Brent Goose (*Branta bernicla hrota*) and the Black Brant (*Branta bernicla nigricans*). Of these, two Dark-bellied and Light-bellied occur in migratory flyways in north-west Europe.

The Dark-bellied Brent Goose breeds in western Siberia migrating to wintering areas on the coast of western Europe. The population is estimated at 200,000 – 280,000 individuals (Wetlands International 2014). In spring nearly the entire population can be found in the Wadden Sea with the White Sea of similar importance during the autumn migration. The migratory route of the population follows the coastline of northern Russia crossing the Kanin Peninsula in the Barents Sea and on through the White Sea across Onega Bay. The migration route then continues via Lake Lagoda in Russia into the Gulf Of Finland through the Bay of Vyborg. Birds are observed from the coast of Estonia and further west from the Swedish coast, passing through Kalmarsund. From the Baltic, birds pass overland into the North Sea across southern Jutland and northern Schleswig, Germany and onwards along the North Sea coast towards wintering areas in France and the UK (Madsen 1987, Ward 2004) (Figure 15).

In Denmark the subspecies primarily occurs between September and November and March to the end of May, when up to 30,000 birds may be present (Pihl et al. 2006). Large numbers of birds pass through Denmark in autumn on passage to the Wadden Sea, with birds staying in Danish waters for only a short period. In spring staging flocks are recorded on the western coast of Denmark including at Ringkøbing Fjord (Pihl et al. 2006). The autumn staging distribution of this species is primarily located on the Danish Wadden Sea coast, with the largest flocks occurring at Fanø and Rømø (Ward 2004).

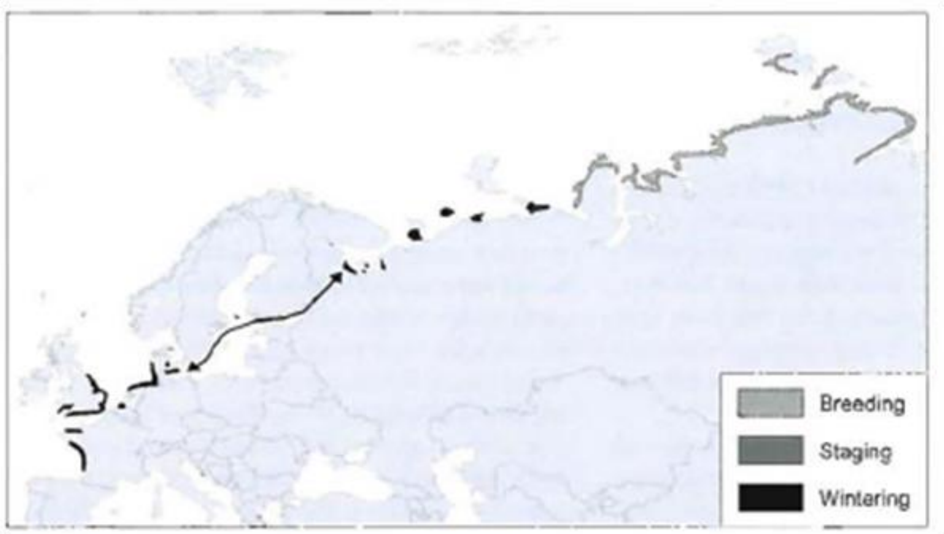

Figure 15: Flyway distribution of the Dark-bellied Brent Goose. Arrows indicate the migration route between the Baltic and the White Sea (Madsen et al. 1999)

6.2.5.2 *Conservation status*

In some cases conservation policy fails to distinguish between the different subspecies of Brent Goose. Therefore for clarity conservation status is mainly presented here at species level. Brent Goose is identified as a species of Least Concern on the IUCN Red List (IUCN 2014) and is classified as SPEC 3. The species is not designated as part of Danish conservation policy1 as only breeding species are considered. The species was categorised as a species of National Responsibility outside of the breeding season. The overall conservation status of the subspecies in Denmark has been preliminarily assessed as being favourable (Pihl et al. 2006).

Dark-bellied Brent Goose is a qualifying feature at five SPAs on the western coast of Denmark due to the presence of at least 1% of the biogeographic population occurring at these sites. These include: Ringkøbing Fjord (7.13 km south-east), Vadehavet (49.77 km south-east), Skallingen og Langli (53.61 km south-east), Mandø (87.56 km, south-east), and Rømø (95.34 km south-east).

There are eight Danish sites that meet both criteria A4 and B1 of the Important Bird Area (IBA) designation for Brent Goose. A further two IBAs, which meet only criteria B1 are also found in Denmark (Heath & Evans 2000). Three of these sites, Fanø, Rømø and Ballum og Husum Enge, Kamper strandenge, are located on the western coast of Denmark and are identified for passage populations of Brent Goose. It is likely that the latter two sites are designated for Dark-bellied Brent Goose given that they are further south on the Danish west coast. It is not known which subspecies Fanø is designated for.

6.2.5.3 *Connectivity*

Figure 16 presents yearly observations of Dark-bellied Brent Geese from Blåvand Bird Observatory located to the south of Vesterhav Syd. These observations indicate on average less than 2,000 birds are recorded from the observatory between September and October. In 2010, over 3,500 geese were observed from the observatory, although in most years it would appear that numbers are lower than this. Additional information relating to flight direction suggests that the majority of these autumn movements occur in a southerly direction.

Green et al. (2002) present GPS tracking data for eight Dark-bellied Brent Geese tracked during spring migration (Figure 17). The geese tracked followed a migratory route which passes across northern Germany between the North Sea and Baltic Sea. It is considered that this may represent the predominant migratory route of Dark-bellied Brent Goose through the Baltic, as described by Madsen (1987), and crossing from the Baltic to the North Sea across southern Jutland and northern Schleswig, Germany. As such, Dark-bellied Brent Goose is not included in the migratory birds collision risk assessment.

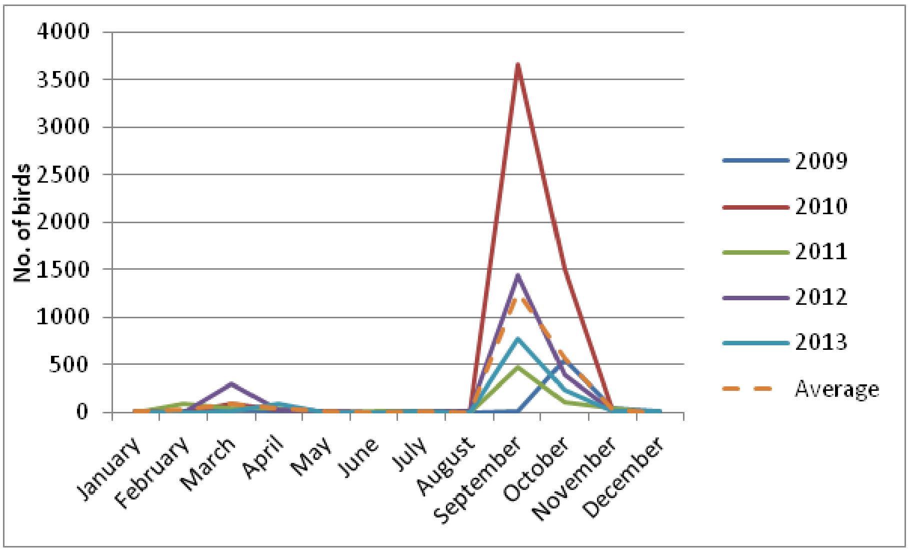

Figure 16: Monthly total passage counts of Dark-bellied Brent Goose at Blåvand Bird Observatory for each year between 2009-2013

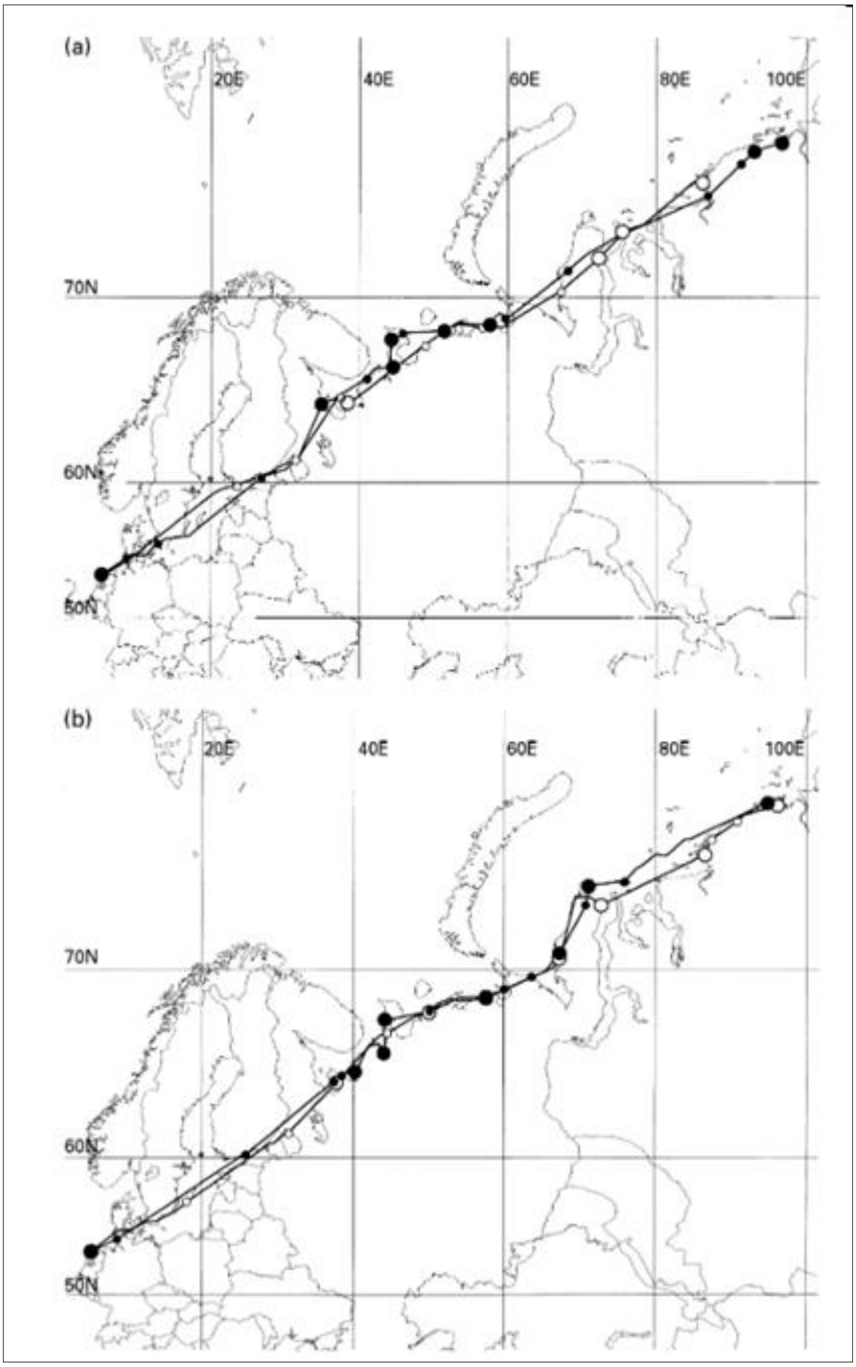

Figure 17: Spring migration tracks of four Dark-bellied Brent Geese. Symbols indicate stopover positions (Green et al. 2002).

6.2.6 *Light-bellied Brent Goose*

6.2.6.1 *Migratory population*

There are four recognised biogeographical populations of Light-bellied Brent Goose (*Branta bernicla hrota*). Three of these population breed in the Canadian Arctic and winter either in Europe, the Pacific coast of the USA or the Atlantic coast of the USA. The remaining population which is the subject of this assessment breeds in Svalbard and north-eastern Greenland and winters around the North Sea (Robinson et al. 2004). This population is estimated at 7,600 individuals (Wetlands International 2014).

The majority of birds breeding in Svalbard leave staging areas in Svalbard in September arriving in Denmark in the same month (Figure 18). However, a substantial proportion of the population also migrate directly to Lindisfarne in north-east England (Clausen et al. 2003). In spring the population concentrates in Denmark before migrating north (Wernham et al. 2002). There exist a number of important wintering areas within Denmark, primarily on the western coast of Jutland. These include the northern Danish Wadden Sea, Nissum Bredning, Agerø and Nissum Fjord (Clausen et al. 1998). Of these sites the main wintering site is Mariager-Randers Fjords although the species now disperses to more sites when compared to the early 1980s. In spring the population is concentrated at two sites in north-west Jutland, Nissum Fjord and Agerø (Clausen et al. 1998). The passage of birds south along the western coast of Jutland has been noted by Madsen (1987).

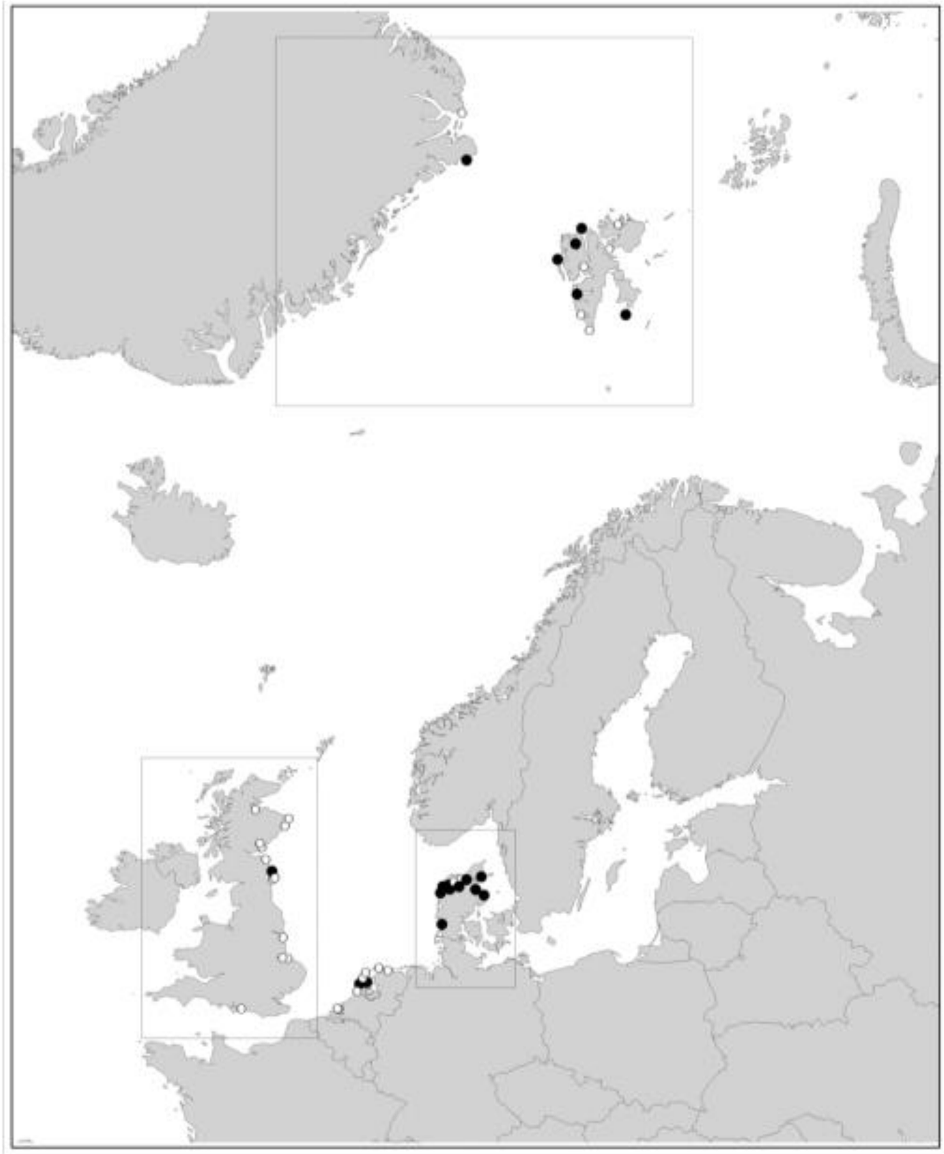

Figure 18: Flyway range of the Light-bellied Brent Goose. Regularly used sites are high-lighted with filled dots indicating possible internationally important sites (Robinson et al. 2004).

6.2.6.2 *Conservation status*

In some cases conservation policy fails to distinguish between the different subspecies of Brent Goose. Therefore for clarity conservation status is presented here at species level. Brent Goose is identified as a species of Least Concern on the IUCN Red List (IUCN 2014) and is classified as SPEC 3. The species is not designated as part of Danish conservation policy[13]. The species is categorised as a species of National Responsibility outside of the breeding season. The

[13] http://www2.dmu.dk/1_Om_DMU/2_Tvaerfunk/3_fdc_bio/projekter/redlist/gpdata_en.asp?Sortorder=NationalKategori&ID=4&mode=default#up

overall conservation status of the subspecies in Denmark has been preliminarily assessed as unfavourable-increasing (Pihl et al. 2006).

Light-bellied Brent Goose is a qualifying feature at five SPAs on the western coast of Denmark due to the presence of at least 1% of the biogeographic population occurring at these sites. These include: Nissum fjord (17.85 km north-east), Vadehavet (49.77 km south-east), Harboøre Tange (50.22 km north-east), Agger Tange (60.79 km north-east), and Fanø (64.97 km south-east).

There are eight Danish sites that meet both criteria A4 and B1 of the Important Bird Area (IBA) designation for Brent Goose. A further two IBAs, which meet only criteria B1 are also found in Denmark (Heath & Evans 2000). Three of these sites, Fanø, Rømø and Ballum og Husum Enge, Kamper strandenge, are located on the western coast of Denmark and are identified for passage populations of Brent Goose. It is likely that the latter two sites are designated for Dark-bellied Brent Goose given that they are further south on the Danish west coast, an area through which only Dark-bellied Brent Goose are likely to migrate (Figure 18).

6.2.6.3 *Connectivity*

Figure 19 presents yearly observations of Light-bellied Brent Geese from Blåvand Bird Observatory located to the south of Vesterhav Syd. These observations indicate migratory movements of Light-bellied Brent Goose occur during October although only small numbers (less than 150 birds) are recorded. Additional information relating to flight direction suggesting that the majority of these autumn movements occur in a southerly direction. It is possible hat these records represent cold weather influxes of birds to wintering areas in the Netherlands with between 3-6% of the total flyway population moving in some winters. Although there is also potential for mthese birds to relate to more locally wintering birds from the northern Danish Wadden Sea. However, up to 18% of the flyway population (approximately 1,400 birds) have been known to occur in the Netherlands with the occurrence of birds negatively correlated with daily average temperatures in Denmark (Koffijberg et al. 2013). The movement of a maximum 1,400 Light-bellied Brent Geese is not predicted to represent a significant impact on the flyway population, however, on a precautionary basis this population is included in the migratory birds collision risk assessment.

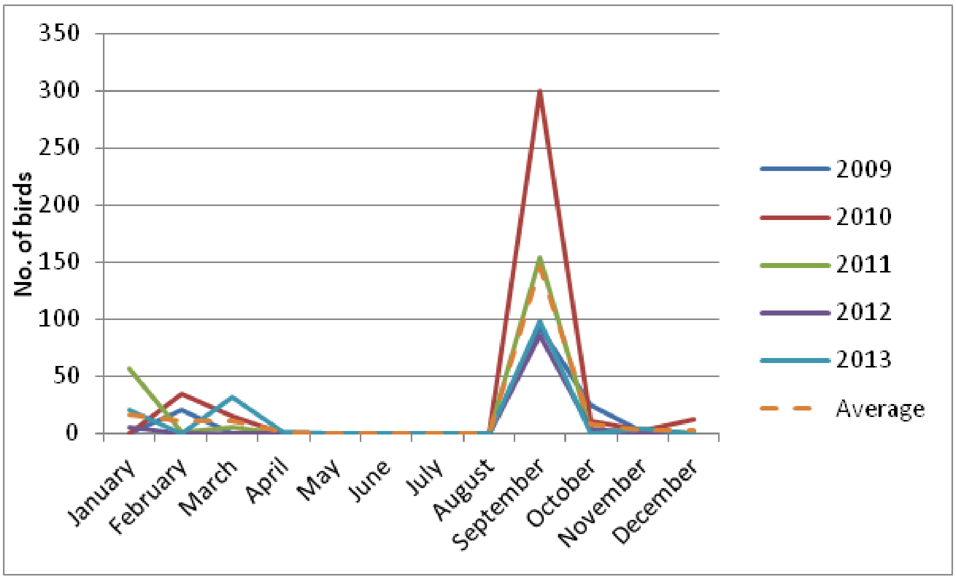

Figure 19: Monthly total passage counts of Light-bellied Brent Goose at Blåvand Bird Observatory for each year between 2009-2013

6.2.7 *Eurasian Wigeon*

6.2.7.1 *Migratory population*

The breeding population of Eurasian Wigeon in western Siberia and north-eastern Europe is split between two wintering areas, one in north-west Europe and the other in the Black Sea and Mediterranean. The wintering population in north-western Europe is estimated at 1,500,000 individuals (Wetlands International 2014). Owen and Mitchell (1988) describe the autumn and spring movements of Eurasian Wigeon from breeding grounds in Russia to wintering areas in the UK. Important staging areas for Eurasian Wigeon occur throughout the Baltic and these sites indicate the general migratory movements of the species (Owen & Mitchell 1988). Autumn passage generally occurs along Baltic and North Sea coasts with spring movements occurring overland (Donker 1959, BWPI 2009). These migratory movements are believed to occur across a broad migratory front although large numbers are observed along the German and southern Swedish coasts (Donker 1959).

Birds that winter in the UK, Ireland, the Netherlands, Belgium and France (i.e. north-west Europe) migrate through Denmark. Denmark is an important staging area for the species during both autumn and spring migration. During autumn surveys in 1987-88, 37,000-39,900 Eurasian Wigeon were recorded in west Jutland with 42,000-44,800 recorded during spring surveys in 1988-1989 (Pihl et al. 2006).

6.2.7.2 *Conservation status*

Eurasian Wigeon is identified as a species of Least Concern on the IUCN Red List (IUCN 2014). The Danish breeding population is designated as Vulnerable as part of Danish conservation policy[14] . The species was categorised as a species of National Responsibility outside of the breeding season. The overall conservation status of the species in Denmark has been preliminarily assessed as favourable (Pihl et al. 2006).

Wigeon is a qualifying feature at 16 SPAs in Denmark due to the presence of at least 1% of the biogeographic population occurring at these sites. Of these SPAs, 11 are located on the western coast of Denmark with one, Ringkøbing Fjord (7.13 km south-east), on the coast adjacent to Vesterhav Syd.

There are three Danish sites that meet both criteria A4 and B1 of the Important Bird Area (IBA) designation for Eurasian Wigeon. A further IBA, which meet only criteria B1 is also found in Denmark (Heath & Evans 2000). One of these sites, Rømø, is located on the western coast of Denmark and is identified for passage populations of Eurasian Wigeon.

6.2.7.3 *Connectivity*

Figure 20 presents yearly observations of Eurasian Wigeon from Blåvand Bird Observatory located to the south of Vesterhav Syd. These observations indicate that migratory movements of Eurasian Wigeon primarily occur during September when, on average, over 2,500 Eurasian Wigeon may be observed. Additional information relating to flight direction suggests that the majority of these autumn movements occur in a southerly direction.

It is thought that the majority of autumn migratory movements occur along the Baltic and North Sea coasts with birds observed from the German coast (BWPI 2009). However, birds have also been observed from the southern Swedish coast suggesting Eurasian Wigeon migrate across a broad migratory front (Donker 1959). Given the observations of Eurasian Wigeon from Blåvand Bird Observatory and the presence of SPAs designated for concentrations of Eurasian Wigeon in the north of Denmark, the autumn movements of the species is included in the collision risk assessment for migratory birds. Spring movements of Eurasian Wigeon occur across mainland Europe and as such it is considered that these movements exhibit no connectivity with Vesterhav Syd.

[14] http://www2.dmu.dk/1_Om_DMU/2_Tvaer-funk/3_fdc_bio/projekter/redlist/gpdata_en.asp?Sortorder=NationalKategori&ID=4&mode=default#up

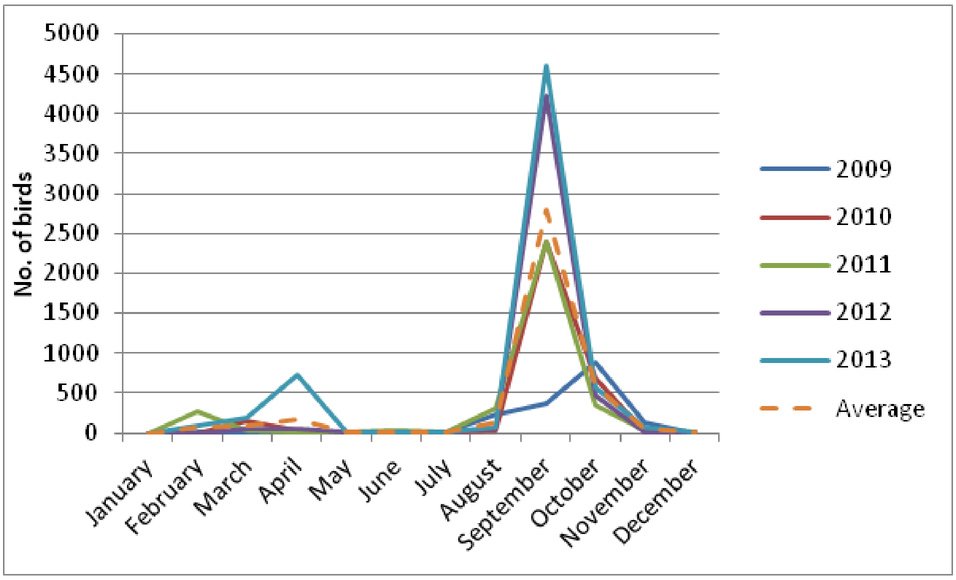

Figure 20: Monthly total passage counts of Eurasian Wigeon at Blåvand Bird Observatory for each year between 2009-2013

6.2.8 Eurasian Teal

6.2.8.1 Migratory population

The breeding range of Eurasian Teal extends Iceland, through Scandinavia to northwest Siberia and it is from those birds from the latter two areas that migrate through Denmark to wintering areas in western and southwest Europe. In Denmark, birds stage during autumn and spring migration, with the country less important as a wintering area for the species (Wernham et al. 2002, Pihl et al. 2006). During countrywide surveys undertaken in autumn in 1987 and 1988, 23,000-33,700 Eurasian Teal were recorded in Denmark. In spring, during 1988 and 1989, 10,300-26,200 Eurasian Teal were recorded. However, the autumn surveys at least, are now likely to be an underestimate as in Vejlerne, Vest Stadil Fjord and Skjern Å alone, 38,000 Eurasian Teal were recorded in November 2000 (Pihl et al. 2006). The wintering population in north-western Europe is estimated at 500,000 individuals (Wetlands International 2014).

The migration of Eurasian Teal occurs through a 'bottle-neck' formed by the Danish, German and Dutch Frisian Islands (Wolff 1966).

6.2.8.2 Conservation status

Eurasian Teal is identified as a species of Least Concern on the IUCN Red List (IUCN 2014). The Danish breeding population is designated as Near Threatened as part of Danish conservation policy[15]. The species was categorised as a species of National Responsibility outside of the breeding season. The overall con-

[15] http://www2.dmu.dk/1_Om_DMU/2_Tvaer-funk/3_fdc_bio/projekter/redlist/gpdata_en.asp?Sortorder=NationalKategori&ID=4&mode=default#up

servation status of the species in Denmark has been preliminarily assessed as favourable (Pihl et al. 2006).

Eurasian Teal is a qualifying feature at 14 SPAs in Denmark due to the presence of at least 1% of the biogeographic population occurring at these sites. Of these SPAs, seven are located on the western coast of Denmark with two, Stadil Fjord og Vest Stadil Fjord (4.76 km north-east) and Ringkøbing Fjord (7.13 km south-east), on the coast adjacent to Vesterhav Syd.

There are five Danish sites that meet criteria B1 of the Important Bird Area (IBA) designation for Eurasian Teal. Two of these sites, Rømø and Ballum og Husum Enge, Kamper strandenge, are located on the western coast of Denmark and are identified for passage populations of Eurasian Teal.

6.2.8.3 Connectivity

Figure 21 presents yearly observations of Eurasian Teal from Blåvand Bird Observatory located to the south of Vesterhav Syd. These observations indicate that migratory movements of Eurasian Teal occur between August and November, with approximately 500 birds recorded during September on average each year, with the spring movement of the species having been recorded in 2013. Additional information relating to flight direction associated with these observations indicate that the majority of autumn migratory movements occur in a southerly direction.

The relatively low numbers of Eurasian Teal are recorded at Blåvand Bird Observatory during autumn (and at times in spring) may reflect movements of Eurasian Teal across a broad migratory front. However, on a precautionary basis and due to a lack of information qualifying the movements of Eurasian Teal, the species is included in the migratory bird collision risk assessment.

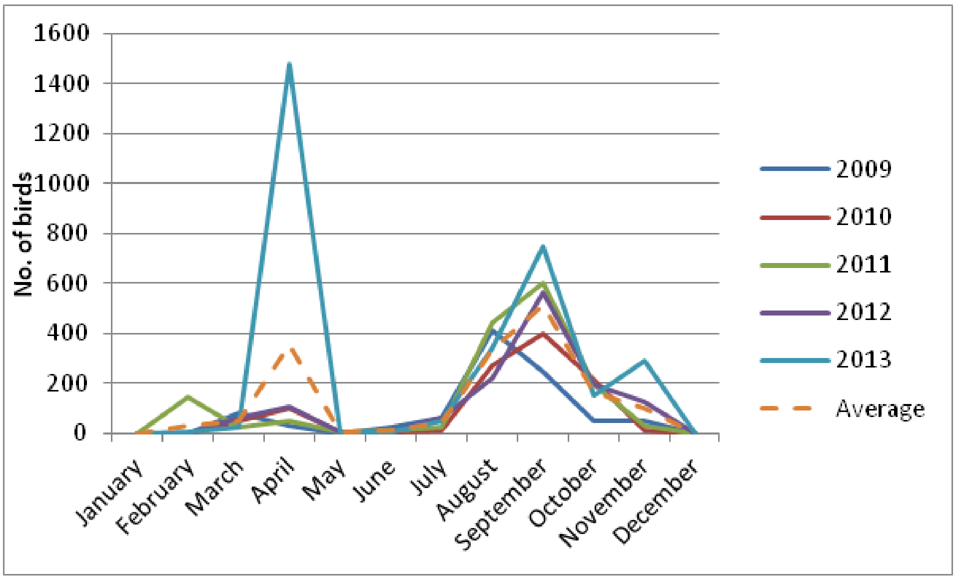

Figure 21: Monthly total passage counts of Eurasian Teal at Blåvand Bird Observatory for each year between 2009-2013

6.2.9 Northern Pintail

6.2.9.1 Migratory population

The breeding range of Northern Pintail covers a large area, across North America and Eurasia, with birds breeding in Russia and western and central Siberia migrating through Denmark to wintering areas in the Netherlands, France, the UK and even as far as north and west Africa (Delany et al. 2006) In Denmark, birds stage during both autumn and spring migration with the country less important as a wintering area for the species (Pihl et al. 2006). Incomplete countrywide surveys undertaken in 1969-73 recorded 17,800-31,500 birds in west Jutland and the Wadden Sea (Pihl et al. 2006). The wintering population in north-western Europe is estimated at 60,000 individuals (Wetlands International 2014).

6.2.9.2 Conservation status

Northern Pintail is identified as a species of Least Concern on the IUCN Red List (IUCN 2014): The Danish breeding population is designated as Vulnerable as part of Danish conservation policy[16]. The species was categorised as a species of National Responsibility outside of the breeding season. The overall conservation status of the species in Denmark has been preliminarily assessed as favourable (Pihl et al. 2006).

[16] http://www2.dmu.dk/1_Om_DMU/2_Tvaer-funk/3_fdc_bio/projekter/redlist/gpdata_en.asp?Sortorder=NationalKategori&ID=4&mode=default#up

Northern Pintail is a qualifying feature at 13 SPAs in Denmark due to the presence of at least 1% of the biogeographic population occurring at these sites. Of these SPAs, nine are located on the western coast of Denmark with two, Stadil Fjord og Vest Stadil Fjord (4.76 km north-east) and Ringkøbing Fjord (7.13 km south-east), on the coast adjacent to Vesterhav Syd.

There are five Danish sites that meet criteria B1 of the Important Bird Area (IBA) designation for Northern Pintail. Two of these sites, Fanø and Rømø, are located on the western coast of Denmark and are identified for passage populations of Northern Pintail.

6.2.9.3 *Connectivity*

Figure 22 presents yearly observations of Northern Pintail from Blåvand Bird Observatory located to the south of Vesterhav Syd. These observations indicate that migratory movements of Northern Pintail occur in September, with approximately 500 birds recorded during this month on average each year. Additional information relating to flight direction associated with these observations indicate that the majority of migratory movements occur in a southerly direction.

Although relatively low numbers of Northern Pintail are recorded at Blåvand Bird Observatory during autumn this may reflect movements of Northern Pintail across a broad migratory front. As such, on a precautionary basis and due to a lack of information qualifying the movements of Northern Pintail, the species is included in the migratory bird collision risk assessment.

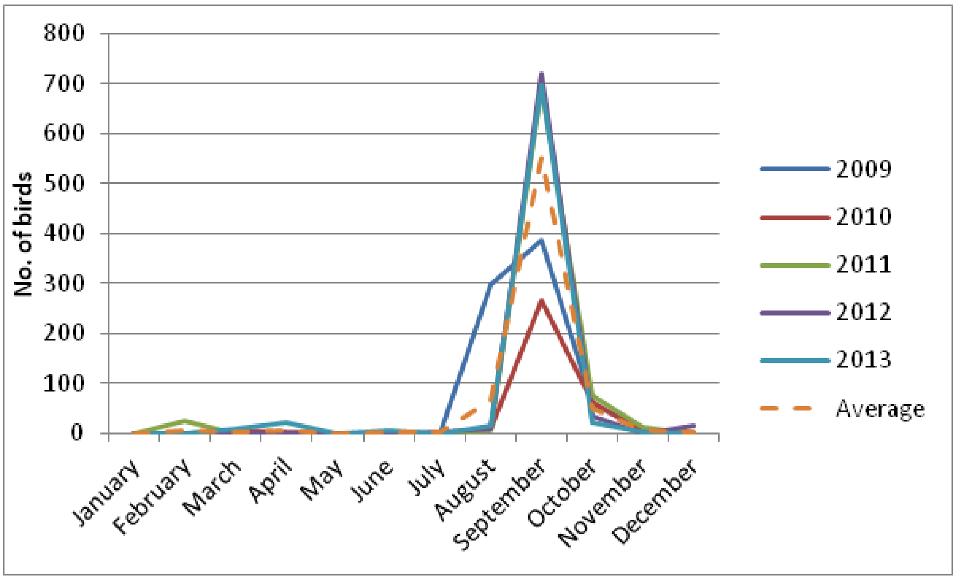

Figure 22: Monthly total observations of Northern Pintail at Blåvand Bird Observatory between 2009-2013

6.2.10 *Summary*

Table 10 presents a summary of the screening process which will be used to inform the collision risk assessment for migratory birds. This table summarises the conservation status of each species initially considered (in Section 6.2) and their potential connectivity with Vesterhav Syd and also provides information as to the migratory movements and biogeographic population sizes of those species included in the impact assessment.

Table 10: Summary of the screening process for the migratory birds collision risk assessment

Species	**Conservation status**	**Connectivity**	**Season(s) of relevance**	**Direction of flyway migration**[17]	**Flyway population (individuals) (WPE5)**	**1% criteria**
Pink-footed Goose	International IUCN Red List – Least Concern SPEC 4 (winter) - Favourable National Overall – Favourable Non-breeding season - Species of National Responsibility	**Yes** - Bird observations from Blåvand Bird Observatory indicate movement of birds along Danish west coast during autumn. Madsen *et al.* (1999) also indicates connectivity in both autumn and spring	Autumn/Spring	North-south	63,000	630

[17] Direction of migration comprises the prevailing direction of the flyway population and not local movements which may differ.

Species	Conservation status	Connectivity	Season(s) of relevance	Direction of flyway migration[17]	Flyway population (individuals) (WPE5)	1% criteria
Greylag Goose	International IUCN Red List – Least Concern National Overall – Favourable Non-breeding season - Species of National Responsibility	**Yes** - Bird observations from Blåvand Bird Observatory indicate movement of birds along Danish west coast during autumn. Madsen *et al.* (1999) also indicates connectivity.	Autumn/Spring	North-south	610,000	6,100
Barnacle Goose	International EU Birds Directive - Annex 1 IUCN Red List – Least Concern SPEC 2 (winter) - Unfavourable National Staging population – Favourable Breeding population – Near-Threatened	**Yes** - Bird observations from Blåvand Bird Observatory indicate movement of birds along Danish west coast during autumn. Eichhorn *et al.* (2006) also indicates connectivity.	Autumn/Spring	East-West	770,000	7,700

Species	Conservation status	Connectivity	Season(s) of relevance	Direction of flyway migration[17]	Flyway population (individuals) (WPE5)	1% criteria
Dark-bellied Brent Goose	International IUCN Red List – Least Concern SPEC 3 - Unfavourable National Overall – Favourable Non-breeding season - Species of National Responsibility	**No** – information indicates migration occurs across northern German following a coastal route along the Baltic and North Sea coasts	N/A	N/A	N/A	N/A
Light-bellied Brent Goose	International IUCN Red List – Least Concern SPEC 3 - Unfavourable National Overall – Unfavourable-increasing Non-breeding season - Species of National Responsibility	**Yes** - Bird observations from Blåvand Bird Observatory indicate movement of birds along Danish west coast during autumn. Madsen *et al.* (1987) also indicates connectivity.	Autumn/Spring	North-south	7,600	76

Species	Conservation status	Connectivity	Season(s) of relevance	Direction of flyway migration[17]	Flyway population (individuals) (WPE5)	1% criteria
Wigeon	International IUCN Red List – Least Concern National Overall – Unfavourable-increasing Breeding – Vulnerable Non-breeding season - Species of National Responsibility	**Yes** - Bird observations from Blåvand Bird Observatory indicate movement of birds along Danish west coast during autumn.	Autumn	East-west	1,500,000	15,000
Eurasian Teal	International IUCN Red List – Least Concern National Overall – Favourable Breeding – Near-threatened Non-breeding season - Species of National Responsibility	**Yes** - Bird observations from Blåvand Bird Observatory indicate movement of birds along Danish west coast during autumn.	Autumn/Spring	East-west	500,000	5,000

Species	Conservation status	Connectivity	Season(s) of relevance	Direction of flyway migration[17]	Flyway population (individuals) (WPE5)	1% criteria
Northern Pintail	International IUCN Red List – Least Concern National Overall – Favourable Breeding – Vulnerable Non-breeding season - Species of National Responsibility	**Yes** - Bird observations from Blåvand Bird Observatory indicate movement of birds along Danish west coast during autumn.	Autumn/Spring	East-west	60,000	600

6.3 Derivation of parameters for Collision Risk Modelling (CRM)

This section outlines the derivation of all parameters for all migratory species screened into the collision risk modelling process for Vesterhav Syd. These include:

- The flyway population;
- The proportion of the flyway population interacting with the wind farm; and
- The proportion of birds at collision height (PCH).

This exercise therefore represents a theoretical modelling process which is distinguished from the CRM process for resting birds by a lack of site-specific information quantifying migratory movements across Vesterhav Syd. The parameters used for the CRM are derived from the scientific literature with any underlying assumptions clearly outlined.

6.3.1 Pink-footed Goose

The Svalbard/north-west Europe flyway population of Pink-footed Goose as defined by Wetlands International, has been estimated at 63,000 individuals from census based methods Wetlands International (2014).

Using data from radar trials at Walney Island (Budgey 2010), a value of the proportion of the Pink-footed Goose population potentially interacting with the Vesterhav Syd projects was calculated. The radar trial indicated that identified goose skein tracks declined on a distinct gradient from nearshore to offshore areas. However, doubts have been raised on the effectiveness of skein detectability with increasing distance. The radar work indicated that 88% of flightlines were within 6 km of the shore or overland and 57% were within 3 km or overland. The closest turbine at the Vesterhav Syd is over 4 km from the shore. Therefore a precautionary 40% of birds are predicted to have potential to interact with Vesterhav Syd giving a population of 25,200 individuals. This population is considered to be suitably precautionary recognising the likely flocking behaviour of geese and evidence from radar tracking that geese may migrate inshore of Vesterhav Syd (Budgey 2010).

The likely migratory flight height of Pink-footed Geese was derived from a study by Walney Bird Observatory (2006) which recorded the flight heights of 4,843 geese; 41.4% of geese were recorded flying at a height no greater than 20 m, with 58.3% recorded flying at heights of 30-150 m. However, offshore studies suggest that for some wind farms as few as 10% of goose flocks will fly at PCH through a constructed wind farm (Plonczkier & Simms 2012). A PCH value of 30% of birds at PCH is used, sourced from Wright *et al.* (2012) and considered appropriate for the Vesterhav Syd assessment.

6.3.2 Greylag Goose

The north-west Europe/south-west Europe population of Greylag Goose, as defined by Wetlands International, has been estimated at 610,000 individuals using census based methods (Wetlands International 2014). However, evidence from Madsen et al. (1999) which presents the September distribution of Greylag Geese in north-western Europe (Figure 8), suggests that the majority of this population will not interact with Vesterhav Syd. As outlined above (Section 6.2.3), the flyway population follows two migratory pathways with only those birds from Norway likely to interact with Vesterhav Syd. This has been illustrated by the Nordic Greylag Goose project that have summarized ringing and recovery areas from Norway, Södermanland, south-west Scania and Hornborgasjön (Figure 23). Based on these data only those birds from Norway are considered within this assessment to exhibit connectivity with Vesterhav Syd.

The Norwegian breeding population was estimated at 10,000-12,000 pairs in 2002 but with an increasing trend (BWPI 2009). Data collected by the National Environmental Research Institute (NERI) in Denmark indicated that there are more than 50,000 birds present staging in west Jutland (i.e. the Norwegian population) in September (Pihl et al. 2006). As such, it is this population which is used as the population that has the potential to interact with Vesterhav Syd.

This population is considered to be suitably precautionary recognising the likely flocking behaviour of geese and evidence from radar tracking that geese may migrate inshore of Vesterhav Syd (Budgey 2010).

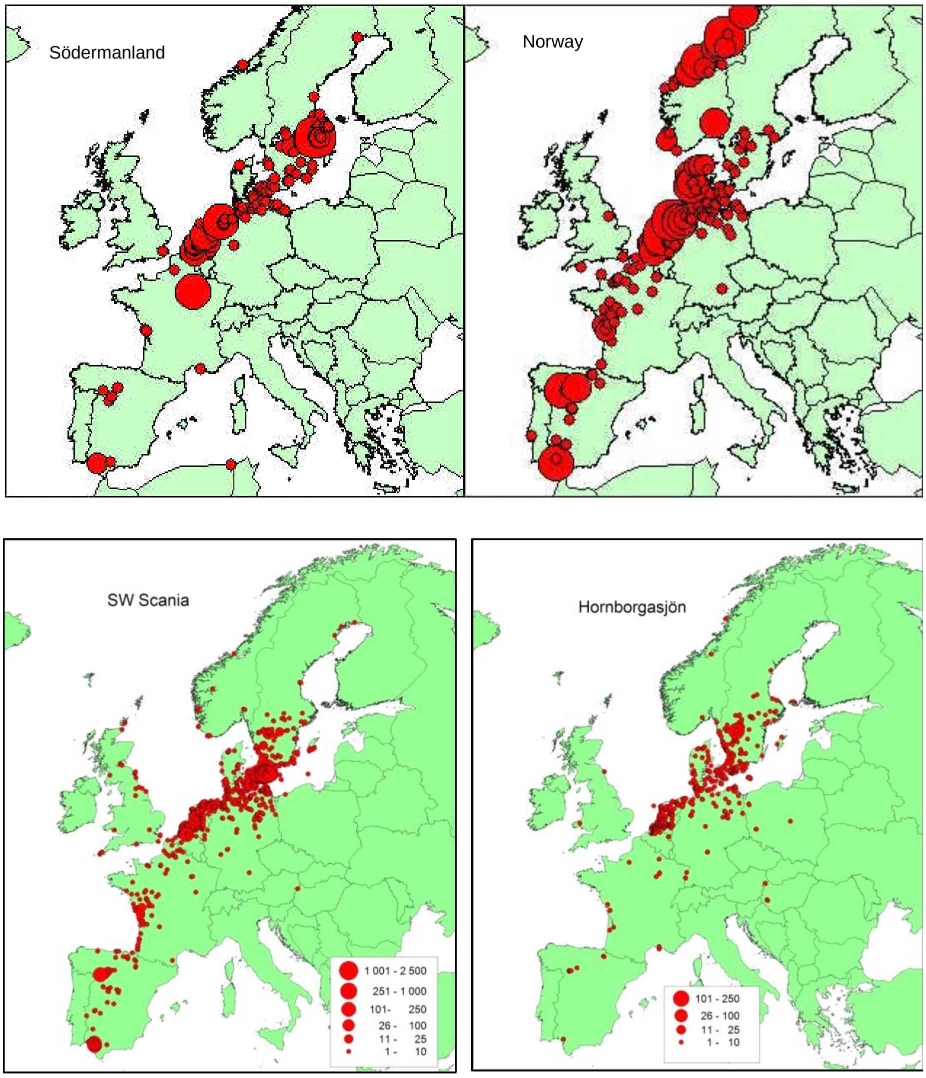

Figure 23: All re-sightings of neck-collared Greylag Geese marked in four different breeding areas (Södermanland, Norway, south-west Scania and Hornborgasjön) [18]

No information specific to the migratory flight height of Greylag Goose was located within the literature. However, surveys undertaken at Horns Rev 3 offshore wind farm provide an indication as to the likely flight heights of this species (Jensen et al. 2014). A total of 5,136 geese of six species were recorded as part of baseline surveys at Horns Rev 3 incorporating offshore and onshore surveys. However, only Pink-footed Goose and Greylag Goose were recorded during offshore surveys. Flight heights of 376 birds were recorded with approximately

[18] Maps sourced from http://www.zoo.ekol.lu.se/waterfowl/nordgas/Migrations.htm

34% recorded between 30-110 metres and similar percentage recorded flying below 5 metres. Less than 10% of birds recorded were between 5-30 metres with the rest of the birds recorded over PCH. Based on this information a precautionary value of 40% was used for the proportion of Greylag Geese at collision height with respect to Vesterhav Syd.

6.3.3 Barnacle Goose

The Western Siberia/Western Europe flyway population of Barnacle Goose is estimated at 770,000 individuals using census based methods (Wetlands International 2014).

It is unlikely that a significant proportion of the flyway population of Barnacle Goose exhibits connectivity with Vesterhav Syd, with tracking studies show the majority of movements occur over northern Germany and southern Denmark. However, the number of birds recorded from Blåvand Bird Observatory do warrant the inclusion of Barnacle Goose in this assessment. Madsen et al. (1999) identify three staging sites in Denmark that regularly support more than 1,000 staging Barnacle Geese. Two of these, Margrethekog/Tøndermarsken and Ballum Enge/Forland are situated to the south of Vesterhav Syd near the Danish-German border. The third site is on the island of Møn in eastern Denmark. There are three additional sites in the region of Vesterhav Syd that support smaller numbers of Barnacle Geese including: Ringkøbing Fjord SPA, on the coast adjacent to Vesterhav Syd (Figure 12) which is designated for a concentration population of 780-2,634 individuals; Nissum Fjord which is designated for a concentration population of 2,500-10,000 individuals; and Stadil Fjord og Vest Stadil Fjord, designated for a concentration population of 7,250-15,000 individuals. Madsen et al. (1999) indicate that up to 20,000 Barnacle Geese now overwinter in Denmark and although these geese may not exhibit connectivity with Vesterhav Syd, it is considered that this is a precautionary population to use within collision risk modelling. This population is also considered to be more precautionary than if it were assumed Barnacle Geese were evenly distributed across a migratory front spanning the eastern North Sea coast between Ringkøbing Fjord and the German coast.

The mean and median flight height of Barnacle Geese migrating between Svalbard and the UK, flying over water was recorded by Griffin et al. (2011) as 81 m and 16 m, respectively with a modal flight band of 0-20 m. This indicates that the number of Barnacle Geese flying at collision height may be relatively low. Wright et al. (2012), which assessed the risk of offshore wind farm development on migratory birds reviewing available information on over-sea migration routes, timings and flight heights of migrating birds, suggests a PCH value of 30%. This is considered a suitably precautionary value for use within collision risk modelling for Barnacle Goose.

6.3.4 *Light-bellied Brent Goose*

The Svalbard/Denmark & UK flyway population of Light-bellied Brent Goose is estimated at 7,600 individuals (Wetlands International 2014). In autumn between 50-75% of this population migrate to Danish wintering areas with the remaining population migrating to Lindisfarne on the English North Sea coast (Pihl et al. 2006). However, in spring the whole population stages at five or six sites all of which are located in Denmark. A proportion of the Light-bellied Brent Goose flyway population has been known to occur in the Netherlands with the magnitude of occurrence negatively correlated with the daily average temperature in Denmark. Up to 18% of the flyway population has been known to occur in the Netherlands representing approximately 1,400 individuals that may exhibit connectivity with Vesterhav Syd (Koffijberg et al. 2013). As such, this population is used to represent the population that may interact with Vesterhav Syd.
This population is considered to be suitably precautionary recognising the likely flocking behaviour of geese and evidence from radar tracking that geese may migrate inshore of Vesterhav Syd (Budgey 2010).

An indication as to the flight height of Light-bellied Brent Goose was obtained from Clausen et al. (2003). This study presents unpublished data relating to the flight height of 4,512 geese. The flight height of 75% of these geese was recorded below 10 metres. Clausen et al. (2003) use these data to assume that geese fly at sea level however, for this assessment a precautionary value of 25% is used for the proportion of geese at collision height. Precaution is required as further information relating to these geese, including whether these data pertain to migratory movements, is not presented.

6.3.5 *Eurasian Wigeon*

The Western Siberia & NE Europe/NW Europe flyway population of Eurasian Wigeon is estimated at 1,500,000 individuals (Wetlands International 2014). There is limited information as to the migratory movements of Eurasian Wigeon. However, as in Section 6.2.7 it has been shown that autumn and spring movement follow different routes (Owen & Mitchell 1988). The median recovery positions of Eurasian Wigeon that migrate to the UK and Ireland are presented in Owen and Mitchell (1988). These recoveries suggest a more southerly return route which takes birds through continental Europe. As such, it is considered that this migratory route exhibits no connectivity with Vesterhav Syd. Therefore the number of transits within the CRM is changed to one to reflect this.

There is evidence to suggest that the migratory movements of Eurasian Wigeon in autumn are concentrated along the Baltic and North Sea coasts with birds having been observed from the German and south Swedish coast (BWPI 2009). However, observations of birds from Blåvand bird observatory and the presence of staging populations of the species at SPAs in the north of Denmark suggest that the migratory movements of Eurasian Wigeons also occur across northern Denmark. Therefore, due to a lack of data to allow quantification of autumn movements, it is assumed that the flyway population of Eurasian Wigeon is evenly distributed across a broad migratory front from the southern coast of Norway to the North Sea coast of Germany, passing through Vesterhav Syd (518 km). The proportion of the migratory front represented by Vesterhav Syd (15.6 km) is then determined to calculate the proportion of the flyway population likely to interact with Vesterhav Syd (3.01%). This provides a population of 45,186 birds with potential to interact with Vesterhav Syd.

Given the likely concentration of birds towards the North Sea coast of Germany (Donker 1959, Owen & Mitchell 1988) this reference population estimate taken forward into the migratory CRM for Vesterhav Syd represents a precautionary assessment of the number of Eurasian Wigeon interacting with Vesterhav Syd. As such, 45,186 birds is used as a maximum population with lower population estimates also modelled and presented.

Wright et al. (2012) assessed the risk of offshore wind farm development on migratory birds reviewing available information on over-sea migration routes, timings and flight heights of migrating birds. Guidance provided within Wright et al. (2012) suggests a generic PCH value of 15% be used for duck species, although a range of 0.1 to 60% is also presented. What is considered a suitably precautionary PCH of 15% is taken forward for use in CRM for Eurasian Wigeon.

Observations of Eurasian Wigeon during baseline surveys at Neart na Gaoithe offshore wind farm showed that the species generally flies below rotor height (22.5 metres, Natural Research Projects and Cork Ecology 2012), further supporting the PCH value presented in Wright et al. (2012).

6.3.6 *Eurasian Teal*

The North-West Europe flyway population of Eurasian Teal is estimated at 500,000 individuals (Wetlands International 2014). Sites in Denmark are used for staging on both autumn and spring migration with SPAs designated for concentrations of Eurasian Teal located along the western coast of Jutland. This suggests that movements of Eurasian Teal occur across a broad migratory front.

It is assumed, for the purposes of this assessment, that the flyway population of Eurasian Teal is evenly distributed across a broad migratory front from the southern coast of Norway to the North Sea coast of Germany, passing through Vesterhav Syd (518 km). The proportion of the migratory front represented by Vesterhav Syd (15.6 km) is then determined to calculate the proportion of the flyway population likely to interact with Vesterhav Syd (3.01%). This provides a population of 15,062 birds with potential to interact with Vesterhav Syd.

Wright et al. (2012) assessed the risk of offshore wind farm development on migratory birds reviewing available information on over-sea migration routes, timings and flight heights of migrating birds. Guidance provided within Wright et al. (2012) suggests a generic PCH value of 15% be used for duck species, although a range of 0.1 to 60% is also presented. What is considered a suitably precautionary PCH of 15% is taken forward for use in CRM for Eurasian Teal.

Observations of Eurasian Teals during baseline surveys at Hornsea Project 1 offshore wind farm indicate that Eurasian Teal generally fly below rotor height. Of 38 birds recorded during boat-based surveys all were below 22.5 metres (SMartWind 2013). This further supports the use of the PCH value presented in Wright et al. (2012).

6.3.7 *Northern Pintail*

The North-West Europe flyway population of Northern Pintail is estimated at 60,000 individuals (Wetlands International 2014). The movements of this species from Russian breeding areas to wintering areas in the Netherlands, north-west France, the UK and as far as north and west Africa suggest movements may be concentrated on the North Sea coast with birds crossing north Germany. However, there are SPAs designated for concentrations of Northern Pintail located along the western coast of Jutland. This suggests that movements of Northern Pintail may occur across a more broad migratory front.

It is assumed, for the purposes of this assessment, that the flyway population of Northern Pintail is evenly distributed across a broad migratory front from the southern coast of Norway to the North Sea coast of Germany, passing through Vesterhav Syd (518 km). The proportion of the migratory front represented by Vesterhav Syd (15.6 km) is then determined to calculate the proportion of the flyway population likely to interact with Vesterhav Syd (3.01%). This provides a population of 1,807 birds with potential to interact with Vesterhav Syd.

Wright et al. (2012) assessed the risk of offshore wind farm development on migratory birds reviewing available information on over-sea migration routes, timings and flight heights of migrating birds. Guidance provided within Wright et al. (2012) suggests a generic PCH value of 15% be used for duck species, although a range of 0.1 to 60% is also presented. What is considered a suitably precautionary PCH of 15% is taken forward for use in CRM for Northern Pintail.

6.3.8 *Summary of species specific CRM parameters*

Table 11 presents the migratory flyway populations considered likely to interact with Vesterhav Syd and the PCH values to be used in the collision risk assessments of the five migratory species included in this assessment.

Table 11: Collision risk modelling parameters for the six species included in the migratory birds collision risk assessment

Species	Flyway population (individuals)	Population likely to interact (Individuals)	PCH (%)
Pink-footed Goose	63,000	25,200	30
Greylag Goose	610,000	50,000	40
Barnacle goose	770,000	20,000	30
Light-bellied Brent Goose	7,600	1,400	25
Wigeon	1,500,000	45,186	15
Eurasian Teal	500,000	15,062	15
Northern Pintail	60,000	1,807	15

Flyway populations range from 1,500,000 individuals (Eurasian Wigeon) to 7,600 individuals (Light-bellied Brent Goose). PCH values range from 15% (Eurasian Wigeon and Eurasian Teal) to 40% (Greylag Goose).

Based on the assumptions and methods of data analyses described in Sections 4.1 and 4.2, collision risk modelling was performed for the identified relevant species.

6.3.9 *Migratory seabirds*

The interacting population of each species considered for collision risk modelling is presented in Table 12. These populations represent the peak population from Blåvand.

Interacting populations were calculated for both the spring and autumn migratory periods. On a precautionary basis data from all months were incorporated into the calculation with data from January to June considered to represent spring migratory movements and data from July to December considered to represent autumn migratory movements. To ensure these populations only represented migrating birds, observations were restricted to those birds flying either north or south

Table 12: Interacting populations of species considered for collision risk modelling

Species	Interacting population		
	Spring	Autumn	Average (population used for modelling)
Common Eider	4,038	3,176	3,607
Common Scoter	18,131	105,817	61,974
Red-breasted Merganser	275	721	498
Red-throated Diver	2,948	3,718	3,333
Arctic Skua	36	263	150
Kittiwake	314	1,767	1,041
Black-headed Gull	1,317	10,619	5,968
Little Gull	123	1,585	854
Common Gull	1,729	3,571	2,650
Lesser Black-backed Gull	139	6,507	3,323
Herring Gull	3,000	640	1,820
Great Black-backed Gull	239	2,718	1,479
Sandwich Tern	1,504	4,983	3,244
Common Tern	401	2,994	1,698
Arctic Tern	235	2,175	1,205

For use within collision risk modelling these populations were averaged and the number of transits set to two representing both spring and autumn movements. Table 13 outlines species-specific parameters incorporated into the collision risk models.

Table 13: Species-specific modelling parameters used for collision risk modelling of migratory seabirds

Species	Bird length (m) [19]	Wingspan (m) [19]	Bird speed (m/s) [20]	Flapping or gliding	PCH (%) [21]	Avoidance rate
Common Eider	0.60	0.94	19.0	Flapping	26.5	98

[19] Robinson *et al.* (2005)

[20] Pennycuick *et al.* (2013), Alerstam *et al.* (2007)

[21] Johnston *et al.* (2014),

Species	Bird length (m) [19]	Wingspan (m) [19]	Bird speed (m/s) [20]	Flapping or gliding	PCH (%) [21]	Avoidance rate
Common Scoter	0.49	0.84	22.1	Flapping	0.9	98
Red-breasted Merganser	0.55	0.78	20.0	Flapping	*5.0*	98
Red-throated Diver	0.61	1.11	20.6	Flapping	3.5	98
Arctic Skua	0.44	1.18	13.8	Flapping	1.3	98
Kittiwake	0.39	1.08	13.1	Flapping	10.2	98
Black-headed Gull	0.36	1.05	11.4	Flapping	9.4	98
Little Gull	0.26	0.78	11.5	Flapping	10.3	98
Common Gull	0.41	1.20	12.9	Flapping	16.2	98
Lesser Black-backed Gull	0.58	1.42	14.4	Flapping	21.9	98
Herring Gull	0.60	1.44	13.4	Flapping	25.4	98
Great Black-backed Gull	0.71	1.58	13.7	Flapping	26.0	98
Sandwich Tern	0.38	1.00	*11.0* [22]	Flapping	4.1	98
Common Tern	0.33	0.88	11.0	Flapping	4.4	98
Arctic Tern	0.34	0.80	10.9	Flapping	2.1	98

A PCH value is unavailable for Red-breasted Merganser, therefore a precautionary 5% PCH value is used based on the sensitivity of the species to collision risk impacts presented in Langston (2010). The sensitivity of red-breasted merganser is similar to that of other diving ducks within Langston (2010) and therefore a low PCH value is deemed appropriate.

[22] The flight speed of Common Tern has been used for Sandwich Tern as no species specific value is available

7 IMPACT ASSESSMENT DURING INSTALLATION

7.1 Introduction

The impact assessment beyond the calculation of collision risk modelling defines several criteria which are species or impact specific including the importance of the species in terms of conservation status and occurrence within the wind farm area, persistence of the impact, likelihood of the impact occurring on a given population. These criteria then able the definition of the magnitude of the impact as described in Section 0).

This report also considers the potential impacts of barrier effects of the populations of migratory birds. The assessment of barrier effects is contained within Section 8.3, although information within 6.3 is also relevant in determining those species included in the assessment of barrier effects.

The assessment of barrier effects follows the same process as used for other sections of this report, using the same criteria to determine the magnitude of the impact.

7.2 Impact assessment on migrating birds during installation

Collision risk within this assessment strictly refers to collision with moving turbine rotors only. Therefore the assessment of collision risk only applies during the operational phase of Vesterhav Syd. The probability of collision impacts arising with other structures within the wind farm footprint or vessels during the installation, operation and decommissioning phases has been considered separately in Table 14. For the latter tabulated assessment the same suite of species is assessed as for collision with moving turbine rotors only. The impact of construction vessels is limited to a relatively small area for a limited time period and the number of collisions is expected to be very low.

During all periods (installation, operation and decommissioning) the magnitude the impact of collision with structures other than turbines on migrating birds is rated as no greater than **Minor**. Even though collisions with e.g. vessels will most probably be an exceptional event (therefore rating “Degree of disturbance” and “Likelihood of occurrence” rated as **Low**) a rating as “Negligible/neutral/no impact” is prevented for those species rated as either of international, national or local importance (abundance and protection status) and the permanent persistence of a collision (death of the bird).

Table 14: The assessment of the maximum collision impacts arising with vessels or structures other than moving turbine rotors within the wind farm footprint for all species considered in this assessment during construction, operation and decommissioning at Vesterhav Syd

Phase	Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
Construction	Low	International	Low	Permanent	Minor
Operation	Low	International	Low	Permanent	Minor
Decommissioning	Low	International	Low	Permanent	Minor

In parallel with collision, barrier effects in the installation phase are not considered to be significant, being limited in their temporal and geographical extents. Barrief effects in all phase of the development are summarised in Table 47.

7.3 Total impacts

The magnitude of impacts during the installation of the wind farm is rated as **Minor**.

8 IMPACT ASSESSMENT DURING OPERATION

8.1 Results of collision risk modelling

8.1.1 Pink-footed Goose

8.1.1.1 Overview

Table 15 presents collision risk estimates for Pink-footed Goose using those parameters outlined in Table 11 which were informed by expert judgement and literature review. The number of collisions predicted for Pink-footed Goose, at a 99% avoidance rate, was predicted to be 7.7 migratory period collisions per annum using the worst case 3 MW turbine scenario. Using the 10 MW turbine scenario, 3.2 migratory collisions per annum are predicted at a 99% avoidance rate.

Table 15: Collision risk modelling results for Pink-footed Goose based on parameters deemed to be appropriately precautionary.

Avoidance rate (%)	Turbine model	
	3MW	10MW
95	38.5	16.0
98	15.4	6.4
99	**7.7**	**3.2**
99.8	1.5	0.6
99.99	0.1	0.0

Due to the precautionary nature of the assessment and the level of assumption associated with the parameters related to the flyway population (e.g. interacting population and PCH) the following two sections present collision risk estimates incorporating a range of values for both the interacting population and PCH.

8.1.1.2 Proportion of Pink-footed Goose population interacting with Vesterhav Syd

By altering the proportion of the Pink-footed Goose population interacting with the wind farm when using the worst case 3 MW turbine scenario, collision risk modelling calculated collision rates of 1.0-19.2 migratory period collisions per annum at an avoidance rate of 99% (Table 16). Even at levels of 100% of the flyway population interacting with Vesterhav Syd, collision risk estimates (19.2 migratory period collisions per annum) do not breach the 1% threshold of the flyway population. Assuming a worst case scenario (100% interacting population at a 95% avoidance rate) for which 96.1 collisions per annum are predicted, the PBR at Rf=1.0 is not surpassed (nor is the 1% threshold of the flyway population).

Table 16: Collision risk modelling results (collisions/annum) for variable proportions of the population of Pink-footed Goose interacting with Vesterhav Syd when using the worst case 3 MW turbine scenario.

Avoidance rate (%)	**Proportion of interacting population interacting with Vesterhav Syd (%)**										
	5	10	20	30	**40**	50	60	70	80	90	100
95	4.8	9.6	19.2	28.8	**38.5**	48.1	57.7	67.3	76.9	86.5	96.1
98	1.9	3.8	7.7	11.5	**15.4**	19.2	23.1	26.9	30.8	34.6	38.5
99	**1.0**	**1.9**	**3.8**	**5.8**	**7.7**	**9.6**	**11.5**	**13.5**	**15.4**	**17.3**	**19.2**
99.8	0.2	0.4	0.8	1.2	**1.5**	1.9	2.3	2.7	3.1	3.5	3.8
99.99	0.0	0.0	0.0	0.1	**0.1**	0.1	0.1	0.1	0.2	0.2	0.2

8.1.1.3 Proportion of Pink-footed Geese at collision height

The results of collision risk modelling for Pink-footed Goose incorporating a range of PCH values are shown in Table 17. Collision risk estimates range from 2.6-25.6 migratory period collisions per annum at an avoidance rate at 99%. If 100% of birds passing through the wind farm were at potential collision height 25.6 migratory period collisions per annum are predicted which does not breach the PBR at Rf=1.0 (nor the 1% threshold of the flyway population). Even assuming a worst case avoidance rate of 95%, which predicts a total of 128.2 migratory period collisions per annum the PBR is still not surpassed.

Table 17: Collision risk modelling results (collisions/annum) for variable proportions of Pink-footed Goose at collision height when using the worst case 3 MW turbine scenario.

Avoidance rate (%)	Proportion of population at collision height (%)									
	10	20	**30**	40	50	60	70	80	90	100
95	12.8	25.6	**38.5**	51.3	64.1	76.9	89.7	102.6	115.4	128.2
98	5.1	10.3	**15.4**	20.5	25.6	30.8	35.9	41.0	46.2	51.3
99	**2.6**	**5.1**	**7.7**	**10.3**	**12.8**	**15.4**	**17.9**	**20.5**	**23.1**	**25.6**
99.8	0.5	1.0	**1.5**	2.1	2.6	3.1	3.6	4.1	4.6	5.1
99.99	0.0	0.1	**0.1**	0.1	0.1	0.2	0.2	0.2	0.2	0.3

8.1.1.4 *Conclusion*

Based on the parameter assumptions as detailed in Section 6.3, a total of 7.7 migratory period collisions per annum is taken forward for the impact assessment for the Svalbard/north-west Europe flyway population of Pink-footed Goose.

8.1.2 *Greylag Goose*

8.1.2.1 *Overview*

Table 18 presents collision risk estimates for Greylag Goose using those parameters outlined in Table 11 which were informed by expert judgement and literature review. The number of collisions predicted for Greylag Goose, at a 99% avoidance rate, was predicted to be 20.9 collisions per annum using the worst case 3 MW turbine scenario. A total of 8.6 collisions per annum are predicted at a 99% avoidance for the 10 MW scenario.

Table 18: Collision risk modelling results for Greylag Goose based on parameters deemed to be appropriately precautionary.

Avoidance rate (%)	Turbine model	
	3MW	**10MW**
95	104.4	43.1
98	41.8	17.2
99	**20.9**	**8.6**
99.8	4.2	1.7
99.99	0.2	0.1

Due to the precautionary nature of the assessment and the level of assumption associated with the parameters related to the flyway population (e.g. interacting population and PCH) the following two sections present collision risk estimates incorporating a range of values for both the interacting population and PCH.

8.1.2.2 *Proportion of Greylag Goose population interacting with Vesterhav Syd*

By altering the proportion of the Greylag Goose population interacting with the wind farm when using the worst case 3 MW turbine scenario, collision risk modelling calculated collision rates of 4.2-41.8 collisions per annum at an avoidance rate of 99% (Table 19). Even at a population size double that considered to interact with Vesterhav Syd, collision risk estimates (41.8 collisions per annum) PBR at Rf=1.0 is not surpassed (nor is the 1% threshold of the flyway population). Assuming a worst case scenario (200% interacting population at a 95% avoidance rate) for which 208.8 migratory period collisions per annum are predicted, the PBR is still not surpassed.

Table 19: Collision risk modelling results (collisions/annum) for variable proportions of the population of Greylag Goose interacting with Vesterhav Syd when using the worst case 3 MW turbine scenario.

Avoidance rate (%)	**Proportion of interacting population interacting with Vesterhav Syd (%)**									
	20	40	60	80	**100**	120	140	160	180	200
95	20.9	41.8	62.6	83.5	**104.4**	125.3	146.1	167.0	187.9	208.8
98	8.4	16.7	25.1	33.4	**41.8**	50.1	58.5	66.8	75.2	83.5
99	**4.2**	**8.4**	**12.5**	**16.7**	**20.9**	**25.1**	**29.2**	**33.4**	**37.6**	**41.8**
99.8	0.8	1.7	2.5	3.3	**4.2**	5.0	5.8	6.7	7.5	8.4
99.99	0.0	0.1	0.1	0.2	**0.2**	0.3	0.3	0.3	0.4	0.4

8.1.2.3 *Proportion of Greylag Geese at collision height*

The results of collision risk modelling for Greylag Goose incorporating a range of PCH values are shown in Table 20. Collision risk estimates range from 5.2-52.2 collisions per annum at an avoidance rate at 99%. If 100% of birds passing through the wind farm were at potential collision height 52.2 collisions per annum are predicted which does not surpass the PBR at Rf=1.0 (nor the 1% threshold of the flyway population). Even assuming a worst case avoidance rate of 95%, which predicts a total of 261.0 migratory period collisions per annum the PBR is still not surpassed.

Table 20: Collision risk modelling results (collisions/annum) for variable proportions of Greylag Goose at collision height when using the worst case 3 MW turbine scenario

Avoidance rate (%)	Proportion of population at collision height (%)									
	10	20	30	**40**	50	60	70	80	90	100
95	26.1	52.2	78.3	**104.4**	130.5	156.6	182.7	208.8	234.9	261.0
98	10.4	20.9	31.3	**41.8**	52.2	62.6	73.1	83.5	93.9	104.4
99	**5.2**	**10.4**	**15.7**	**20.9**	**26.1**	**31.3**	**36.5**	**41.8**	**47.0**	**52.2**
99.8	1.0	2.1	3.1	**4.2**	5.2	6.3	7.3	8.4	9.4	10.4
99.99	0.1	0.1	0.2	**0.2**	0.3	0.3	0.4	0.4	0.5	0.5

8.1.2.4 *Conclusion*

Based on the parameter assumptions as detailed in Section 6.3, a total of 20.9 migratory period collisions per annum is taken forward for the impact assessment for the north-west Europe/south-west Europe flyway population of Greylag Goose.

8.1.3 *Barnacle Goose*

8.1.3.1 *Overview*

Table 21 presents collision risk estimates for Barnacle Goose using those parameters outlined in Table 11 which were informed by expert judgement and literature review. The number of collisions predicted for Barnacle Goose, at a 99% avoidance rate, was predicted to be 5.6 collisions per annum using the worst case 3 MW turbine scenario. A total of 2.4 collisions per annum are predicted at a 99% avoidance for the 10 MW scenario.

Table 21: Collision risk modelling results for Barnacle Goose based on parameters deemed to be appropriately precautionary.

Avoidance rate (%)	Turbine model	
	3MW	**10MW**
95	28.1	11.8
98	11.3	4.7
99	**5.6**	**2.4**
99.8	1.1	0.5
99.99	0.1	0.0

Due to the precautionary nature of the assessment and the level of assumption associated with the parameters related to the flyway population (e.g. interacting population and PCH) the following two sections present collision risk estimates incorporating a range of values for both the interacting population and PCH.

8.1.3.2 *Proportion of Barnacle Goose population interacting with Vesterhav Syd*

By altering the proportion of the Barnacle Goose population interacting with the wind farm when using the worst case 3 MW turbine scenario, collision risk modelling calculated collision rates of 1.1-11.3 collisions per annum at an avoidance rate of 99% (Table 22). Even at a population size double that considered to interact with Vesterhav Syd, collision risk estimates (11.3 collisions per annum) PBR at Rf=1.0 is not surpassed (nor is the 1% threshold of the flyway population). Assuming a worst case scenario (200% interacting population at a 95% avoidance rate) for which 56.3 migratory period collisions per annum are predicted, the PBR is still not surpassed.

Table 22: Collision risk modelling results (collisions/annum) for variable proportions of the population of Barnacle Goose interacting with Vesterhav Syd when using the worst case 3 MW turbine scenario.

Avoidance rate (%)	**Proportion of interacting population interacting with Vesterhav Syd (%)**									
	20	40	60	80	**100**	120	140	160	180	200
95	5.6	11.3	16.9	22.5	**28.1**	33.8	39.4	45.0	50.7	56.3
98	2.3	4.5	6.8	9.0	**11.3**	13.5	15.8	18.0	20.3	22.5
99	**1.1**	**2.3**	**3.4**	**4.5**	**5.6**	**6.8**	**7.9**	**9.0**	**10.1**	**11.3**
99.8	0.2	0.5	0.7	0.9	**1.1**	1.4	1.6	1.8	2.0	2.3
99.99	0.0	0.0	0.0	0.0	**0.1**	0.1	0.1	0.1	0.1	0.1

8.1.3.3 *Proportion of Barnacle Geese at collision height*

The results of collision risk modelling for Barnacle Goose incorporating a range of PCH values are shown in Table 23. Collision risk estimates range from 1.9-18.8 collisions per annum at an avoidance rate at 99%. If 100% of birds passing through the wind farm were at potential collision height 18.8 collisions per annum are predicted which does not surpass the PBR at Rf=1.0. Even assuming a worst case avoidance rate of 95%, which predicts a total of 93.8 collisions per annum the PBR is not surpassed (nor is the 1% threshold of the flyway population).

Table 23: Collision risk modelling results (collisions/annum) for variable proportions of Barnacle Goose at collision height when using the worst case 3 MW turbine scenario

Avoidance rate (%)	Proportion of population at collision height (%)									
	10	20	**30**	40	50	60	70	80	90	100
95	9.4	18.8	**28.1**	37.5	46.9	56.3	65.7	75.1	84.4	93.8
98	3.8	7.5	**11.3**	15.0	18.8	22.5	26.3	30.0	33.8	37.5
99	**1.9**	**3.8**	**5.6**	**7.5**	**9.4**	**11.3**	**13.1**	**15.0**	**16.9**	**18.8**
99.8	0.4	0.8	**1.1**	1.5	1.9	2.3	2.6	3.0	3.4	3.8
99.99	0.0	0.0	**0.1**	0.1	0.1	0.1	0.1	0.2	0.2	0.2

8.1.3.4 ***Conclusion***

Based on the parameter assumptions as detailed in Section 6.3, a total of 5.6 collisions per annum is taken forward for the impact assessment for the north-west Europe/south-west Europe flyway population of Barnacle Goose

8.1.4 *Light-bellied Brent Goose*

8.1.4.1 *Overview*

Table 24 presents collision risk estimates for Light-bellied Brent Goose using those parameters outlined in Table 11 which were informed by expert judgement and literature review. The number of collisions predicted for Light-bellied Brent Goose, at a 99% avoidance rate, was predicted to be 0.3 collisions per annum using the worst case 3 MW turbine scenario. A total of 0.1 collisions per annum are predicted at a 99% avoidance for the 10 MW scenario.

Table 24: Collision risk modelling results for Light-bellied Brent Goose based on parameters deemed to be appropriately precautionary

Avoidance rate (%)	Turbine model	
	3MW	**10MW**
95	1.5	0.7
98	0.6	0.3
99	**0.3**	**0.1**
99.8	0.1	0.0
99.99	0.0	0.0

Due to the precautionary nature of the assessment and the level of assumption associated with the parameters related to the flyway population (e.g. interacting population and PCH) the following two sections present collision risk estimates incorporating a range of values for both the interacting population and PCH.

8.1.4.2 *Proportion of Light-bellied Brent Goose population interacting with Vesterhav Syd*

By altering the proportion of the Light-bellied Brent Goose population interacting with the wind farm when using the worst case 3 MW turbine scenario, collision risk modelling calculated 0.1-1.7 migratory period collisions per annum from 0-100% of the flyway population interacting with Vesterhav Syd at an avoidance rate of 99% (Table 25). At levels of 100% of the flyway population interacting with Vesterhav Syd, collision risk modelling estimates 1.7 migratory period collisions per annum. Assuming a worst case scenario (100% interacting population at a 95% avoidance rate) for which 8.3 collisions per annum are predicted, the PBR at Rf=0.1 is not surpassed (nor is the 1% threshold of the flyway population).

Table 25: Collision risk modelling results (collisions/annum) for variable proportions of the population of Light-bellied Brent Goose interacting with Vesterhav Syd when using the worst case 3 MW turbine scenario

Avoidance rate (%)	**Proportion of interacting population interacting with Vesterhav Syd (%)**										
	5	10	**18**	30	40	50	60	70	80	90	100
95	0.4	0.8	**1.5**	2.5	3.3	4.1	5.0	5.8	6.6	7.5	8.3
98	0.2	0.3	**0.6**	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3
99	**0.1**	**0.2**	**0.3**	**0.5**	**0.7**	**0.8**	**1.0**	**1.2**	**1.3**	**1.5**	**1.7**
99.8	0.0	0.0	**0.1**	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
99.99	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

8.1.4.3 *Proportion of Light-bellied Brent Geese at collision height*

The results of collision risk modelling for Light-bellied Brent Goose incorporating a range of PCH values are shown in Table 26. Collision risk estimates range from 0.1-1.2 collisions per annum at an avoidance rate at 99%. Even assuming a worst case avoidance rate of 95%, which predicts a total of 6.1 collisions per annum the PBR is not surpassed.

Table 26: Collision risk modelling results (collisions/annum) for variable proportions of Light-bellied Brent Goose at collision height when using the worst case 3 MW turbine scenario

Avoidance rate (%)	Proportion of population at collision height (%)										
	10	20	**25**	30	40	50	60	70	80	90	100
95	0.6	1.2	**1.5**	1.8	2.4	3.1	3.7	4.3	5.5	6.1	6.1
98	0.2	0.5	**0.6**	0.7	1.0	1.2	1.5	1.7	2.2	2.4	2.4
99	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.9**	**1.1**	**1.2**	**1.2**
99.8	0.0	0.0	**0.1**	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
99.99	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

8.1.4.4 *Conclusion*

Based on the parameter assumptions as detailed in Section 6.3, a total of 0.3 collisions per annum is taken forward for the impact assessment for the north-west Europe/south-west Europe flyway population of Light-bellied Brent Goose.

8.1.5 *Eurasian Wigeon*

8.1.5.1 *Overview*

Table 27 presents collision risk estimates for Wigeon using those parameters outlined in Table 11 which were informed by expert judgement and literature review. The number of collisions predicted for Eurasian Wigeon, at a 98% avoidance rate, was predicted to be 5.2 collisions per annum using the worst case 3 MW turbine scenario. A total of 2.3 collisions per annum are predicted at a 98% avoidance for the 10 MW scenario.

Table 27: Collision risk modelling results for Eurasian Wigeon using those parameters based on expert judgement

Avoidance rate (%)	Turbine model	
	3 MW	**10 MW**
95	13.0	5.7
98	**5.2**	**2.3**
99	2.6	1.1
99.8	0.3	0.1
99.99	0.0	0.0

Due to the precautionary nature of the assessment and the level of assumption associated with the parameters related to the flyway population (e.g. interacting population and PCH) the following two sections present collision risk estimates incorporating a range of values for both the interacting population and PCH.

8.1.5.2 *Proportion of Eurasian Wigeon population interacting with Vesterhav Syd*

By altering the proportion of the Eurasian Wigeon population interacting with the wind farm when using the worst case 3 MW turbine scenario, collision risk modelling calculated collision rates of 1.0-10.4 collisions per annum at an avoidance rate of 98% (Table 28). Even at a population size double that considered to interact with Vesterhav Syd andat a 95% avoidance rate, for which 26.0 migratory period collisions per annum are predicted, PBR at Rf=0.5 is not surpassed (nor is the 1% threshold of the flyway population).

Table 28: Collision risk modelling results (collisions/annum) for variable proportions of the population of Eurasian Wigeon interacting with Vesterhav Syd when using the worst case 3 MW turbine scenario

Avoidance rate (%)	**Proportion of interacting population interacting with Vesterhav Syd (%)**									
	20	40	60	80	**100**	120	140	160	180	200
95	2.6	5.2	7.8	10.4	**13.0**	15.6	18.2	20.8	23.4	26.0
98	**1.0**	**2.1**	**3.1**	**4.2**	**5.2**	**6.2**	**7.3**	**8.3**	**9.3**	**10.4**
99	0.5	1.0	1.6	2.1	**2.6**	3.1	3.6	4.2	4.7	5.2
99.8	0.1	0.1	0.2	0.2	**0.3**	0.3	0.4	0.4	0.5	0.5
99.99	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.1

8.1.5.3 *Proportion of Eurasian Wigeon at collision height*

The results of collision risk modelling for Eurasian Wigeon incorporating a range of PCH values are shown in Table 29. Collision risk estimates range from 3.5-34.6 collisions per annum at an avoidance rate at 98%. If 100% of birds passing through the wind farm were at potential collision height 34.6 migratory period collisions per annum is predicted which does not breach the PBR at Rf=0.5. Even assuming a worst case avoidance rate of 95%, which predicts a total of 86.6 migratory period collisions per annum the PBR is not surpassed (nor is the 1% threshold of the flyway population).

Table 29: Collision risk modelling results (collisions/annum) for variable proportions of Eurasian Wigeon at collision height when using the worst case 3 MW turbine scenario

Avoidance rate (%)	Proportion of population at collision height (%)										
	10	**15**	20	30	40	50	60	70	80	90	100
95	8.7	**13.0**	17.3	26.0	34.6	43.3	51.9	60.6	69.3	77.9	86.6
98	**3.5**	**5.2**	**6.9**	**10.4**	**13.9**	**17.3**	**20.8**	**24.2**	**27.7**	**31.2**	**34.6**
99	1.7	**2.6**	3.5	5.2	6.9	8.7	10.4	12.1	13.9	15.6	17.3
99.8	0.2	**0.3**	0.3	0.5	0.7	0.9	1.0	1.2	1.4	1.6	1.7
99.99	0.0	**0.0**	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2

8.1.5.4 *Conclusion*

Based on the parameter assumptions as detailed in Section 6.3, a total of 5.2 collisions per annum is taken forward for the impact assessment for the Western Siberia & NE Europe/NW Europe flyway population of Eurasian Wigeon.

8.1.6 *Eurasian Teal*

8.1.6.1 *Overview*

Table 30 presents collision risk estimates for Eurasian Teal using those parameters outlined in Table 11 which were informed by expert judgement and literature review. The number of collisions predicted for Eurasian Teal, at a 98% avoidance rate, was predicted to be 3.2 collisions per annum using the worst case 3 MW turbine scenario. A total of 1.4 collisions per annum are predicted at a 98% avoidance for the 10 MW scenario.

Table 30: Collision risk modelling results for Eurasian Teal based on parameters deemed to be appropriately precautionary

Avoidance rate (%)	Turbine model	
	3 MW	**10 MW**
95	7.9	3.6
98	**3.2**	**1.4**
99	1.6	0.7
99.9	0.2	0.1
99.99	0.0	0.0

Due to the precautionary nature of the assessment and the level of assumption associated with the parameters related to the flyway population (e.g. interacting population and PCH) the following two sections present collision risk estimates incorporating a range of values for both the interacting population and PCH.

8.1.6.2 *Proportion of Eurasian Teal population interacting with Vesterhav Syd*

By altering the proportion of the Eurasian Teal population interacting with the wind farm when using the worst case 3 MW turbine scenario collision risk modelling calculated collision rates of 0.6-6.3 collisions per annum at an avoidance rate of 98% (Table 31). Even at a population size double that considered to interact with Vesterhav Syd, collision risk estimates (6.3 migratory period collisions per annum) do not breach the PBR at Rf=0.5. Assuming an overly precautionary analysis (200% interacting population at a 95% avoidance rate) for which 15.8 migratory period collisions per annum are predicted, PBR at Rf=0.5 is not surpassed (nor is the 1% threshold of the flyway population).

Table 31: Collision risk modelling results (collisions/annum) for variable proportions of the population of Eurasian Teal interacting with Vesterhav Syd when using the worst case 3 MW turbine scenario

Avoidance rate (%)	**Proportion of interacting population interacting with Vesterhav Syd (%)**									
	20	40	60	80	**100**	120	140	160	180	200
95	1.6	3.2	4.7	6.3	**7.9**	9.5	11.1	12.7	14.2	15.8
98	**0.6**	**1.3**	**1.9**	**2.5**	**3.2**	**3.8**	**4.4**	**5.1**	**5.7**	**6.3**
99	0.3	0.6	0.9	1.3	**1.6**	1.9	2.2	2.5	2.8	3.2
99.8	0.0	0.1	0.1	0.1	**0.2**	0.2	0.2	0.3	0.3	0.3
99.99	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0

8.1.6.3 *Proportion of Eurasian Teal at collision height*

The results of collision risk modelling for Eurasian Teal incorporating a range of PCH values are shown in Table 32. Collision risk estimates range from 2.1-21.1 collisions per annum at an avoidance rate at 98%. If 100% of birds passing through the wind farm were at potential collision height 21.1 collisions per annum are predicted which does not breach PBR at Rf=0.5. Even assuming a worst case avoidance rate of 95%, which predicts a total of 52.7 collisions per annum PBR at RF=0.5 is not surpassed (nor is the 1% threshold of the flyway population).

Table 32: Collision risk modelling results (collisions/annum) for variable proportions of Eurasian Teal at collision height when using the worst case 3 MW turbine scenario

Avoidance rate (%)	**Proportion of population at collision height (%)**										
	10	**15**	20	30	40	50	60	70	80	90	100
95	5.3	**7.9**	10.5	15.8	21.1	26.4	31.6	36.9	42.2	47.5	52.7
98	**2.1**	**3.2**	**4.2**	**6.3**	**8.4**	**10.5**	**12.7**	**14.8**	**16.9**	**19.0**	**21.1**
99	1.1	**1.6**	2.1	3.2	4.2	5.3	6.3	7.4	8.4	9.5	10.5
99.8	0.1	**0.2**	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.1
99.99	0.0	**0.0**	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1

8.1.6.4 Conclusion

Based on the parameter assumptions as detailed in Section 6.3, a total of 3.2 collisions per annum is taken forward for the impact assessment for the North-West Europe flyway population of Eurasian Teal.

8.1.7 Northern Pintail

8.1.7.1 Overview

Table 33 presents collision risk estimates for Northern Pintail using those parameters outlined in Table 11 which were informed by expert judgement and literature review. The number of collisions predicted for Northern Pintail, at a 98% avoidance rate, was predicted to be 0.4 migratory period collisions per annum using the worst case 3 MW turbine scenario. Less than one migratory period collision per annum is also predicted at a 98% avoidance for the 10 MW scenario. At higher levels of avoidance such as 99.8% as applied to geese species, predicted collisions are of a negligible value.

Table 33: Collision risk modelling results for Northern Pintail based on parameters deemed to be appropriately precautionary

Avoidance rate (%)	Turbine model	
	3 MW	**10 MW**
95	1.1	0.5
98	**0.4**	**0.2**
99	0.2	0.1
99.9	0.0	0.0
99.99	0.0	0.0

Due to the precautionary nature of the assessment and the level of assumption associated with the parameters related to the flyway population (e.g. interacting population and PCH) the following two sections present collision risk estimates incorporating a range of values for both the interacting population and PCH.

8.1.7.2 *Proportion of Northern Pintail population interacting with Vesterhav Syd*

By altering the proportion of the Northern Pintail population interacting with the wind farm when using the worst case 3 MW turbine scenario, collision risk modelling calculated collision rates of 0.1-0.9 collisions per annum at an avoidance rate of 98% (Table 34). Even at a population size double that considered to interact with Vesterhav Syd, collision risk estimates (0.9 collisions per annum) do not breach the PBR at Rf=0.1. Assuming an overly precautionary analysis (200% interacting population at a 95% avoidance rate) for which 2.2 collisions per annum are predicted, PBR at Rf=0.1 is not surpassed (nor is the 1% threshold of the flyway population).

Table 34: Collision risk modelling results (collisions/annum) for variable proportions of the population of Northern Pintail interacting with Vesterhav Syd when using the worst case 3 MW turbine scenario

Avoidance rate (%)	Proportion of population interacting with Vesterhav Syd (%)									
	20	40	60	80	**100**	120	140	160	180	200
95	0.2	0.4	0.7	0.9	**1.1**	1.3	1.6	1.8	2.0	2.2
98	**0.1**	**0.2**	**0.3**	**0.4**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
99	0.0	0.1	0.1	0.2	**0.2**	0.3	0.3	0.4	0.4	0.4
99.8	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0
99.99	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0

8.1.7.3 *Proportion of Northern Pintail at collision height*

The results of collision risk modelling for Northern Pintail incorporating a range of PCH values are shown in Table 35. Collision risk estimates range from 0.4-3.6

collisions per annum at an avoidance rate at 98%. If 100% of birds passing through the wind farm were at potential collision height collisions per annum are predicted which does not breach the PBR at Rf=0.1. Even assuming a worst case avoidance rate of 95%, which predicts a total of 8.9 collisions per annum PBR at Rf=0.1 is not surpassed (nor is the 1% threshold of the flyway population).

Table 35: Collision risk modelling results (collisions/annum) for variable proportions of Northern Pintail at collision height when using the worst case 3 MW turbine scenario

Avoidance rate (%)	Proportion of population at collision height (%)										
	10	**15**	20	30	40	50	60	70	80	90	100
95	0.7	**1.1**	1.5	2.2	3.0	3.7	4.4	5.2	5.9	6.7	7.4
98	**0.3**	**0.4**	**0.6**	**0.9**	**1.2**	**1.5**	**1.8**	**2.1**	**2.4**	**2.7**	**3.0**
99	0.1	**0.2**	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.5
99.9	0.0	**0.0**	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
99.99	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

8.1.7.4 *Conclusion*

Based on the parameter assumptions as detailed in Section 6.3, 0.4 collisions per annum is taken forward for the impact assessment for the North-West Europe flyway population of Northern Pintail.

8.1.8 *Migratory seabirds*

The results presented in this section are calculated using the worst case turbine scenario for migratory birds of 66 x 3 MW turbines, as identified within the assessment for migratory wildfowl. The results of collision risk modelling for all migratory seabirds included in this assessment are shown in Table 36.

Table 36:Collision risk modelling results for migratory seabird species at Vesterhav Syd

Species	Avoidance rate (%)			
	95	**98**	**99**	**99.5**
Common Eider	4.1	**1.6**	0.8	0.4
Common Scoter	2.1	**0.8**	0.4	0.2
Red-breasted merganser	0.1	**0.0**	0.0	0.0
Red-throated Diver	0.5	**0.2**	0.1	0.0
Arctic Skua	0.0	**0.0**	0.0	0.0
Kittiwake	0.4	**0.2**	0.1	0.0

Species	Avoidance rate (%)			
	95	98	99	99.5
Black-headed Gull	2.4	**1.0**	0.5	0.2
Little Gull	0.3	**0.1**	0.1	0.0
Common Gull	1.9	**0.7**	0.4	0.2
Lesser Black-backed Gull	3.5	**1.4**	0.7	0.4
Herring Gull	2.3	**0.9**	0.5	0.2
Great Black-backed Gull	2.1	**0.8**	0.4	0.2
Sandwich Tern	0.6	**0.2**	0.1	0.1
Common Tern	0.3	**0.1**	0.1	0.0
Arctic Tern	0.1	**0.0**	0.0	0.0

At a 98% avoidance rate less than one migratory collision per annum is predicted for Common Scoter, Red-breasted Merganser, Red-throated Diver, Arctic Skua, Kittiwake, Black-headed Gull, Little Gull, Common Gull, Herring Gull, Great Black-backed Gull, Sandwich Tern, Common Tern and Arctic Tern (Table 36). These results apply to the worst case scenario of 66 x 3 MW turbines.

8.2 Collision Risk Assessment

Collision risk within this assessment strictly refers to collision with moving turbine rotors only. Therefore the assessment of collision risk only applies during the operational phase of Vesterhav Syd. The probability of collision impacts arising with other structures within the wind farm footprint or vessels during the construction and decommissioning phases is considered to be negligible and is therefore not assessed in relation to migrating birds.

Vesterhav Syd will cover an area of approximately 60 km² and the turbines (both 66 turbines with 3 MW and 20 turbines with 10 MW considered) present an obstacle causing potential collision and barrier impacts. The magnitude of this impact is assessed in the following sections for each of the identified species of interest.

8.2.1 Pink-footed Goose

8.2.1.1 Degree of disturbance

When implementing an avoidance rate of 99% and applying parameters within the CRM that are considered to be an appropriate precautionary scenario, 7.7 collisions of migratory Pink-footed Goose is predicted to occur per annum at Vesterhav Syd (Table 15). This prediction applies to the worst case scenario involving 66 x 3 MW turbines. Should 20 X 10 MW turbines be included within the built design of Vesterhav Syd then three collisions per annum is predicted.

The biogeographic migratory flyway of Pink-footed Goose relevant to Vesterhav Syd is 63,000 individuals. Using the Rf value of 1.0, the estimate of collision mortality represents 0.1% of the PBR value (or 0.01% of the total flyway population). Even when using the overly precautionary Rf value of 0.5 the CRM predicts that 0.26% of the PBR value will be affected. The CRM incorporated the entire flyway population of Pink-footed Goose. As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Pink-footed Goose arising from collision impacts is defined as **Low**.

8.2.1.2 Importance

Pink-footed Goose is considered to be of favourable conservation status (SPEC 4) by Burfield et al. (2004) and is listed as a species of National Responsibility outside of the breeding season in Denmark. Migratory Pink-footed Goose is considered to be of High importance in terms of their conservation status, while their abundance within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to appropriately record migratory movements. The likely abundance of this species with Vesterhav Syd has however been estimated within this assessment and, on a precautionary basis is considered to be Very High. For the purposes of this assessment migratory Pink-footed Goose is considered to be of **International** importance.

8.2.1.3 Likelihood

Pink-footed Goose, albeit different biogeographic populations to that considered within this assessment, is considered by Langston & RSPB (2010) as being of moderate risk of collision with offshore wind farms. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. The likelihood of an effect occurring on the Pink-footed Goose flyway population is therefore considered to be **Low**.

8.2.1.4 Persistence

Potential collision effects on migratory Pink-footed Goose are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect.

The magnitude of collision impacts on migratory Pink-footed Goose are therefore considered to be **Minor** (Table 37).

Table 37: Collision risk assessment for Pink-footed Goose during operation at Vesterhav Syd

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

8.2.2 Greylag Goose

8.2.2.1 Degree of disturbance

When implementing an avoidance rate of 99% and applying parameters within the CRM that are considered to be an appropriate precautionary scenario, 20.9 collisions of migratory Greylag Goose are predicted to occur per annum at Vesterhav Syd (Table 18). This prediction applies to the worst case scenario involving 66 x 3 MW turbines. Should 10 MW turbines be included within the built design of Vesterhav Syd then nine collisions per annum are predicted.

The biogeographic migratory flyway of Greylag Goose relevant to Vesterhav Syd is 610,000 individuals. Using the Rf value of 1.0, the estimate of collision mortality represents 0.04% of the PBR value (or 0.003% of the total flyway population). Even when using the overly precautionary Rf value of 0.5 the CRM predicts that 0.08% of the PBR value will be affected. As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Greylag Goose arising from collision impacts is defined as **Low**.

8.2.2.2 Importance

Greylag Goose is listed as a species of National Responsibility outside of the breeding season in Denmark. Migratory Greylag Geese are considered to be of High importance in terms of their conservation status, while their abundance within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to appropriately record migratory movements. The likely abundance of this species with Vesterhav Syd has however been estimated within this assessment and, on a precautionary basis is considered to be Very High. Therefore the importance is rated as **International**.

8.2.2.3 Likelihood

Greylag Goose, albeit different biogeographic populations to that considered within this assessment, is considered by Langston & RSPB (2010) as being of moderate risk of collision with offshore wind farms. However, the tracking of geese at Nysted Offshore Wind Farm, which calculated that only 0.9% of nocturnally and 0.6% diurnally migrating geese were at risk of colliding with turbines (Desholm & Kahlert 2005).

The CRM has predicted that a low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. The likelihood of an effect occurring on the Greylag Goose flyway population is therefore considered to be **Low**.

8.2.2.4 *Persistence*

Potential collision effects on migratory Greylag Goose are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect.

The magnitude of collision impacts on migratory Greylag Goose are therefore considered to be Minor (Table 38).

Table 38: Collision risk assessment for Greylag Goose during operation at Vesterhav Syd

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

8.2.3 *Barnacle Goose*

8.2.3.1 *Degree of disturbance*

When implementing an avoidance rate of 99% and applying parameters within the CRM that are considered to be an appropriate precautionary scenario, 5.6 collisions of migratory Barnacle Goose are predicted to occur per annum at Vesterhav Syd (Table 21). This prediction applies to the worst case scenario involving 66 x 3 MW turbines. Should 10 MW turbines be included within the built design of Vesterhav Syd then three collisions per annum is predicted.

The biogeographic migratory flyway of Barnacle Goose relevant to Vesterhav Syd is 770,000 individuals. Using the Rf value of 1.0, the estimate of collision mortality represents 0.01% of the PBR value (or 0.0007% of the total flyway population). Even when using the overly precautionary Rf value of 0.5 the CRM predicts that 0.02% of the PBR value will be affected. As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Barnacle Goose arising from collision impacts is defined as **Low**.

8.2.3.2 *Importance*

Barnacle Goose is listed on Annex 1 of the EU Birds Directive and as a SPEC 2 species (i.e. unfavourable European conservation status).The abundance of Barnacle Goose within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to appropriately record migratory movements. The likely abundance of this species with Vesterhav Syd has however been estimated within this assessment and, on a precautionary basis is considered to be Very High. Therefore the importance is rated as **International**.

8.2.3.3 *Likelihood*

Barnacle Goose, albeit different biogeographic populations to that considered within this assessment, is considered by Langston & RSPB (2010) as being of moderate risk of collision with offshore wind farms. However, the tracking of geese at Nysted offshore wind farm, which calculated that only 0.9% of nocturnally and 0.6% diurnally migrating geese were at risk of colliding with turbines (Desholm & Kahlert 2005).

The CRM has predicted that a low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. The likelihood of an effect occurring on the Barnacle Goose flyway population is therefore considered to be **Low**.

8.2.3.4 *Persistence*

Potential collision effects on migratory Barnacle Goose are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect.

The magnitude of collision impacts on migratory Barnacle Goose are therefore considered to be **Minor** (Table 39).

Table 39: Collision risk assessment for Barnacle Goose during operation at Vesterhav Syd

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

8.2.4 *Light-bellied Brent Goose*

8.2.4.1 *Degree of disturbance*

When implementing an avoidance rate of 99% and applying parameters within the CRM that are considered to be an appropriate precautionary scenario, 0.3 collisions of migratory Light-bellied Brent Goose are predicted to occur per annum at Vesterhav Nord (Table 24). This prediction applies to the worst case scenario involving 66 x 3 MW turbines. Should 20 X 10 MW turbines be included within the built design of Vesterhav Nord then 0 collisions are also predicted per annum.

The biogeographic migratory flyway of Light-bellied Brent Goose relevant to Vesterhav Nord is 7,600 individuals). The estimate of collision mortality represents 0.39% of the PBR value at Rf=0.1. The CRM incorporated the entire flyway population of Light-bellied Brent Goose. As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Light-bellied Brent Goose arising from collision impacts is defined as **Low**.

8.2.4.2 *Importance*

Light-bellied Brent Goose is considered to have an Unfavourable conservation status (SPEC 3) by Burfield et al. (2004) and is a Species of National Responsibility within Denmark. Migratory Light-bellied Brent Goose are considered to be of High importance in terms of their conservation status, while their abundance within the Vesterhav Nord study area is unknown due to a lack of direct survey methods that are likely to appropriately record migratory movements. The likely interaction of this species and Vesterhav Nord has however been estimated within this assessment and on a precautionary basis is considered to be Very High. For the purposes of this assessment migratory Light-bellied Brent Goose is considered to be of **International** importance.

8.2.4.3 *Likelihood*

Light-bellied Brent Goose is considered by Langston & RSPB (2010) as being of moderate risk of collision with offshore wind farms. Desholm (2006), which ranked 38 bird species recorded at the Nysted offshore wind farm based on relative abundance and demographic vulnerability (i.e. elasticity of population growth rate to changes in adult survival), identified Brent Goose as a species vulnerable to wind farm development. However, the tracking of geese at Nysted offshore wind farm, which calculated that only 0.9% of nocturnally and 0.6% diurnally migrating geese were at risk of colliding with turbines (Desholm & Kahlert 2005).

The CRM has predicted that a low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. The likelihood of an effect occurring on the Light-bellied Brent Goose flyway population is therefore considered to be **Low**.

8.2.4.4 *Persistence*

Potential collision effects on migratory Light-bellied Brent Goose are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect.

The magnitude of collision impacts on migratory Light-bellied Brent Goose are therefore considered to be **Minor** (Table 40).

Table 40: Collision risk assessment for Light-bellied Brent Goose during operation at Vesterhav Syd

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

8.2.5 Eurasian Wigeon

8.2.5.1 Degree of disturbance

When implementing an avoidance rate of 98% and applying parameters within the CRM that are considered to be an appropriate precautionary scenario, 5.2 collisions of migratory Eurasian Wigeon are predicted to occur per annum at Vesterhav Syd (Table 27). This prediction applies to the worst case scenario involving 66 x 3 MW turbines. Should 10 MW turbines be included within the built design of Vesterhav Syd then two collisions per annum are predicted.

The biogeographic migratory flyway of Eurasian Wigeon relevant to Vesterhav Syd is 1,500,000 individuals. Using the Rf value of 0.5, the estimate of collision mortality represents 0.002% of the PBR (or 0.0003% of the total flyway population). Even when using the overly precautionary Rf value of 0.1, the CRM predicts that 0.01% of the PBR value will be affected. As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Eurasian Wigeon to collision impacts is defined as **Low**.

8.2.5.2 Importance

Eurasian Wigeon is listed as a species of National Responsibility outside of the breeding season in Denmark. Migratory Eurasian Wigeon are considered to be of High importance in terms of their conservation status, while their abundance within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to appropriately record migratory movements. The likely abundance of this species with Vesterhav Syd has however been estimated within this assessment and, on a precautionary basis is considered to be Very High. For the purposes of this assessment Eurasian Wigeon is considered to be of **International** importance.

8.2.5.3 Likelihood

Desholm (2006), which ranked 38 bird species recorded at the Nysted offshore wind farm based on relative abundance and demographic vulnerability (i.e. elasticity of population growth rate to changes in adult survival) identified Eurasian Wigeon as a species not very vulnerable to wind farm development. Willmott et al. (2013) identified American Wigeon, a species considered for this assessment to be identical to Eurasian Wigeon in terms of sensitivity to collision as being of low risk of collision with offshore wind farms.

The CRM has predicted that a low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. The likelihood of an effect occurring on the Eurasian Wigeon flyway population is therefore considered to be **Low**.

8.2.5.4 *Persistence*

Potential collision effects on migratory Eurasian Wigeon are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect.

The magnitude of collision impacts on migratory Eurasian Wigeon are therefore considered to be **Minor** (Table 41).

Table 41: Collision risk assessment for Eurasian Wigeon during operation at Vesterhav Syd

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

8.2.6 *Eurasian Teal*

8.2.6.1 *Degree of disturbance*

When implementing an avoidance rate of 98% and applying parameters within the CRM that are considered to be an appropriate precautionary scenario, 3.2 collisions of migratory Eurasian Teal are predicted to occur per annum at Vesterhav Syd (Table 30). This prediction applies to the worst case scenario involving 66 x 3 MW turbines. Should 10 MW turbines be included within the built design of Vesterhav Syd then one collision per annum is predicted.

The biogeographic migratory flyway of Eurasian Teal relevant to Vesterhav Syd is 500,000 individuals. Using the Rf value of 0.5, the estimate of collision mortality represents 0.004% of the PBR value (or 0.0006% of the total flyway population). Even when using the overly precautionary Rf value of 0.1 the CRM predicts that 0.02% of the PBR value will be affected. As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Eurasian Teal arising from collision impacts is defined as **Low**.

8.2.6.2 *Importance*

Eurasian Teal is listed as a species of National Responsibility outside of the breeding season in Denmark. Migratory Eurasian Teal are considered to be of High importance in terms of their conservation status, while their abundance within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to appropriately record migratory movements. The likely abundance of this species with Vesterhav Syd has however been estimated within this assessment and, on a precautionary basis is considered to be Very High. For the purposes of this assessment migratory Eurasian Teal is considered to be of **International** importance.

8.2.6.3 *Likelihood*

Willmott et al. (2013) identified Green-winged Teal, a species considered for this assessment to be identical to Eurasian Teal in terms of sensitivity to collision as being of low risk of collision with offshore wind farms.

The CRM has predicted that a low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. The likelihood of an effect occurring on the Eurasian Teal flyway population is therefore considered to be **Low**.

8.2.6.4 *Persistence*

Potential collision effects on migratory Eurasian Teal are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect.

The magnitude of collision impacts on migratory Eurasian Teal are therefore considered to be **Minor** (Table 37).

Table 42: Collision risk assessment for Eurasian Teal during operation at Vesterhav Syd

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

8.2.7 *Northern Pintail*

8.2.7.1 *Degree of disturbance*

When implementing an avoidance rate of 98% and applying parameters within the CRM that are considered to be an appropriate precautionary scenario, 0.4 collisions of migratory Northern Pintail are predicted to occur per annum at Vesterhav Syd (Table 33). This prediction applies to the worst case scenario involving 66 x 3 MW turbines. Should 10 MW turbines be included within the built design of Vesterhav Syd then less than one collision is predicted per annum.

The biogeographic migratory flyway of Northern Pintail relevant to Vesterhav Syd is 60,000 individuals. The estimate of collision mortality represents 0.02% of the PBR value at Rf=0.1. As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Northern Pintail arising from collision impacts is defined as **Low**.

8.2.7.2 *Importance*

Northern Pintail is listed as a species of National Responsibility outside of the breeding season in Denmark. Migratory Northern Pintail are considered to be of High importance in terms of their conservation status, while their abundance within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to appropriately record migratory movements. The likely abundance of this species with Vesterhav Syd has however been estimated within this assessment and, on a precautionary basis is considered to be Very High. For the purposes of this assessment migratory Northern Pintail is considered to be of **International** importance.

8.2.7.3 *Likelihood*

Desholm (2006), which ranked 38 bird species recorded at the Nysted offshore wind farm based on relative abundance and demographic vulnerability (i.e. elasticity of population growth rate to changes in adult survival) identified Northern Pintail as a species not very vulnerable to wind farm development. A similar conclusion was reached by Wilmott et al. (2013) with Northern Pintail assigned a collision sensitivity score of 12, where 876,000 was the maximum score.

The CRM has predicted that a low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. The likelihood of an effect occurring on the Northern Pintail flyway population is therefore considered to be **Low**.

8.2.7.4 *Persistence*

Potential collision effects on migratory Northern Pintail are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect.

The magnitude of collision impacts on migratory Northern Pintail are therefore considered to be **Minor** (Table 43).

Table 43: Collision risk assessment for Northern Pintail during operation at Vesterhav Syd

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

8.2.8 *Migratory seabirds*

At a 98% avoidance rate less than one migratory collision per annum is predicted for Common Scoter, Red-breasted Merganser, Red-throated Diver, Arctic Skua, Kittiwake, Black-headed Gull, Little Gull, Common Gull, Herring Gull, Great Black-backed Gull, Sandwich Tern, Common Tern and Arctic Tern (Table 36). These results apply to the worst case scenario of 66 x 3 MW turbines.

Kittiwake, Common Gull, Herring Gull and Great Black-backed Gull are considered by Furness *et al.* (2013) to be of high risk of collision with offshore wind farms with Red-throated Diver, Arctic Skua, Black-headed Gull, Sandwich Tern, Common Tern and Arctic Tern considered to be of moderate risk. Common Scoter, Red-breasted Merganser and Little Gull are considered to be of Low risk of collision with offshore wind farms (Furness *et al.,* 2013; Langston, 2010). Considering the limited levels of collision predicted for all of these species, the degree of disturbance due to collisions (or vulnerability to collision) is considered to be Low.

The importance of each species is based on the conservation status of the species and the population of each species present at Vesterhav Syd. The abundance of each species within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to appropriately record migratory movements. Therefore based on the interacting populations used in this assessment the populations of Common Scoter, Red-throated Diver, Little Gull and Sandwich Tern interacting with Vesterhav Syd in the migratory period is considered to be Very High, the population of Great Black-backed Gull is considered to be High, the populations of Red-breasted Merganser, Arctic Skua, Black-headed Gull, Common Gull, Herring Gull, Common Tern and Arctic Tern considered to be Medium and the population of Kittiwake, considered to be Low. In terms of conservation status Red-throated Diver, Little Gull, Common Gull, Sandwich Tern, Common Tern and Arctic Tern are all listed on Annex 1 of the EU Birds Directive or hold SPEC 2 status and as such are considered to be of Very High conservation importance. Black-headed Gull, Herring Gull and Great Black-backed Gull are of Non-SPEC-E status and as a consequence are considered to be of Medium conservation importance, whilst the remaining species are not considered to be of conservation concern in Europe and are therefore rated as having a Low conservation status.

Potential collision effects are considered likely to result on direct mortality and are therefore categorised as being a Permanent effect. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors for all species. Therefore the likelihood of an effect occurring on the biogeographic populations of all those species for which less than one collision was predicted is considered to be Low.

Based upon less than one migratory collision per annum being predicted for these species and the use of expert judgment, the magnitude of collision impacts upon these species are considered to be Negligible/No impact (Table 44).

Table 44: Collision risk assessment for those species for which no collisions are predicted at a 98% avoidance rate.

Phase	Species	Vulnera-bility (degree of distur-bance)	Impor-tance	Impact Likeli-hood	Persi-stence	Magnitu-de[23]
Opera-tion	Common Scoter	Low	Internati-onal	Low	Perma-nent	Negligib-le/No im-pact
	Red-breasted Merganser	Low	Not impor-tant	Low	Perma-nent	Negligib-le/No im-pact
	Red-throated Diver	Low	Internati-onal	Low	Perma-nent	Negligib-le/No im-pact
	Arctic Skua	Low	Not impor-tant	Low	Perma-nent	Negligib-le/No im-pact
	Kittiwake	Low	Not impor-tant	Low	Perma-nent	Negligib-le/No im-pact
	Black-headed Gull	Low	Local	Low	Perma-nent	Negligib-le/No im-pact
	Little Gull	Low	Internati-onal	Low	Perma-nent	Negligib-le/No im-pact
	Common Gull	Low	Natio-nal/Regio nal	Low	Perma-nent	Negligib-le/No im-pact
	Herring Gull	Low	Local	Low	Perma-nent	Negligib-le/No im-pact
	Great black-backed Gull	Low	Local	Low	Perma-nent	Negligib-le/No im-pact
	Sandwich Tern	Low	Internati-onal	Low	Perma-nent	Negligib-le/No im-pact

[23] The assessment of Magnitude is based on expert judgment.

Phase	Species	Vulnera-bility (degree of distur-bance)	Impor-tance	Impact Likeli-hood	Persi-stence	Magnitu-de[23]
	Common Tern	Low	Natio-nal/Regional	Low	Perma-nent	Negligib-le/No im-pact
	Arctic Tern	Low	Natio-nal/Regional	Low	Perma-nent	Negligib-le/No im-pact

Further migratory seabird species are considered below, where greater than one mortalty is predicted per annum.

8.2.8.1 *Common Eider*

When implementing an avoidance rate of 98%, 1.6 collisions of migratory Common Eider are predicted to occur per annum (Table 36). This prediction applies to the worst case scenario involving 66 x 3 MW turbines.

The biogeographic population of Common Eider relevant to Vesterhav Syd is 976,000 individuals. Using the PBR Rf value of 0.1, the estimate of collision represents 0.02% of the PBR value (or 0.0002% of the biogeographic population). As a low level impact on this population has been predicted the sensitivity of the biogeographic population of Common Eider to collision impacts is defined as **Low**.

Common Eider is considered by Furness *et al.* (2013) as being of low risk of collision with offshore wind farms. Considering the limited levels of collision predicted for Common Eider at Vesterhav Syd, the degree of disturbance due to collision (or vulnerability to collision) is considered to be **Low**.

Common Eider has a favourable conservation status, however the global population is concentrated in Europe (Non-SPEC-E). The species is therefore considered of Medium conservation concern.. The abundance of Common Eider within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to record migratory movements. The likely abundance of this species with Vesterhav Syd has however been estimated within this assessment and, on a precautionary basis is considered to be Medium. For the purposes of this assessment migratory Common Eider is considered to be of **Local** importance.

Potential collision effects on migratory Common Eider are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors. The likelihood of an effect occurring on the biogeographic population of Common Eider is therefore considered to be **Low**.

The magnitude of collision impacts on migratory Common Eider are therefore considered to be **Minor** (Table 45).

Table 45: Collision risk assessment for those species for Common Eider at a 98% avoidance rate.

Phase	Species	Vulnerability	Importance	Impact Likelihood	Persistence	Magnitude
Operation	Common Eider	Low	Local	Low	Permanent	Minor

8.2.8.2 *Lesser Black-backed Gull*

When implementing an avoidance rate of 98%, 1.4 collisions of migratory Lesser Black-backed Gull are predicted to occur per annum (Table 36). This prediction applies to the worst case scenario involving 66 x 3 MW turbines.

The biogeographic population of Lesser Black-backed Gull relevant to Vesterhav Nord is 530,000-570,000 individuals. Using a PBR Rf value of 1.0, the estimate of collision represents 0.005% of the PBR value (or 0.0002% of the biogeographic population). As a low level impact on this population has been predicted the sensitivity of the biogeographic population of Lesser Black-backed Gull to collision impacts is defined as **Low**.

Lesser Black-backed Gull is considered by Furness *et al.* (2013) as being of very high risk of collision with offshore wind farms. Considering the limited levels of collision predicted for Lesser Black-backed Gull at Vesterhav Syd, the degree of disturbance due to collision (or vulnerability to collision) is considered to be Low. Lesser Black-backed Gull has a favourable conservation status, however the global population is concentrated in Europe (Non-SPEC-E). The species is therefore considered of Medium conservation concern.. The abundance of Lesser Black-backed Gull within the Vesterhav Syd study area has not been quantified due to a lack of direct survey methods that are likely to record migratory movements. The likely abundance of this species with Vesterhav Syd has however been estimated within this assessment and, on a precautionary basis is considered to be Very High. For the purposes of this assessment migratory Lesser Black-backed Gull is considered to be of **International** importance.

Potential collision effects on migratory Lesser Black-backed Gull are considered likely to result in direct mortality and are therefore categorised as being a **Permanent** effect. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors. The likelihood of an effect occurring on the biogeographic population of Lesser Black-backed Gull is therefore considered to be **Low**.

The magnitude of collision impacts on migratory Lesser Black-backed Gull are therefore considered to be **Minor** (Table 46).

Table 46: Collision risk assessment for those species for Lesser Black-backed Gull at a 98% avoidance rate.

Phase	Species	Vulnera-bility	Im-portance	Impact Likeli-hood	Persis-tence	Magni-tude
Opera-tion	Lesser Black-backed Gull	Low	Interna-tional	Low	Perma-nent	Minor

8.3 Barrier effects

8.3.1 Overview

Barrier effects may arise in addition to displacement. However, unlike displacement (which is defined as the effect on birds that would have utilised resources that have since become occupied by turbines), barrier effects do not suggest such links with resource inside the proposed wind farm (MacLean et al. 2009). The effect refers to the disruption of preferred flight lines, so that birds need to re-navigate to alternative routes. Such re-navigation has the potential to lead to increased energetic costs and could affect species on foraging excursions from breeding colonies or flights between foraging and roosting sites outside of the breeding season (Masden et al. 2009b). Barrier effects also have the potential to affect birds on annual migration and as such this is assessed within this section for Vesterhav Syd.

A review of available evidence suggests that barrier effects, to a degree, have the potential act upon migrating geese. For example, at Nysted Offshore Wind Farm the percentage of waterbird flocks (including goose species and Eider) entering the wind farm area decreased significantly between the pre-construction and operation of the wind farm. During operation, 13.8% of the flocks recorded at night entered the wind farm area whilst in the day only 4.5% entered the wind farm (Desholm & Kahlert 2005).

An insignificant increase in the energetic costs associated with migration is incurred due to the presence of offshore wind farms. Masden et al. (2009b) showed that as a result of the presence of Nysted Offshore Wind Farm, migrating Eider experienced an increase in migratory distance of 500 m with no significant increases in energy expenditure. Even when this distance was doubled to 1 km, increases in energetic cost were still insignificant. A significant increase in energy expenditure (1% of bird body mass) would only be experienced should the overall distance travelled increase from 1400 km to 1,450 km i.e. by 3.6%.

8.3.2 *Impact assessment*

Installation-related vessel movements have the potential to result in the reduction of barrier free flight paths for migratory birds. However, the overall spatial and temporal extent of these impacts is considered to be very low. As such, barrier effects are considered for the operational phase only; barriers presented during the construction and decommissioning phases from vessels and construction infrastructure are considered to be negligible.

Data from Blåvand Bird Observatory indicates that the migratory movements of species included in this assessment occur predominantly in a north-south orientation only the western coast of Denmark.

The size of the barrier presented to migrating birds represented by Vesterhav Syd is assumed to be the linear width of the wind farm measured at right angles to a projected bird flight line heading on a north-south trajectory towards the centre. This width is assumed to be Vesterhav Syd plus a 1 km buffer area around the wind farm. This width is considered to be larger than the likely average macro avoidance distance exhibited by birds that are affected and allows for a precautionary assessment. This approach has previously been used to assess the impact of barrier effects on migrating birds at the Neart na Gaoithe, Dogger Bank Creyke Beck and Dogger Bank Teesside Offshore Wind Farms (Mainstream Renewable Power 2012, Forewind 2013, 2014).

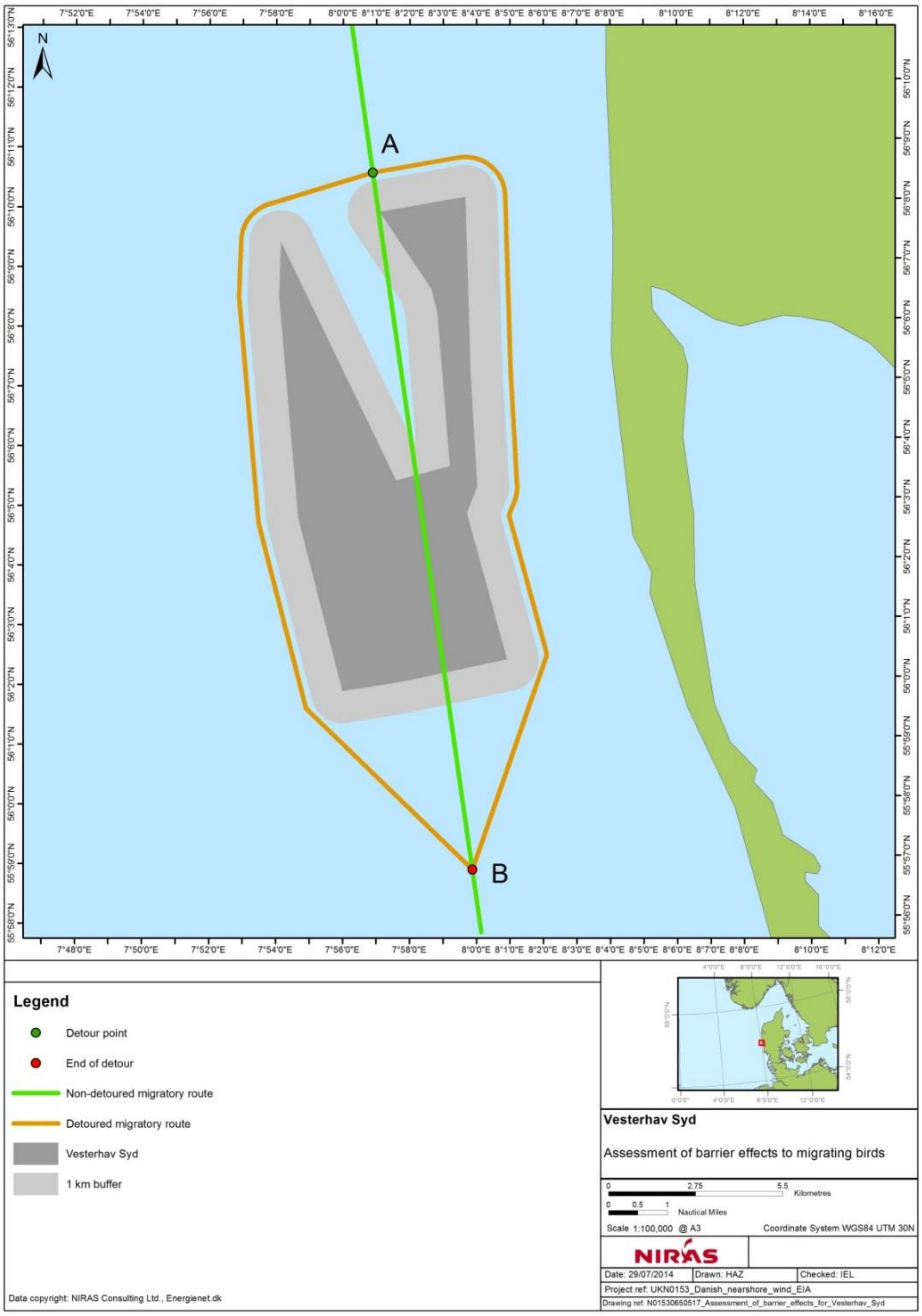

Figure 24: Assessment of barrier effects to migrating birds for Vesterhav Syd

Figure 24 presents the likely increase in migratory movements if it is assumed that birds exhibit macro-avoidance and travel around Vesterhav Syd. The assessment of barrier effects was based on calculating the average detoured flight path. This was assumed to be the average of the two potential detoured pathways available to a bird around Vesterhav Syd with the bird encountering the barrier halfway between one of the ends and the centre of the front edge of the barrier (Point A on Figure 24). Point B on Figure 24 indicates the point at which birds are assumed to have returned to the non-detoured flight path and where measurement of the detoured route stops. The length of detour is also affected by the distance at which birds exhibit macro-avoidance and the distance that birds stay away from the barrier. These values were both assumed to be 1 km. The two detoured pathways around the wind farm were both measured with an average of these two values used within the assessment.

The length of the flight path through the study area that migrating birds would take if uninhibited by the barrier was estimated to be 22.2 km. Assuming birds exhibit macro-avoidance at 1 km from the barrier the average detoured flight path was calculated to be 26.98 km. This therefore represents an increase of 4.78 km as a result of the Vesterhav Syd barrier.

8.3.3 Pink-footed Goose

8.3.3.1 Degree of disturbance

The breeding areas of Pink-footed Goose are located on the island of Svalbard, with birds migrating to and from wintering areas in Belgium, the Netherlands and Denmark. The migratory path of this species is therefore represented for the purposes of this assessment as being over 2,500 km in length. As such, an increase in length of the migratory path of 4.78 km (0.19%) is considered to have the potential to represent only a negligible shift in flight path route and associated additional energy expenditure. The degree of disturbance to Pink-footed Goose arising from barrier effects at Vesterhav Syd is therefore considered to be **Low**.

8.3.3.2 Importance

As defined in Section 8.1.1, Pink-footed Goose is considered to be a species of **International** importance in terms of this assessment.

8.3.3.3 Likelihood

The assessment has predicted that a low level of impact is likely due to barrier effects, even when considering precautionary parameters within the assessment. The likelihood of an effect occurring on the Pink-footed Goose flyway population is therefore considered to be **Low**.

8.3.3.4 Persistence

Potential barrier effects on migratory Pink-footed Goose are considered to occur throughout the operational lifetime of the project and are therefore categorised as being a **Permanent** effect.

The magnitude of barrier effects on migratory Pink-footed Goose are therefore considered to be **Minor** (Table 47).

8.3.4 Greylag Goose

8.3.4.1 Degree of disturbance

The breeding areas of Greylag Goose are located in Norway, with wintering areas in the Netherlands. The migratory path of this species is therefore represented for the purposes of this assessment as being approximately 500-2,300 km. As such, an increase in length of the migratory path of 4.78 km (0.96-0.21%) is considered to have the potential to represent only a negligible shift in flight path route and associated additional energy expenditure. The degree of disturbance to Greylag Goose arising from barrier effects at Vesterhav Syd is therefore considered to be **Low**.

8.3.4.2 Importance

As defined in Section 8.1.2, Greylag Goose is considered to be a species of **International** importance in terms of this assessment.

8.3.4.3 Likelihood

The assessment has predicted that a low level of impact is likely due to barrier effects, even when considering precautionary parameters within the assessment. The likelihood of an effect occurring on the Greylag Goose flyway population is therefore considered to be **Low**.

8.3.4.4 Persistence

Potential barrier effects on migratory Greylag Goose are considered to occur throughout the operational lifetime of the project and are therefore categorised as being a **Permanent** effect.

The magnitude of barrier effects on migratory Greylag Goose are therefore considered to be **Minor** (Table 47).

8.3.5 Barnacle Goose

8.3.5.1 Degree of disturbance

The breeding areas of Barnacle Goose are located in the tundra zone of the Russian Arctic, along the coast of the Barents Sea and western Kara Sea with the Baltic population breeding on Swedish, Estonian, Finnish and Danish islands within the Baltic.The migratory path of this species is therefore represented for the purposes of this assessment as being approximately 500 km to over 3,300 km depending on the breeding origin of individual geese (e.g. Russia or the Baltic. As such, an increase in length of the migratory path of 4.78 km (0.96-0.14%) is considered to have the potential to represent only a negligible shift in flight path route and associated additional energy expenditure. The degree of disturbance to Barnacle Goose arising from barrier effects at Vesterhav Syd is therefore considered to be **Low**.

8.3.5.2 Importance

As defined in Section 8.1.3, Barnacle is considered to be a species of **International** importance in terms of this assessment.

8.3.5.3 *Likelihood*

The assessment has predicted that a low level of impact is likely due to barrier effects, even when considering precautionary parameters within the assessment. The likelihood of an effect occurring on the Barnacle Goose flyway population is therefore considered to be **Low**.

8.3.5.4 *Persistence*

Potential barrier effects on migratory Barnacle Goose are considered to occur throughout the operational lifetime of the project and are therefore categorised as being a **Permanent** effect.

The magnitude of barrier effects on migratory Barnacle Goose are therefore **Minor** (Table 47).

8.3.6 *Light-bellied Brent Goose*

8.3.6.1 *Degree of disturbance*

The breeding areas of Light-bellied Brent Goose are located on the island of Svalbard and north-east Greenland, with birds migrating to wintering areas around the North Sea. The migratory path of this species is therefore represented for the purposes of this assessment as being over 2,500 km in length. As such, an increase in length of the migratory path of 3.47 km (0.14%) is considered to have the potential to represent only a negligible shift in flight path route and associated additional energy expenditure. The degree of disturbance to Light-bellied Brent Goose arising from barrier effects at Vesterhav Nord is therefore considered to be **Low**.

8.3.6.2 *Importance*

As defined in Section 8.1.4, Light-bellied Brent Goose is considered to be a species of **International** importance in terms of this assessment.

8.3.6.3 *Likelihood*

The assessment has predicted that a low level of impact is likely due to barrier effects, even when considering precautionary parameters within the assessment. The likelihood of an effect occurring on the Light-bellied Brent Goose flyway population is therefore considered to be **Low**.

8.3.6.4 *Persistence*

Potential barrier effects on migratory Light-bellied Brent Goose are considered to occur throughout the operational lifetime of the project and are therefore categorised as being a **Permanent** effect.

The magnitude of barrier effects on migratory Light-bellied Brent Goose are therefore considered to be **Minor** (Table 47).

8.3.7 Eurasian Wigeon

8.3.7.1 Degree of disturbance

The breeding areas of Eurasian Wigeon are located in north-east Europe and Siberia, with wintering areas located in the UK, Ireland, the Netherlands, Belgium and France. The migratory path of this species is therefore represented for the purposes of this assessment as being over 2,000 km in length. As such, an increase in length of the migratory path of 4.78 km (0.24%) is considered to have the potential to represent only a negligible shift in flight path route and associated additional energy expenditure. The degree of disturbance to Eurasian Wigeon arising from barrier effects at Vesterhav Syd is therefore considered to be **Low**.

8.3.7.2 Importance

As defined in Section 8.1.5, Eurasian Wigeon is considered to be a species of **International** importance in terms of this assessment.

8.3.7.3 Likelihood

The assessment has predicted that a low level of impact is likely due to barrier effects, even when considering precautionary parameters within the assessment. The likelihood of an effect occurring on the Eurasian Wigeon flyway population is therefore considered to be **Low**.

8.3.7.4 Persistence

Potential barrier effects on migratory Eurasian Wigeon are considered to occur throughout the operational lifetime of the project and are therefore categorised as being a **Permanent** effect.

The magnitude of barrier effects on migratory Eurasian Wigeon are therefore considered to be **Minor (**Table 47**).**

8.3.8 Eurasian Teal

8.3.8.1 Degree of disturbance

The breeding areas of Eurasian Teal are located in Scandinavia and north-west Siberia, with wintering areas located in western and south-west Europe. The migratory path of this species is therefore represented for the purposes of this assessment as being over 2,000 km in length. As such, an increase in length of the migratory path of 4.78 km (0.24%) is considered to have the potential to represent only a negligible shift in flight path route and associated additional energy expenditure. The degree of disturbance to Eurasian Teal arising from barrier effects at Vesterhav Syd is therefore considered to be **Low**.

8.3.8.2 Importance

As defined in Section 8.1.6, Eurasian Teal is considered to be a species of **International** importance in terms of this assessment.

8.3.8.3 *Likelihood*

The assessment has predicted that a low level of impact is likely due to barrier effects, even when considering precautionary parameters within the assessment. The likelihood of an effect occurring on the Eurasian Teal flyway population is therefore considered to be **Low**.

8.3.8.4 *Persistence*

Potential barrier effects on migratory Eurasian Teal are considered to occur throughout the operational lifetime of the project and are therefore categorised as being a **Permanent** effect.

The magnitude of barrier effects on migratory Eurasian Teal are therefore considered to be **Minor** (Table 47).

8.3.9 *Northern Pintail*

8.3.9.1 *Degree of disturbance*

The breeding areas of Northern Pintail are located in Russia and western and central Siberia, with wintering areas located in the Netherlands, France, the UK and north and west Africa. The migratory path of this species is therefore represented for the purposes of this assessment as being over 3,500 km in length. As such, an increase in length of the migratory path of 4.78 km (0.14%) is considered to have the potential to represent only a negligible shift in flight path route and associated additional energy expenditure. The degree of disturbance to Northern Pintail arising from barrier effects at Vesterhav Syd is therefore considered to be **Low**.

8.3.9.2 *Importance*

As defined in Section 8.1.7, Northern Pintail is considered to be a species of **International** importance in terms of this assessment.

8.3.9.3 *Likelihood*

The assessment has predicted that a low level of impact is likely due to barrier effects, even when considering precautionary parameters within the assessment. The likelihood of an effect occurring on the Northern Pintail flyway population is therefore considered to be **Low**.

8.3.9.4 *Persistence*

Potential barrier effects on migratory Northern Pintail are considered to occur throughout the operational lifetime of the project and are therefore categorised as being a **Permanent** effect.

The magnitude of barrier effects on migratory Northern Pintail are therefore considered to be **Minor** (Table 47).

Table 47: Assessment of the barrier impact on migrating birds at Vesterhav Syd.

Phase	Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude
Construction	Low	International	Low	Temporary	Minor
Operation	Low	International	Low	Permanent	Minor
Decommissioning	Low	International	Low	Temporary	Minor

8.3.10 *Migratory seabirds*

The origin and many migratory seabirds likely to pass through the Vesterhav Syd area has not been defined within the scope of this report. It is however considered likely that migratory flyways for all species considered in this assessment will be substantial and mirror the lengths detailed for wildfowl species. Most of the seabirds considered (gulls, terns, skuas) show little or no avoidance of wind farms (Maclean et al. 2009) and therefore will not perceive the Vesterhav Nord wind farm as a barrier. Red-throated Diver is deemed by Maclean et al. (2009) to be relatively highly sensitive to barrier effects compared to other species. However, the limited barrier to migration presented by Vesterhav Nord is not considered likely to materially affect this species through direct mortality. This is likewise the conclusion for Common Scoter which is considered moderately sensitive to barrier effect (Maclean et al. 2009). The maximum magnitude of barrier effects on migratory seabirds are therefore considered to be **Minor** (Table 47).

8.3.10.1 *Summary*

Table 48: Assessment of the maximum barrier effect impacts on migrating birds

Phase	Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude
Construction	Low	International	Low	Temporary	Minor
Operation	Low	International	Low	Permanent	Minor
Decommissioning	Low	International	Low	Temporary	Minor

8.4 Conclusion

A summary of potential magnitude of collision risk and barrier effects on the migratory species included in this assessment is presented in Table 49. No impacts with a magnitude of above **Minor** are predicted for those migrating bird species considered in this assessment with Vesterhav Syd.

Table 49: Summary of the magnitude of impacts on migratory species as a result of Vesterhav Syd

Species	Collision risk[24]	Barrier effects
Pink-footed Goose	Minor	Minor
Greylag Goose	Minor	Minor
Barnacle Goose	Minor	Minor
Light-bellied Brent Goose	Minor	Minor
Eurasian Wigeon	Minor	Minor
Eurasian Teal	Minor	Minor
Northern Pintail	Minor	Minor
Common Eider	Minor	Minor
Common Scoter	Negligible/No impact	Minor
Red-breasted Merganser	Negligible/No impact	Minor
Red-throated Diver	Negligible/No impact	Minor
Arctic Skua	Negligible/No impact	Minor
Kittiwake	Negligible/No impact	Minor
Black-headed Gull	Minor	Minor
Little Gull	Negligible/No impact	Minor
Common Gull	Negligible/No impact	Minor
Lesser Black-backed Gull	Minor	Minor
Herring Gull	Negligible/No impact	Minor
Great Black-backed Gull	Minor	Minor
Sandwich Tern	Negligible/No impact	Minor
Common Tern	Negligible/No impact	Minor
Arctic Tern	Negligible/No impact	Minor

[24] Operational impacts only, effects during construction and decommissioning are considered to be negligible

9 IMPACT ASSESSMENT DURING DECOMMISSIONING

The decommissioning of the wind farm is planned after a period of operation of approximately 25 to 30 years in order to minimise both the short and long term effects on the environment.

The impacts of decommissioning on migrating birds is thought to be similar to the impacts during installation (Section 7.2) and the magnitude of collision and the barrier impacts are therefore also rated as no greater than **Minor**.

10 CUMULATIVE IMPACT ASSESSMENT: MIGRATORY SPECIES

10.1 Overview

Projects considered within the cumulative assessment for migratory species are identical to those considered for ‘resting species’ (NIRAS 2015) in Section 10.1 (see there for site selection rationale). The three projects considered cumulatively with Vesterhav Syd are therefore Horns Rev 3, Vesterhav Nord and Nissum Bredning wind farms (Figure 25). All of these sites are currently in planning and do not have consent for construction at the time of writing of this assessment. Horns Rev 1 & 2 are currently operational and are considered to form part of the current baseline condition with respect to ornithological interests.

It is therefire considered that these two projects should not be included within this assessment. Annex 1 does however, investigate the implications for the cumulative assessment should Horns Rev 1 & 2 provide additive effects to the projects currently screened in. The key results presented in Annex 1 are also carried forward into this report to provide clarity and full interpretation of the implications of either screening in or out of the Horns Rev 1 & 2 projects for a contemporary cumulative assessment with respect to Vesterhav Nord.

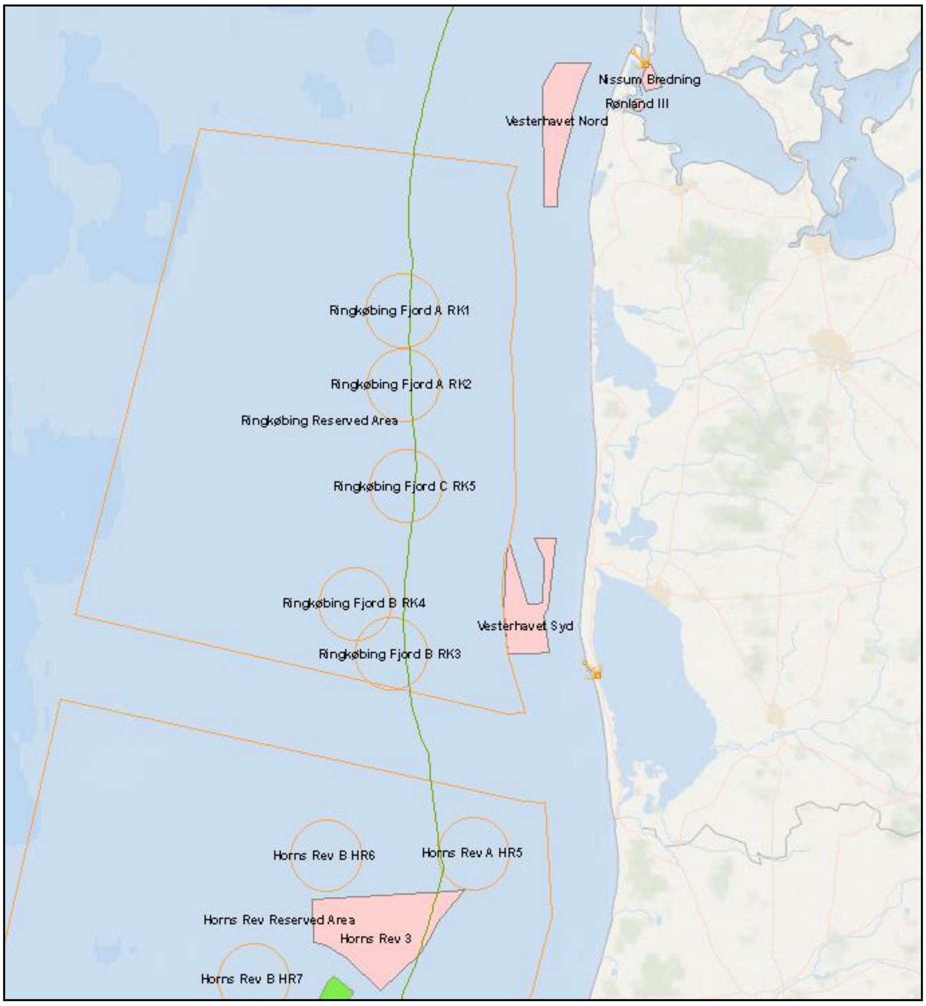

Figure 25: Windfarms considered for cumulative effects: Vesterhav Nord, Vesterhav Syd and Nissum Bredning plus Horns Rev projects (source: http://www.4coffshore.com/offshorewind/)

Explanation: rings are areas outlined by Danish Government for possible offshore wind farms

10.2 Cumulative collision risk

Cumulative collision risk has been considered for all species included in the assessment of Vesterhav Syd alone, with the exception of Barnacle Goose. There was considered to be no connectivity between the migratory movements of Barnacle Goose and Vesterhav Nord or Nissum Bredning based on the migratory route of Barnacle Geese between the Baltic and North Sea, across southern Jutland and northern Schleswig (Section 6.2.4).

The following sections describe each of the projects considered cumulatively and outline the connectivity between these projects and the migratory flyway populations considered in the Vesterhav Syd assessment.

10.2.1 *Horns Rev 3*

Horns Rev 3 Offshore Wind Farm is located approximately 34 km south-west of Vesterhav Syd, approximately 18 km off the western coast of Denmark. The wind farm has a projected output of 400 MW and although the turbine model is as yet undecided the final wind farm will consist of 40-136 turbines with rated power outputs between 3 MW and 10 MW.

Collision risk modelling has been undertaken for migrating birds at Horns Rev 3 (Jensen et al. 2014) although the suite of species did not include the species of goose and duck included in the assessment for Vesterhav Syd. These species were not included in the assessment based on the results of site-specific surveys and a review of the sensitivity of these species to collision. A total of 5,136 individual geese were however recorded at Horns Rev 3 from three survey locations, one onshore at Blåvandshuk and two offshore. A substantially higher proportion of the geese recorded were from the onshore survey station. It is suggested within Jensen et al. (2014) that this may be explained by the specific flyway characteristics of these social migrants which tend to follow coastlines and habitually stop in saltmarsh habitats. The majority of geese recorded at Horns Rev 3 were also recorded outside of the wind farm footprint suggesting a low likelihood of collision. Geese were defined as having a Low sensitivity to collision at Horns Rev 3 (Jensen et al. 2014). As such, there was considered to be a negligible risk of collision to migrating birds from Horns Rev 3.

Observations of Geese outside of Horns Rev 3 may suggest macro-avoidance leading to potential barrier effects. Geese are identified as a species group with a medium sensitivity to barrier effects at Horns Rev 3, although are not considered within the impact assessment (Jensen et al. 2014). The offshore location of Horns Rev 3 and the low numbers of birds recorded during site-specific surveys suggests minimal connectivity between migrating flyway populations of geese and the wind farm.

In conclusion, Horns Rev 3 is not considered in the cumulative assessment for collision and barrier impacts on wildfowl species. This is due to low numbers of those species included within the Vesterhav Syd assessment, recorded during site-specific surveys at Horns Rev 3. Horns Rev 3 is however, considered for migratory seabird species. Collision risk estimates are sourced from (Jensen et al., 2014) for the majority of species included in the Vesterhav Syd alone assessment. However, it is important to take into consideration a number of methodological issues with those collision risk estimates calculated in (Jensen et al., 2014) that result in compatibility problems with those estimates calculated for Vesterhav Syd and are likely to result in significant overestimates of the cumulative collision risk to migratory seabirds.

The interacting populations calculated for Vesterhav Syd (and also for this cumulative assessment Vesterhav Nord and Nissum Bredning) are considered to represent migratory bird movements only. For Horns Rev 3 (and also for Horns Rev 1 and 2), collision risk estimates are presented representing collision risk between January and September (Skov et al., 2012). This time period covers a number of months that are outside of the migratory period, representing the wintering and breeding periods. As such, it is likely that the collision risk estimates presented for Horns Rev 3 in the migratory period are over-estimates. The extended time period used at Horns Rev 3 also means that the cumulative assessment presented here for migratory bird species overlaps considerably with that presented in the resting birds assessment.

10.2.2 Vesterhav Nord

Vesterhav Nord is located approximately 42 km to the north of Vesterhav Syd on the western coast of Denmark. Vesterhav Nord is of similar design to Vesterhav Syd with two turbine scenarios being considered, 66 x 3 MW turbines and 20 x 10 MW turbines. The 3 MW turbine scenario was identified as the worst case scenario for Vesterhav Nord.

An assessment investigating potential impacts on the populations of migratory birds has been produced for Vesterhav Nord, following the methodology used for Vesterhav Syd (Section 0). The turbines modelled for Vesterhav Nord have similar parameters to those modelled for Vesterhav Syd (Table 50). The parameters used in collision risk modelling were consistent with those used for Vesterhav Syd with the exception of the width of the risk window which is project specific (Section 4.2). For Eurasian Wigeon, Eurasian Teal and Northern Pintail the calculation of the population interacting with the wind farm followed the same methodology as used at Vesterhav Syd (see Section 6.3).

10.2.3 Nissum Bredning

Nissum Bredning Wind Farm is located approximately 57 km to the north of Vesterhav Syd within Nissum Bredning fjord, to the south of the Thyborøn Channel, adjacent to Vesterhav Nord. This wind farm is significantly smaller than the two Vesterhav projects with only 12 x 6 MW turbines in planning. No information relating to the collision risk of migrating birds is currently available for this project. As such, a theoretical modelling approach comparable to that used for Vesterhav Syd has been undertaken for Nissum Bredning Wind Farm incorporating site-specific parameters. The turbine parameters used for collision risk modelling are shown in Table 50.

Table 50: Turbine parameters used for collision risk modelling for migratory species at Vesterhav Nord and Nissum Bredning wind farms.

Parameter	Vesterhav Nord	Nissum Bredning
Width of risk window (m)	7,184	2,752
Height of rotors (m)	137	200
No. of turbines	66 x 3 MW	14 x 6 MW

Parameter	Vesterhav Nord	Nissum Bredning
Rotor radius (m)	56	70
Blade width (m)	3.5	4.2
Pitch (°)	6	6
Rotation period (sec)	3.8	4.62

Project specific values for blade width, pitch and rotation period were unavailable for both projects considered for cumulative assessment. Therefore these parameters were estimated based on information relating to turbine models with similar megawatt output that are currently available to developers.

10.2.4 *Migratory species modelling parameters*

Migratory species biometrics and modelling parameters (including the estimated proportion of birds interacting with each wind farm and proportion of birds at collision height) used for Nissum Bredning and Vesterhav Nord wind farms remained consistent with those used in the modelling for Vesterhav Syd. The exception to this being the interacting population sizes for Eurasian Wigeon, Eurasian Teal and Northern Pintail. Due to a lack of information pertaining to the broad migratory routes used by these species the population interacting with each wind farm cannot be quantified with a reasonable degree of confidence. As such, the population predicted to interact with each wind farm for these three species is calculated based on the proportion of the migratory front occupied by the wind farm. The calculation of the interacting population for these three species is shown in Table 51.

The migratory front was measured as the shortest distance between south Norway and the coast of the Netherlands (518 km). The north-south width of Vesterhav Nord and Nissum Bredning were then measured (18.78 km and 3.66 km respectively) and the proportion these widths represented of the migratory front calculated. These proportions were then applied to the flyway population of each species to calculate the proportion of the flyway population predicted to interact with each wind farm.

Migratory wildfowl are considered no further in the cumulative assessment for collision effect impacts at Horns Rev 3 (plus also Horns Rev 1 and 2). This is due to low numbers of those species included within the Vesterhav Nord and Vesterhav Syd assessments, recorded during site-specific surveys at Horns Rev (Annex 1).

Table 51: Calculation of the Eurasian Wigeon, Eurasian Teal and Northern Pintail populations interacting with each wind farm considered for cumulative assessment

Wind farm	Species	Flyway population (no. of individuals)	Width of migratory front (km)	Width of wind farm (km)	Interacting population (no. of individuals)
Vesterhav Nord	Eurasian Wigeon	1,500,000	518	18.78	54,338
	Eurasian Teal	500,000	518	18.78	18,113
	Northern Pintail	60,000	518	18.78	2,175
Nissum Bredning	Eurasian Wigeon	1,500,000	518	3.66	10,604
	Eurasian Teal	500,000	518	3.66	3,535
	Northern Pintail	60,000	518	3.66	424

The avoidance rates used for each species remain consistent with those used in the assessment of Vesterhav Syd alone. The cumulative assessment of colli-sion risk only considers collision risk in the operational phase of these wind farms given the negligible likelihood of collision during the construction and decommissioning phases.

Collision risk estimates produced through the modelling process account for twice annual migratory movements only (with the exception of Eurasian Wigeon that is considered to interact with the wind farms in autumn only).

10.3 Barrier effects

Cumulative barrier effects are considered for all species included in the assessment for Vesterhav Syd alone with the exception of Barnacle Goose for which there is considered to be no connectivity between the migratory movements of Barnacle Goose and Vesterhav Nord or Nissum Bredning. The methodology implemented follows that presented Section 5.2.2.

10.4 Cumulative collision risk impact assessment

10.4.1 Pink-footed Goose

Collision risk modelling for Vesterhav Nord Offshore Wind Farm predicted a total of ten collisions per annum at an avoidance rate of 99%, with the magnitude of this impact defined as Minor. Collision risk modelling conducted for Nissum

Bredning Wind Farm predicted a total of two collisions per annum at an avoidance rate of 99% (Table 52).

Table 52: Cumulative collision risk modelling results for migratory Pink-footed Goose (collisions/annum)

Avoidance rate (%)	Vesterhav Syd	Vesterhav Nord	Nissum Bredning	Total
95	38	50	10	98
98	15	20	4	39
99	**8**	**10**	**2**	**20**
99.8	2	2	0	4
99.99	0	0	0	0

A cumulative total of twenty collisions per annum are predicted for Pink-footed Goose at an avoidance rate of 99%. Using the Rf value of 1.0, this represents 0.3% of the PBR value (and 0.03% of the total flyway population). As a limited level of impact on this population has been predicted, the degree of disturbance to the flyway population of Pink-footed Goose arising from cumulative collision impacts is defined as **Low**.

Pink-footed Goose is considered to be a species of **International** importance in terms of this assessment. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. Therefore the likelihood of an effect occurring on the Pink-footed Goose flyway population is therefore considered to be **Low**. Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect..

The magnitude of cumulative collision impacts on migratory Pink-footed Goose is therefore considered to be **Minor** (Table 53).

Table 53: Cumulative collision risk assessment for migratory Pink-footed Goose.

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

10.4.2 *Greylag Goose*

Collision risk modelling for Vesterhav Nord Offshore Wind Farm predicted a total of 27 collisions per annum at an avoidance rate of 99%, with the magnitude of this impact defined as Minor. Collision risk modelling conducted for Nissum

Bredning Wind Farm predicted a total of 11 collisions per annum at an avoidance rate of 99% (Table 54).

Table 54: Cumulative collision risk modelling results for migratory Greylag Goose (collisions/annum)

Avoidance rate (%)	Vesterhav Syd	Vesterhav Nord	Nissum Bredning	Total
95	104	135	55	294
98	42	54	22	118
99	**21**	**27**	**11**	**59**
99.8	4	5	2	11
99.99	0	0	0	0

A cumulative total of 59 collisions per annum are predicted for Greylag Goose at an avoidance rate of 99%. Using the Rf value of 1.0, this represents 0.1% of the PBR value (and 0.01% of the total flyway population). As a low level impact on this population has been predicted the degree of disturbance to the migratory flyway population of Greylag Goose arising from cumulative collision impacts is defined as **Low**.

Greylag Goose is considered to be a species of **International** importance in terms of this assessment. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. Therefore the likelihood of an effect occurring on the Greylag Goose migratory flyway population is therefore considered to be **Low**. Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Greylag Goose is therefore considered to be **Minor** (Table 55).

Table 55: Cumulative collision risk assessment for migratory Greylag Goose.

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

10.4.3 *Light-bellied Brent Goose*

Collision risk modelling for Vesterhav Nord Offshore Wind Farm predicted a total of two collisions per annum at an avoidance rate of 99%, with the magnitude of this impact defined as Minor. Collision risk modelling conducted for Nissum

Bredning Wind Farm predicted a total of one collision per annum at an avoidance rate of 99% (Table 56).

Table 56: Cumulative collision risk modelling results for migratory Light-bellied Brent Goose (collisions / annum)

Avoidance rate (%)	Vesterhav Syd	Vesterhav Nord	Nissum Bredning	Total
95	2	9	4	15
98	1	4	2	7
99	**0**	**2**	**1**	**3**
99.8	0	0	0	0
99.99	0	0	0	0

A cumulative total of three collisions per annum are predicted for Light-bellied Brent Goose at an avoidance rate of 99%. Using the Rf value of 0.1, this represents 3.95% of the PBR value (and 0.04% of the total flyway population). As a low level impact on this population has been predicted the degree of disturbance to the migratory flyway population of Light-bellied Brent Goose arising from cumulative collision impacts is defined as **Medium**.

Light-bellied Brent Goose is considered to be a species of **International** importance in terms of this assessment. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. Therefore the likelihood of an effect occurring on the Light-bellied Brent Goose migratory flyway population is therefore considered to be **Low**. Should cumulative collision impacts occur they will affect the flyway population throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Light-bellied Brent Goose is therefore considered to be **Moderate** (Table 57).

Table 57: Cumulative collision risk assessment for migratory Light-bellied Brent Goose

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Medium	International	Low	Permanent	Moderate

10.4.4 *Eurasian Wigeon*

Collision risk modelling for Vesterhav Nord Offshore Wind Farm predicted a total of eight collisions per annum at an avoidance rate of 98%, with the magnitude of this impact defined as Minor. Collision risk modelling conducted for Nissum Bredning Wind Farm predicted a total of one collision per annum at an avoidance rate of 98% (Table 58).

Table 58: Cumulative collision risk modelling results for Eurasian Wigeon (collisions/annum)

Avoidance rate (%)	Vesterhav Syd	Vesterhav Nord	Nissum Bredning	Total
95	13	20	1	34
98	**5**	**8**	**1**	**14**
99	3	4	0	7
99.9	1	0	0	1
99.99	0	0	0	0

A cumulative total of 14 migratory period collisions per annum are predicted for Eurasian Wigeon at an avoidance rate of 98%. Using the Rf value of 0.5, this represents 0.01% of the PBR value (and 0.001% of the total flyway population). As a low level impact on this population has been predicted, the degree of disturbance to the flyway population of Eurasian Wigeon arising from cumulative collision impacts is defined as **Low**.

Eurasian Wigeon is considered to be a species of **International** importance in terms of this assessment. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. Therefore the likelihood of an effect occurring on the Eurasian Wigeon flyway population is therefore considered to be **Low**. Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Eurasian Wigeon is therefore considered to be **Minor** (Table 59).

Table 59: Cumulative collision risk assessment for migratory Eurasian Wigeon (migratory period collisions per annum).

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

10.4.5 *Eurasian Teal*

Collision risk modelling for Vesterhav Nord Offshore Wind Farm predicted a total of five collisions per annum at an avoidance rate of 98%, with the magnitude of this impact defined as Minor. Collision risk modelling conducted for Nissum Bredning Wind Farm predicted a total of 0 collisions per annum at an avoidance rate of 98% (Table 60).

Table 60: Cumulative collision risk modelling results for migratory Eurasian Teal (collisions / annum).

Avoidance rate (%)	Vesterhav Syd	Vesterhav Nord	Nissum Bredning	Total
95	8	12	1	21
98	**3**	**5**	**0**	**8**
99	2	2	0	4
99.9	0	0	0	0
99.99	0	0	0	0

A cumulative total of eight collisions per annum are predicted for Eurasian Teal at an avoidance rate of 98%. Using the Rf value 0.5, this represents 0.01% of the PBR value (and 0.002% of the total flyway population). As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Eurasian Teal arising from cumulative collision impacts is defined as **Low**.

Eurasian Teal is considered to be a species of **International** importance in terms of this assessment. The CRM has predicted that a very low level of impact is likely through collision with turbine rotors, even when considering overly precautionary parameters within the modelling process. Therefore the likelihood of an effect occurring on the Eurasian Teal flyway population is therefore considered to be **Low**. Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Eurasian Teal is therefore considered to be **Minor** (Table 61).

Table 61: Cumulative collision risk modelling results for migratory Eurasian Teal (collisions / annum).

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

10.4.6 *Northern Pintail*

Collision risk modelling for Vesterhav Nord Offshore Wind Farm predicted a total of one collision per annum at an avoidance rate of 98%, with the magnitude of this impact defined as Minor. Collision risk modelling conducted for Nissum Bredning Wind Farm predicted a total of 0 collisions per annum at an avoidance rate of 98% (Table 62).

Table 62: Cumulative collision risk modelling results for migratory Northern Pintail (migratory period collisions per annum).

Avoidance rate (%)	Vesterhav Syd	Vesterhav Nord	Nissum Bredning	Total
95	1	2	0	3
98	**0**	**1**	**0**	**1**
99	0	0	0	0
99.9	0	0	0	0
99.99	0	0	0	0

A cumulative total of one collision per annum is predicted for Northern Pintail at an avoidance rate of 98%. Using the Rf value of 0.1, this represents 0.06% of the PBR value (and 0.002% of the total flyway population). As a low level impact on this population has been predicted the degree of disturbance to the flyway population of Northern Pintail arising from cumulative collision impacts is defined as **Low**.

Northern Pintail is considered to be a species of **International** importance in terms of this assessment. The likelihood of an effect occurring on the Northern Pintail flyway population is considered to be **Low**. Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Northern Pintail is therefore considered to be **Minor** (Table 63).

Table 63: Cumulative collision risk assessment for migratory Northern Pintail.

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

10.4.7 *Migratory seabirds*

Table 64 presents the cumulative collision risk estimates for all seabird species considered for Vesterhav Syd, Vesterhav Nord and Horns Rev 3 at a 98% avoidance rate. The potential cumulative impacts to migratory seabirds at Horns Rev 1 & 2 are considered within Annex 1, with key results also indicated in this report for each migratory seabird species. Nissum Bredning is not considered as part of the cumulative impact assessment for seabirds. There exists no project specific data which quantifies the collision risk or presence of any of the seabird species including in the assessment of Vesterhav Nord alone for Nissum Bredning. It is further considered that there will be minimal connectivity between those migratory seabirds exhibiting connectivity with the two Vesterhav projects and Nissum Bredning.

Table 64: Cumulative collision risk for migratory seabirds at a 98% avoidance rate (migratory collisions per annum)

Species	Vesterhav Syd	Vesterhav Nord	Horns Rev 3	Total
Common Eider	1.6	2.1	-	3.7
Common Scoter	0.8	0.8	5.0	6.6
Red-breasted Merganser	0.0	0.1	-	0.1
Red-throated Diver	0.2	0.3	0.0	0.5
Arctic Skua	0.0	0.0	-	0.0
Kittiwake	0.2	0.6	2.0	2.8
Black-headed Gull	1.0	1.2	19.0	21.2
Little Gull	0.1	0.2	-	0.3
Common Gull	0.7	1.0	18.0	19.7
Lesser Black-backed Gull	1.4	1.8	115.0	118.2
Herring Gull	0.9	1.2	148.0	150.1
Great Black-backed Gull	0.8	1.1	4.0	5.9
Sandwich Tern	0.2	0.3	2.0	2.5
Common Tern	0.1	0.2	1.0	1.3
Arctic Tern	0.0	0.1	1.0	1.1

The assessment of impact upon all migratory seabird species is included Table 64. Following the assessment approach used for the Project alone, the magnitude of impact is considered to be Negligible/No impact for any species where the total number of collisions is less than one. This is therefore applicable to Red-breasted Merganser, Red-throated Diver, Arctic Skua and Little Gull is considered to represent a impact with a Negligible/No impact magnitude.

10.4.7.1 *Common Eider*

A cumulative total of 3.7 migratory period collisions is predicted for Common Eider at an avoidance rate of 98%. This represents 0.04% of the PBR value at Rf=0.1 or 0.0004% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Common Eider to cumulative collision impacts is defined as **Low**.

Common Eider is considered to be a species of **Local** importance in terms of this assessment.

The likelihood of an effect occurring on the Common Eider flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Common Eider is therefore considered to be **Minor** (Table 65).

Skov et al. (2012) reports that no Common Eider collsions are estimated for Horns Rev 1 and 2. Therefore, the cumulative aassessments conclusions would remain unchanged should Horns Rev 1 & 2 be included.

10.4.7.2 *Common Scoter*

A cumulative total of 6.6 migratory period collisions is predicted for Common Scoter at an avoidance rate of 98%. This represents 0.09% of the PBR value at Rf=0.1 or 0.001% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Common Scoter to cumulative collision impacts is defined as **Low**.

Common Scoter is considered to be a species of **International** importance in terms of this assessment.

The likelihood of an effect occurring on the Common Scoter flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Common Scoter is therefore considered to be **Minor** (Table 65).

The total collision risk at Horns Rev 1 and 2 for Common Scoter was estimated at 209 collisions (Skov et al. 2012). This therefore equates to a cumulative total of 215.6 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 and 2 representing nearly 97% of this total. This cumulative total represents 2.8% of the PBR at Rf=0.1 or 0.04% of the biogeographic population. Annex 1 concludes that should Horns Rev 1 and 2 be included in the cumulative assessment the magnitude of collision impacts on migratory Common Scoter would therefore be considered to be **Moderate.**

10.4.7.3 *Kittiwake*

A cumulative total of 2.8 migratory period collisions is predicted for Kittiwake at an avoidance rate of 98%. This represents 0.006% of the PBR value at Rf=0.1 or 0.00004% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Kittiwake to cumulative collision impacts is defined as **Low**.

Kittiwake is considered to be **Not Important** in terms of this assessment due to the low interacting population and low conservation status.

The likelihood of an effect occurring on the Kittiwake flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Kittiwake is therefore considered to be Negligible/no impact(Table 65).The total collision risk at Horns Rev 1 and 2 for Kittiwake was estimated at 16.6 collisions (Skov et al. 2012). This therefore equates to a cumulative total of 19.4 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 and 2 representing over 85% of this total. This cumulative total represents 0.04% of the PBR at Rf=0.1 or 0.0003% of the biogeographic population. Annex 1 concludes that should Horns Rev 1 and 2 be included in the cumulative assessment the magnitude of collision impacts on migratory Kittiwake would therefore be considered to be **Negligible.**

10.4.7.4 *Black-headed Gull*

A cumulative total of 21.2 migratory period collisions is predicted for Black-headed Gull at an avoidance rate of 98%. This represents 0.01% of the PBR value at Rf=0.5 or 0.0004-0.0005% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Black-headed Gull to cumulative collision impacts is defined as **Low**.

Black-headed Gull is considered to be a species of **Local** importance in terms of this assessment.

The likelihood of an effect occurring on the Black-headed Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Black-headed Gull is therefore considered to be **Minor** (Table 65).

The total collision risk at Horns Rev 1 and 2 for Black-headed Gull was estimated at 13.4 collisions (Skov et al. 2012). This therefore equates to a cumulative total of 34.6 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 36% of this total. This cumulative total represents 0.02% of the PBR at Rf=0.5 or 0.0007-0.0009% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. Annex 1 concludes that should Horns Rev 1 and 2 be included in the cumulative assessment the magnitude of collision impacts on migratory Black-headed Gull would therefore be considered to be **Minor.**

10.4.7.5 Common Gull

A cumulative total of 19.7 migratory period collisions is predicted for Common Gull at an avoidance rate of 98%. This represents 0.19% of the PBR value at Rf=0.1 or 0.0008-0.002% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Common Gull to cumulative collision impacts is defined as **Low**.

Common Gull is considered to be a species of **National/Regional** importance in terms of this assessment.

The likelihood of an effect occurring on the Common Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Common Gull is therefore considered to be **Minor** (Table 65).

The total collision risk at Horns Rev 1 & 2 for Common Gull was estimated at 4.5 collisions (Skov et al. 2012). This therefore equates to a cumulative total of 24.4 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 18% of this total. This cumulative total represents 0.23% of the PBR at Rf=0.1 or 0.001-0.002% of the biogeographic population. Annex 1 concludes that should Horns Rev 1 and 2 be included in the cumulative assessment the magnitude of collision impacts on migratory Common Gull would therefore be considered to be **Minor.**

10.4.7.6 Lesser Black-backed Gull

A cumulative total of 118.2 migratory period collisions is predicted for Lesser Black-backed Gull at an avoidance rate of 98%. This represents 0.38% of the PBR value at Rf=1.0 or 0.02% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Lesser Black-backed Gull to cumulative collision impacts is defined as **Low**.

Lesser Black-backed Gull is considered to be a species of **International** importance in terms of this assessment.

The likelihood of an effect occurring on the Lesser Black-backed Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Lesser Black-backed Gull is therefore considered to be **Minor** (Table 65).

The total collision risk at Horns Rev 1 & 2 for Lesser Black-backed Gull was estimated at 403.7 collisions (Skov et al. 2012). This therefore equates to a cumulative total of 521.9 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 77% of this total. This cumulative total represents 1.66% of the PBR at Rf=1.0 or 0.09-0.1% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. Annex 1 concludes that should Horns Rev 1 and 2 be included in the cumulative assessment the magnitude of collision impacts on migratory Lesser Black-backed Gull would therefore be considered to be **Moderate.**

10.4.7.7 *Herring Gull*

A cumulative total of 150.1 migratory period collisions is predicted for Herring Gull at an avoidance rate of 98%. This represents 0.34% of the PBR value at Rf=0.5 or 0.005-0.01% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Herring Gull to cumulative collision impacts is defined as **Low**.

Herring Gull is considered to be a species of **Local** importance in terms of this assessment.

The likelihood of an effect occurring on the Herring Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Herring Gull is therefore considered to be **Minor** (Table 65).

The total collision risk at Horns Rev 1 & 2 for Herring Gull was estimated at 250.1 collisions (Skov et al. 2012). This therefore equates to a cumulative total of 400.2 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 62% of this total. This cumulative total represents 0.92% of the PBR at Rf=0.5 or 0.01-0.03% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. Annex 1 concludes that should Horns Rev 1 and 2 be included in the cumulative assessment the magnitude of collision impacts on migratory Herring Gull would therefore be considered to be **Minor.**

10.4.7.8 *Great Black-backed Gull*

A cumulative total of 5.9 migratory period collisions is predicted for Great Black-backed Gull at an avoidance rate of 98%. This represents 0.03% of the PBR value at Rf=1.0 or 0.001-0.002% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Great Black-backed Gull to cumulative collision impacts is defined as **Low**.

Great Black-backed Gull is considered to be a species of **Local** importance in terms of this assessment.

The likelihood of an effect occurring on the Great Black-backed Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Great Black-backed Gull is therefore considered to be **Minor** (Table 65).

The total collision risk at Horns Rev 1 & 2 for Great Black-backed Gull was estimated at 84.2 collisions (Skov et al. 2012). This therefore equates to a cumulative total of 90.1 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 93% of this total. This cumulative total represents 0.5% of the PBR at Rf=1.0 or 0.02-0.03% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. Annex 1 concludes that should Horns Rev 1 and 2 be included in the cumulative assessment the magnitude of collision impacts on migratory Great Black-backed Gull would therefore be considered to be **Minor.**

10.4.7.9 Sandwich tern

A cumulative total of 2.5 migratory period collisions is predicted for Sandwich Tern at an avoidance rate of 98%. This represents 0.04% of the PBR value at Rf=0.5 or 0.002% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Sandwich Tern to cumulative collision impacts is defined as **Low**.

Sandwich Tern is considered to be a species of **International** importance in terms of this assessment.

The likelihood of an effect occurring on the Sandwich Tern flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Sandwich Tern is therefore considered to be **Minor** (Table 65).

The total collision risk at Horns Rev 1 & 2 for Sandwich Tern was estimated at 1.5 collisions (Skov et al. 2012). This therefore equates to a cumulative total of 4.1 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 36% of this total. This cumulative total represents 0.06% of the PBR at Rf=0.5 or 0.002% of the biogeographic population. Even at an Rf value of 0.1 the PBR value is still not surpassed. Annex 1 concludes that should Horns Rev 1 and 2 be included in the cumulative assessment the magnitude of collision impacts on migratory Sandwich Tern would therefore be considered to be **Minor.**

10.4.7.10 *Common tern*

A cumulative total of 1.3 migratory period collisions is predicted for Common Tern at an avoidance rate of 98%. This represents 0.02% of the PBR value at Rf=0.5 or 0.0007-0.0008% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Common Tern to cumulative collision impacts is defined as **Low**.

Common Tern is considered to be a species of **National/Regional** importance in terms of this assessment.

The likelihood of an effect occurring on the Common Tern flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Common Tern is therefore considered to be **Minor** (Table 65).

Skov et al. 2012 reports less than one Common Tern collsison per annum for Horns Rev 1 & 2. Therefore, should Horns Rev 1 & 2 be included in the cumulartive assessment the magntitude of collision effects would remain unchanged (Annex 1).

10.4.7.11 *Arctic tern*

A cumulative total of 1.1 migratory period collisions is predicted for Arctic Tern at an avoidance rate of 98%. This represents 0.004% of the PBR value at Rf=0.5 or 0.0001% of the biogeographic population. As a low level impact on this population has been predicted the sensitivity of the flyway population of Arctic Tern to cumulative collision impacts is defined as **Low**.

Arctic Tern is considered to be a species of **National/Regional** importance in terms of this assessment.

The likelihood of an effect occurring on the Arctic Tern flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Arctic Tern is therefore considered to be **Minor** (Table 65).

Skov et al. 2012 reports less than one Arctic Tern collsison per annum for Horns Rev 1 & 2. Therefore, should Horns Rev 1 & 2 be included in the cumulartive assessment the magntitude of collision effects would remain unchanged (Annex 1).

Table 65: Cumulative collision risk assessment for all migratory seabird species

Phase	Species	Vulnerability (degree of disturbance)	Importance	Impact Likelihood	Persistence	Magnitude of impact
Operation	Common Eider	Low	Local	Low	Permanent	Minor
	Common Scoter	Low	International	Low	Permanent	Minor
	Red-breasted Merganser	Low	Not important	Low	Permanent	Negligible/no impact
	Red-throated Diver	Low	International	Low	Permanent	Negligible/no impact
	Arctic Skua	Low	Not important	Low	Permanent	Negligible/no impact
	Kittiwake	Low	Not important	Low	Permanent	Negligible/no impact
	Black-headed Gull	Low	Local	Low	Permanent	Minor
	Little Gull	Low	International	Low	Permanent	Minor
	Common Gull	Low	National/Regional	Low	Permanent	Minor
	Lesser Black-backed Gull	Low	International	Low	Permanent	Minor
	Herring Gull	Low	Local	Low	Permanent	Minor
	Great Black-backed Gull	Low	Local	Low	Permanent	Minor

Phase	Species	Vulner-ability (degree of dis-turbance)	Im-portance	Impact Likeli-hood	Persis-tence	Magni-tude of impact
	Sandwich Tern	Low	Internation-al	Low	Perma-nent	Minor
	Common Tern	Low	Nation-al/Regional	Low	Perma-nent	Minor
	Arctic Tern	Low	Nation-al/Regional	Low	Perma-nent	Minor

10.5 Cumulative barrier effects impact assessment

This section considers the potential cumulative barrier effects for all species that are considered for Vesterhav Syd alone. The impacts are predicted to be identical for each species and as such within the assessment the criteria presented are considered to be applicable to all species.

Barrier effects are unlikely to be significant on any species/population interacting with Nissum Bredning alone as the wind farm only occupies an area of 5 km^2 which is not considered sufficient to affect the energetic expenditure of migratory species. As such, cumulative barrier effects are only considered for Vesterhav Syd and Vesterhav Nord. The location of Nissum Bredning also suggests, in terms of barrier effects, that there will be minimal cumulative connectivity with the two Vesterhav projects. Nissum Bredning is located within Nissum Bredning fjord, to the south of the Thyborøn Channel, adjacent to Vesterhav Nord and is significantly smaller than the two Vesterhav projects with only 12 x 6 MW turbines in planning The majority of migratory movements are considered to occur offshore exhibiting a higher degree of connectivity with the two Vesterhav projects.

Significant cumulative barrier effects with the potential to affect flyway populations of migratory species considered in this assessment as a result of avoiding the areas occupied by Vesterhav Syd and Vesterhav Nord are considered unlikely to occur. Masden et al. (2009a) showed that as a result of the presence of Nysted Offshore Wind Farm, migrating Common Eider experienced an increase in migratory distance of 500 m with no significant increases in energy expenditure. Even when this distance was doubled to 1 km, increases in energetic cost were still insignificant. The estimated length of the likely migration route taken by the birds tracked as part of this study was approximately 1,400 km with a significant increase in energy expenditure (1% of bird body mass) only experienced should the overall distance travelled increase to 1,450 km. The increase in flight path associated with Vesterhav Syd was calculated as 4.78 km with a distance of 3.74 km for Vesterhav Nord. As such, it is unlikely that cumulative barrier effects associated with these two projects will result in a significant increase in energetic costs for any of the migratory species included in this assessment.

Table 66 presents the maximum cumulative barrier effects assessment for all species included in the assessment for Vesterhav Syd alone. Negligible increases in energy expenditure are predicted for all species included in the assessment with the vulnerability if these species to barrier effects therefore considered to be **Low**. The importance of all species is defined in section 8.3. The impact of barrier effects is considered to be a **Permanent** effect. The likelihood of an effect occurring on the flyway populations of all species is considered to be **Low** based on the negligible increases in energy expenditure predicted for individual birds. The magnitude of cumulative barrier impacts on the migratory species considered in this assessment is therefore considered to be **Minor** or **Negligible/No impact** (Table 66).

Table 66: Maximum cumulative barrier effects for all migratory species included in the assessment

Degree of disturbance	Importance	Impact Likelihood	Persistence	Magnitude of impact
Low	International	Low	Permanent	Minor

11 CROSS-BORDER EFFECTS

The Espoo Convention on Environmental Impact Assessment in a Transboundary Context and EU Directive 85/337/EEC aims to identify effects on a trans-boundary scale in order to prevent, mitigate and monitor environmental damage.

As no mitigation measures have to be considered and the effects are very likely not to cause irreversible effects (see definition of “minor impact” in Table 8 in Section 0) no cross-border effects are expected for migratory birds during the periods of construction, operation and decommissioning. The same holds true for bats. Resident bats are restricted to a limited area and for them as well as for migrating bat only minor impact are expected (section 12.5). Therefore, cross-border effects are not anticipated.

12 BATS

12.1 Introduction

Of the 17 Danish bat species all are protected under national law and through implementation of EU's Habitats Directive Article 12 – Annex IV. In addition to this they are also protected under both the Bern- and Bonn-convention (Møller et al. 2013). As bats have long lives and a low reproduction rate even loss of a limited number of individuals can affect populations negatively. It is known that wind turbines on land can have a major impact on bats (Møller et al. 2013) but very little is known about the interaction between bats and offshore wind farms. Even though bats are known to forage over the sea it is likely offshore wind farms effect migrating bats the most.

In the following section the occurrence of bats in Denmark, West Jutland (close to the Vesterhav Syd site) and on the North Sea coast is described. The abundance of bats in the relevant area and the current knowledge on behaviour of bats interacting with wind farms will be the basis for the impact assessment

12.2 Methods and data sources

The knowledge and assessment of impacts on bats is based on a literature research on bats near wind farms in Scandinavia, migration over sea and knowledge of bat observations in the North Sea.

12.3 Occurrence of bats in the North Sea and West Jutland

Bats are known to migrate over the North Sea, including from Denmark. Observations of bats over the North Sea mainly come from German (Walter et al. 2007), Dutch (Boshamer & Bekker 2008) and English coastlines (Baagøe & Bloch 1994). The most numerous observations are of 34 bats on 65 platforms in the Netherlands over a period of 19 years (Boshamer & Bekker 2008). The individuals reported in this study were in rather poor condition and were often caught by hand (Boshamer & Bekker 2008).

Bats are known to be more numerous near the coastline, especially in areas where migration occurs. In the German Bight it is estimated that annually approximately 3700 *Pipistrellus nathusii* and approximately 990 *Nyctalus noctula* migrate within the inner 200 km of the bight (Skiba 2007). These species are thought to leave land in the northern parts of the Wadden Sea including Blåvandshuk and not further north (HR3: Orbicon 2014).

The species found in the German Bight are among the species known to migrate over the longest distances and most likely to migrate over water. Other species are *Nyctalus leisleri*, *Vespertilio murinus* and to some extent *Pipistrellus pygmaeus* (Baagøe & Bloch 1994, Ahlén et al. 2007, 2009) but 11 species have been found over the sea in Scandinavia (Ahlén et al. 2009). Of these the most numerous over open water is *Pipistrellus nathusii* both in the Baltic Sea (FEBI 2013, DCE/DHI 2014) and in the North Sea (Boshamer & Bekker 2008, Poerink et al. 2013). Most of these bats are thought to originate from populations in the Baltic countries and winter in Germany, Netherlands and England (Russ et al. 2000). *P. nathusii* are known to originate from Russia and the Baltics, *N. noctula* from Scandinavia (Voigt et al. 2012).

The western parts of Jutland are generally characterised by low densities of bats recorded in the Danish national monitoring program. This monitoring is conducted in 10x10 km squares with ultrasound equipment. is the low density of bats is probably due to the open windswept landscape with few large old trees or other suitable breeding sites preferred by many bat species (Møller et al. 2013). The windy conditions combined with the lack of wind breaks (trees) where insects can congregate makes the west coast of Jutland a suboptimal foraging area for bat.

On the coast near Vesterhav Nord no bats have been found during the national monitoring program (Møller et al. 2013). The most likely species occur at the wind farm site that have occurred inland are *Myotis daubentonii* and *Eptesicus serotinus* (see Figure 26, Figure 27). *Eptesicus serotinus* only becomes slightly more abundant in coastal areas south of Vesterhav Syd. But also *Myotis dasycneme*, *Pipistrellus nathusii* and *Nyctalus noctula* occur in coastal areas, although in lower numbers (Møller et al. 2013). Due to the low abundance of these species also few individuals are likely forage or migrate though the Vesterhav Syd wind farm area.

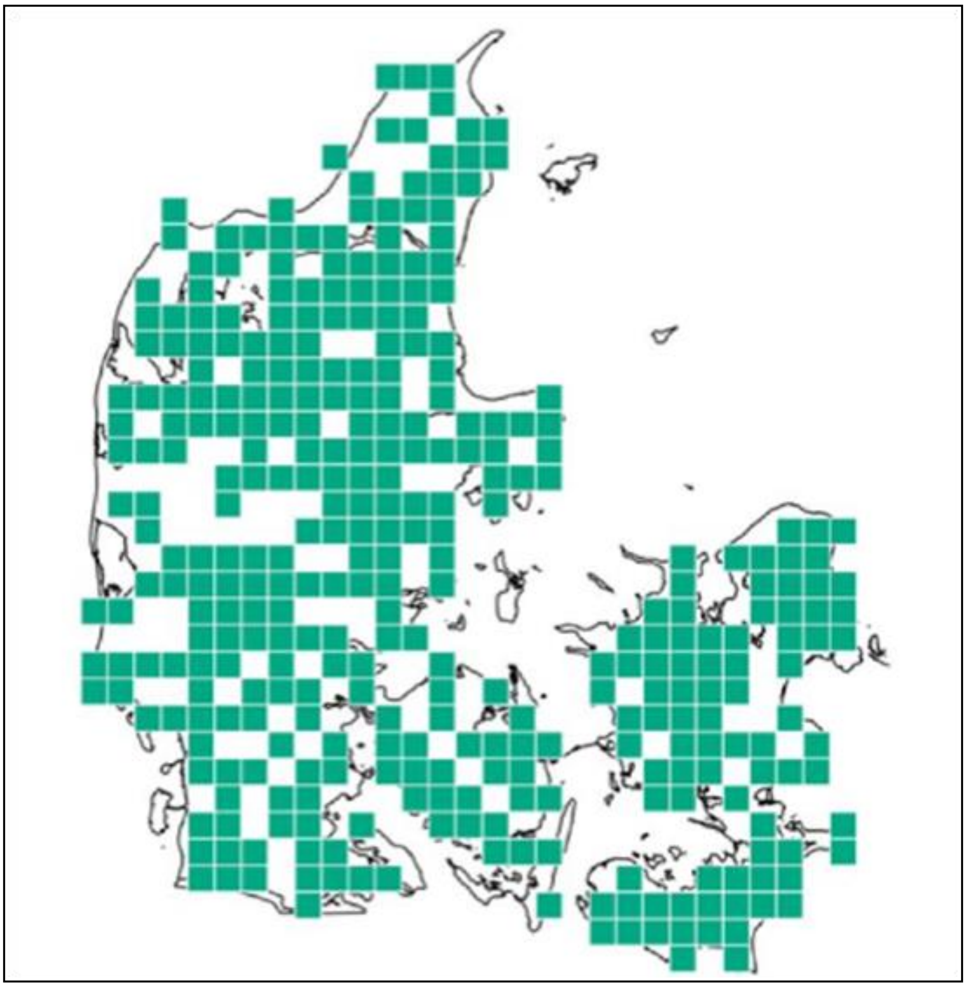

Figure 26: Distribution of *Myotis daubentonii* in Denmark (Møller et al. 2013).

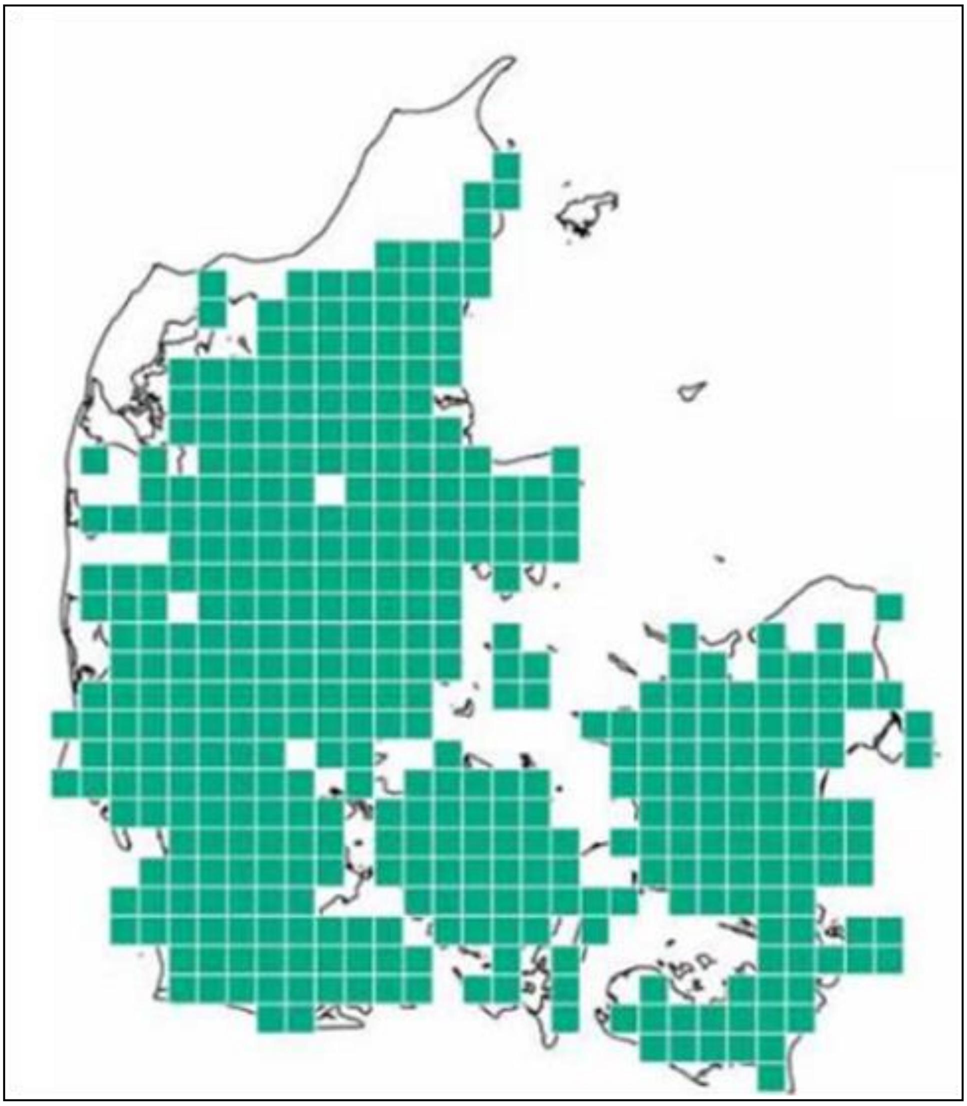

Figure 27: Distribution of Eptesicus serotinus in Denmark (Møller et al. 2013).

12.4 Methodology of impact assessment

The methodology of impact assessment in bats follows with one described for migrating birds in Section 0 (see general information in the introduction Section 5.1). The parameter are defined as follows:

12.4.1 Degree of disturbance

The key pressure relating to bats is collision. The rates of collision are assessed according to the expected number of bats in the area derived from literature. The higher the number of bats in the development area the higher the likely risk of collision. Due to the lack of information of relevant population sizes or migratory flyway populations a referrence to populations is not possible.

This will be modified by other factors that are taken into consideration by the assessment, e.g. flight behaviour.

12.4.2 *Importance*

Of the 17 Danish species of bats all are protected under both national law and through implementation of the EU's Habitats Directive Article 12 – Annex IV. In addition, they are also protected under the Bern- and Bonn-convention (Møller et al. 2013). Hence, bats have a very high conservation status and the degree of importance depends in the abundance of the species (see Table 7 in Section 5.3). The abundance in the area is estimated according to data on literature.

12.4.3 *Likelihood of occurrence*

The likelihood of occurrence of collisions in bats is derived from the number of bats potentially at risk as judged from literature. The behaviour of bats is also considered (attraction to turbines, flight altitude, frequency of relevant wind speeds).

12.4.4 *Persistence*

In terms of collisions the duration of the effect is by definition "Permanent" as the result of colliding bats is usually death and this is a permanent status.

12.5 Impact assessment

12.5.1 *Current knowledge about the impacts of wind turbines on bats*

It is known that bats are attracted to insects that congregate around wind turbines in calm and warm weather. The insects are probably attracted to the wind turbines as they during the night radiate heat accumulated during the day. The phenomenon is most common in low wind speeds (below 5-6 m/s) in the late summer and early autumn when insects are most numerous. It is known both for onshore and offshore wind turbines (Ahlén et al. 2007).

Hunting bats as well as migrating bats can collide directly with the rotor blade or can indirectly be killed by the change in air pressure around the rotor blade (a phenomenon known as 'barotrauma'; Baerwald et al. 2008). The mortality rate is strongly dependent on the location of the wind turbines but has been known to be as high as 50 bats per turbine annually (Hötker et al. 2004, Brinkmann et al. 2006). Mortality is highest in forest, along ridges and the coastline. It is lowest in open intensively used farmland where it is not reported higher than 3.2 bats per turbine annually (Hötker et al. 2004). The mortality also increases with increasing wind turbine size (Rydell et al. 2011). There is currently no published knowledge of the mortality rate in Denmark.

All these above mentioned studies are done on land and it is unknown whether similar numbers of fatalities are found in offshore wind turbines. It is difficult to study bat mortality in offshore wind farms as fatality searches obviously cannot be performed in the sea. Radar observations can often only detect larger species such as *Nyctalus noctula* and Vespertilio murinus (Ahlén et al. 2007). Species identification is impossible and bats cannot be distinguished from birds or insects with certainty. Acoustic studies are currently the best method to study bats in offshore wind farms. By recording the echolocation of bats from the nacelle of wind turbines the number of fatalities can be estimated (Korner-Nievergelt et al. 2011).

Bats are known to hunt offshore and several species migrate over water. Normally they fly low over the water (less than 10 m) but around structures (e.g. lighthouses, bridges and wind turbines) they follow the structures upwards to hunt insects even on migration (Møller et al. 2013).

Offshore foraging always take place in calm and dry weather. Bats mainly hunt insects but also spiders drifting on the wind or small crustaceans on the water surface (Ahlén et al. 2007, 2009, Poerink et al. 2013).

Most studies of offshore foraging bats in or around Denmark have been done in straits or sounds in the Baltic Sea close to larger onshore population of bats (Ahlén et al. 2007, 2009). Bats are however known to follow linear landscapes such as coastlines both during commuting flights to foraging areas as well as during migration. During bad weather both bats and birds accumulate in large numbers at certain stopover sites awaiting favourable weather before migrating over larger bodies of water. In Denmark these are known to be the southern tips of the islands of Lolland, Falster and Bornholm (Ahlén et al. 2009, FEBI 2013).

Bats normally leave the coast in good weather with winds below 5 m/s and on nights without rain or predicted precipitation. The activity of bats over water seems to increase with temperature (FEBI 2013). The major period of migration takes place from mid-August to mid-October and again from mid-April to the end of May. The exact time varies from species to species and it seems to be more concentrated in the fall around specific departure sites than the more broad-front spring migration (Ahlén et al. 2009, FEBI 2013).

12.5.2 Impact assessment during installation

The relevant pressure on bats during installation are potential collisions with vessels.

As Vesterhav Syd wind farm area is not near any known populations of bats it is not thought to be a potential forage area for bats (Section 12.3). Therefore, the main issue concerns migratory bats. The Vesterhav Syd wind farm area is, however, not located on any known migratory route. Only *Myotis dasycneme*, *Pipistrellus nathusii* and *Nyctalus noctula* have populations in western Norway and most of these populations are thought to be sedentary (Dietz et al. 2009). This knowledge of relevant populations is the basis for judgment of the “Degree of disturbance” both during construction and operation.

During installation of the wind farm, increased vessel traffic is likely to occupy an area of up to 4 km from the coastline. The light emission of the vessels may attract insects and bats may follow insects toward operating vessels. On the other hand, species like *Myotis dasycneme* may be disturbed by light emission, but they are expected to occur in only low numbers. Due to the restricted area of operation and number of vessels and the coast of Jutland not being populated by bats in high numbers (see Section 12.3) only low number of bats are expected to occur close to vessels and the “Degree of disturbance” is rated as **Low**.

A combination of a very high conservation status and an estimated low abundance (see description of bats in coastal areas in West Jutland in Section 12.3) leads to an importance of **Local** level (Table 7).

As movement of vessels is slow and bats are capable of high manoeuvrability due to their ultrasonic orientation the likelihood of collision during installation is regarded as **Low.**

If collisions occur then bats usually die and the persistence of the impact collision is therefore rated as **Permanent**.

The combination of rating of parameters leads to a **Minor** magnitude of impact (Table 67).

Table 67: Impact assessment on bats during the period of construction

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
Low	Local	Low	Permanent	Minor

12.5.3 *Impact assessment during operation*

During operation the turbines at Vesterhav Syd offshore wind farm will be equipped with markings for vessels (yellow light on piles along peripheral turbines with an effective reach of at least 5 nautical miles) and aircrafts (flashing red light during night on the nacelle). The lighting may result in an attraction of insect, or insects are “caught” by the light and accumulate around the turbines. Further, the heat radiation from the wind turbines at night could potentially also attract insects and thereby bats. Insects are attracted to the turbines only in light winds (below 6 m/s) reducing the number of days per year in which bats potentially are present around the turbines and collide. In very calm wind conditions turbines will stand still the navigation system of bats will detect them avoiding collisions.

Bat species recorded in offshore areas are usually migrating bats. Compared to sedentary species they basically have to be regarded as species of higher risk regarding collisions with offshore structures. *Nyctalus noctula* and *Pipistrelloids* are most relevant migrating species at higher risk, whereas *Myotids* are not considered as risk species (although *M. dasycneme* is known to migrate up to 350 km between breeding and wintering areas). *Nyctalus noctula* and e.g. *Pipistrellus nathusii* are both long distance migrants travelling in autumn from Scandinavia and eastern Europe to western Europe. Both species have been recorded in the Dutch offshore wind farms PAWA and OWEZ (Poerink et al. 2013). They also used the area for foraging, but data base was not sufficient for final conclusions about the relationship between migration, foraging and roosting. In the Vesterhav Syd area the number of individuals of *Nyctalus noctula* and *Pipistrellus nathusii* is presumably low according to their spatial distribution pattern. Further, migration routes leaving the coast in north Denmark are not known and very unlikely. The most common species in the Vesterhav Syd area *Myotis daubentonii* (and *Eptisicus serotinus*) are not regarded as risk species.

Though the turbines are relatively close to land the number of insects near the west coast of Jutland is probable also much lower than at similar coastlines on inner Danish waters and along the Baltic Sea. There are, however, no studies to support this assumption. In combination with the finding that coastal areas in West Jutland are populated by comparable low number of bats (Section 12.3) the “Degree of disturbance” is rated as **Low**.

All bats have a very high conservation status. Combined with an estimated abundance in the coastal areas of West Jutland of a low magnitude the parameter importance is rated as **Local**.

The migration through Vesterhav Syd offshore wind farm is considered to be very sparse and most species migrate below 10 metres and only *Nyctalus noctula* are known to fly up to 40 meters above sea level. The only time bats move up along constructions are during light airs when insects are present. Therefore, it is thought that only few individuals of bats will come in contact with the rotor blades, even considering the high flying species *Nyctalus noctula*. Due to this behaviour and the low number of expected bats the likelihood of occurrence of collision is rated as **Low**.

Colliding bats usually die and the persistence of the impact collision is therefore rated as **Permanent**.

The assessment of impacts by the operation of Vesterhav Syd wind farm is thought to be **Minor** on bats given the present knowledge and literature (Table 68).

Table 68: Impact assessment on bats during the period of operation

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
Low	Local	Low	Permanent	Minor

12.5.4 *Impact assessment during decommissioning*

The impacts of the decommissioning on bats is thought to be similar to the impacts during installation and therefore rated as **Minor** (Table 69).

Table 69: Impact assessment on bats during the period of decommissioning

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
Low	Local	Low	Permanent	Minor

12.6 Total impact

Vesterhav Syd offshore wind farm is located in an area with few bats present inland from the wind farm and not in any known or likely unknown migratory pathway. Therefore, very few bats are thought to be present in the project area.

The magnitude of impact is assessed as **Minor** for installation, operation and decommissioning

12.7 Cumulative effects

Assessing the cumulative effects on bats the wind farm project Vesterhav Nord (approximately 42 km north of Vesterhav Syd) and the wind farm Nissum Bredning / Fjordgrundene Havmøller are considered (descriptions and selection of of projects is given in Section 10).

According to the results of the national monitoring program the expected species on the landside near Vesterhav Nord will be similar to that near Vesterhav Syd (Møller et al. 2013). *Myotis daubentonii* and *Eptecicus serotinus* dominate with *Eptecicus serotinus* being less dominant than near Vesterhav Syd (Figure 27). Besides *Myotis dasycneme*, *Pipistrellus nathusii* and *Nyctalus noctula* as further species in lower number also *Pipistrelluns pipistrellus* was found in a single 10 x 10 km² east of the Ringkøbing Fjord.

In Vesterhav Nord the situation is very similar to Vesterhav Syd with respect to the dimension of the wind farm and its distance from the coastline. Given the similar spectrum and abundance of bat species the impact of the wind farm Vesterhav Nord is assessed to be similar to that of Vesterhav Syd. The Environmental Impact Assessment for the Nissum Bredning wind farm project predicts that there will be no impacts of the wind farm on bats (Hansen 2011). The assessment is based on the same monitoring data from the national monitoring program (Møller et al. 2013) and there were no specific studies are carried out for the project.

As in all projects a low impact of the wind farms is predicted it can be assumed that on a cumulative basis the impact will not be rated higher than **Minor**.

12.8 Cross-border effects

With regards to bats only minor impacts were predicted for all species with respect to collisions. As no mitigation measures have to be considered and the effects are very likely not to cause irreversible effects (see definition of "minor impact" in Table 8 in Section 0) no cross-border effects are expected for bats during the periods of construction, operation and decommissioning.

12.9 Mitigation measures

With regards to bats no impact levels higher than Minor were found and no mitigation measures have been considered.

13 HABITATS REGULATIONS ASSESSMENT

13.1 Habitats Regulations Appraisal Process

13.1.1 EC Directives and Regulations

The Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the ‘Habitats Directive’) protects habitats and species of European nature conservation importance. Together with the Council Directive (2009/147/EC) on the conservation of wild birds (the ‘Birds Directive’), the Habitats Directive establishes a network of internationally important sites designated for their ecological status, known as Natura 2000.

Special Protection Areas (SPAs) are designated under the Birds Directive in order to protect rare, vulnerable and migratory birds. Together with Special Areas of Conservation (SACs), designated under the Habitats Directive, SPAs contribute to the Natura 2000 network of European designated areas. In addition, internationally important wetlands designated under the Ramsar Convention 1971 (Ramsar sites) are afforded the same protection as SPAs and SACs, for the purpose of considering development proposals that may affect them. This report considers ornithological features only, therefore only refers to SPAs and Ramsar sites. In this report, SPAs and Ramsar sites are referred to collectively as ‘European sites’.

13.1.2 The Habitats Regulations Assessment Process

Projects which are not directly connected with, or necessary to the management of, any Natura 2000 sites, but may have a significant effect on them are subject to a Habitat Regulation Assessment (HRA). This process is detailed in Figure 28.

The first stage is a screening process to assess if a project is likely to have a significant effect on any Natura 2000 sites. This is also known as the test for Likely Significant Effect (LSE).

Following initial screening for LSE, any project, alone or in combination with other projects and plans, that is likely to significantly affect the conservation status of any European sites, must be subject to an Appropriate Assessment (AA); in accordance with executive order no. 1476 13/12/2010 (Bekendtgørelse om konsekvensvurdering vedrøren-de internationale naturbeskyttelsesområder samt beskyttelse af visse arter ved projekter om etablering m.v. af elproduktion-sanlæg og elforsyningsnet).

The purpose of an AA is to provide an assessment of the implications of the project with regard to the conservation objectives of the European sites, individually or in combination with other plans or projects. Approval for the project may only be granted if the AA shows that the project will not adversely affect the integrity of any European sites.

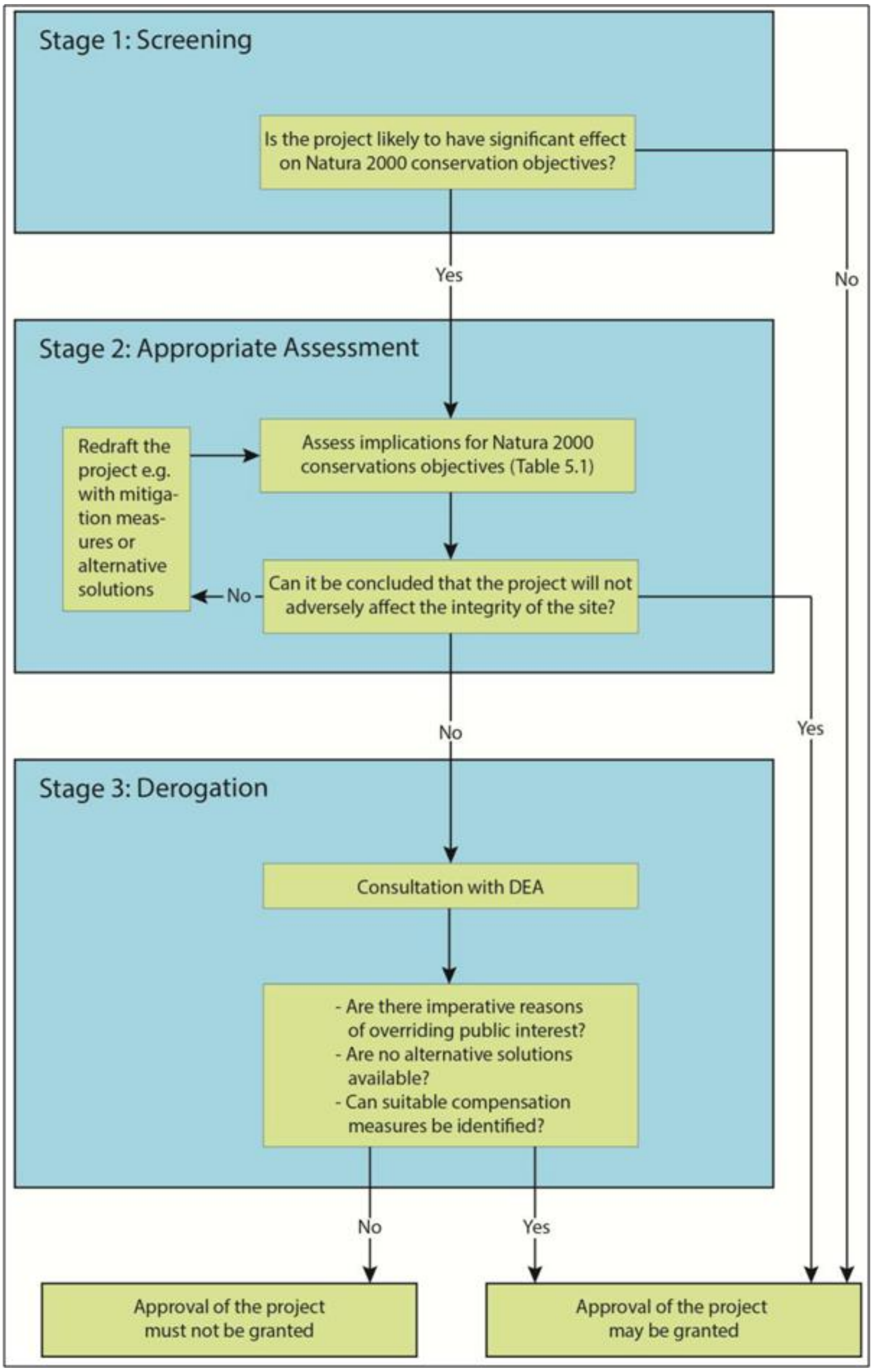

Figure 28: HRA process flow chat (NIRAS 2013)

13.2 Approach to HRA

13.2.1 Stage 1: Screening

Screening is a relatively coarse filter to identify those sites and features for which a LSE cannot be discounted. The screening exercise undertaken for Vesterhav Syd has been undertaken with reference to the following guidance:

- Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC): Assessment of plans and projects significantly affecting Natura 2000 sites. EU Commission guidance on Nature (November 2001);
- Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC (2012);
- EU Guidance document on wind energy development in accordance with EU nature legislation. (2010);
- Habitat Directive guidelines: Vejledning til Habitatbekendtgørelsen (VEJ nr. 408 af 01/05/2007); and
- Danish Energy Agency Guidance document on Environmental Impact Assessment, Danish Offshore Wind Farms (NIRAS 2013).

Once a site/feature is identified the screening exercise considers whether or not a significant effect can be foreseen, both directly and indirectly, within the context of the site's conservation objectives and characteristics, including the specific environmental conditions of the site.

A filtering process is undertaken whereby all of the sites that can be identified as having connectivity with the project, based upon proximity and designated features, can be discerned from those which do not. Subsequent analysis of the interactions of the qualifying features of a European site with the project, and its potential impacts, is then required in order to further screen for LSE. When considering the potential for LSE in relation to associated sites, evidence will be required to demonstrate that: there are no processes which might occur with the potential to result in a significant impact upon a feature as a result of the proposed development; or, where a potential impact is identified, there must be certainty that the magnitude of any potential impact would be sufficiently minor to ensure that the feature would not be significantly affected.

NIRAS (2013) outlines the following key steps to be considered as part of HRA screening for offshore wind farm projects:

i) Identify the geographic scope of the project;

ii) Identify all European sites/qualifying features and their conservation objectives, that might be affected by the project;

iii) Determine which of the qualifying features might be affected by the project activities;

iv) Analyse other plans or projects which could, in combination with the planned activities, give rise to a likely significant effect on a Natura 2000 site; and

v) Analyse the possible interactions between the project and the qualifying features, including the ecological functions and processes that support them.

Following the screening process, a subsequent conclusion will be drawn which will state that either:

- No LSE(s) have been identified on the European site(s) scoped in during the screening process, and therefore no further assessment will be required; or

- LSE(s) have been identified for one or more European site(s) and an Appropriate Assessment will be required.

13.2.2 Stage 2: Appropriate Assessment

The undertaking of an AA entails the consideration of the impacts on the integrity of a European site, either alone or in-combination with other plans and projects, with regard to the site's structure and function and its conservation objectives. The AA must demonstrate, with supporting evidence, that there will be no adverse effects on the site integrity.

The integrity of a site is defined as the coherence of the site's ecological structure and function, across the whole of its area, which enables it to sustain the habitat, complex of habitats and/or populations of species for which the site has been designated (European Commission 2001). An adverse effect on integrity is likely to be one which prevents the site from making the same contribution to favourable conservation status as it did at the time of designation.

NIRAS (2013) outlines the following key steps to be undertaken as part of AA for offshore wind farm projects:

i) Define the study area, including the offshore wind farm project site and the European sites;

ii) Identify the conservation objectives of the European sites;

iii) Identify all species to be considered in the assessment. This includes analysis of the sensitivity of species towards the project;

iv) Collect information on each species from existing information and/or site-specific surveys;

v) Collect information from other relevant plans or projects that may have an effect on the integrity of the species and/or habitat;

vi) Assess the effect on the European site, including ecological structure and functions;

vii) In case of significant impact, design preventative and mitigation measures; including any monitoring programme required; and

viii) Determine the effects on the integrity of the European site.

13.3 Screening for the proposed develpment

This report has been produced in support of the ornithological Environmental Impact Assessment (EIA) for Vesterhav Syd, therefore only considers bird features. The following sections describe the process undertaken to screen for potential LSE on ornithological features of European sites, for Vesterhav Syd.

13.3.1 Screening criteria

The criteria used in screening for European sites takes account of the location of the sites relative to Vesterhav Syd, the zone of influence of potential impacts associated with the project and the ecology and distribution of ornithological qualifying features. These criteria are:

1. European sites with bird features which overlap with Vesterhav Syd;

2. European sites that support mobile designated populations (e.g., migratory birds) with potential connectivity with Vesterhav Syd;

3. Mean-max foraging range of a qualifying species of a European site that interacts with Vesterhav Syd; and

4. Presence of a qualifying feature in site-specific surveys.

European sites which meet one or more of these criteria have been included in the initial identification of sites.

The screening assessment followed a two stage process to determine the potential for LSE on European sites:

i) Identification of potentially affected sites: a relatively coarse filter based on the location of the site in relation to the wind farm and the potential for connectivity with the site; and

ii) Identification of possible effects on European sites.

13.3.2 Results of Vesterhav Syd specific surveys

Site-specific surveys of the Vesterhav Syd project site and surrounding area have been carried out to inform the EIA on resting birds (NIRAS 2015). Six aerial surveys, following Camphuysen et al. (2004) methodology, have been completed between November 2013 and May 2014, covering 945 km^2. These surveys provided baseline pre-construction data on bird abundance and distribution for a selection of key seabird species. Further analysis of the data has been undertaken to provide population and density estimates for the study area, in addition to collision risk modelling.

It is difficult to quantify the movements of migratory species in offshore areas given the snapshot nature of survey methods used to collect data. A literature review was conducted (see Section 6.2) which incorporates information relating to flyway populations and the potential interactions between these populations and Vesterhav Syd.

Direct bird observation data were obtained from Blåvand Bird Observatory to the north-west of Esbjerg on the western coast of Denmark; approximately 50 km south of Vesterhav Syd. These data were investigated, alongside information relating to the migratory movements of birds through the region containing Vesterhav Syd, to determine those species with likely migratory flyway connectivity with Vesterhav Syd.

13.3.3 Stage 1 screening: Potential connectivity with European sites

In respect of Vesterhav Syd, a total of 63 SPAs have been screened in. Details of these sites and the distance from Vesterhav Syd are provided in Table 70. All sites within 150 km radius of the project site were considered and those with potential for connectivity were identified using the criteria outlined in Section 13.3.1. The wind farm site, including the cable route corridor, does not overlap with any SPAs.

Table 70: Initial screening for Natura 2000 sites with potential for connectivity to Vesterhav Syd

Natura 2000 site	Justification for inclusion in screening (see Section 13.3.1)	Distance from Vesterhav Syd (km)
Stadil Fjord Og Vest Stadil Fjord	2	4.76
Ringkøbing Fjord	2, 3	7.13
Nissum Fjord	2, 3	17.85
Fiilsø	2	33.71
Borris Hede	-	38.36
Kallesmærsk Hede Og Grærup Langsø	-	38.75
Engarealer Ved Ho Bugt	-	47.12
Nissum Bredning	-	47.32
Vadehavet	2, 4	49.77
Harboøre Tange, Plet Enge Og Gjeller Sø	2	50.22
Venø, Venø Sund	2	52.34
Skallingen Og Langli	2	53.61
Sønder Feldborg Plantage	-	59.58
Agger Tange	2	60.79
Glomstrup Vig, Agerø, Munkholm Og Katholm Odde, Lindholm Og Rotholme	2	62.10
Sydlige Nordsø	2, 4	62.39
Flyndersø Og Skalle Sø	2	62.42
Fanø	2	64.97
Hedeområder Ved Store Råbjerg	-	68.23
Ribe Holme Og Enge Med Kongeåens Udløb	2	69.38
Mågerodde Og Karby Odde	2	71.44
Ovesø	2	78.36
Randbøl Hede	-	78.85
Skovområde Syd For Silkeborg	-	84.06
Vejen Mose	-	85.87
Lovns Bredning	2	86.91
Mandø	2	87.56
Hjarbæk Fjord Og Simested Fjord	-	87.57
Ålvand Klithede Og Førby Sø	2	89.69
Dråby Vig	2	91.77
Uldum Kær, Tørring Kær Og Ølholm Kær	-	93.99
Rømø	2	95.34
Vangså Hede	-	95.83
Ballum Og Husum Enge Og Kamper Strandenge	2	95.92
Salten Langsø	-	96.21

Natura 2000 site	Justification for inclusion in screening (see Section 13.3.1)	Distance from Vesterhav Syd (km)
Spa Östliche Deutsche Bucht	2, 4	98.28
Løgstør Bredning, Livø, Feggesund Og Skarrehage	2, 4	100.49
Ramsar-Gebiet S-H Wattenmeer Und Angrenzende Küstengebiete	2, 3, 4	102.68
Mossø	-	102.88
Hanstholm Reservatet	2	102.93
Tjele Langsø	-	103.24
Lønnerup Fjord	2	105.20
Skovområde Ved Vejle Fjord	-	105.53
Vestlige Vejler, Arup Holm Og Hovsør Røn	2	106.23
Lindet Skov, Hønning Plantage, Lov-drup Skov Og Skrøp	-	107.15
Østlige Vejler	2	115.47
Kogsbøl Og Skast Mose	-	116.89
Kysten Fra Aggersund Til Bygholm Vejle	2	118.68
Lillebælt	2, 4	119.00
Pamhule Skov Og Stevning Dam	-	120.25
Horsens Fjord Og Endelave	2, 4	122.01
Vidåen, Tøndermarsken Og Saltvands-søen	2	122.26
Kongens Mose Og Draved Skov	-	124.78
Rold Skov	-	125.13
Ulvedybet Og Nibe Bredning	2	127.32
Æbelø Og Kysten Ved Nærå	2, 4	133.42
Gotteskoog-Gebiet	-	133.55
Kysing Fjord	2	134.91
Madum Sø	-	136.70
Sønder Ådal	-	138.24
Tinglev Sø Og Mose, Ulvemose Og Terkelsbøl Mose	-	138.96
Randers Og Mariager Fjorde Og Ål-borg Bugt, Sydlige Del	2, 4	141.10
Hostrup Sø, Assenholm Mose Og Fel-sted Vestermark	-	145.09

13.3.3.1 *Qualifying features and conservation objectives*

All ornithological qualifying features of the sites identified were considered, taking into account potential connectivity between designated populations and Vesterhav Syd including:

- Breeding and passage seabirds; and
- Migratory and wintering wildfowl.

According to Section 4(3) of the Habitats Directive act: Habitatbekendtgørelsen. Bekendtgørelse om ud-pegning og administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter (Bek. nr. 408 af 1. maj 2007 med ændringer), the conservation objective applicable to all SPAs is as follows:

The conservation objective for Natura 2000 sites is to maintain or restore, at favourable conservation status, the species and habitats for which they are designated, where:

- A species is the result of all the influences acting on the species concerned, that has long-term effects on its populations, distribution and abundance; and
- A species at a favourable conservation status is where:
    - Population dynamics data on the species concerned indicate that the species can remain a viable component of its natural habitats in the long term;
    - The natural range is neither declining nor is it likely that it will be diminished in the foreseeable future; and
    - There is, and will probably continue to be, a sufficiently large habitat to maintain its populations, in the long term.

13.3.3.2 Breeding seabirds

The site-specific surveys carried out for Vesterhav Syd, supported by an extensive literature review (see Section 6.2; migrating birds with connectivity to Vesterhav Syd wind farm have the potential to breed in the region), identified a number of seabirds which utilise the proposed offshore wind farm site which have the potential to be breeding within the region. In order to determine connectivity between Vesterhav Syd and SPAs designated for these breeding seabirds, the mean-maximum and maximum foraging ranges of each species were analysed (see Table 71). It has to be noted that this table presents a list of *potential* breeding species and a species specific analyses of breeding sites was not performed.

Table 71: Foraging ranges for seabirds during the breeding season (error is presented as ±1 SD and sample sizes are shown in parentheses)

Species	Mean-max foraging range (km)
Common Scoter	8.2 **
Velvet Scoter	19 **
Red-throated Diver	9(1) *
Northern Fulmar	400 ± 245.8(3) *
Northern Gannet	229.4 +/- 124.3 (7) *
Great Cormorant	25 ± 10(3) *
Atlantic Puffin	105.4 ± 46.0(8) *
Black Guillemot	12 **
Razorbill	48.5 ± 35.0(4) *
Common Guillemot	84.2 +/- 50.1 (5) *
Little Tern	6.3 ± 2.4(6) *
Sandwich Tern	49.0 ± 7.1(2) *
Common Tern	15.2 ± 11.2(6) *
Arctic Tern	24.2 ± 6.3(4) *
Black-legged Kittiwake	60 +/- 23.3 (6) *
Little Gull	Max 50, Mean 23.58 ***
Common Gull	50(1) *
Lesser Black-backed Gull	141 +/- 50.8 (3) *
Great Black-backed Gull	60 ***
Herring Gull	61.1 +/- 44 (2) *

*Thaxter et al. (2012)
**http://seabird.wikispaces.com/ (Accessed 30/06/2014)
***Seys et al. (2001))

There are three SPAs designated for breeding populations of four identified species within foraging range of Vesterhav Syd. These are outlined in Table 72 and are discussed in more detail in the following sections.

Table 72: Foraging ranges for seabirds during the breeding season

Species	Mean-max foraging range (km)	SPA	Distance to VHS (km)
Sandwich Tern	49.0 ± 7.1(2)	Ringkøbing Fjord	7.13
		Nissum Fjord	17.85
Common Tern	15.2 ± 11.2(6)	Ringkøbing Fjord	7.13
Arctic Tern	24.2 ± 6.3(4)	Ringkøbing Fjord	7.13
		Nissum Fjord	17.85
Lesser Black-backed Gull	141 +/- 50.8 (3)	Ramsar-Gebiet S-H Wat-tenmeer Und Angrenzende Küstengebiete	102.68

Sandwich Tern

Sandwich Tern is a designated species within the Ringkøbing Fjord and Nissum Fjord SPAs, located 7 km and 18km from Vesterhav Syd respectively. According to the Natura 2000 data forms, the estimated population within the Ringkøbing Fjord site is between 0 and 400 pairs[25] and at Nissum Fjord 0 pairs[26] are predicted. As the Sandwich Tern are not present within the Nissum Fjord SPA it is not anticipated that the species will be affected by the development at the Project site. It is concluded that there is no potential for LSE on Sandwich Tern within the Nissum Fjord SPA.

Numbers are higher at Ringkøbing Fjord SPA and Skov et. al. (1995) indicate a key area for the species (Lyngvig – Lodbjerg) close to Vesterhav Syd which supports a density of up to 0.40 individuals/km^2 in the breeding season. Using this as a precautionary density estimate for the Vesterhav Syd Project site, which has a proposed area 60 km^2, a maximum population of 24 birds have the potential to interact with the Project. Any Sandwich Tern present within the Vesterhav Syd area may originate from the Ringkøbing Fjord SPA or any other colony within the region.

A very precautionary population estimate of 24 birds does not represent a significant proportion of the estimated Sandwich Tern population, as a qualifying feature of the Ringkøbing Fjord SPA (i.e. 3%). Due to the uncertainties regarding monthly densities of this species within the Project area no collision risk modelling has been undertaken. However, assuming an appropriate flight height per-

[25] http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=DK00CX043 [Accessed 20/08/14]

[26] http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=DK00CX038 [Accessed 20/08/14]

centage (3.6% presented in Cook et al. 2012) and avoidance rate (i.e . 98%) then the likely collision effects on the feature are considered to be negligible. Therefore, it is concluded that there is no potential for LSE on the Sandwich Tern qualifying feature of the Ringkøbing Fjord SPA.

Common Tern

Common Tern is a designated species within the Ringkøbing Fjord SPA, located 7 km from Vesterhav Syd. Estimated population within the site is between two and twelve pairs[27]. Common Tern are not featured in Skov et. al. (1995), but estimates for both Common and Arctic Tern in Stone et. al. (1995) indicate a density of up to 0.45 individuals/km^2 in the South and east North Sea in the breeding season. As this estimation includes two species and the more densely populated breeding colonies off the coasts of Belgium and Holland, a more realistic density for the Vesterhav Syd survey area has been taken from Orbicon (2014); 0.1 individuals/km^2.

Therefore, using the survey area of 60 km^2, a maximum population of 6 birds have the potential to interact with the Project. On this basis, the potential for LSE for Common Tern as qualifying features of Ringkøbing Fjord SPA cannot be excluded at this stage, therefore, they are considered further in Stage 2.

Arctic Tern

Arctic Tern is a designated species within the Ringkøbing Fjord and Nissum Fjord SPAs, located 7 km and 18km from Vesterhav Syd respectively. Estimated population within the Ringkøbing Fjord site is between 0 and 16 pairs[28] and at Nissum Fjord between 0 and 10 pairs[29] are predicted. Arctic Tern are not featured in Skov et. al. (1995), but estimates for both Arctic and Common Tern in Stone et. al. (1995) indicate a density of up to 0.45 individuals/km^2 in the South and east North Sea in the breeding season. As this estimation includes two species and the more densely populated breeding colonies off the coasts of Belgium and Holland, a more realistic density for the Vesterhav Syd survey area has been taken from Orbicon (2014); 0.1 individuals/km^2.

Therefore, using the survey area of 60 km^2, a maximum population of 6 birds have the potential to interact with the Project. On this basis, the potential for LSE for Arctic Tern as qualifying features of Ringkøbing Fjord and Nissum Fjord SPAs cannot be excluded at this stage, therefore, they are considered further in Stage 2.

[27] http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=DK00CX043 [Accessed 20/08/14]

[28] http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=DK00CX043 [Accessed 20/08/14]

[29] http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=DK00CX038 [Accessed 20/08/14]

Lesser Black-backed Gull is a designated species within the Ramsar-Gebiet S-H Wattenmeer Und Angrenzende Küstengebiete SPA, located 103 km from Vesterhav Syd. This SPA is located off the coast of Germany, in the Wadden Sea. The Wadden Sea is known to be a rich area for prey species for Lesser Black-backed Gull and it is expected that any species within the area will not forage to the full extent of their range (Schwemmer & Garthe 2005). As the SPA is within the outer limit of the species' foraging range, it is not anticipated that Lesser Black-backed Gull will be affected by the development at the Project site. It is concluded that there is no potential for LSE on Lesser Black-backed Gull.

13.3.3.3 *Migratory wildfowl*

An in-depth analysis of the potential effects of Vesterhav Syd on migratory bird species has been undertaken as part of the EIA (Section 0), considering the population dynamics and migratory flyways of these species, identifying potential for connectivity with Vesterhav Syd.

Based on an extensive literature review, potential connectivity between the project site and the following species on migration has been investigated:

- Pink-footed Goose;
- Greylag Goose;
- Barnacle Goose;
- Dark-bellied Brent Goose;
- Light-bellied Brent Goose;
- Eurasian Wigeon;
- Eurasian Teal; and
- Northern Pintail.

In order to screen for Natura 2000 sites with potential for connectivity with Vester-hav Nord for bird species on migration, all sites within a buffer area of 150 km from the wind farm site have been considered. This area is deemed sufficient to ensure that those sites within the migratory corridor for each species, based on observations of the direction of migration, are included. In addition, designated populations of birds on migration with potential to interact with the wind farm will be captured within this wide area.

Table 73 provides details of the European sites and the designated species, with potential for connectivity with Vesterhav Syd, within 150 km of the wind farm site. LSE for these European sites and features cannot be excluded at this stage, therefore, they are considered further in Stage 2.

Table 73: SPAs and designated features with potential for connectivity with Vesterhav Syd.

Species	Migratory flyway	SPAs with potential for connectivity
Pink-footed Goose	North-south along Danish West coast	Stadil Fjord Og Vest Stadil Fjord
		Ringkøbing Fjord
		Nissum Fjord
		Fiilsø
		Vadehavet
		Harboøre Tange, Plet Enge Og Gjeller Sø
		Ribe Holme Og Enge Med Kongeåens Udløb
		Ballum Og Husum Enge Og Kamper Strand-enge
		Løgstør Bredning, Livø, Feggesund Og Skar-rehage
		Lønnerup Fjord
		Vestlige Vejler, Arup Holm Og Hovsør Røn
		Østlige Vejler
		Kysten Fra Aggersund Til Bygholm Vejle
		Vidåen, Tøndermarsken Og Saltvandssøen
		Ulvedybet Og Nibe Bredning
Greylag Goose	North-south along Danish West coast	Stadil Fjord Og Vest Stadil Fjord
		Ringkøbing Fjord
		Fiilsø
		Vadehavet
		Ålvand Klithede Og Førby Sø
		Vestlige Vejler, Arup Holm Og Hovsør Røn
		Østlige Vejler
		Vidåen, Tøndermarsken Og Saltvandssøen

Species	Migratory flyway	SPAs with potential for connectivity
		Ulvedybet Og Nibe Bredning
Barnacle Goose	East-west	Stadil Fjord Og Vest Stadil Fjord
		Ringkøbing Fjord
		Nissum Fjord
		Vadehavet
		Harboøre Tange, Plet Enge Og Gjeller Sø
		Agger Tange
		Ribe Holme Og Enge Med Kongeåens Udløb
		Mandø
		Ballum Og Husum Enge Og Kamper Strand-enge
		Ramsar-Gebiet S-H Wattenmeer Und Angren-zende Küstengebiete
		Vidåen, Tøndermarsken Og Saltvandssøen
Dark-bellied Brent Goose	North-south along German north coast	Ringkøbing Fjord
		Vadehavet
		Skallingen Og Langli
		Rømø
		Mandø
Light-bellied Brent Goose	North-south along Danish West coast	Nissum Fjord
		Vadehavet
		Harboøre Tange, Plet Enge Og Gjeller Sø
		Venø, Venø Sund
		Agger Tange

Species	Migratory flyway	SPAs with potential for connectivity
		Glomstrup Vig, Agerø, Munkholm Og Katholm Odde, Lindholm Og Rotholme
		Fanø
		Mågerodde Og Karby Odde
		Løgstør Bredning, Livø, Feggesund Og Skarrehage
		Kysten Fra Aggersund Til Bygholm Vejle
		Ulvedybet Og Nibe Bredning
		Æbelø Og Kysten Ved Nærå
		Randers Og Mariager Fjorde Og Ålborg Bugt, Sydlige Del
Eurasian Wigeon	East-west	Ringkøbing Fjord
		Nissum Fjord
		Vadehavet
		Skallingen Og Langli
		Agger Tange
		Ramsar-Gebiet S-H Wattenmeer Und Angrenzende Küstengebiete
		Østlige Vejler
		Vidåen, Tøndermarsken Og Saltvandssøen

Species	Migratory flyway	SPAs with potential for connectivity
		Ulvedybet Og Nibe Bredning
Eurasian Teal	East-west	Stadil Fjord Og Vest Stadil Fjord
		Ringkøbing Fjord
		Nissum Fjord
		Vadehavet
		Agger Tange
		Ramsar-Gebiet S-H Wattenmeer Und Angrenzende Küstengebiete
		Østlige Vejler
		Ulvedybet Og Nibe Bredning
Northern Pintail	East-west	Stadil Fjord Og Vest Stadil Fjord
		Ringkøbing Fjord
		Nissum Fjord
		Vadehavet
		Agger Tange
		Ramsar-Gebiet S-H Wattenmeer Und Angrenzende Küstengebiete
		Vidåen, Tøndermarsken Og Saltvandssøen

13.3.3.4 *Wintering populations*

Whooper Swan have a maximum core foraging range of 5 km from their night roosts during the winter season, however, actual foraging range is likely to be less than this (SNH 2013). One SPA, Stadil Fjord Og Vest Stadil Fjord, located along the West coast of Denmark, north-east of Vesterhav Syd, supports wintering populations of Whooper Swan. As Stadil Fjord Og Vest Stadil Fjord SPA is 4.8 km away from Vesterhav Syd, just within the maximum core foraging range, it is expected that roosting and/or foraging flights are not likely to occur offshore. Therefore, it can be concluded that there will be no LSE on designated populations of Whooper swan of this SPA.

13.3.4 *Stage 2 screening: Potential effects*

Table 74 identifies the potential impacts that may occur during the lifetime of the project. The following section identifies which of these impacts are likely to result in a LSE on the sites detailed in Table 73.

Table 74: Development phases and potential effects on ornithological features

Development phase	Potential effect
Construction	Disturbance/displacement
Operation	Disturbance/displacement Collision risk Barrier effect
Decommissioning	Disturbance/displacement

13.3.5 *Disturbance/displacement during construction, operation and decommissioning phases*

Displacement is defined as the effect on birds that would have utilised resources within the wind farm area that have now been taken up by wind turbines. Migratory wildfowl are not considered to be exposed to the effects of boat based traffic during the construction phase or the presence of turbines during the operational phase. These species potentially interact with the site during biannual migratory flights only and do not rely on the area for foraging opportunities.

Terns are often associated with vessels and their sensitivities to disturbance are often regarded as low (Garthe & Hüppop 2004, Mendel et al. 2008). Present studies indicate no avoidance behaviour of terns with respect to wind farms. This was observed in the wind farms Horns Rev 1 and Nysted (Petersen et al. 2006) as well as in British wind farms Kentish Flats and North Hoyle (PMSS 2007, Gill et al. 2008). A number of other studies (Blew et al. 2008, Krijgsveld et al. 2010, Leopold et al. 2010) suggest a medium to weak avoidance of offshore wind farms for terns.

Therefore, no LSE is predicted on the sites and features identified in Stage 1 as a result of disturbance/displacement during any phase of the project.

13.3.6 Barrier effects during construction, operation and decommissioning phases

Barrier effects may arise in addition to displacement. However unlike displacement (which is defined as the effect on birds that would have utilised resources that have since become occupied by turbines), barrier effects do not suggest such links with resource inside the proposed wind farm (Maclean et al. 2007). The effect refers to the disruption of preferred flight lines, so that birds need to re-navigate to alternative routes. Such re-navigation has the potential to lead to increased energetic costs and could affect species on annual migration as well as their flights between roosting and feeding areas (Masden et al. 2009a).

The size of the barrier presented to migrating birds represented by Vesterhav Syd is assumed to be the linear width of the wind farm, measured at right angles to a projected bird flight line heading on a north-south trajectory towards the centre. The length of the flight path through the study area that migrating birds would take if uninhibited by the barrier was estimated to be 22.2 km. Assuming birds exhibit macro-avoidance at 1 km from the barrier the average detoured flight path was calculated to be 26.98 km. This therefore represents an increase of 4.78 km as a result of the Vesterhav Syd barrier.

An increase in length of the migratory path of 4.78 km is considered to represent only a negligible shift in flight path route for all migratory species considered, which would therefore not result in significant changes in energy expenditure.

Barriers presented during the construction and decommissioning phases from vessels and construction activity are considered to be negligible. No LSE is predicted on the sites and features identified in Table 73 as a result of barrier effects during any phase of the project.

13.3.7 Collision related mortality during the operational phase

13.3.7.1 Migratory wildfowl

Potential collision effects on migratory waterbirds have been assessed using a theoretical collision modelling exercise (Section 6.3). Table 75 provides details of the predicted collisions for each of the species identified as features of SPAs with potential connectivity with Vesterhav Syd and the potential for LSE.

Table 75: Predicted collision mortalities for features and sites screened into assessment

Species	Collisions predicted per annum	EIA Magnitude of Impact	Potential for LSE
Pink-footed Goose	8	Minor	No
Greylag Goose	21	Minor	No
Barnacle Goose	16	Minor	No
Dark-bellied Brent Goose	1	Minor	No
Light-bellied Brent Goose	0	Minor	No
Eurasian Wigeon	5	Minor	No
Eurasian Teal	3	Minor	No
Northern Pintail	<1	Minor	No

The significance of any collision effects on these migratory species has been assessed, through detailed consideration of the percentage of the migratory flyway populations which are potentially affected (Section 0). To establish the significance of any collision effects upon the respective migratory species features of the sites included in Table 73, further screening has been undertaken.

Collision risk modelling was not required for Dark-bellied Brent Goose as part of the EIA process for Vesterhav Syd. Therefore, the collision risk has been calculated separately for the purposed of the Natura 2000 assessment. To estimate the flyway population, it was assumed that there is an even distribution across a broad migratory front from the southern coast of Norway to the North Sea coast of Germany, passing through Vesterhav Syd (518 km). The proportion of the migratory front represented by Vesterhav Syd (15.6 km) is then determined to calculate the proportion of the flyway population likely to interact with Vesterhav Syd (3.01%). This provides a population of 6,020 birds with potential to interact with Vesterhav Syd, this is likely to be an overestimate of the number of birds exhibiting connectivity with Vesterhav Syd during migratory movements taking into account that the majority of movements occur between North Schleswig and Southern Jutland. However, as undertaken earlier in this report, additional scenarios are considered where alternative proportions of the population could interact with Vesterhav Syd. For the purposes of this assessment an approximate doubling of the interacting population (i.e. 12,040 birds) is therefore considered, which would effectively double the presented collision riks modelling results.

At each SPA, the maximum populations of each designated feature have been compared with the flyway populations for each species to establish the proportion of the flyway population represented by the SPA population. The number of collisions for the entire flyway population has then been apportioned to each respective SPA population using the proportions calculated to provide the maximum number of collisions predicted for that SPA population. The predicted collisions for each feature have then been compared to the 1% threshold of the respective maximum SPA populations, to identify the potential for LSE where the 1% threshold is exceeded.No LSEs have been identified for the designated features at each site listed within Table 73, and therefore no LSE is predicted for these sites (even if for Dark-bellied Brent Goose, the interacting population is doubled).

Should all mortality predicted for a given species be applied to an individual SPA (rather than apportioned), 1% thresholds are exceeded for the following species / sites:

- Barnacle Goose (Harboøre Tange, Plet Enge Og Gjeller Sø SPA)

Harboøre Tange , Plet Enge Og Gjeller Sø SPA supports a relatively low number (115 individuals) of Barnacle Geese. The SPA lies 50.2 km from Vesterhav Syd. Therefore, it is considered very unlikely that any collisions from Vesterhav Syd will relate to this SPA and that there is no potential for an LSE.

13.3.7.2 Breeding seabirds

The respective density estimates of Sandwich Tern, Common Tern and Arctic Tern for the Project site, when considering that at other offshore wind farms (e.g Horns Rev 1 and 3), the proportion of birds at rotor height is low (HR3: Orbicon 2014), representing a low number of individuals at risk from collision mortality. In particular when taking into account likely low levels of flight activity (Cook et al. 2012) and a precautionary avoidance rate of 98%. Therefore, there are no LSE predicted on the Tern qualifying features of the European sites identified, as a result collision mortality during the operational phase of the project.

13.4 In-combination assessment

Three wind farms, Vesterhav Nord, Horns Rev 3 and Nissum Bredning (Figure 25), have also been screened for LSE as part of the in-combination assessment for Vesterhav Syd. All three of these sites are currently in development and do not have consent for construction at the time of writing of this assessment. Horns Rev 3 is not considered in the migratory wildfowl cumulative assessment for collision and barrier impacts. This is due to low numbers of those species included within the Vesterhav Syd assessment, recorded during site-specific surveys at Horns Rev 3.The in-combination assessment considers the period of operation only.

13.4.1 *In-combination barrier effects*

Barrier effects are unlikely to be significant on any species/population interacting with Nissum Bredning alone as the wind farm only occupies an area of 5 km² which is not considered sufficient to affect the energetic expenditure of migratory species. As such, in-combination barrier effects are only considered for Vesterhav Syd and Vesterhav Nord. The location of Nissum Bredning also suggests, in terms of barrier effects, that there will be minimal connectivity with the two Vesterhav projects. The majority of migratory movements are considered to occur offshore exhibiting a higher degree of connectivity with the two Vesterhav projects.

In-combination barrier effects with the potential to have LSE on SPA populations of migratory wildfowl species considered in this assessment, as a result of avoiding the areas occupied by Vesterhav Syd and Vesterhav Nord, are considered unlikely to occur. The increase in flight path associated with Vesterhav Syd was calculated as 4.78 km, with a distance of 3.47 km for Vesterhav Nord.

Present studies indicate no avoidance behaviour of terns with respect to wind farms.

As such, No LSE as a result of in-combination barrier effects associated with these two projects are predicted.

13.4.2 In-combination collision risk

The number of collisions for the entire flyway population, as a result of Vesterhav Syd in combination with Vesterhav Nord and Nissum Bredning, of each qualifying feature has then been apportioned to each respective European site population. This has been achieved using the proportions calculated to provide the maximum number of collisions predicted for that SPA population. The predicted collisions for each feature have then been compared to the 1% threshold of the respective maximum designated populations of each European site, to identify the potential for LSE where the 1% threshold is exceeded.

As a result of this exercise it can be concluded that there are no LSE predicted on the migratory qualifying features of the European sites identified, as a result of collision mortality during the operational phase of the Vesterhav Syd, in combination with Vesterhav Nord and Nissum Bredning.

With respect to tern species from Ringkøbing Fjord and Nissum Fjord SPAs, it has been considered that collision risk from Vesterhav Nord alone is likely to be negligible. Terns have a relatively limited foraging range (Thaxter et al., 2012) and as such any low level of impacts from a respective project are unlikely to occur on the same feature at a second project.

13.5 Summary

Once the Natura 2000 sites have been identified, the potential for LSE (likely significant effect) is considered. Where there is no potential impact pathway, or potential effect associated with an impact considered to be insignificant, a site may be screened out of further consideration in HRA. Where the potential for LSE cannot be excluded, sites are taken forward for further consideration of the potential for adverse effect on site integrity.

Stage 1 of the screening assessment identified a number of European sites, ornithological features and potential impacts for which LSE could not be excluded.

Stage 2 of the screening assessment details the potential for LSE on the sites and features identified during Stage 1 as a result of project specific impacts.

It can be concluded that no LSE is predicted on any Natura 2000 sites as a result of Vesterhav Syd wind farm project, alone or in-combination with other plans or projects, and as such no further assessment is necessary.

14 MITIGATION MEASURES

If a potential impact is assessed as moderate negative, it is deemed necessary to consider mitigation measures. If impacts are evaluated as major, mitigation measures are deemed to be mandatory.

With regards to migrating birds and bats no impact levels higher than minor were found and no mitigation measures have to be considered.

15 POTENTIAL INSUFICIENT INFORMATION OR KNOWLEDGE OF IMPORTANCE REGARDING THE ASSESSMENTS

The data base used for this assessment is regarded as sufficient.

For migrating birds studies from nearby wind farms in conjunction with a large data base on migrating birds covering a period of 10 years was analysed. Based on these data relevant migrating species were identified. Few data on migrating species is available for the area directly encompassing Vesterhav Syd however; this assessment makes the best use of information available.

For bats, conclusions are based on a national monitoring program. It gives nationwide information of the occurrence on a species level. The results are clear with comparably low abundance of bats in the north western area close to the coastline and the investigated wind farm. Generally, there is limited knowledge on migrating bats over offshore areas and on the attraction of nearshore wind farms for bats. The information available is considered.

16 CONCLUSION (CONCLUSION OF THE TOTAL IMPACT)

In Table 76 all impacts on migrating birds and bats are summarised that are of at least of minor magnitude.

16.1 Migrating birds

For the following migrating birds identified to have connectivity with Vesterhav Syd, the magnitude of impact is assessed as **Minor** for the pressure ”collision” in all stages of the wind farm: Pink-footed Goose, Greylag Goose, Barnacle Goose, Light-bellied Brent Goose, Eurasian Wigeon, Eurasian Teal, Northern Pintail, Common Eider, Common Scoter, Black-headed Gull, Lesser Black-backed Gull and Great Black-backed Gull. This rating results from a low number of expected collisions and a high importance of the species due to their conservation status and abundance in the area.

In respect of the following migrating birds identified to have connectivity with Vesterhav Syd, the magnitude of impact is assessed as **Negligible/No Impact** for the pressure ”collision” in all stages of the wind farm: Red-breasted Merganser, Red-throated Diver, Common Scoter, Arctic Skua, Kittiwake, Little Gull, Common Gull, Herring Gull, Sandwich Tern, Common Tern and Arctic Tern. This rating results from a negligible number of collisions predicted (less than one migratory collision per annum) for these species and the use of expert judgment.

The barrier effect during operation for all migrating birds is assessed as no greater than **Minor** for all species (low impact, but high importance).

16.2 Bats

In bats, the magnitude of impact is assessed as **Minor** as a low number of individuals is expected to be affected by collision.

Table 76: Summary of impact of at least minor magnitude for all pressures, periods and species

Pressure	Phase	Species	Magnitude of impact	Comments
Migrating birds				
Collision	Installation	Species identified to have connectivity with Vestehav Syd	Minor	Low no. of collisions, but high Importance
	Operation		Minor	
	Decommission		Minor	
Barrier effect	Operation	Species identified to have connectivity with Vestehav Syd	Minor	Low impact but high importance
Bats				
Collision	Installation	Most likely: *Myotis daubentonii*, *Eptesicus serotinus, Pipistrellus nathusii*	Minor	Low no. of expected individuals, high importance and persistence
	Operation		Minor	
	Decommission		Minor	

17 REFERENCES

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18 APPENDIX

18.1 Tables for determination of the magnitude of impact

Table 77: Assessment of degree of impact (high degree of disturbance)

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
High	International interests	High (>75 %)	Permanent (> 5 years)	Major
			Temporary (1-5 years)	Major
			Short-term (0-1 year)	Moderate
		Medium (25-75 %)	Permanent (> 5 years)	Major
			Temporary (1-5 years)	Major
			Short-term (0-1 year)	Moderate
		Low (<25 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Moderate
			Short-term (0-1 year)	Minor
	National or regional interests	High (>75 %)	Permanent (> 5 years)	Major
			Temporary (1-5 years)	Moderate
			Short-term (0-1 year)	Moderate
		Medium (25-75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Moderate
			Short-term (0-1 year)	Minor
		Low (<25 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Minor
	Local inter-ests (im-	High (>75 %)	Permanent (> 5 years)	Moderate

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
	portant for the area directly affected or for the immediate surroundings)		Temporary (1-5 years)	Moderate
			Short-term (0-1 year)	Minor
		Medium (25-75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Negligible/neutral/no impact
		Low (<25 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Negligible/neutral/no impact
			Short-term (0-1 year)	Negligible/neutral/no impact
	Negligible/not important	High (>75 %)	Permanent (> 5 years)	Negligible/neutral/no impact
			Temporary (1-5 years)	Negligible/neutral/no impact
			Short-term (0-1 year)	Negligible/neutral/no impact
		Medium (25-75 %)	Permanent (> 5 years)	Negligible/neutral/no impact
			Temporary (1-5 years)	Negligible/neutral/no impact
			Short-term (0-1 year)	Negligible/neutral/no impact
		Low (<25 %)	Permanent (> 5 years)	Negligible/neutral/no impact
			Temporary (1-5 years)	Negligible/neutral/no impact

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
			Short-term (0-1 year)	Negligi-ble/neutral/no impact

Table 78: Assessment of degree of impact (medium degree of disturbance)

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
Medium	International interests	High (>75 %)	Permanent (> 5 years)	Major
			Temporary (1-5 years)	Moderate
			Short-term (0-1 year)	Moderate
		Medium (25-75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Moderate
			Short-term (0-1 year)	Minor
		Low (<25 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Minor
	National or regional in-terests	High (>75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Moderate
			Short-term (0-1 year)	Minor
		Medium (25-75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Minor
		Low (<25 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Minor
			Short-term (0-	Negligi-

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
			1 year)	ble/neutral/no impact
	Local interests (important for the area directly affected or for the immediate surroundings)	High (>75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Minor
		Medium (25-75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Negligible/neutral/no impact
		Low (<25 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Negligible/neutral/no impact
	Negligible/not important	High (>75 %)	Permanent (> 5 years)	Negligible/neutral/no impact
			Temporary (1-5 years)	Negligible/neutral//no impact
			Short-term (0-1 year)	Negligible/neutral/no impact
		Medium (25-75 %)	Permanent (> 5 years)	Negligible/neutral/no impact
			Temporary (1-5 years)	Negligible/neutral/no impact
			Short-term (0-1 year)	Negligible/neutral/no impact
		Low (<25 %)	Permanent (> 5 years)	Negligible/neutral/no impact
			Temporary (1-5 years)	Negligible/neutral/no impact

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
			Short-term (0-1 year)	Negligi-ble/neutral/no impact

Table 79: Assessment of degree of impact (low degree of disturbance)

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
Low	International interests	High (>75 %)	Permanent (> 5 years)	Moderate
			Temporary(1-5 years)	Minor
			Short-term (0-1 year)	Minor
		Medium (25-75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Negligi-ble/neutral/no impact
		Low (<25 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Negligi-ble/neutral/no impact
	National or regional in-terests	High (>75 %)	Permanent (> 5 years)	Moderate
			Temporary (1-5 years)	Minor
			Short-term (0-1 year)	Negligi-ble/neutral/no impact
		Medium (25-75 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Negligi-ble/neutral/no impact
			Short-term (0-1 year)	Negligi-ble/neutral/no impact

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
		Low (<25 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Negligible / neutral/no impact
			Short-term (0-1 year)	Negligible/ neutral/no impact
	Local interests (important for the area directly affected or for the immediate surroundings)	High (>75 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Negligible/ neutral/no impact
			Short-term (0-1 year)	Negligible/ neutral/no impact
		Medium (25-75 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Negligible/ neutral/no impact
			Short-term (0-1 year)	Negligible/ neutral/no impact
		Low (<25 %)	Permanent (> 5 years)	Minor
			Temporary (1-5 years)	Negligible/ neutral/no impact
			Short-term (0-1 year)	Negligible/ neutral/no impact
	Negligible/not important	High (>75 %)	Permanent (> 5 years)	Negligible/ neutral/no impact
			Temporary (1-5 years)	Negligible/ neutral/no impact
			Short-term (0-1 year)	Negligible/ neutral/no impact
		Medium (25-75 %)	Permanent (> 5 years)	Negligible/ neutral/no impact
			Temporary (1-	Negligible/

Degree of disturbance	Importance	Likelihood of occurrence	Persistence	Magnitude of impact
			5 years)	neutral/no impact
			Short-term (0-1 year)	Negligible/ neutral/no impact
		Low (<25 %)	Permanent (> 5 years)	Negligible/ neutral/no impact
			Temporary (1-5 years)	Negligible/ neutral/no impact
			Short-term (0-1 year)	Negligible/ neutral/no impact

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Only enter input parameters in blue | W Band | 13/11/2014

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3						Upwind:			Downwind:	
MaxChord	3.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.64	m	0.025	0.575	7.34	25.04	1.00	0.00125	24.62	1.00	0.00125
Wingspan	1.38	m	0.075	0.575	2.45	8.49	0.39	0.00296	8.07	0.37	0.00281
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.47	5.87	0.27	0.00341	5.36	0.25	0.00311
			0.175	0.860	1.05	4.90	0.23	0.00398	4.27	0.20	0.00347
Bird speed	17	m/sec	0.225	0.994	0.82	4.31	0.20	0.00451	3.59	0.17	0.00375
RotorDiam	112	m	0.275	0.947	0.67	3.47	0.16	0.00443	2.77	0.13	0.00354
RotationPeriod	3.80	sec	0.325	0.899	0.56	2.88	0.13	0.00434	2.22	0.10	0.00335
			0.375	0.851	0.49	2.44	0.11	0.00425	1.81	0.08	0.00316
			0.425	0.804	0.43	2.14	0.10	0.00423	1.55	0.07	0.00307
			0.475	0.756	0.39	1.93	0.09	0.00426	1.38	0.06	0.00304
Bird aspect ratioo: β	0.46		0.525	0.708	0.35	1.76	0.08	0.00429	1.24	0.06	0.00303
			0.575	0.660	0.32	1.62	0.08	0.00431	1.13	0.05	0.00302
			0.625	0.613	0.29	1.49	0.07	0.00433	1.04	0.05	0.00303
			0.675	0.565	0.27	1.38	0.06	0.00433	0.97	0.04	0.00304
			0.725	0.517	0.25	1.29	0.06	0.00433	0.91	0.04	0.00305
			0.775	0.470	0.24	1.20	0.06	0.00432	0.86	0.04	0.00308
			0.825	0.422	0.22	1.12	0.05	0.00430	0.81	0.04	0.00311
			0.875	0.374	0.21	1.05	0.05	0.00427	0.78	0.04	0.00315
			0.925	0.327	0.20	0.99	0.05	0.00423	0.75	0.03	0.00321
			0.975	0.279	0.19	0.92	0.04	0.00419	0.72	0.03	0.00326
				Overall p(collision) =			**Upwind**	**8.1%**		**Downwind**	**6.2%**
								Average	**7.1%**		

Collision Risk Model			
		Units	
Step 1	**Birds flying through risk window**		
1.1	Population	ind	20,000
1.2	No of transits		2
1.3	Proportion at PCH		0.3
1.4	Number passing through	ind	12000
Step 2	**Passage rates**		
2.1	Flight length through wind farm (average)		
2.2	Flight speed		
Step 3	**Flight risk window**		
3.1	Width of risk window (maximum) (W)	m	7184
3.2	Height of rotors (h)	m	137
3.3	Size of risk window: Vw=W*h	m2	984208
Step 4	**Area swept by wind farm rotors**		
4.1	Number of turbines (N)		66
4.2	π		3.141593
4.3	Rotor radius (R)	m	56
4.4	Rotor-swept area: Ar=N*π*R2	m2	650234.3
Step 5	**No of transits**		
5.1	Flights at risk		7928.011
Step 6	**Collision risk**		
6.1	p		7.100%
6.2	Collisions per year		562.8887
Step 7	**Avoidance rates**		
7.1	95.00%		28.1
7.2	98.00%		11.3
7.3	99.00%		5.6
7.4	99.80%		1.1
7.5	99.99%		0.1

18.3 Cumulative Assessment Annex

See separate file.

Energinet.dk

April 2015

VESTERHAV NORD AND SYD OFFSHORE WIND FARMS

Cumulative Assessment Annex

PROJECT

Vesterhav Nord and Syd Offshore Wind Farms
EIA - Migratory Birds Cumulative Assessment Annex
Energinet.dk

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CONTENTS

1 INTRODUCTION

Projects considered within the cumulative assessment for migratory species were those sites currently in planning and do not have consent for construction at the time of writing of this assessment. Horns Rev 1 and 2 are currently operational and are considered to form part of the current baseline condition with respect to ornithological interests. These two projects were therefore not considered within this assessment. The purpose of this Annex is to investigate the implications for the cumulative assessment should Horns Rev 1 and 2 provide additive effects to the projects currently screened in.

2 CUMULATIVE COLLISION RISK

The following sections describe Horns Rev 1 and 2 projects considered cumulatively and outline the connectivity between these projects and the migratory flyway populations considered in the assessments for Vesterhav Nord and Vesterhav Syd.

Cumulative collision risk has been considered for all species included in the assessments for Vesterhav Nord alone and Vesterhav Syd alone.

2.1 Horns Rev 1

Horns Rev 1 Offshore Wind Farm is located approximately 114.1 km south-west of Vesterhav Nord and 57.1 km from Vesterhav Syd, approximately 13.6 km off the western coast of Denmark. The wind farm, commissioned in 2002, has an output capacity of 160 MW and consists of 80 turbines with a rated power output of 2 MW.

Collision risk modelling is presented by Skov et al. (2012) for migrating birds at Horns Rev 1 using data gathered at the operational wind farm during autumn 2010 – spring 2012. This is considered to be the most contemporaneous and robust modelling of collision risk for Horns Rev 1 using data gathered at the operational wind farm. Skov et al. (2012) presents collision probabilities derived quantitatively through collision risk models (Band model), into which is inputted density estimates for the operational wind farm Horns Rev 1 for the period November to April and wind farm area.

2.2 Horns Rev 2

Horns Rev 2 Offshore Wind Farm is located approximately 101.4 km south-west of Vesterhav Nord and 46.5 km from Vesterhav Syd, approximately 28.2 km off the western coast of Denmark. The wind farm, commissioned in 2002, has an output capacity of 209.3 MW and consists of 91 turbines with a rated power output of 2.3 MW.

Collision risk modelling is presented by Skov et al. (2012) for migrating birds at Horns Rev 2 using data gathered at the operational wind farm during autumn 2010 – spring 2012. This is considered to be the most contemporaneous and robust modelling of collision risk for Horns Rev 2 using data gathered at the operational wind farm. Skov et al. (2012) presents collision probabilities derived quantitatively through collision risk models (Band model), into which is inputted density estimates for the operational wind farm Horns Rev 2 for the period November to April and wind farm area.

3 IMPACT ASSESSMENT METHODOLOGY

3.1 Geese

Migratory wildfowl have been screened out of this assessment based on the results of the site-specific surveys in the vicinity of the operational wind farms, Horns Rev 1 and 2 (autumn 2010 – spring 2012), and a review of the sensitivity of these species to collision. A marked difference was found in the distribution of 5,136 individual geese recorded within the vicinity of Horns Rev area between three survey locations, one onshore at Blåvandshuk and two offshore at Horns Rev 1 and 2. A substantially higher proportion of the geese recorded were from the onshore survey station. It is suggested within Jensen et al. (2014) that this may be explained by the specific flyway characteristics of these social migrants which tend to follow coastlines and habitually stop in saltmarsh habitats. The majority of geese recorded within the Horns Rev area were recorded outside of the wind farm footprint suggesting a low likelihood of collision. Geese were defined as having a Low sensitivity to collision at Horns Rev (Jensen et al. 2014). As such, there was considered to be a negligible risk of collision to migrating birds from wind farms at Horns Rev.

In conclusion, geese are considered no further in the cumulative assessment for collision effect impacts at Horns Rev 1 and 2. This is due to low numbers of those species included within the Vesterhav Nord and Vesterhav Syd assessments, recorded during site-specific surveys at Horns Rev 1 and 2.

3.2 Migratory seabirds

A species is not included in this assessment if it was not part of the suite of species considered for collision risk modelling at Horns Rev 1 and 2. Collision risk modelling presented by Skov et al. (2012) for migrating seabirds at Horns Rev 1 & 2, does not differentiate results to species level for the following groupings: small gulls, large gulls, terns and divers. The current assessment takes these results and apportions (hereafter referred to as ‘species group partitioning’) to species level.

Maclean et al. (2009) recommend that, in order to apportion unidentified individuals to species level (hereafter referred to as ‘partitioning’), the relative abundance of each of the species comprising the unidentified taxon is calculated from positively identified individuals. Those birds in the unidentified taxon should be partitioned to the relative species level using the ratio of those birds positively identified during site-specific surveys. This is the approach followed for unidentified taxa recorded at Horns Rev as described below for categories of unidentified taxon used by Skov et al. (2012).

Gull species

Two taxonomic groups were used by Skov et al. (2012) to represent unidentified gulls. These were:

- Small gulls representing Little Gull, Sabine's Gull, Black-headed Gull, Common Gull and Kittiwake;
- Large gulls representing Herring Gull, Lesser Black-backed Gull, Glaucous Gull and Great Black-backed Gull.

Data available for gulls were visually observed birds at the three observations sites at Horns Rev (i.e. Horns Rev 1, Horns Rev 2 and Blåvandshuk) during the period autumn 2010 – spring 2012 (Skov et al. 2012). For each species a proportion was calculated from proportions of positively identified birds from the summation of surveys undertaken at Horns Rev 1 and 2. Blåvandshuk was not included as it is unlikely that this onshore survey location would be representative of the species composition present offshore at Horns Rev. Once the species proportions were calculated they were applied to the collisions attributed to the relevant species groupings for each of the two wind farms (i.e. Horns Rev 1 and 2) to provide the number of collisions for each of the species.

Tern species

Skov et al. (2012) used one species group, Arctic/Common Tern sp., to represent unidentified Arctic Tern and Common Tern. For these two species a proportion was calculated from proportions of positively identified birds from the summation of surveys undertaken at Horns Rev 1 and 2 during the period autumn 2010 – spring 2012 (Skov et al. 2012). Once these proportions were calculated they were applied to the Arctic/Common Tern sp. grouping. When the proportion of the species group attributable to each species was calculated, these were combined with the counts for positively identified birds to provide revised species totals that included partitioned birds. The proportion of the total number of terns counted represented by each of the six species recorded was calculated from the summation of surveys undertaken at Horns Rev 1 and 2. Once the species proportions were calculated they were applied to the collisions attributed to the relevant species groupings for each of the two wind farms (i.e. Horns Rev 1 and 2) to provide the number of collisions for each of the species.

Diver species

Skov et al. (2012) used one species group, Red-throated/Black-throated Diver sp., to represent unidentified Red-throated Diver and Red-throated Diver. For these two species a proportion was calculated from proportions of positively identified birds from the summation of surveys undertaken at Horns Rev 1 and 2 during the period autumn 2010 – spring 2012 (Skov et al. 2012). Once these proportions were calculated they were applied to the Red-throated/Black-throated Diver sp. grouping. Once the species proportions were calculated they were applied to the collisions attributed to the relevant species groupings for each of the two wind farms (i.e. Horns Rev 1 and 2) to provide the number of collisions for each of the species.

Assessment

The assessment of cumulative collisions risk is consistent with that presented in the migratory birds reports for Vesterhav Nord and Vesterhav Syd. The total cumulative collision risk is assessed against the PBR value for the appropriate biogeographic population as defined in Wetlands International (2014). The PBR values and Rf value considered relevant to the biogeographic population depending on its status (i.e. increasing, stable or decreasing) is shown in Table 1. Where the biogeographic population presented in Wetlands International (2014) is provided as a range (e.g. for Red-throated Diver) the lower population estimate is used in order to calculate the PBR values. The Rf value used for assessment (based on the population trend) is highlighted in bold.

Table 1: PBR values for all species included in this cumulative assessment

Species	**Population size (Nmin)**	**Age of First Breeding (*α*)**[1]	**Annual Adult Survival (*s*)**[2]	**Growth Rate (λ_{max})**	**Population Trend**[3]	**Rf=0.1**	**Rf=0.5**	**Rf=1.0**
Common Eider	976,000	3	0.820	1.192	Declining	**9,379**	46,895	93,789
Common Scoter	550,000	2	0.783	1.280	Declining	**7,689**	38,442	76,885
Red-throated Diver	150,000-450,000	3	0.840	1.184	Stable	1,378	**6,888**	13,776
Kittiwake	6,600,000	4	0.882	1.133	Declining	**43,928**	219,638	439,277
Black-headed Gull	3,700,000-4,800,000	2	0.900	1.200	Stable	37,000	**185,000**	370,000
Little Gull	110,000	3	0.800	1.200	Increasing	1,100	5,500	**11,000**
Common Gull	1,200,000-2,500,000	3	0.860	1.174	Possible decline	**10,461**	52,302	104,605
Lesser Black-backed Gull	530,000-570,000	4	0.913	1.118	Increasing	3,138	15,691	**31,381**
Herring Gull	1,300,000-3,100,000	4	0.880	1.134	Stable	8,707	**43,536**	87,071
Great Black-backed Gull	330,000-540,000	4	0.930	1.109	Increasing	1,792	8,961	**17,922**

[1] Age of first breeding sourced from Robinson (2005) and if not given, BWPi (2009).

[2] Annual adult survival rate sourced from Robinson (2005) and if not given BWPi (2009).

[3] Population trend sourced from BirdLife International 2004 for waterbirds.

Species	Population size (Nmin)	Age of First Breeding (α)[1]	Annual Adult Survival (s)[2]	Growth Rate (λ_{max})	Population Trend[3]	Rf=0.1	Rf=0.5	Rf=1.0
Sandwich Tern	166,000-171,000	3	0.898	1.153	Stable	1,274	**6,370**	12,740

4 CUMULATIVE COLLISION EFFECTS IMPACT ASSESSMENT

Collision risk estimates for those wind farms considered in the migratory birds cumulative impact assessment within the Vesterhav Nord and Vesterhav Syd reports are shown in Table 2. These are totalled within the table to show the total number of cumulative collisions assessed within the migratory bird report. Partitioned collision risk estimates based on those estimates presented in Skov et al. (2012) for Horns Rev 1 and 2 are added to the original cumulative total to provide an overall collision risk estimate. These estimates are discussed for each species in the following sections.

Table 2: Collision risk estimates for all wind farms considered within this report

Species	Vesterhav Nord	Vesterhav Syd	Horns Rev 3	Cumulative total – projects in planning	Horns Rev 1	Horns Rev 2	Total including operational projects
Common Scoter	0.8	0.8	5.0	**6.6**	31.0	178.0	**215.6**
Red-throated Diver	0.3	0.2	0.0	**0.5**	0.0	4.7	**5.2**
Kittiwake	0.6	0.2	2.0	**2.8**	7.7	8.9	**19.4**
Black-headed Gull	1.2	1.0	19.0	**21.2**	8.6	4.8	**34.6**
Little Gull	0.2	0.1	-	**0.3**	4.8	2.7	**7.8**
Common Gull	1.0	0.7	18.0	**19.7**	2.9	1.6	**24.2**
Lesser Black-backed Gull	1.8	1.4	115.0	**118.2**	206.8	196.9	**521.9**
Herring Gull	1.2	0.9	148.0	**150.1**	128.1	122.0	**400.2**
Great Black-backed Gull	1.1	0.8	4.0	**5.9**	43.1	41.1	**90.1**
Sandwich Tern	0.3	0.3	2.0	**2.6**	0.0	1.5	**4.1**
Common Tern	0.2	0.1	1.0	**0.4**	0.0	0.4	**0.8**
Arctic Tern	0.1	0.0	1.0	**1.1**	0.0	0.0	**1.1**

The assessment of impact upon all migratory seabird species is included in Table 2. For those species for which a cumulative total of less than one collision is calculated, no further assessment is conducted. This follows the assessment approach used for the Vesterhav Nord and Vesterhav Syd alone. This is therefore applicable to Common Tern. Less than 0.1 collisions from Horns Rev 1 and 2 are also predicted for Arctic Tern, therefore additional assessment for this species is not considered necessary.

4.1 Common Scoter

The cumulative collision risk for Common Scoter at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 6.6 collisions, with the majority of these attributable to Horns Rev 3. The total collision risk at Horns Rev 1 and 2 for Common Scoter was estimated at 209 collisions. This therefore equates to a cumulative total of 215.6 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 and 2 representing nearly 97% of this total. This cumulative total represents 2.8% of the PBR at Rf=0.1 or 0.04% of the biogeographic population. As a consequencethe degree of disturbance of the flyway population of Common Scoter to cumulative collision impacts is defined as **Medium**.

Common Scoter is considered to be a species of **International** importance in terms of this assessment.

The likelihood of an effect occurring on the Common Scoter flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Common Scoter is therefore considered to be **Moderate** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3).

4.2 Red-throated Diver

The cumulative collision risk for Red-throated Diver at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 0.5 collisions. The total collision risk at Horns Rev 1 and 2 for Red-throated Diver was estimated at 4.7 collisions. This therefore equates to a cumulative total of 5.2 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 and 2 representing over 90% of this total. This cumulative total represents 0.08% of the PBR at Rf=0.5 or 0.001-0.003% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. As a low level impact on this population has been predicted the degree of disturbance of the flyway population of Red-throated Diver to cumulative collision impacts is defined as **Low**.

Red-throated Diver is considered to be a species of **International** importance in terms of this assessment.

The likelihood of an effect occurring on the Red-throated Diver flyway population is considered to be **Low** .

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Red-throated Diver is therefore considered to be **Minor** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

4.3 Kittiwake

The cumulative collision risk for Kittiwake at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 2.8 collisions, with the majority of these attributable to Horns Rev 3. The total collision risk at Horns Rev 1 and 2 for Kittiwake was estimated at 16.6 collisions. This therefore equates to a cumulative total of 19.4 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 and 2 representing over 85% of this total. This cumulative total represents 0.04% of the PBR at Rf=0.1 or 0.0003% of the biogeographic population. As a low level impact on this population has been predicted the degree of disturbance of the flyway population of Kittiwake to cumulative collision impacts is defined as **Low**.

Kittiwake is considered to be **Not Important** in terms of this assessment due to the low interacting population and low conservation status.

The likelihood of an effect occurring on the Kittiwake flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Kittiwake is therefore considered to be **Negligible** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

4.4 Black-headed Gull

The cumulative collision risk for Black-headed Gull at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 21.2 collisions, with the majority of these attributable to Horns Rev 3. The total collision risk at Horns Rev 1 and 2 for Black-headed Gull was estimated at 13.4 collisions. This therefore equates to a cumulative total of 34.6

migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 36% of this total. This cumulative total represents 0.02% of the PBR at Rf=0.5 or 0.0007-0.0009% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. As a low level impact on this population has been predicted the degree of disturbance of the flyway population of Black-headed Gull to cumulative collision impacts is defined as **Low**.

Black-headed Gull is considered to be a species of **Local** importance in terms of this assessment.

The likelihood of an effect occurring on the Black-headed Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Black-headed Gull is therefore considered to be **Minor** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

4.5 Little Gull

The cumulative collision risk for Little Gull at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 0.3 collisions. The total collision risk at Horns Rev 1 & 2 for Little Gull was estimated at 7.5 collisions. This therefore equates to a cumulative total of 7.8 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 96% of this total. This cumulative total represents 0.07% of the PBR at Rf=1.0 or 0.007% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. As a low level impact on this population has been predicted the degree of disturbance of the flyway population of Little Gull to cumulative collision impacts is defined as **Low**.

Little Gull is considered to be a species of **International** importance in terms of this assessment.

The likelihood of an effect occurring on the Little Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Little Gull is therefore considered to be **Minor** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

4.6 Common Gull

The cumulative collision risk for Common Gull at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 19.7 collisions, with the majority of these attributable to Horns Rev 3. The total collision risk at Horns Rev 1 & 2 for Common Gull was estimated at 4.5 collisions. This therefore equates to a cumulative total of 24.4 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 18% of this total. This cumulative total represents 0.23% of the PBR at Rf=0.1 or 0.001-0.002% of the biogeographic population. As a low level impact on this population has been predicted the degree of disturbance of the flyway population of Common Gull to cumulative collision impacts is defined as **Low**.

Common Gull is considered to be a species of **National/Regional** importance in terms of this assessment.

The likelihood of an effect occurring on the Common Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Common Gull is therefore considered to be **Minor** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

4.7 Lesser Black-backed Gull

The cumulative collision risk for Lesser Black-backed Gull at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 118.2 collisions, with the majority of these attributable to Horns Rev 3. The total collision risk at Horns Rev 1 & 2 for Lesser Black-backed Gull was estimated at 403.7 collisions. This therefore equates to a cumulative total of 521.9 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 77% of this total. This cumulative total represents 1.66% of the PBR at Rf=1.0 or 0.09-0.1% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. As a consequence the degree of disturbance of the flyway population of Lesser Black-backed Gull to cumulative collision impacts is defined as **Medium**.

Lesser Black-backed Gull is considered to be a species of **International** importance in terms of this assessment.

The likelihood of an effect occurring on the Lesser Black-backed Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Lesser Black-backed Gull is therefore considered to be **Moderate** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

4.8 Herring Gull

The cumulative collision risk for Herring Gull at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 150.1 collisions, with the majority of these attributable to Horns Rev 3. The total collision risk at Horns Rev 1 & 2 for Herring Gull was estimated at 250.1 collisions. This therefore equates to a cumulative total of 400.2 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 62% of this total. This cumulative total represents 0.92% of the PBR at Rf=0.5 or 0.01-0.03% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. As a low level impact on this population has been predicted the degree of disturbance of the flyway population of Herring Gull to cumulative collision impacts is defined as **Low**.

Herring Gull is considered to be a species of **Local** importance in terms of this assessment.

The likelihood of an effect occurring on the Herring Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Herring Gull is therefore considered to be **Minor** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

4.9 Great Black-backed Gull

The cumulative collision risk for Great Black-backed Gull at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 5.9 collisions, with the majority of these attributable to Horns Rev 3. The total collision risk at Horns Rev 1 & 2 for Great Black-backed Gull was estimated at 84.2 collisions. This therefore equates to a cumulative total of 90.1 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 93% of this total. This cumulative total represents 0.5% of the PBR at Rf=1.0 or 0.02-0.03% of the biogeographic population. At an Rf value of 0.1 the PBR value is still not surpassed. As a low level impact on this population has been predicted the degree of disturbance of the flyway population of Great Black-backed Gull to cumulative collision impacts is defined as **Low**.

Great Black-backed Gull is considered to be a species of **Local** importance in terms of this assessment.

The likelihood of an effect occurring on the Great Black-backed Gull flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Great Black-backed Gull is therefore considered to be **Minor** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

4.10 Sandwich Tern

The cumulative collision risk for Sandwich Tern at those projects considered cumulatively in the migratory bird reports for Vesterhav Nord and Vesterhav Syd was estimated as 2.6 collisions, with the majority of these attributable to Horns Rev 3. The total collision risk at Horns Rev 1 & 2 for Sandwich Tern was estimated at 1.5 collisions. This therefore equates to a cumulative total of 4.1 migratory period collisions at an avoidance rate of 98%, with Horns Rev 1 & 2 representing over 36% of this total. This cumulative total represents 0.06% of the PBR at Rf=0.5 or 0.002% of the biogeographic population. Even at an Rf value of 0.1 the PBR value is still not surpassed. As a low level impact on this population has been predicted the degree of disturbance of the flyway population of Sandwich Tern to cumulative collision impacts is defined as **Low**.

Sandwich Tern is considered to be a species of **International** importance in terms of this assessment.

The likelihood of an effect occurring on the Sandwich Tern flyway population is considered to be **Low**.

Cumulative collision impacts are considered to occur throughout the operational lifetime of the projects and are therefore categorised as being a **Permanent** effect.

The magnitude of cumulative collision impacts on migratory Sandwich Tern is therefore considered to be **Minor** should Horns Rev 1 and 2 be included in the cumulative impact assessment (Table 3)**.**

Table 3: Collision risk assessment for all migratory seabird species during operation

Species	Degree of disturban-ce	Impor-tance	Impact Likeli-hood	Persis-tence	Magnitude of impact
Common Scoter	Medium	Interna-tional	Low	Perma-nent	Moderate
Red-throated Diver	Low	Interna-tional	Low	Perma-nent	Minor
Kittiwake	Low	Not im-portant	Low	Perma-nent	Negligilbe
Black-headed Gull	Low	Local	Low	Perma-nent	Minor
Little Gull	Low	Interna-tional	Low	Perma-nent	Minor
Common Gull	Low	Nation-al/Region al	Low	Perma-nent	Minor
Lesser Black-backed Gull	Medium	Interna-tional	Low	Perma-nent	Moderate
Herring Gull	Low	Local	Low	Perma-nent	Minor
Great Black-backed Gull	Low	Local	Low	Perma-nent	Minor
Sandwich Tern	Low	Interna-tional	Low	Perma-nent	Minor

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